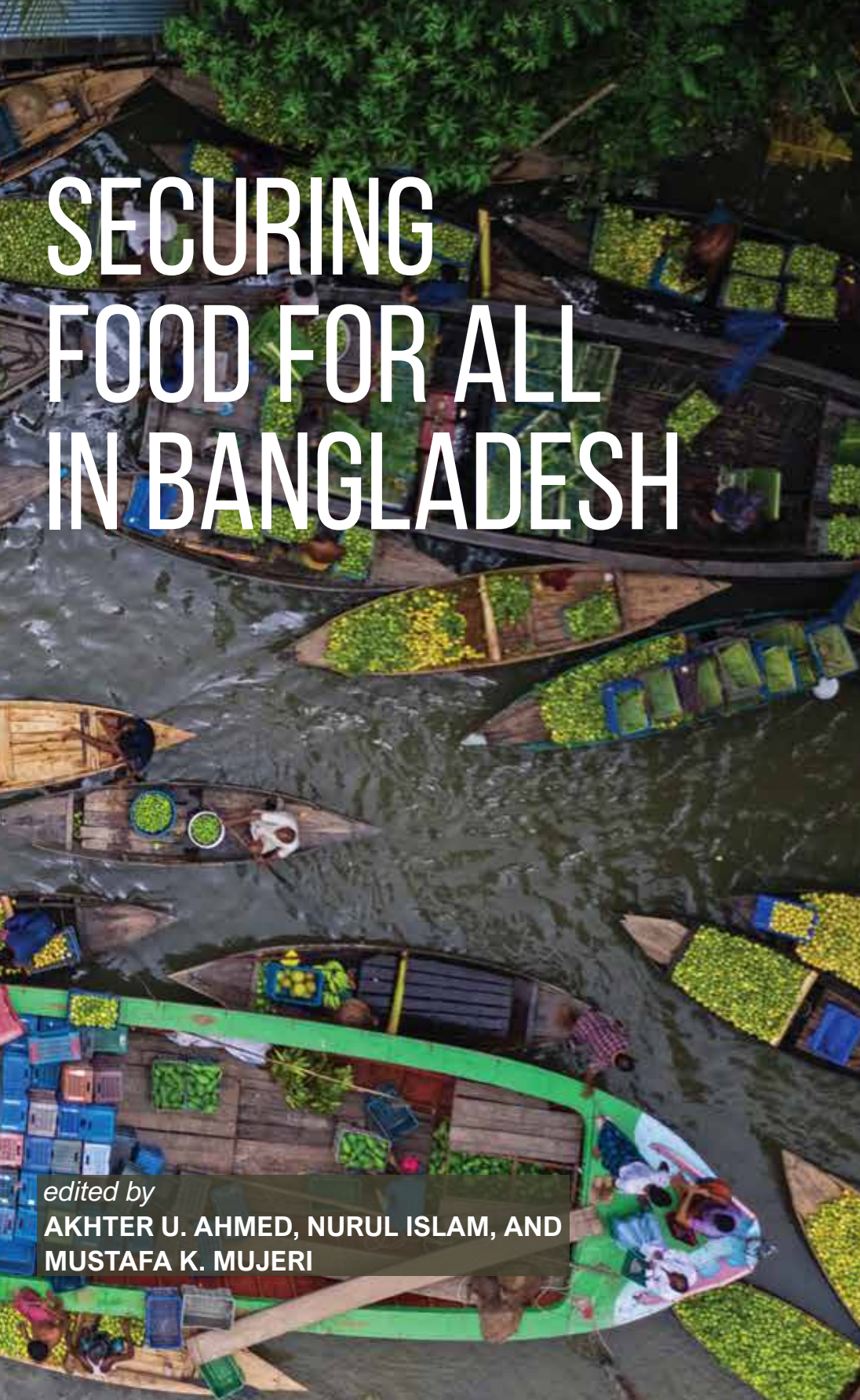
SECURING FOOD FOR ALL IN BANGLADESH



edited by
AKHTER U. AHMED, NURUL ISLAM, AND MUSTAFA K. MUJERI

The availability, access, and consumption of nutritious food is extremely important. Despite declining arable agricultural land, Bangladesh has made substantial progress in boosting domestic food production, improving access to food by increasing household income, and enhancing nutritional outcomes. Nevertheless, the challenges to food and nutrition security remain formidable. Future agricultural growth and food and nutrition security are threatened by population growth, worsening soil fertility, diminishing access to land and other scarce natural resources, increasing vulnerability of crop varieties to pests and diseases, and persistent poverty leading to poor access to food. In addition, the impacts of climate change—an increase in the incidence of natural disasters, sea intrusion, and salinity—will exacerbate food and nutrition insecurity in the coming decades if corrective measures are not taken.

In this context, this book presents an array of research that collectively focus on securing food for all in Bangladesh. Specifically, this book has 15 chapters that address four broad issues: (1) agricultural technology adoption; (2) input use and agricultural productivity; (3) food security and output market; and (4) poverty, food security, and women's empowerment.

BDT 2200 | INR 2090 | USD 65

SECURING FOOD FOR ALL IN BANGLADESH

edited by
AKHTER U. AHMED, NURUL ISLAM, AND MUSTAFA K. MUJERI

University Press Limited

The University Press Limited
74/B/1 Green Road
RH Home Centre (Level 3)
Suite No. 224-239
Tejgaon, Dhaka 1215
Phone: (+8802) 44815288-9
Mobile: (+880) 1917733741
E-mail: info@uplbooks.com.bd
Website: www.uplbooks.com

First published: October 2021

Copyright © International Food Policy Research Institute (IFPRI)

All rights are reserved. No part of this publication may be reproduced or transmitted in any form or by any means without prior permission in writing from the publisher. Any person who does any unauthorized act in relation to this publication may be liable to criminal prosecution and civil claims for damages.

Recommended citation: Ahmed, A. U., N. Islam, and M. K. Mujeri, eds. 2021. Securing Food for All in Bangladesh. Washington, DC: International Food Policy Research Institute (IFPRI). Retrieved from http://uplbooks.com.bd/book/securing-food-all-bangladesh.

Any opinions stated herein are those of the author(s) and are not necessarily representative of or endorsed by IFPRI.

Cover photograph © Insight-Photography/Shutterstock.com

Cover layout design by Mamun Islam

ISBN 978 984 506 371 5

Published by Mahrukh Mohiuddin, The University Press Limited, 74/B/1 Green Road, RH Home Centre, Tejgaon, Dhaka 1215. Book designed by Md. Nazmul Haque and produced by Abarton, 354 Dilu Road, Moghbazar, Dhaka. Printed at the Akota Offset Press, 119 Fakirapool, Dhaka, Bangladesh.

Contents

List of Tables and Figures ix
Abbreviation and Acronyms xix
Contributors xxiii
Acknowledgements xxv

Introduction 1
Akhter U. Ahmed, Nurul Islam, and Mustafa K. Mujeri

PART 1: AGRICULTURAL TECHNOLOGY ADOPTION

Chapter 1 **Agricultural Technology Adoption in the Feed the Future Zone of Influence in Bangladesh** 19
Akhter U. Ahmed, Ricardo Hernandez, and Firdousi Naher

Chapter 2 **Challenges and Opportunities for Hybrid Rice in Bangladesh** 62
David J. Spielman, Patrick S. Ward, Deepthi E. Kolady, and Harun-Ar-Rashid

Chapter 3 **Agricultural Technology Potential for Rice in Bangladesh** 87
Hua Xie, Nicola Cenacchi, and Claudia Ringler

PART 2: INPUT USE AND AGRICULTURAL PRODUCTIVITY

Chapter 4 **Rice Productivity in Bangladesh: What Are the Benefits of Irrigation?** 109
Andrew Reid Bell, Elizabeth Bryan, Claudia Ringler, and Akhter Ahmed

Chapter 5 **Fertilizer Policy in Bangladesh: State Intervention in Markets and Prices** 128
Nurul Islam and Mustafa K. Mujeri

Chapter 6 **Economics of Water Resources Management in Bangladesh** 193
Quazi Shahabuddin, Mohammad Yunus, and K.M. Nabiul Islam

Chapter 7 **Seeding the Future: Accelerating Seed System Development in Bangladesh** 241
Firdousi Naher and David J. Spielman

PART 3: FOOD SECURITY AND OUTPUT MARKET

Chapter 8 **Promoting National and Household Food Security in Bangladesh: Evolving Roles of Public Stocks, Cereal Distribution and Private Trade** 277
Paul Dorosh

Chapter 9 **Food Security Implications of Rice Value Chain Management in Bangladesh** 297
Mustafa K. Mujeri, Nazneen Ahmed, and M. I. Hossain

Chapter 10 **Escalation of Real Wages in Bangladesh: Is it the Beginning of Structural Transformation?** 343
Xiaobo Zhang, Shahidur Rashid, Ahmad Kaikaus, and Akhter Ahmed

Chapter 11 **Sudden Onion Price Surge in Bangladesh: A Situation Analysis for Policy** 375
Akhter U. Ahmed and Ahmad Kaikaus

Chapter 12 **The 'Quiet Revolution' in the Aquaculture Value Chain in Bangladesh** 412
Ricardo Hernandez, Ben Belton, Thomas Reardon, Chaoran Hu, Xiaobo Zhang, and Akhter Ahmed

PART 4: POVERTY, FOOD SECURITY, AND WOMEN'S EMPOWERMENT

Chapter 13 **Climbing Up the Ladder and Watching Out for the Fall: Poverty Dynamics in Rural Bangladesh** 453
Akhter U. Ahmed and Salauddin Tauseef

Chapter 14 Women's Empowerment in Agriculture: What Role for Food Security in Bangladesh? 483
Esha Sraboni, Agnes Quisumbing, and Akhter Ahmed

Chapter 15 Transfers, Behavior Change Communication, and Intimate Partner Violence: Post-program Evidence from Rural Bangladesh 549
Shalini Roy, Melissa Hidrobo, John Hoddinott, and Akhter U. Ahmed

Index 591

List of Tables and Figures

Tables

1.1 Characteristics of Survey Households by Farm Size Groups: Feed the Future Zone 23

1.2 Distribution of Operated Land: Feed the Future Zone 24

1.3 Average Size of Operated Land by Farm Size Groups: Feed the Future Zone 25

1.4 Land Tenure Arrangements by Farm Size Groups: Feed the Future Zone 26

1.5 Usage of Guti Urea by Farmers in 2013 by Farm-Size Groups 29

1.6 Information about Guti Urea 30

1.7 Percentage of Rice Farm Area under Guti Urea in 2013 by Farm-Size Groups 35

1.8 Reasons for Not Using Guti Urea 37

1.9 Percentage of Farmers Cultivating Top 10 Popular Rice Varieties in Feed the Future Zone in 2013 40

1.10 Percentage of Farmers Cultivating Top 10 Popular Rice Varieties in Feed the Future Zone for the First Time since 2000 42

1.11 Percentage of Farmers Stopping Cultivating Top 10 Rice Varieties since 2000 42

1.12 Percentage of Feed the Future Zone Rice Area under Cultivation of Stress-Tolerant Rice Varieties, 2013 44

1.13 Seed Rate for Preparing Seed Bed for Top 10 Popular Rice Varieties, 2013 45

1.14 Cohort Analysis of Retention and Drop Out of Guti Urea Technology in Feed the Future Zone from 2010 to 2013 46

1.15 Adoption and Duration Analysis of Guti Urea in the Feed the Future Zone 48

1.16 Cohort Analysis of Retention and Drop Out of Stress-Tolerant Rice Varieties in the Feed the Future Zone from 2009 to 2013 50

1.17 Adoption and Duration Analysis of Stress-Tolerant Rice Varieties in the Feed the Future Zone 52

2.1	Key Stages and Strategies in ST&I Framework	65
2.2	Seed Replacement Rates for Different Crops in South Asian Countries	68
2.3	Hybrid Seed Use and Share of Imports in Bangladesh, 1998-2007	69
2.4	Hybrid Rice Adoption by Division, 2011	71
2.5	Farmers' Perceptions about Quality of Hybrid Rice in Bangladesh	72
2.6	Hybrid Rice Adoption in Bangladesh by Income Quintiles, 2011	75
2.7	Research and Development of Hybrid Rice in Asia, Selected Countries	79
3.1	Rice Technologies Identified by Workshop Participants by Rice Season	89
3.2	Top Ranked Technology Improvements Needed by AEZ	90
3.3	Average Yields of HYV Rice and Local Variety Rice	92
3.4	Cultivation Rates and Yields of Local and HYV Rice in the Feed the Future Zone	93
3.5	Assessed Total Potential for Implementing HYV Technologies across *aus* and *aman* Seasons in Bangladesh and Feed the Future Zone	93
3.6	Main Data Sets for SWAT-Bangladesh Development	95
3.7	Estimated Rice Production Increase due to Adoption of Drought-Tolerant Technologies	96
3.8	Estimated Rice Production Increase due to Adoption of Cold Tolerance Technology	97
3.9	Estimated Rice Yield Increase due to Adoption of Drought-Tolerance Technology under Future Climate Projected CSIRO-Mk3.0 Model under A1B Scenario for 2050	99
3.10	Soil Salinity in Three Agroecological Zones of Southern Bangladesh	100
3.11	Cultivation Rates of *boro* Rice in Three Sub-zones of Tidal Floodplain AEZ of Southern Bangladesh	100
3.12	Rice Production Increase due to Adoption of Salinity-Tolerant Technology	101
3.13	Expected Rice Loss Percentage under Different Submergence Durations	102
3.14	Estimated Rice Production Loss Reduction due to Adoption of Submergence-Tolerant Technology	103
3.15	Estimated Impacts of Rice Production Technology Adoption in Bangladesh	103
4.1	Descriptive Statistics—Weighted Mean and Standard Deviation	114
4.2	Multivariate Regression Results	117
4.3	Variable Descriptions	119

4.4	Mean Production Intensity (kg/acre/season) across Regions, Income Classes and Rice Crops	120
5.1	Contribution of Fertilizer to Crop Yields in Bangladesh	132
5.2	Land Ownership and Fertilizer Use in Bangladesh	135
5.3	Evolution and Major Changes in Fertilizer Marketing and Distribution System in Bangladesh	137
5.4	Trends in Prices and Marketing Margin of Fertilizer	148
5.5	Trend in Fertilizer-Rice Price Ratio, 1977-1994	151
5.6	Nominal and Economic Fertilizer Subsidies, 1970-1990	163
5.7	Fertilizer Budgetary Subsidy during 1996-2009	165
5.8	Coverage of Irrigation and Adoption of Improved Varieties, 1988 and 2004	176
6.1	Laws, Regulations, and Administrative Procedures for Water Sector Management	206
6.2	Sustainability of Groundwater Use for Irrigation in Northwest Bangladesh	212
6.3	Annual Increase in Net Crop Income per Hectare from Modern Irrigation by Flood Depths	227
6.4	Capital Costs and O&M Costs of Irrigation Water by Modes	228
6.5	Financial and Economic Viability of Modes of Irrigation	230
6.6	Characteristics of Sample Farm Holdings	231
6.7	Contribution of Agriculture in Household Income and Employment	232
6.8	Land Allocation under Irrigated Crops and Incidence of Water Scarcity by Crops	233
6.9	Nature of Scarcity of Irrigation Water by Crops	234
6.10	Severity of Scarcity of Irrigation Water by Crops	234
6.11	Causes of Scarcity of Irrigation Water	235
6.12	Cultivation Plan for Future	235
7.1	Registered Cultivars introduced by Public and Private Agencies, 1971-present	251
7.2	Representation of the Private Sector in Regulatory Bodies	252
7.3	Quantity of Foundation, Certified and TFL Seed of Select Non-Notified Crops produced by BADC since 2003-2004	255
7.4	Proportion of Commercial Seed distributed by BADC, DAE and Private Sector	255

7.5	Seed Requirement and Commercial Seed Distribution for Select Crops, 2008-09 to 2011-12	256
7.6	Rice Cultivated Area by Variety and Average Variety Age in Bangladesh	258
7.7	Most Popular *Aman* and *Boro* Rice Varieties by Division	259
7.8	Farmers cultivating Stress-tolerant Rice Varieties in Southern Bangladesh, 2013	260
7.9	Share of Farmers Cultivating Selected Varieties for the First Time since 2000	261
7.10	Availability of Agricultural Extension Services to Farmers	266
8.1	Bangladesh Food Stocks and PFDS Distribution, 1972-1973 to 2015-2016	284
8.2	Bangladesh Cereal Rice Trade Regimes, Imports and Stocks, 1996-1997 to 2015-2016	288
8.3	Bangladesh: Availability, Stocks and Market Prices in Major Flood Years	291
9.1	Area, Production and Yield of Rice in Bangladesh	300
9.2	Import of Rice in Bangladesh	301
9.3	Sources of Public Procurement of Rice	303
9.4	Educational Level of the Value Chain Actors	317
9.5	Capital Investment of Rice Value Chain Actors	317
9.6	Sources of Paddy for Different Millers	318
9.7	Major Buyers of Rice from Millers	318
9.8	Determinants of Input Prices Perceived by Rice Growers	319
9.9	Determinants of Source of Paddy/Rice Supply	320
9.10	Major Actors Influencing Rice Market	321
9.11	Factors affecting Price Determination of Paddy and Rice	322
9.12	Leadership Perception of Supply Chain Actors	323
9.13	Gross and Net Marketing Margins of Rice	325
9.14	Profit Earned by Different Actors	328
9.15	Share of Gross Margin among Modern Rice Value Chain Actors	329
10.1	Rural Nominal and Real Wages by Gender and Season (at December 2010 Prices)	351
10.2	Urban Nominal and Real Daily Wages by Gender (HIES)	355
10.3	Share of Income from Different Sources	358
10.4	Changes in Nonfarm Income by Sources in Bangladesh, 2000-2010	361
10.5	Share of Employment in Formal and Informal Activities by Sector and Gender	363

10.6	Share of Household Income from Social Safety Nets	366
10.7	Simulated Effects of Changes in Income Sources on Poverty Reduction in Bangladesh, 2000-2010	368
12.1	Zones and Sampled Districts	418
12.2	Definitions of Actor Size by Actor Type	419
12.3	Zone Characteristics	420
12.4	Structural Change in Hatchery Clusters over 10 Years	423
12.5	Structural Change in Feed Mill Clusters over 10 Years	425
12.6	Structural Change in Feed Dealer Clusters over 10 Years	427
12.7	Structural Change in Fish Farmer Cluster over 10 Years	428
12.8	Landholdings and Tenancy by Year and Zone	429
12.9	Factor Productivity in 2013	430
12.10	Structural Change by Rural Fish Traders Cluster over 10 Years	432
12.11	Disposal of Fish Farm Harvest by Final User Type, 2013	435
12.12	Disposal of Fish Farm Harvest by Final User Location, 2013	436
12.13	Aquaculture Production by Fish Category, 2008 and 2013	440
12.14	Fish Farm Capital to Labor Ratio by Zone, 2008 and 2013	443
13.1	Status of Households Surveyed in 2011-2012 and 2015 BIHS	456
13.2	Poverty Transition Matrix, 2011-2012 to 2015 (Raw Number of Households, Not Weighted)	459
13.3	Summary Statistics of Variables Used for Analysis, 2011-2012 BIHS Data	463
13.4	Results of the Multinomial Logit Model with Base Equal to "Never Poor", 2011-2012 to 2015	465
13.5	Logit Regression of Transient Poverty Categories, 2011-2012 to 2015	470
13.6	Simultaneous Quantile Regression Estimates of Log Per Capita Expenditure in 2015	472
14.1	Five Domains of Empowerment in WEAI	489
14.2	Summary Statistics	499
14.3	Model 1: Women's Empowerment Score and Household Food Security Outcomes	504
14.4	Model 2: Women's Group Membership and Household Food Security Outcomes	508
14.5	Model 3: Women's Decisions on Credit and Household Food Security Outcomes	512

14.6 Model 4: Women's Ownership of Assets and Household Food Security Outcomes 516
14.7 Model 5: Women's Rights over Assets and Household Food Security Outcomes 520
14.8 Model 6: Gender Parity Gap and Household Food Security Outcomes 524
14.9 Estimates from Household Food Security Outcome Regressions with Land Interactions 530
14.10 Elasticities of Calorie Availability, Dietary Diversity, and Adult BMI with respect to Empowerment Indicators and Other Household Characteristics 538
14.11 Model 1: Women's Empowerment Score and Per Adult Equivalent Calorie Availability 540
15.1 Impact of Treatment Arms on Prevalence of IPV in Past 6 Months, Post-Endline, Pooled North and South 562
15.2 Impact of Treatment Arms on Frequency of IPV in Past 6 Months, Post-Endline, Pooled North and South 563
15.3 Impact of Treatment Arms on Prevalence of IPV Acts in Past Six months, Post-Endline, Pooled North and South 564
15.4 Impact of Treatment Arms on Prevalence of IPV in Past Six Months, Post-Endline, North vs. South 565
15.5 Impact of Treatment Arms on a Woman's Economic Resources, across Rounds, Pooled North and South 567
15.6 Impact of Treatment Arms on Agency, Endline, Pooled North and South 568
15.7 Impact of Treatment Arms on Household Resources, Endline, Pooled North and South 570

Figures

1.1 Distribution of Operated Land by Farm Size Group 25
1.2 Methods of Irrigation used by Farmers for *Boro* Rice Cultivation in Feed the Future Zone 27
1.3 Share of *Aman*, *Aus*, and *Boro* Rice in Total Rice Land in Feed the Future Zone 28
1.4 Percentage of Rice Farmers Using Guti Urea for Crops in 2013 31
1.5 Percentage of Rice Farmers Using Guti Urea for Different Rice Crops in 2013 31
1.6 Usage of Guti Urea since 2010 in Feed the Future Zone 32
1.7 Annual Frequency of Usage of Guti Urea in at least One out of Four Years (beginning in 2010) 32

1.8	Percentage of Rice Farmers Using Guti Urea in 2013 by Districts in Feed the Future Zone	33
1.9	Percentage of Rice Farmers Using Guti Urea for Different Rice Crops in 2013	34
1.10	Usage of Guti Urea by Farmers in 2013 by Tenancy Categories	34
1.11	Amount of Guti versus Prilled Urea Used in *Boro* Rice (kilograms per hectare), 2013	36
1.12	Yield of *Boro* Paddy with Guti versus Prilled Urea (kilograms per hectare), 2013	37
1.13	Major Reasons for Not Using Guti Urea (percentage of farmers)	38
1.14	Percentage of Farmers Cultivating Any Stress-Tolerant Rice Varieties by Farm Size Group, 2013	40
1.15	Percentage of Farmers Cultivating Any Stress-Tolerant Rice Varieties by Districts in Feed the Future Zone in 2013	41
1.16	Percentage of Rice Area under any Stress-Tolerant Rice Varieties by Rice Season, 2013	43
1.17	Source of Seeds for Farmers in Feed the Future Zone, 2012	45
1.18	Adoption and Withdrawal Survivor Rates of Guti Urea	47
1.19	Adoption and Withdrawal Survivor Rates of Stress-Tolerant Rice Varieties	51
2.1	Hybrid Rice Cultivation, Bangladesh, 1998-2010	70
2.2	Hybrid Rice Adoption in Bangladesh by Income Quintiles, 2011	74
3.1	Agro-ecological Zones and Feed the Future Zones in Bangladesh	88
3.2	Area Share of High-Yielding Varieties of Rice in Bangladesh	91
3.3	Area Share of HYV Rice Cultivation in Bangladesh by AEZ	92
3.4	Basins in Bangladesh Defined for SWAT Modeling	94
3.5	Estimated Rice Yield Increase due to Adoption of Drought-Tolerance Technology	96
3.6	Estimated Rice Yield Increase due to Adoption of Cold-Tolerance Technology	97
3.7	Estimated Rice Yield Increase due to Adoption of Drought-Tolerant Technologies under Future Climate (CSIRO-Mk3.0 Model under A1B scenario) for 2050	98
3.8	Salinity Affected Agroecological Zones in Bangladesh	100
3.9	Expected Rice Yield Loss Reduction Brought from Submergence-Tolerance Traits	102
5.1	Trend in Per Hectare Use of Fertilizers in Bangladesh	133

5.2	Fertilizer Distribution under the New Marketing System, 1983-1984	141
5.3	Composite Domestic Retail and World Prices	172
5.4	Urea Domestic Retail and World Prices	173
6.1	Distribution of Water Sellers and Buyers by Land Holding Sizes	199
6.2	A Framework for Water Resource Management in Bangladesh	200
6.3	Salinity Intrusion in Southwest Bangladesh (CSIRO-IWM 2014)	221
7.1	Elements of a Seed System	243
7.2	Seed System in Bangladesh: Functions, Actors and Regulatory Bodies	249
7.3	Share of Farmers Cultivating Modern Varieties, 2011-12	257
7.4	Share of Farmers adopting of HYV versus Hybrid for *Boro* Rice	262
7.5	Farmers' Sources of Seeds	262
7.6	Proportion of Farmers from Poorest and Richest Quintile who Purchased	263
7.7	Demand for Commercial Seed by Marginal versus Large Farmers	263
7.8	Proportion of GDP from Agriculture Spent on R&D	265
7.9	Percentage of Farmers Consulting Agriculture Extension Agent in Last One Year	267
8.1	Bangladesh: Net Production and Food Gap (1980-1981 to 2014-2015)	280
8.2	Food Aid and PFDS Distribution, 1976-1977 to 2014-2015 (3-year centred moving average)	280
8.3	Bangladesh: Public Rice and Wheat Stocks, 1996-1997 to 2015-2016	282
8.4	Bangladesh: Import Parity and Wholesale Rice Prices and Private Sector Rice Imports, 2005-2016	283
8.5	Bangladesh: Real (2014) Import Parity and Wholesale Rice Prices and Private Sector Rice Imports, 2005-2016	285
8.6	Bangladesh: Public Food grain Distribution Channels, 2004-2005 to 2015-2016	286
8.7	Bangladesh: Public Rice and Wheat Stocks, 1996-1997 to 2015-2016	287
8.8	Bangladesh: PFDS Distribution and Domestic Procurement of Rice, 1997-1998 to 2015-2016	289
8.9	Bangladesh: PFDS Distribution and Domestic Procurement of Wheat, 1997-1998 to 2015-2016	290
9.1	Production of Different Rice Varieties in Bangladesh	301
9.2	Bangladesh National Food Security Policy Framework	307
9.3	Links between Rice Value Chain and Food Security Policy in Bangladesh	310

9.4	Map showing the Study Areas	312
9.5	Rice Value Chain in Bangladesh	313
9.6	Share of Different Actors in Net Marketing Margin	327
10.1	Conceptual Model of Lewis Turning Point	347
10.2	Monthly Real Wages of Rural and Urban Workers in Bangladesh, June 2001-2012. (a) Urban and Rural Real Wage at December 2010 Prices (Deflated by General CPI), (b) Urban and Real Wage at December 2010 Prices (Deflated by Food CPI), and (c) Nominal Daily Wages/Coarse Rice Price	349
10.3	Seasonality of Real Wages by Gender	354
10.4	Foreign Direct Investment (FDI) and Employment in the Garments Sector	359
10.5	Share of Working-Age Population in Manufacturing Sector by Gender	363
10.6	Agricultural Labor Productivity	364
11.1	Daily Retail Prices of Bangladeshi and Indian Onions in Dhaka City, 1 August to 16 September 2013	377
11.2	Daily Retail Prices of Bangladeshi and Indian Onions in Dhaka City, 1 July 2012 to 16 September 2013	377
11.3	Daily Wholesale and Retail Prices of Bangladeshi Onion in Dhaka City, 1 July 2012 to 16 September 2013	378
11.4	Daily Wholesale and Retail Prices of Indian Onion in Dhaka City, 1 July 2012 to 16 September 2013	378
11.5	Monthly Average Retail Prices of Bangladeshi and Indian Onions, July 2010-August 2013	379
11.6	Monthly Prices of Bangladeshi Onions, July 2010-August 2013 (actual versus deseasonalized prices)	379
11.7	Irregular Variations in Prices of Bangladeshi Onions, July 2010-August 2013	380
11.8	Daily Stocks and Selling Prices of Indian Onion at Shyambazar Wholesale Market in Dhaka City, 22 July-22 August 2013	381
11.9	Daily Stocks and Selling Prices of Bangladeshi Onion at Shyambazar Wholesale Market in Dhaka City, 22 July-22 August 2013	381
11.10	Daily Average Stocks of Bangladeshi and Indian Onions at Shyambazar Wholesale Market in Dhaka City, 22 July-22 August 2013	382
11.11	Domestic Onion Production and Real Wholesale Onion Prices, 2001-2002 to 2011-2012	383
11.12	Discrepancies in Estimates of Onion Production: BBS versus DAE	384

11.13 Annual Growth Rates of Onion Production, Area, and Yields, 2004-2005 to 2011-2012 385
11.14 Cost of Production of Onion per Hectare, 2012 386
11.15 Cost of Production of Onion per Metric Ton, 2012 386
11.16 Shares (percent) of Input Costs in cash and Full Costs of Production of Onion, 2012 387
11.17 Uses of Onion produced by Bangladeshi Farm Households 388
11.18 Trends in Monthly Onion Imports, June 2011-July 2013 390
11.19 Trends in Annual Onion Imports, 2005-2006 to 2012-2013 390
11.20 Onion Availability for Consumption, 2011-2012 391
11.21 Trends in Per Capita Onion Consumption, 2000, 2005, and 2010 392
11.22 Projected Onion Demand, 2010-2020 393
12.1 Average Weekly Consumption Per Capita of Ten Most Consumed Fish Species in Rural Bangladesh 440
13.1 Poverty Dynamics Categories as Percentage of the Total Rural Population 458
14.1 Contribution of Each of the 5 Domains to the Disempowerment of Women 495
14.2 Contribution of Each of the 10 Domain Indicators to Disempowerment of Women 495

Abbreviation and Acronyms

ACI	Advanced Chemical Industries Ltd
AEZ	Agro-Ecological Zone
AFT	Accelerated Failure Time
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCIC	Bangladesh Chemical Industries Corporation
BCR	Benefit-Cost Ratio
BFA	Bangladesh Fertilizer Association
BFRI	Bangladesh Fisheries Research Institute
BIADP	Barind Integrated Area Development Project
BIDS	Bangladesh Institute of Development Studies
BIHS	Bangladesh Integrated Household Survey
BINA	Bangladesh Institute of Nuclear Agriculture
BIWTA	Bangladesh Inland Water Transport Authority
BKB	Bangladesh Krishi Bank
BMI	Body-Mass Index
BNPI	Basic Needs Price Index
BPRSSP	Bangladesh Policy Research and Strategy Support Program
BRRI	Bangladesh Rice Research Institute
BS	Breeder Seed
BSRI	Bangladesh Sugarcrop Research Institute
BWDB	Bangladesh Water Development Board
CGIAR	Consultative Group for International Agricultural Research
CK	Community Capital

CRP	Coarse Rice Price
CSISA	Cereal Systems Initiative for South Asia
DAE	Department of Agricultural Extension
DATA	Data Analysis and Technical Assistance
DFSMC	District Fertilizer and Seed Monitoring Committee
DoE	Department of Environment
DoF	Department of Fisheries
DPHE	Department of Public Health Engineering
DTW	Deep Tube Well
DUS	Distinctness, Uniformity and Stability
EGHP	Employment Generation for the Hardcore Poor
EPIC	Erosion Productivity Impact Calculator
ETP	Effluent Treatment Plant
FAO	Food and Agriculture Organization
FK	Farm Capital
FPMU	Food Planning and Monitoring Unit
FS	Foundation Seed
GCM	General Circulation Model
GCPI	General Consumer Price Index
GMM	Gross Marketing Margin
GRiSP	Global Rice Science Partnership
HIES	Household Income and Expenditure Survey
HK	Human Capital
HRDC	Hybrid Rice Development Consortium
HYV	High Yielding Variety
ICZM	Integrated Coastal Zone Management
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IPV	Intimate Partner Violence
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
LFS	Labour Force Survey

LGED	Local Government Engineering Department
MFI	Microfinance Institution
MMIS	Market Monitoring Information System
MOWCA	Ministry of Women and Children Affairs
MP	Member of Parliament
MPO	Master Plan Organization
NARS	National Agricultural Research System
NCEP	National Centers for Environmental Prediction
NFDCC	National Fertilizer Distribution Coordination Committee
NGO	Nongovernmental Organization
NMM	Net Marketing Margin
NMS	New Marketing System
NPV	Net Present Value
NWMP	National Water Management Plan
O&M	Operation & Maintenance
OMS	Old Marketing System
OMS	Open Market Sales
PFDS	Public Food Distribution System
PSU	Primary Sampling Unit
PVP	Plant Variety Protection
RRI	River Research Institute
SANEI	South Asia Network of Economic Research Institutes
SCA	Seed Certification Agency
SSN	Social Safety Net
STRASA	Stress-Tolerant Rice for Africa and South Asia
STW	Shallow Tube Well
SWAT	Soil and Water Assessment Tool
TC	Technical Committee
TDP	Transportation Discount Point
TLS	Truthfully Labeled Seed
UDP	Urea Deep Placement
UFFL	Urea Fertilizer Factory Limited

USAID	United States Agency for International Development
UZAO	Upazila Agriculture Office
VCU	Value in Cultivation and Use
VGD	Vulnerable Group Development
WARPO	Water Resources Planning Organization
WASA	Water and Sewerage Authority
WFP	World Food Programme
WHO	World Health Organization
WMCA	Water Management Cooperative Association
WUA	Water User Association

Contributors

Agnes Quisumbing, Poverty, Health, and Nutrition Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Ahmad Kaikaus, Prime Minister's Office, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh

Akhter U. Ahmed, Poverty, Health, and Nutrition Division, International Food Policy Research Institute (IFPRI), Dhaka, Bangladesh

Andrew Reid Bell, Department of Environmental Studies, New York University, USA

Ben Belton, Department of Agricultural, Food, and Resource Economics, Michigan State University, USA

Chaoran Hu, Department of Agricultural, Food, and Resource Economics, Michigan State University, USA

Claudia Ringler, Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

David J. Spielman, Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Deepthi E. Kolady, Department of Economics, South Dakota State University, USA

Elizabeth Bryan, Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Esha Sraboni, Department of Sociology, Brown University, Rhode Island, USA

Firdousi Naher, Department of Economics, University of Dhaka, Dhaka, Bangladesh

Harun-er-Rashid, Senior Consultant, Dhaka, Bangladesh

Hua Xie, Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

John Hoddinott, Division of Nutrition Sciences, Cornell University, Ithaca, New York, USA

K.M. Nabiul Islam, Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh

M. I. Hossain, Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh

Melissa Hidrobo, Poverty, Health, and Nutrition Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Mohammad Yunus, Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh

Mustafa K. Mujeri, Institute for Inclusive Finance and Development (InM), Dhaka, Bangladesh

Nazneen Ahmed, Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh

Nicola Cenacchi, Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Nurul Islam, Research Fellow Emeritus, International Food Policy Research Institute (IFPRI), Washington DC, USA

Patrick S. Ward, Department of Economics, Duke Kunshan University, Jiangsu, China

Paul Dorosh, Development Strategy and Governance Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Quazi Shahabuddin, Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh

Ricardo Hernandez, The International Center for Tropical Agriculture (CIAT), Hanoi, Vietnam

Salauddin Tauseef, Department of Economics, University of Manchester, UK

Shahidur Rashid, South Asia Regional Office, International Food Policy Research Institute (IFPRI), New Delhi, India

Shalini Roy, Poverty, Health, and Nutrition Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Thomas Reardon, Department of Agricultural, Food, and Resource Economics, Michigan State University, Michigan, USA

Xiaobo Zhang, Development Strategy and Governance Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

Acknowledgements

For over three decades, the International Food Policy Research Institute (IFPRI) has conducted research and policy analysis on priority issues in Bangladesh. Since 2010, IFPRI scaled up its support in Bangladesh with the Policy Research and Strategy Support Program for Food Security and Agricultural Development (PRSSP) funded by the U.S. Agency for International Development (USAID). The IFPRI-PRSSP researchers conducted and contributed to a wide body of research ranging from agricultural development, food security, nutrition, social protection, and women's empowerment, much of which was in concert with the government, national research institutes, and renowned universities globally.

Although some of the chapters in this edited book are exclusively IFPRI outputs, a significant portion of this book is a product of collaborative research between IFPRI, national research institutes such as the Bangladesh Institute of Development Studies (BIDS) and the Institute for Inclusive Finance and Development (InM), researchers from renowned universities in Bangladesh, the United States, the United Kingdom, and China, and other leading experts. As a result, this edited book represents a culmination of groundbreaking research, enriched through multidisciplinary perspectives and synergies.

We committed to publishing this edited book to compile evidence, document lessons learned, and establish guideposts for emerging food policies. In doing so, we received a great deal of help and cooperation from individuals and institutions. We gratefully acknowledge the USAID for funding the research in this collection through the PRSSP under USAID Grant Number EEM-G-00-04-00013-00. Anonymous reviewers from University Press Limited (UPL) provided constructive comments on the manuscript that significantly improved the original. We thank them for their contribution. The co-editors received permission to reproduce copyrighted material prior to publication of this edited book. For this, we gratefully acknowledge the following journals: *Applied Economic Perspectives and Policy*, *Aquaculture*, *Land Use Policy*, *The Review of Economics and Statistics*, and *World Development*.

Finally, at IFPRI, we sincerely appreciate the support of Shenggen Fan, Marie Ruel, and Rajul Pandya-Lorch; and thank Indira Yerramareddy, Pamela Stedman-Edwards, and Julie Ghostlaw, who processed and monitored the book at various stages.

Introduction

Akhter U. Ahmed, Nurul Islam, and Mustafa K. Mujeri

Food is the most important basic need for sustenance and survival, and the right to food is among the fundamental human rights. Access to sufficient food at all times to meet dietary needs of millions of people in Bangladesh is a matter of critical importance and should be an issue of paramount concern to those responsible for the nation's welfare. According to Article 15 (a) of the Constitution of the People's Republic of Bangladesh, it is a principal responsibility of the State to meet the basic food needs of all citizens. Furthermore, Article 18(1) of the Constitution has made the improvement of the nutritional status of the people and the improvement of public health, the primary responsibilities of the state.

This book assembles a set of papers that collectively focus on the extensive undertaking of securing food for all in Bangladesh. The book addresses four broad issues: (1) agricultural technology adoption; (2) input use and agricultural productivity; (3) food security and output market; and (4) poverty, food security and women's empowerment. The chapters, fifteen in total, address diverse aspects within these four themes.

Country Profile

Bangladesh is located in South Asia and is bordered by India on the west, north, and northeast, by Myanmar on the southeast, and by the Bay of Bengal to the south. The country mostly consists of low, flat, and fertile land, except for the hilly regions in the southeast and to a lesser extent in the northeast, and patches of highlands in the central and northwest regions. A river system of some 230 rivers and their tributaries, with a total length of about 24,140 kilometres, flows across the country down to the Bay of Bengal. The alluvial soil is enriched by heavy silts deposited by overflowing rivers during the rainy season. The country has a subtropical monsoon climate characterized by heavy seasonal rainfall, high temperatures, and high humidity. Summer, monsoon, and winter are the most prominent of its six seasons. Natural hazards such as floods and cyclones accompanied by storm surges periodically affect the country.

With a population of 164.7 million in mid-2020 inhabiting an area of 147,570 square kilometres (56,977 square miles), Bangladesh is the second most densely populated country in the world after the city-state of Singapore. In 2019, the annual rate of population growth was 1.04 percent, according to the World Bank (Trading Economics 2020) with about 63 percent of the population living in rural areas.

Although the share of agriculture in gross domestic product (GDP) declined from 31 percent in 1990 to 13 percent in 2018-2019, the agricultural sector continues to be the largest employer, involving about 41 percent of the total labor force in 2016 as reported by the BBS in 2020 (Labor Force Survey [LFS] 2016-17). Agriculture has a profound impact on several macroeconomic objectives, such as employment generation, poverty reduction, human resources development, and food security (Biogeny 2018). Bangladesh's labor-intensive agriculture has steadily increased food grain production despite the often-unfavorable weather conditions (Islam 2011; Islam 2014).

A Rapidly Changing Economy

Bangladesh's GDP growth rate has increased from less than 4 percent in the 1980s to 8.2 percent in 2019 (Ministry of Finance 2019). GDP grew at a rate of 6.8 percent on average per year between 2010 and 2019. Enhancements in economic growth have been driven by the acceleration of structural reforms, shift towards a rule-based policy framework, and low global commodity prices. Recent deregulation measures and efforts aimed at improving the ease of doing business have boosted foreign investment.

Steady progress in economic growth contributed to the reduction in the rate of poverty. The incidence of poverty in Bangladesh was cut in half in 16 years, dropping from 48.9 percent in 2000 to 24.3 percent in 2016. In rural areas, poverty headcount declined from 52.3 percent to 26.4 percent over the same period (BBS 2019). Rapid growth enabled Bangladesh to reach the lower middle-income country status in 2015.

Since independence in 1971, Bangladesh transitioned from dependence on foodgrain imports to self-sufficiency in foodgrain production. Life expectancy has nearly doubled since the early 1950s, literacy rates have significantly multiplied, health conditions have improved, and a sizable middle class has emerged. Overall, despite seemingly insurmountable odds, Bangladesh has made tremendous progress in many aspects of economic and social development over a relatively short period, leading Mujeri and Sen to term Bangladesh's progress as a 'development puzzle' (Mujeri and Sen 2006).

Over the past several decades, as Bangladesh has continued to develop, there has been an increase in rural-to-urban migration. Looking ahead,

Bangladesh needs to generate employment opportunities to accommodate a growing population, establish housing facilities for the large number of new households, and plan adequate infrastructure to meet the demands of the expanding economy. Inclusive growth is the key to uplifting the nearly 30 million people who are still living in poverty. Further, for many of those who have escaped poverty, they continue to suffer from multiple deprivations with high risks of falling back into poverty—a risk that must be mitigated.

Bangladesh has undergone unprecedented economic and social transformations, yet more is needed to promote rural revitalization. Rural livelihoods are derived mostly from smallholder farming including livestock and fisheries, agricultural wage labor, and wage or self-employment in the rural non-farm economy. While some households rely primarily on one type of activity, most seek to diversify their livelihood as a way to enhance family income and reduce risks. As a result, apart from agricultural income, non-farm income sources are becoming increasingly important, and income gains at the household level are generally associated with a shift towards more non-agricultural wages and self-employment income.

Developing the Rural Economy

In Bangladesh, poverty continues to remain a predominantly rural phenomenon despite increasing urbanization. Rural areas for the most part, depend on agriculture, forestry, fisheries, and related activities for survival. As such, the development of the rural economy has the potential to increase employment opportunities in the rural areas, reducing regional disparities, and ultimately reducing poverty. In addition, sustainable development of rural areas has the potential to contribute to the preservation of the rural ecology and protection from the adverse impact of climate change.

Globally, the debate on rural development has always centred on the relationship between agriculture and the rural economy (World Bank 2001; Harriss 1982).

The entry points for developing rural areas in Bangladesh will change over time. The role of agriculture will decline as the process of development gains momentum; however, one needs to recognize that the labor share in agriculture declines at much slower rates than the share of agriculture in GDP. Unless policies and investments to foster greater agricultural productivity are implemented, the relative decline of agriculture may be accompanied by increased rural poverty, some of which may find its way into the urban areas as well. At the same time, policies and programs designed to increase human capital of the rural poor and to facilitate their entry into more remunerative labor markets, are powerful tools to ensure a smooth transition of people out of agriculture.

An unprecedented transformation of the agricultural sector is currently underway in Bangladesh. Growing per capita income is raising the demand for high value food products with greater emphasis on food quality and safety issues. The role of traditional supply chains is shrinking, creating modern food chains and new anti-poverty entry points requiring new skills and capital. Market integration is weakening the links between agriculture and the local economy, and opening up new links to larger national and global markets, thus creating new challenges of domestic and foreign competition for small farmer dominated agriculture. However, the characteristics of small farmers and their rural livelihoods are not without opportunities: access to larger markets and higher value alternatives will also be available for those who innovate and are able to take up opportunities created by the changing agriculture (UNDP and FAO 2007).

Further, the growth of nonfarm activities is often driven by growth in agricultural productivity in the initial stages because of the linkages in production, consumption, and the labor market, between the farm and nonfarm sectors. Diversification out of agriculture in rural areas may also raise agricultural wages as rural labor market contracts. Policymakers in Bangladesh can significantly leverage nonfarm activities that typically connect rural areas, especially to smaller and more dispersed urban locations to reduce poverty. For this, it is important to focus on provision of connectivity between rural areas, smaller urban locations, as well as larger cities, provision of electricity in rural areas, and establishment of efficient land and labor markets.

Progress in Food Security Improvement

Bangladesh has progressed well in improving food security. The focus of its food policy has shifted perceptibly in the past decades. A complete picture of food security is provided under the framework of food availability, access, and utilization.

Food availability

Food availability at the national level is determined by domestic food production, public and private food stockholding, food imports including food aid, and food exports. With the liberalization of international trade, global availability of food is of increasing importance for national food security. Availability of food at the household-level depends on the household's own capacity to produce food, household food stockholding, and availability of food in the local markets, which, in turn, is a function of market operations, infrastructure, flow of information, and seasonal variations in domestic food production.

Against the backdrop of declining arable land, Bangladesh has progressed well in feeding a large population with domestic agricultural production. The growth in overall food production has been keeping ahead of population growth resulting in higher per capita availability of food over time. In the early 1970s, Bangladesh was a food-deficit country with a population of about 75 million. Today, the population is 165 million, and the country is now self-sufficient in rice production, which has tripled over the past three decades. Seed, fertilizer and irrigation technologies known as 'Green Revolution technologies' have played major roles in the growth of rice production in Bangladesh.

In the 1980s, the government liberalized the input markets, gradually eliminated subsidies on agricultural inputs, and removed bans on private sector imports of agricultural machinery. These policy changes induced private investment into small-scale irrigation, such as shallow tube wells and power pumps, all of which have contributed to accelerated growth of dry-season irrigated rice (boro) during the last two decades. However, fertilizer subsidies were reintroduced in the 1990s, which currently account for over two-thirds of the public sector's expenditure on agriculture.

Bangladesh has made tremendous progress in fish production, registering an average annual growth rate of 6.2 percent over the four-year period from 2015-2016 to 2018-2019. The livestock sub-sector experienced a growth rate of 3.4 percent over the same period (FPMU 2020). However, there are still shortfalls in the production of certain non-rice crops, such as pulses, vegetables, and fruits.

Food access

Households' access to food depends on food prices, household income, and assets or resource base. Increased income of households can improve household food security in terms of improved access to food. In addition, expanded asset bases reduce the vulnerability of households to short-term disruptions in income flows, because part of the asset base can be sold in times of adversity. This helps to prevent degradation of household food security. Poverty is a major determinant of chronic household food insecurity. The poor do not have adequate purchasing power to secure their access to food, even when food is available in local markets. Moreover, the poor are particularly vulnerable to shocks (such as natural hazards and crop failure) that cause transitory food insecurity. Increased food prices also result in transitory food insecurity of low-income households by lowering their real income and, hence, eroding their purchasing power.

Along with food availability, people's access to food has also improved in Bangladesh. Bangladesh's average annual GDP growth rate of 6.1 percent

from 2000 to 2016 contributed to the reduction in the rate of poverty from 48.9 percent to 24.3 percent during the same period (BBS 2019). With 1.1 percent annual population growth, per capita income increased steadily by 5 percent per year. Increased income has improved access to food. According to the Household Income and Expenditure Survey (HIES), per capita food consumption has increased from 893 grams in 2000 to 914 grams in 2016 (BBS 2019). Most significantly, real wages in Bangladesh have accelerated in recent years. As more workers have shifted to the formal sector and other non-farm jobs, labor in rural areas has become scarcer, bidding up rural real wages and thereby enhancing total labor earnings (Zhang et al. 2014). On average, the daily wage of a male agricultural laborer could buy 5.4 kg of rice in 2005. In 2019, it could buy 13.3 kg of rice.

Bangladesh possesses significant experience in helping the poor through safety nets and social protection programs; it allocates a significant share of its national budget to run the programs. For perspective, in fiscal year 2018-2019, the government allocated BDT 642 billion (USD 8 billion) to social protection (inclusive of government pensions), or about 2.5 percent of GDP and 13.8 percent of the total budget. Social safety net programs have been effective in augmenting the incomes of extremely poor households in Bangladesh and helping them cope with stresses and shocks. Evaluations of social safety net programs in Bangladesh demonstrated considerable positive impacts on food security of the poor.

Food utilization

Food utilization—the other dimension of food security—is closely related to nutrition. As food availability and accessibility to food increase, hunger may decrease, but not necessarily malnutrition. One reason for persistent malnutrition may lie in the complex interaction between food intakes and illness, affecting the food utilization by the body, which in turn, is influenced by the overall health and care-giving environment. Improvements in availability and access to the foods that are important for good nutritional status may be offset by poor access to nonfood inputs, such as quality healthcare facilities and services, education (particularly for mothers), sanitation, and safe water, or ineffective mechanisms for delivering these services. Proper care giving practices can improve household food security and community-level health and sanitation for children, women, and other vulnerable household members.

There has been significant progress in nutritional outcomes in Bangladesh. A cross-country study concluded that from 1997 to 2007 Bangladesh had recorded one of the fastest prolonged reductions in child underweight and

stunting prevalence in history (Headey 2013). The rate of stunting (low height-for-age) among children under five, which reflects the state of chronic undernutrition, has decreased from 55 percent in 1997 to 31 percent in 2017 (Osmani et al. 2016; NIPORT 2019).

Another indicator of nutritional status is maternal undernutrition, as measured by low body mass index (BMI), which is a symptom of chronic energy deficiency in adult women. According to this measure, undernutrition among women of reproductive age has declined sharply from 34 percent in 2004 to 19 percent in 2014 (NIPORT 2016). Yet another indicator is child mortality. Although various factors can influence the level of child mortality, undernutrition is known to be one of the major factors: international evidence suggests that almost half (45 percent) of all under-five deaths in the developing world can be attributed to undernutrition (Black et al. 2013). The under-five mortality rate has declined in Bangladesh from 65 deaths per thousand live births in 2007 to 45 deaths per thousand in 2017-2018 (NIPORT 2019).

The recently formulated National Food and Nutrition Security Policy 2020 provides guidance for the development of a nutrition-sensitive food system in Bangladesh. This policy complements and builds upon current policies and strategies aimed at achieving the goal of food and nutrition security. For example, the stated goals of the National Nutrition Policy 2015 include improving the nutritional status of the population, especially mothers, children, adolescent girls and the underprivileged, alongside controlling malnutrition and expediting national development through improved living standards.

Remaining Issues and Challenges

Although Bangladesh has made substantial progress in enhancing food security by increasing domestic production of food and improving access to food by increasing household income and strengthening safety net transfer programmes over the years, the challenges to food and nutrition security are still formidable. Future agricultural growth and food and nutrition security are threatened by population growth, worsening soil fertility, deteriorating access to increasingly scarce natural resources (water and land), increasing vulnerability of improved crop varieties to pests and diseases, and persistent poverty leading to poor access to food. In addition, the impacts of climate change—an increase in the incidence of natural disasters, sea intrusion, and salinity—will exacerbate food and nutrition insecurity in the coming decades if corrective measures are not taken. The impacts of both environmental degradation and climate change are usually

more severe for small farmers than for large farmers because small farmers have less access to human, social and financial capital and information than large farmers (FAO 2019).

Land is the most important factor in agricultural production. However, IFPRI's 2012 nationally representative rural household survey results show that about one-third of all farmers are 'pure tenants' meaning they do not own the land they cultivate. Therefore, they likely have insecure, prohibitive, and unstable access to land through sharecropping or land-leasing arrangements, which may act as a deterrent for adoption of technology. These farmers must pay rent for the land they cultivate, making farming a low-profit enterprise for them. They remain in agriculture probably because of a lack of alternative employment opportunities (Ahmed et al. 2013). Agricultural development policies and programs in Bangladesh should consider the implications of this important constraint arising from the prevailing agrarian structure in the country.

Marginal and small farmers constitute the largest share of farmers in Bangladesh. However, the outreach of agricultural extension services to these two groups of farmers is very low in absolute terms and considerably less than the service provided to large farmers. In general, farmers receive information about inputs primarily from other farmers (Hossain et al. 2003).

Credit is a critical input for farmers. However, their access to formal agricultural credit institutions, such as the Bangladesh Krishi Bank (BKB) and the Rajshahi Krishi Unnayan Bank (RAKUB), is relatively very small. Moreover, the outreach of these two credit institutions is more toward medium and large farmers than marginal and small farmers. Insufficient access to credit is a major barrier to the use of improved agricultural inputs. There are a large number of landless, marginal and small farmers that do not or cannot get agricultural credit from the government banks (Barkat et al. 2010).

The imperfect dairy market in Bangladesh has allowed milk importers to transfer any increase in cost due to rising global prices or taxes and tariffs to consumers directly without transferring the benefits of any price increases to producers, thereby dissolving any incentives to increase productivity. The opposite situation occurs when global prices or taxes and tariffs fall—the benefit of such a decline has been transferred to consumers very slowly. Thus, the imperfect dairy market has rendered tax and tariff policies ineffective for dairy sector growth in Bangladesh (Jabbar 2010). Key challenges for livestock development include adulterated and inferior quality of commercial feeds and feed ingredients; inadequate feed labeling and control; limited access to technical support from livestock officers; shortage of feed and fodder;

inadequate supply of veterinary services; inadequate coverage of animal health services; and problems of quality control in livestock products, drugs, vaccines, feeds, and breeding materials (Ahmed et al. 2011).

Year-to-year price fluctuations are much larger for non-rice crops than for rice, indicating relatively high levels of market-induced risks for production of non-rice crops such as fruits and vegetables. High-value crops have thin domestic markets owing to relatively low levels of demand for them due to widespread poverty and inadequate purchasing power. An increase in production causes a sharp decline in market prices (Ahmed and Ghostlaw 2019). Horticultural crops, milk, and fish also face special problems related to perishability, which increases the risks of marketing. The interplay of these factors contributes to low agricultural diversity in Bangladesh.

Rice is overwhelmingly dominant in the cropping patterns, as well as in the diet of people in Bangladesh. Rice accounts for 77 percent of total cropped area and 71 percent of the total dietary energy intakes on average (Ahmed et al. 2013). Food consumption patterns therefore contain very little dietary diversity. One of the most important causes of widespread malnutrition is the extant deficiency in the habitual diet in Bangladesh, with rice contributing most of the total dietary energy and other foods contributing a fraction of what is required. A large share of the population is food-insecure due to poor dietary quality. The solution lies in increased consumption of high-quality foods (such as fruits, vegetables, fish, meat, milk), which the poor desire but cannot afford.

Poor nutrition in Bangladesh is rooted in poverty, food insecurity, gender inequality, and lack of access to basic health, education, and WASH services, and the nutrition profile is passed on intergenerationally. Early childhood malnutrition increases the risk of disease and impairs productivity at all stages of the life cycle. In this cycle, underweight and malnourished women bear children who are undernourished in the womb, are born with low weight and then suffer from malnutrition during the critical first two years of life. This leaves them vulnerable to disease and early death. For the surviving children, their potential for physical and cognitive development are impaired. As a result, these children are less likely to perform well in school and later find gainful employment; thus, they are less likely to escape poverty. In the case of girls, early poor nutrition increases the likelihood that they too will become underweight mothers, with increased chances of suffering maternal mortality, or giving birth to babies of low weight. In this way, malnutrition can be transmitted across generations.

There are three broad types of household food insecurity in Bangladesh. First, there are the chronically food-insecure who cannot purchase enough

rice to meet energy requirements, despite a falling real price of rice over the last several decades. The level of technology and institutional innovations that made this price decline possible must be maintained. Second, those who normally meet energy requirements, but run a very real risk of losing access to food due to shocks are also food insecure. Shocks, such as floods, cyclones, and droughts, lead to sudden losses of income, and hence can result in acute food insecurity. Family coping strategies, such as sale of productive assets to meet food consumption needs, often aggravate the risks of destitution. Income seasonality in rural Bangladesh translates into vulnerability; many non-poor slip into transient poverty. Third, a large percentage of the population is food-insecure due to diet quality rather than diet quantity. Although the real price of rice has fallen steadily over the past decades, the real prices of some foods that are rich in micronutrients, such as fruits and vegetables, have increased. This probably reflects supply-side constraints. If policies are not undertaken to increase supply of non-cereal, nutrient-rich foods, then their prices will continue to increase in the face of income and population growth. Consequently, the diet quality and nutritional status of the poor are likely to deteriorate further.

Future Trajectory for Food Security Improvement

Increasing incomes of small commercial farmers

Sustainable improvement in food security requires a process of rapidly increasing the incomes of small commercial farmers. These farmers dominate agricultural production in Bangladesh, and it is the expenditure of their rising incomes that provides the basis for employment and income growth for the food insecure. Thus, the solution to food insecurity involves defining the priority actions and processes needed to efficiently increase the income of small commercial farmers, who spend their incremental incomes on the goods and services provided by the rural nonfarm sector (Mellor 2010).

Historically, the government has provided strong support to small farmers in Bangladesh. While there are political economic concerns and other challenges in reforming the institutional and policy support systems in favor of smallholder agriculture, institutional innovations can play an important role in the provision of inputs and services to small farmers when there are market failures. In some cases, the private sector also has adequate incentives to innovate, such as in expanding contract farming and developing supermarkets. However, the key role of the government should be to ensure effective coordination in the delivery of inputs and

provision of financial, technical, and output marketing services to small farms and protect the interests of the small farmers. Support is also needed to enable the small farmers to face emerging challenges related to climate change impacts and market volatility.

Increasing investments in agricultural research and extension services

Since there is little or no fallow land now available, future crop production increases in Bangladesh will have to come from higher yields. This means developing new technologies and innovations through research to address production problems such as flood, drought, and salinity-induced stress conditions, while at the same time trying to reduce yeild gaps and pushing the yield frontier further up in high potential areas. Emerging food and agricultural technologies offer significant promise for augmenting agricultural productivity, but can be realized only if the technologies are disseminated to farmers through effective extension systems and are supported by appropriate policies and institutions.

Creating non-farm employment opportunities

Generally, labor productivity is known to be relatively low in agriculture compared with other sectors of the economy. In Bangladesh, the capacity to absorb the growing rural labor force in agriculture is extremely limited because of no scope for expansion of the land; the intensity of cropping has almost reached the limit, and the growth of crop production now depends almost entirely on technological progress, resulting in low employment response of increased output. Therefore, a shift of rural labor force from agriculture to non-farm employment, accompanied by faster agricultural growth, is key to boosting rural incomes. This would require the creation of non-farm employment opportunities in higher-productivity sectors. For instance, promoting micro, small, and medium-sized enterprises (MSMEs) to develop rural-urban food value chains through improved packaging, storage, transportation, and processing of foods, can generate nonfarm employment and incomes.

Moreover, mobilizing the rural youth to develop their skills for repair and maintenance of farm machinery through appropriate vocational training is a promising way for rural employment generation. Additionally, rural youth can be motivated to form community service providers who can purchase combined harvesters, reapers, and tractors, provide the services to farmers (for example, tilling farm land and harvesting rice) for a service charge that includes their profit. This will generate employment and income to a

large segment of the rural population—the youth—who may not want to be involved in agriculture directly.

Increasing production of high-value crops

Crops that give relatively low value output per unit of land, such as rice, offer less scope for sustained income growth than high-value agricultural commodities. Because smallholder farmers have relatively less access to land, their production of high-value crops such as horticulture has the potential for generating increased incomes for them. It would be profitable for smallholder farmers to use family labor to grow more labor-intensive and higher-value crops. Providing them with adequate access to institutional credit and effective agricultural extension services is critical for raising incomes and enhancing agricultural development.

Revamping social safety nets to reach the most vulnerable

A well-functioning social safety net system can effectively improve food security by increasing the real incomes of the poor. Bangladesh has extensive experience in assisting the poor through social safety net programs and some of them have been quite effective in smoothing the consumption and the incomes of poor households and helping them cope with stresses and shocks. However, important issues and challenges remain in the safety net system. The targeting errors of exclusion and inclusion are large in most programs. Many programs have limited coverage, are uncoordinated, and are not adequately funded. Program resources and, hence benefits to program participants, are spread too thin. Safety nets will become even more important in Bangladesh as the country faces economic downturn, food price fluctuations, climate change, and other developments that increase the vulnerability of the poor.

There is a lack of safety nets available to the urban poor. The rapid urbanization of Bangladesh calls for a range of measures to tackle urban food insecurity; a strong safety net or social protection system for the urban poor is an important one.

Priority investment areas for strengthening the safety net system in Bangladesh would include: improving the targeting performance; scaling up effective programs; ensuring sustainability of program benefits; promoting nutrition-sensitive safety nets by integrating nutrition behavior change communication; increasing the size of transfers to generate substantial impacts on food security and nutritional outcomes; consolidating and simplifying programs and phasing out high-cost, inefficient programs; and improving the monitoring and evaluation system.

Ensuring nutrition during pregnancy

The goal of food security is to improve nutrition for the most vulnerable, especially mothers and children. Food insecurity can present major, long-term consequences, such as child stunting—that is, when children are too short for their age. Although stunting in Bangladesh has dropped significantly over the past two decades, one out of three children is still suffering from stunting. An important cause of stunting is related to mothers not intaking enough healthy, nutritious food during pregnancy. A second cause is that the diets of young children in Bangladesh do not contain the nutrients they need to grow and develop. Efforts to further reduce the problem of child undernutrition will have to focus on improving maternal nutrition during pregnancy and the nutrition of the child. Towards this end, the 2015 National Social Security Strategy (NSSS) calls for the development of a national Child Benefit Program (CBP) to improve the nutrition and health of women during pregnancy and their children up to age four.

Reaching adolescent girls with health, nutrition, and empowerment interventions

Given the importance of improving women's nutritional status and childcare knowledge prior to childbearing, related interventions should reach women in early adolescence and before marriage.

Early marriage of girls is a serious concern for nutrition and other social issues in Bangladesh. Despite recent decline, 38 percent of girls still marry between ages 15 and 18 (Ahmed, Sufian, and Ghostlaw 2016). A massive social campaign is needed to increase the age of marriage, as well as to postpone pregnancy of those girls who do marry early. Effective family planning support should be provided to delay pregnancy after marriage.

Organization of the Book

Against this background, Part 1 of the book focuses on *agricultural technology adoption*. The agricultural technologies evaluated in this study are urea deep placement (UDP)—popularly known as 'Guti urea'—and modern, stress-tolerant varieties of rice in the southwest part of Bangladesh (Chapter 1); challenges and opportunities for producing hybrid rice (Chapter 2); and the potential for adoption of several promising agricultural production technologies (Chapter 3).

Part 2 highlights issues on *input use and agricultural productivity*. It covers the relative contribution of agricultural inputs, from irrigation to rice

productivity across Bangladesh by cropping season (Chapter 4); a historic review of the fertilizer policy in Bangladesh in terms of state interventions in markets and prices and their consequences for the agriculture sector (Chapter 5); economics of water resources management (Chapter 6); and the seed system in Bangladesh and the policies that influence its reach and growth (Chapter 7).

The central theme of Part 3 is *food security and output market*. It assesses the impact of public cereal stocks and market interventions in Bangladesh over time and highlights future policy options (Chapter 8); addresses the importance of value chain management in the rice sector and limitations of traditional food security policies (Chapter 9); explains the underlying factors of a sharply rising trend of rural wages in Bangladesh within a coherent theoretical framework (Chapter 10); analyzes reasons for a sudden onion price surge and provides policy options (Chapter 11); and addresses important gaps in knowledge about the fish value chain transformation in Bangladesh (Chapter 12).

Part 4 analyses *poverty, food security, and women's empowerment*. Chapter 13 identifies the factors that determine households' movements into and out of poverty, and helps explain why some households remain poor. Chapter 14 presents how the Women's Empowerment in Agriculture Index (WEAI) can be used to assess the extent of women's empowerment in agriculture, diagnose areas where gaps in empowerment exist, and examine the extent to which improvements in the underlying indicators in these areas can improve food security in rural Bangladesh. Finally, Chapter 15 investigates the sustained effects of social safety net transfers, with or without nutrition behavior change communication (BCC), on intimate partner violence (IPV).

References

Ahmed, Akhter U., and Julie Ghostlaw. 2019. "Diversifying Rice-centric Agriculture and Diets: The Bangladesh Experience." In Agriculture for Improved Nutrition: Seizing the Momentum, edited by Shenggen Fan, Sivan Yosef, and Rajul Pandya-Lorch. Wallingford, UK: International Food Policy Research Institute (IFPRI) and CABI.

Ahmed, Akhter U., Farha Sufian, and Julie Ghostlaw. 2016. *An end in sight to early marriage? Evidence from IFPRI's 2015 survey in rural Bangladesh.* Bangladesh and Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/132876

Ahmed, Akhter U., Ahmad Kaikaus, Victoria Chou, Ricardo Hernandez, Purnim Menon, Farria Naeem, Firdousi Naher, Wahid Quabili, Esha Sraboni, and Bingxin Yu. 2013. *The Status*

of Food Security in the Feed the Future Zone and Other Regions of Bangladesh: Results from the 2011-2012 Bangladesh Integrated household Survey. Project Report prepared for the US Agency for International Development. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Ahmed, Akhter U., Noora-Lisa Aberman, Mohammad A. Jabbar, and Nazneen Akhtar. 2011. *Policy Perspectives on the Country Investment Plan for Food and Nutrition Security in Bangladesh.* Report prepared for the Bangladesh Food Security Investment Forum, May 2010, Dhaka, Bangladesh. Dhaka: International Food Policy Research Institute (IFPRI).

Bangladesh Bureau of Statistics (BBS). 2018. *Statistical Year Book 2017*. Dhaka: Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh.

___. 2019. "National Accounts." https://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/057b0f3b_a9e8_4fde_b3a6_6daec3853586/2019-12-12-11-55-26007214ee20f95f34bf0446aa81e646.pdf

Barkat, Abul, Rushad Faridi, Syed Naimul Wadood, Subhash Kumar Sengupta, and S.N.M. Ehsanul Hoque. 2010. *A quantitative analysis of fertilizer demand and subsidy policy in Bangladesh*. National Food Policy Capacity Strengthening Programme (NFPCSP), FAO, Dhaka.

Biogeny. 2018, January 9. "Agriculture in Bangladesh." biogeny.net/view/Agriculture_in_Bangladesh.

Black, Robert E., Cesar G. Victora, Susan P. Walker, Zulfiqar A. Bhutta, Parul Christian, Mercedes de Onis, Majid Ezzati, Sally Grantham-McGregor, Joanne Katz, Reynaldo Martorell, and Ricardo Uauy. 2013. "Maternal and Child Undernutrition and Overweight in Low-Income and Middle-Income Countries." Lancet 382, no. 9890: 427-451. https://doi.org/10.1016/S0140-6736(13)60937-X

FAO (Food and Agriculture Organization). 2019. *Agriculture and Climate Change: Challenges and Opportunities at the Global and Local Level Collaboration on Climate-Smart Agriculture*. Food and Agriculture Organization of the United Nations, Rome.

FPMU (Food Planning and Monitoring Unit). 2020. *Bangladesh Second Country Investment Plan Nutrition-Sensitive Food Systems (CIP2 2016-2020) Monitoring Report*. http://fpmu.gov.bd/agridrupal/sites/default/files/file/MR-2020/MonitoringReport2020.pdf

Food and Agriculture Organization (FAO). 1996. *Low External Input Sustainable Agriculture (LEISA) in Selected Countries of Asia*. Bangkok: Regional Office for Asia and the Pacific, Food and Agriculture Organization of the United Nations.

Harriss, J., ed. 1982. *Rural Development Theories of Peasant Economy and Agrarian Change*. London: Hutchinson.

Headey, Derek D. "Developmental drivers of nutritional change: a cross-country analysis." *World Development* 42 (2013): 76-88. https://doi.org/10.1016/j.worlddev.2012.07.002

Hossain, Mahabub, David Lewis, Manik L. Bose, Alamgir Chowdhury. 2003. *Rice research Technological Change, and Impacts on the Poor: The Bangladesh Case (Summary Report).* EPTD Discussion Paper No. 110. Washington, D.C.: International Food Policy Research Institute. http://www.fao.org/docs/eims/upload/166333/Hossain,Lewis, Bose, Chowdhury.pdf

International Food Policy Research Institute (IFPRI). 2018. *Global Hunger Index 2018: Forced Migration and Hunger*. Washington, D.C.: International Food Policy Research Institute (IFPRI); Bonn: Welthungerhilfe; Dublin: Concern Worldwide.

Islam, Nurul. 2011. *Foreign Aid to Agriculture: Review of Facts and Analysis*. IFPRI Discussion Paper no. 01053. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Islam, Nurul. 2014. *Political Economy of State Interventions in the Bangladesh Food-grain Sector*. IFPRI Discussion Paper no. 01404. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Jabbar, Mohammad A. 2010. *Policy barriers for dairy value chain development in Bangladesh with a focus on the north west region*. No. 138-2016-2026.

Mellor, John W. 2010. *Strategies and Investment to Increase Income of the Small Commercial Farmer – and Thereby Increase Food Security*. Paper presented at the 2010 Food Security Investment Forum, Dhaka, Bangladesh, 26-27 May 2010.

Ministry of Finance (MOF). 2019. *Bangladesh Economic Review 2019*. Dhaka: Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh.

Mujeri, Mustafa K., and Binayak Sen. 2006. "Economic Growth in Bangladesh, 1970-2000." In *Explaining Growth in South Asia*, edited by K. S. Parikh. New Delhi: Oxford University Press.

National Institute of Population Research and Training (NIPORT), and ICF. 2019. *Bangladesh Demographic and Health Survey 2017-18: Key Indicators*. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT, and ICF. https://dhsprogram.com/pubs/pdf/PR104/PR104.pdf

National Institute of Population Research and Training (NIPORT), Mitra and Associates, and ICF International. 2016. *Bangladesh Demographic and Health Survey 2014*. Dhaka, Bangladesh: NIPORT, Mitra and Associates, and ICF International. https://dhsprogram.com/pubs/pdf/FR311/FR311.pdf

Osmani, S. R., Akhter U. Ahmed, Tahmeed Ahmed, Naomi Hossain, Saleemul Huq, and Asif Shahan. 2016. *Strategic Review of Food Security and Nutrition in Bangladesh.* Dhaka: World Food Programme.

Trading Economics. 2020. "Bangladesh Population Growth." https://tradingeconomics.com/bangladesh/population-growth-annual-percent-wb-data.html accessed on September 15, 2020.

United Nations Development Programme (UNDP), and Food and Agriculture Organization (FAO). 2007. *Globalization, Agriculture and the Least Developed Countries*. United Nations Ministerial Conference of the Least Developed Countries, Making Globalization Work for the LDCs, Istanbul, 9-11 July 2007.

___. 2001. *South Asia: Strategy and Action Plan for Rural Development*. South Asia Rural Development Working Paper Series no. 23667. Washington, D.C.: World Bank.

Zhang, Xiaobo, Shahidur Rashid, Ahmad Kaikaus, and Akhter U. Ahmed. 2014. "Escalation of Real Wages in Bangladesh: Is It the Beginning of Structural Transformation?" *World Development* 64: 273-285. https://doi.org/10.1016/j.worlddev.2014.06.015.

PART 1

AGRICULTURAL TECHNOLOGY ADOPTION

Chapter 1

Agricultural Technology Adoption in the Feed the Future Zone of Influence in Bangladesh

Akhter U. Ahmed, Ricardo Hernandez, and Firdousi Naher

1.1 Introduction

Technology is the basis for sustainable agricultural growth. Enhanced agricultural productivity and growth depend, to a large extent, upon the widespread adoption of appropriate technologies by farmers. Seed, fertilizer and irrigation technologies known as the 'Green Revolution' technologies have long played major roles in the growth of agriculture production in Bangladesh. The country has made commendable progress in domestic rice production through farmers' adoption of these technologies. In the early 1970s, Bangladesh was a seriously food-deficit country with a population of about 75 million. Today, the population is more than 160 million, and Bangladesh is on the brink of self-sufficiency in rice production, which has tripled over the past three decades.

This study examines the adoption of agricultural technologies in USAID's Feed the Future zone of influence in the south and southwest regions of the country. The Feed the Future is the US government's global hunger and food security initiative to support country-driven approaches to address the root causes of poverty, hunger, and undernutrition. In Bangladesh, Feed the Future's collective efforts aim to improve the livelihood and nutritional status of households through: (i) increased on-farm productivity, (ii) increased investment in market systems and value chains, (iii) enhanced food security policy and planning capacity, (iv) enhanced agriculture innovation capacity, and (v) improved nutritional status of rural poor.

The agricultural technologies evaluated in this study are: (a) urea deep placement (UDP)—popularly known as "Guti urea"; and (b) modern, stress-tolerant varieties of rice. The study presents results of analyses of

survey-based data on adoption of UDP and stress-tolerant rice varieties by rice farmers in the Feed the Future zone of influence. The chapter is organized in seven sections. Section 2 describes the survey that provided the data used in the empirical work. Section 3 gives a profile of survey households. Section 4 presents the results of analyses of the usage of the UDP technology by farmers. Section 5 discusses the findings of analyses of farmers' usage of modern, stress-tolerant varieties of rice technology. Section 6 provides an analysis of the determinants of farmers' adoption of technologies and the duration of adoption. Finally, Section 7 summarizes the main findings and provides policy conclusions.

1.2 Data

The data for the study came from the 2013 IFPRI-PRSSP Agricultural Technology Adoption Survey of 2,400 rice farmers in the Feed the Future zone of influence.

1.2.1 Sampling

The Feed the Future zone level survey is statistically representative of all rice farmers in the Feed the Future zone and its domain included all 120 Feed the Future upazilas within the 20 Feed the Future districts. The sampling process and survey administration included the following steps:

1. List all villages in each of the 120 Feed the Future upazilas from the 2011 National Population Census.
2. Randomly select two villages in each upazila with probability proportional size (PPS) sampling, using the village-level population data from the 2011 National Population Census.
3. Conduct complete census of each of the 240 selected villages.
4. List all farm households that cultivated rice in the 12-month period prior to the survey, then randomly select 10 farm households from village census list.
3. Conduct interviews of 2,400 selected rice-farm households.

1.2.2 Survey Questionnaire

The IFPRI-PRSSP team prepared a draft questionnaire for the agricultural technology adoption survey, received comments on the draft questionnaire from USAID, and revised the questionnaire by addressing the comments. The questionnaire included eight modules: (1) sample household identification;

(2) household composition, literacy, and education; (3) roster of land owned or under operation; (4) plot-level information on seeds, irrigation, and urea fertilizer usage; (5) information on use of Guti urea; (6) information on usage of paddy varieties; (7) information on use rate of paddy seeds; and (8) access to credit.

1.2.3 Training and Survey Administration

IFPRI contracted the Data Analysis and Technical Assistance (DATA) Limited, a Bangladeshi consulting firm with expertise in conducting complex surveys and data analysis, to implement the survey. DATA worked under the supervision and guidance of senior IFPRI researchers.[1]

DATA provided 100 experienced survey enumerators and 20 supervisors to administer the surveys. IFPRI-PRSSP provided the survey questionnaire to DATA for training of the survey team. DATA translated the questionnaire into Bangla. IFPRI-PRSSP researchers and senior DATA staff pre-tested the questionnaire in the Feed the Future zone and trained survey workers, in both a formal classroom setting and closely monitored practice fieldwork.

DATA conducted the survey from 1 to 19 November 2013 under IFPRI-PRSSP supervision. DATA completed the survey of 2,400 farm households by engaging 20 teams consisting of six members per team (five enumerators and a supervisor). The enumerators conducted one-on-one, face-to-face interviews with the respondents assigned to them, under the supervision of their field supervisor. To show appreciation for respondents' time, a gift of two plates and one bowl (a BDT 200 value) was given to each household. Completed questionnaires were sent to DATA central office in Dhaka on a regular basis for simultaneous data entry. IFPRI and DATA took extensive care to ensure the quality of the household survey data, and IFPRI researchers made field visits to supervise the fieldwork.

1.2.4 Data Entry, Cleaning and Analysis

Staff at the DATA office in Dhaka carried out the data entry simultaneously during data collection, with about four days of lag time. DATA used a

[1] In the past two decades, DATA has carried out all IFPRI surveys in Bangladesh, including more than 50 household surveys and several market, school, and other institutional surveys. In addition, DATA has conducted numerous surveys for various international organizations, including CARE-Bangladesh, European Union, IRIS Centre at the University of Maryland, Population Council, Save the Children (USA), Tufts University School of Nutrition Science and Policy, US Department of Agriculture, World Bank, World Food Programme-Bangladesh, and World Vision-Bangladesh.

software specialized for data entry (Microsoft Access) that was programmed to identify out-of-range or inconsistent values. After receiving the cleaned dataset from DATA, IFPRI-PRSSP researchers analyzed the data using Stata software. Senior IFPRI researchers provided guidance for data analysis.

1.3 Profile of Survey Farmers

Using data from the 2013 IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future zone, this section presents the profile of rice-farm households living in the Feed the Future zone of influence. Much of the farmer-level analysis in this study disaggregates the sample farmers into four operated farm size groups: (1) marginal (farmers operating less than half an acre of land); (2) small (farmers operating 0.5 to 1.49 acres); (3) medium (farmers operating 1.5 to 2.49 acres); and (4) large (farmers operating 2.5 acres or more).

The ranges of farm size groups are the same as those used in the IFPRI-PRSSP report of the 2011-2012 Bangladesh Integrated Household Survey (Ahmed et al. 2013). The four farm size groups match the cut-off points of the six operated farm size groups presented in the 2010 Household Income and Expenditure Survey (HIES) report of the Bangladesh Bureau of Statistics (BBS 2011) by aggregating the smallest two HIES farm size groups under the marginal farm category and the largest two groups under the large farm category.

1.3.1 Household Characteristics

Table 1.1 shows household size, educational attainment, and literacy rates of sample households in the Feed the Future zone survey by farm size groups. Smaller rice-farming households tend to be a bit smaller than larger farm households; the average household size declines from 5.6 for the large farm group to 4.6 for the marginal farm group in the Feed the Future zone. The following are additional highlights of household characteristics:

- Primary school-age children (age 6-10) from about 8 percent of rice farm households and secondary school-age children (age 11-18) from 25 percent of rice farm households in the Feed the Future zone do not go to school.
- Educational attainment in terms of years of schooling of male household head and wife of household head is positively correlated with farm size.
- Educational attainment in terms of years of schooling of adult family members is positively correlated with farm size.

- In the Feed the Future zone, 36 percent of adult males and 43 percent of adult females in rice farm households never attended school. The rate of no schooling of adults declines as farm size of households increases.
- A person who can read and write a sentence in Bangla is considered to be literate. Table 1.1 shows the literacy rates for ages 15 and above. Overall, the female population has a lower literacy rate than the male population. Literacy rates have strong, positive relationships with farm size.

Table 1.1: Characteristics of Survey Households by Farm Size Groups: Feed the Future Zone

Item	Marginal	Small	Medium	Large	All
Household size (person)	4.6	4.8	5.3	5.6	5.0
Primary-school-age children (6-10 years) who do not go to school (percent)	7.3	7.9	8.4	7.7	7.8
Secondary-school-age children (11-18 years) who do not go to school (percent)	28.5	23.6	27.4	20.8	25.0
Years of schooling, male household head	3.3	4.0	4.4	4.9	4.0
Years of schooling, wife of household head	3.2	3.8	4.2	4.3	3.8
Years of schooling of adult male aged 15 and above	4.6	5.3	5.8	6.3	5.5
Years of schooling of adult female aged 15 and above	3.9	4.7	5.2	5.5	4.8
No schooling adult male (percent)	44.7	37.2	32.4	27.5	36.0
No schooling adult female (percent)	53.0	45.0	37.0	33.0	43.0
Literacy rate for people aged 15 years and over					
All	58.9	65.6	71.4	75.3	67.2
Male	62.2	67.4	72.7	76.7	69.2
Female	55.5	63.7	70.0	73.6	65.0

Source: IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

1.3.2 Inequality in Distribution of Operated Land

Land is the most important factor of agricultural production. However, about one-fifth of the rice farmers in the Feed the Future zone are pure tenants, that is, they do not own any cultivable land. These farmers have either sharecropping or cash-lease arrangements with landlords for their operated land (see Section 1.3.4). Table 1.2 describes the pattern of distribution of operated land in the Feed the Future zone, the simplest way to measure inequality. In the table, the

sample rice farm households are divided into 20 equal groups and are ranked from lowest to highest according to the size of their total operated land. The average size of operated land for each group is also reported in the table. The figures indicate that the distribution of operated land is highly unequal. The bottom 25 percent of all rice-farm households own only 6.5 percent of total operated land in the Feed the Future zone. At the other extreme, the top 5 percent of all households own 22.5 percent.

Table 1.2: Distribution of Operated Land: Feed the Future Zone

Group	Average size of operated land	Share of total operated land in each group
	(decimal/household)	(percent)
1 (lowest)	15.51	0.50
2	27.93	0.90
3	36.61	1.23
4	46.64	1.58
5	56.54	2.27
6	64.65	1.77
7	71.37	1.84
8	80.15	2.73
9	91.20	2.76
10	100.99	3.30
11	112.78	3.66
12	127.74	4.07
13	142.01	4.80
14	161.39	5.06
15	183.96	5.87
16	208.83	6.66
17	241.20	7.62
18	285.16	9.17
19	365.47	11.75
20 (highest)	698.02	22.45
All households	155.33	100.00

Source: IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

1.3.3 Farm-Size Groups and Size of Operated Land

Figure 1.1 shows the distribution of operated land by each of the four farm size groups as a percentage of all rice farmers in the Feed the Future zone. Small farmers dominate the Feed the Future zone—about 45 percent of all rice farmers are small farmers.

Table 1.3: Average Size of Operated Land by Farm Size Groups: Feed the Future Zone

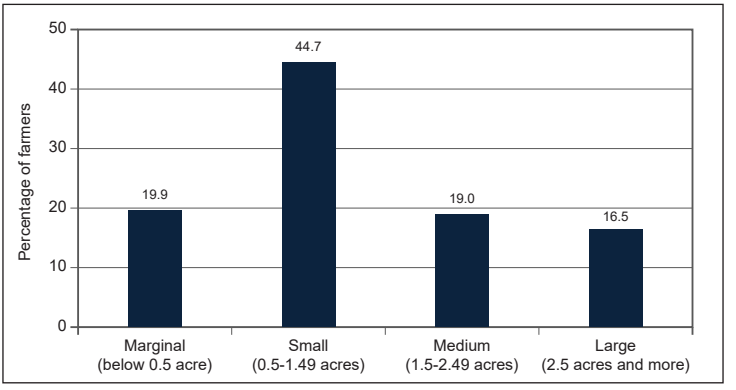
Farm size group	Operated land size		
	Mean	Minimum	Maximum
	(acres/farm household)		
Marginal (>0-<0.5 acre)	0.31	0.01	0.50
Small (0.5-1.49 acres)	0.93	0.50	1.49
Medium (1.50-2.49 acres)	1.92	1.50	2.48
Large (≥2.5 acres)	4.31	2.50	20.16
All	1.55	0.01	20.16

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

Source: IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

Table 1.3 shows the size of operated land by farm size groups as a percentage of all rice farmers in the Feed the Future zone. The average size of operated land per rice farm household is 1.6 acres, ranging from only 0.3 acre per marginal farmer to 4.3 acres per large farmer.

Figure 1.1: Distribution of Operated Land by Farm Size Group



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.3.4 Patterns of Land Tenure

Table 1.4 presents land tenure arrangements by farm size groups in the Feed the Future zone. About one-fifth of all rice farm households are pure

tenants, meaning they do not own any cultivable land. About 49 percent of rice farmers cultivate only their own land. The proportion of mixed-tenant farmers—those who cultivate their own land and also take land in as sharecroppers and/or leaseholders—is 31 percent.

The dominant tenurial arrangement in the Feed the Future zone is sharecropping, where the produce is shared between the cultivator and the landowner in different proportions that have been agreed upon prior to cultivation. About 31 percent of the rice farmers are sharecroppers. This group of sharecroppers includes those who do not own any cultivable land (that is "pure tenant") as well as those who own land and sharecrop other people's land. About 15 percent of the rice farmers have cash-lease arrangements either as pure tenants or as those with their own land plus cash-leased land. The proportion of rice farmers operating both sharecropped and cash-leased land (either as tenants or landowners) is about 5 percent (calculated from Table 1.4).

About 56 percent of all marginal farmers in the Feed the Future zone do not have any land lease arrangements; they cultivate only their own land. This is perhaps a manifestation of their risk aversion. For the marginal farmers who are pure tenants (33.2 percent), the sharecropping arrangements represent an overwhelming majority—about 70 percent of all pure-tenant farmers are sharecroppers. Only about 13 percent of the large farmers are pure tenants, and 48 percent of them opt for sharecropping as the mode of renting land. It is interesting to note that about 47 percent of the large farmers supplement their own land with some form of sharecropping and/or cash leasing (Table 1.4).

Table 1.4: Land Tenure Arrangements by Farm Size Groups: Feed the Future Zone

Tenurial arrangement	Farm size groups (operated land)				
	Marginal	Small	Medium	Large	All
	(percent)				
Pure tenant	33.19	19.58	14.09	13.02	20.16
Sharecropping	69.93	61.58	53.23	48.00	61.75
Cash lease	28.10	26.60	35.48	30.00	28.63
Both	1.96	11.82	11.29	22.00	9.62
Own land only	55.53	49.76	46.82	40.10	48.75
Mixed tenant (own land + land taken in)	11.28	30.67	39.09	46.88	31.09
Sharecropping	76.92	65.41	56.40	51.67	60.66
Cash lease	21.15	27.99	33.14	33.33	30.06
Both	1.92	6.60	10.47	15.00	9.28

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

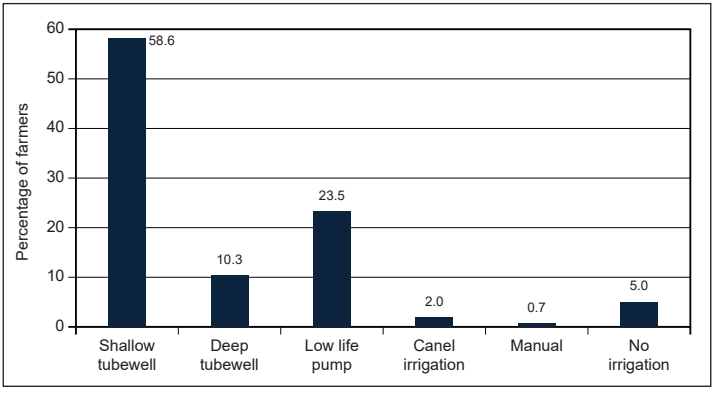
Source: IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

1.3.5 Irrigation

Irrigation is one of the most critical factors of agricultural production in Bangladesh. Tripling rice production in the country since the early 1970s would not have been possible without irrigation. It plays three crucial roles in increasing food grain production in Bangladesh: (i) irrigation enables farmers to grow an additional *boro* rice or wheat crop during the dry winter season and thus increases cropping intensity and eases the land constraint; (ii) irrigation complemented with fertilizers and modern high-yielding rice varieties significantly raises rice yields in comparison to rain-fed rice cultivation; and (iii) supplemental irrigation can take much of the risk out of the two predominantly rain-fed rice seasons—*aus* and *aman* (Ahmed and Sampath 1992).

Bangladeshi farmers use both traditional and modern methods of irrigation. Traditional methods include *done* (a water-lifting devise), swing basket, and dug-well. Modern techniques include shallow tubewell, deep tubewell, low-lift pump, hand pump, and sophisticated canal gravity-flow irrigation schemes. Among these, *done,* swing basket, low-lift pump, and canal irrigation use surface water while dug-well, shallow tubewell, deep tubewell, and hand pump use groundwater as irrigation sources.

Figure 1.2: Methods of Irrigation used by Farmers for Boro Rice Cultivation in Feed the Future Zone



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

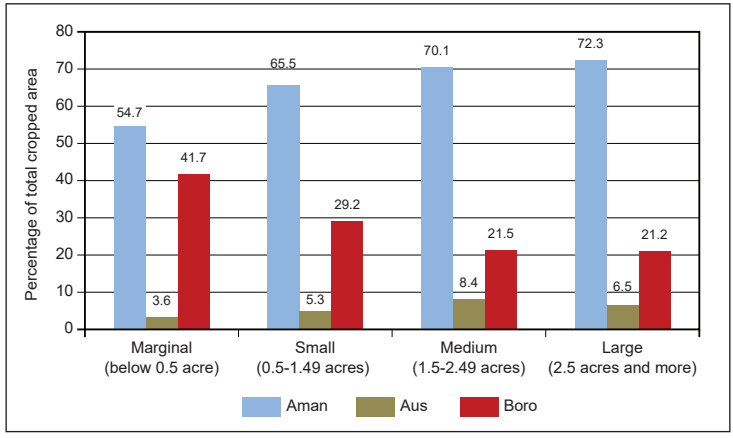
The shallow tubewell is the predominant method of irrigation used by about 59 percent of rice farmers in the Feed the Future zone for *boro* rice

cultivation. The second most important method is low-lift pump, used by more than one-fifth of the rice farmers. About 5 percent of the rice farmers cultivate *boro* rice without irrigation (Figure 1.2).

1.3.6 Share of Rice Crops on Total Rice Land

Figure 1.3 shows the share of *aman*, *aus*, and *boro* rice crops on total rice land of farmers in the Feed the Future zone. *Aman* and *boro* rice show opposite patterns across the four farm size groups: while the share of *aman* rice area increases as farm size increases, the relationship is negative in the case of *boro* rice crop.

Figure 1.3: Share of Aman, Aus, and Boro Rice in Total Rice Land in Feed the Future Zone



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.4 Usage of Urea Deep Placement Technology

Urea Deep Placement (UDP)—popularly known as "Guti urea" has been promoted in Bangladesh by the Accelerating Agriculture Productivity Improvement (AAPI) project, which is funded by USAID and implemented by the International Fertilizer Development Centre (IFDC) in collaboration with and the Department of Agricultural Extension (DAE) of the Ministry of Agriculture, Government of Bangladesh. Emphasis is on improving farmer access to and use of UDP technology to improve crop yields and

economic returns to farmers. This section presents the results of the Feed the Future zone level survey on the usage of the UDP technology (Guti urea) by rice-growing farmers.

1.4.1 Usage by Percentage of Farmers

Table 1.5 presents the percentages of rice farmers who used Guti urea at least once for cultivation of crops harvested in 2013.[2] The results are disaggregated by rice, all crops (rice and non-rice together), and farm size. The results of the survey suggest that 10.8 percent of all rice farmers used Guti urea for crops harvested in 2013. The 95 percent confidence intervals of the rates of usage of Guti urea are from 9.5 percent to 12 percent for the Feed the Future zone survey sample. The percentage of farmers who used Guti urea increases as farm size increases. The rate of use by large farmers is close to double the rate of use by marginal farmers (Figure 1.4).

Table 1.5: Usage of Guti Urea by Farmers in 2013 by Farm-Size Groups

Crop	Farm-size group				
	Marginal	Small	Medium	Large	All
	(percentage of farmers)				
Rice	7.61	10.22	9.77	13.54	10.08
All crops	7.98	11.19	10.23	14.32	10.79

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

About 94 percent of the survey sample had heard about Guti urea from various sources. Among the most prevalent sources of information were fellow farmers, (77 percent) followed by fertilizer dealers then television (Table 1.6). Among the three rice crops, the rates of use of Guti urea are highest for *boro* rice and lowest for *aman* rice. In 2013, 11.5 percent of farmers in the Feed the Future zone used Guti urea with *boro* rice (Figure 1.5).

[2] The 2013 *aman* rice crop was partially harvested during the period when the survey was conducted (1-19 November 2013).

Table 1.6: Information about Guti Urea

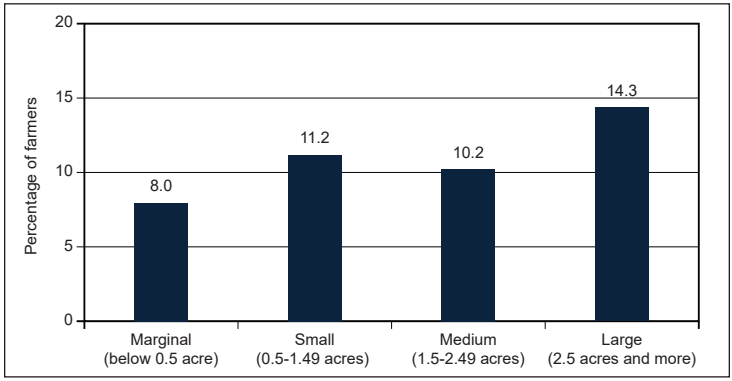
Item	Marginal	Small	Medium	Large	All
			(percent)		
Heard about Guti urea	92.6	94.0	95.2	92.7	93.7
Source of information about Guti urea					
Discussion with other farmers	80.4	76.0	76.6	75.8	77.1
Fertilizer dealers	48.1	48.8	45.4	38.5	46.4
Television	35.9	42.6	48.2	42.4	42.1
Government extension workers	27.1	35.6	42.5	43.5	36.2
Seeing the neighbors	27.3	24.4	23.2	23.0	24.6
Billboard/signboard	12.8	17.0	19.1	20.5	17.0
Farmers' meeting	8.8	11.1	13.4	12.4	11.2
Guti urea producers	11.6	10.7	10.0	11.5	10.9
Exhibition	5.8	8.9	12.9	11.5	9.4
IFDC/AAPI training center	4.4	7.3	8.4	15.7	8.2
Radio	5.2	7.5	8.6	6.2	7.0
Banner/festoon	6.2	5.6	6.7	7.6	6.3
NGO	3.8	5.5	6.7	8.7	5.9
Wall advertisement	3.2	3.3	7.4	5.3	4.4
Announcement through mike	3.4	3.6	3.6	2.5	3.4
Newspaper	1.6	2.9	4.5	3.9	3.1
Field day	2.6	2.8	3.6	3.4	3.0
Video	2.0	2.8	2.4	3.7	2.7
Handbill from the IFDC staff at mosque	0.4	1.7	1.4	1.4	1.3
Handbill from the IFDC staff at school	0.6	1.2	1.7	1.7	1.2

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

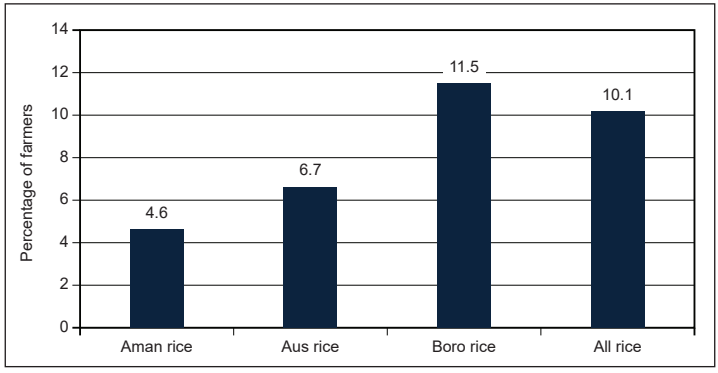
Guti urea usage has increased for the survey sample over time: while only 5.3 percent of all rice farmers in the Feed the Future zone used Guti urea in 2010, the rate increased to 10.8 percent in 2013 (Figure 1.6).

Figure 1.4: Percentage of Rice Farmers Using Guti Urea for Crops in 2013



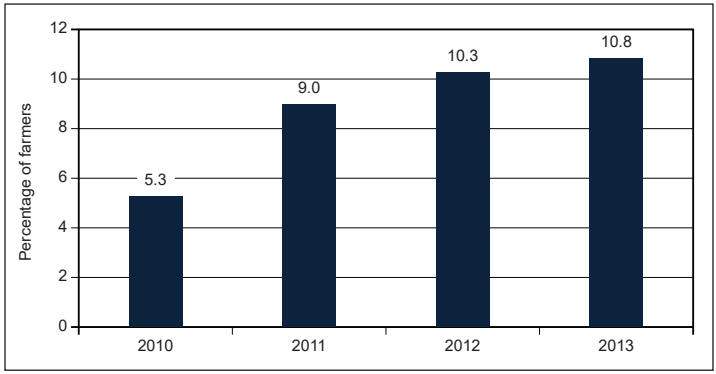
Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Figure 1.5: Percentage of Rice Farmers Using Guti Urea for Different Rice Crops in 2013



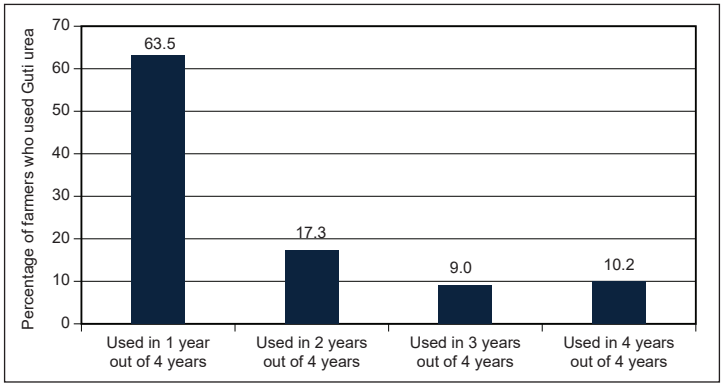
Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Figure 1.6: Usage of Guti Urea since 2010 in Feed the Future Zone



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Figure 1.7: Annual Frequency of Usage of Guti Urea in at least One out of Four Years (beginning in 2010)



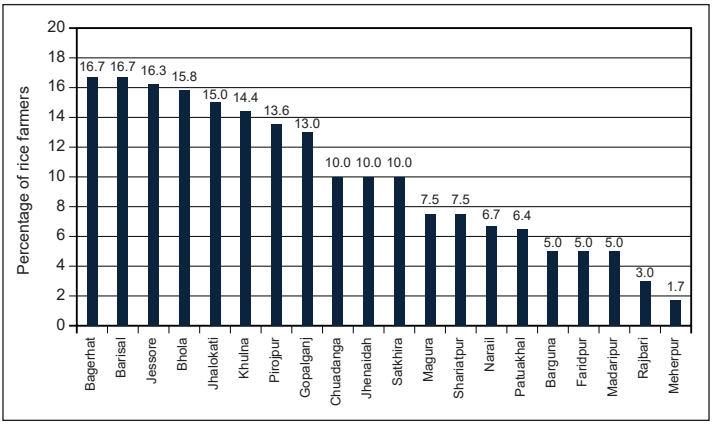
Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

The results of the survey suggest that 21.2 percent of all rice farmers used Guti urea at least once since 2010. Figure 1.7 shows the annual frequency of usage of Guti urea in terms of percentage of farmers who used it in one year, two years, three years, and four years (beginning in 2010). For example, among the 21.2 percent of farmers in the Feed the Future zone who used Guti urea at least once since 2010, 63.5 percent of them used it only in one out of

four years, 17.3 percent in two out of four years, 9 percent in three out of four years, and 10.2 percent in four out of four years.

Figure 1.8 shows the rate of usage of Guti urea by rice farmers in each of the 20 districts in the Feed the Future zone of influence. The rate varies between 16.7 percent in Bagerhat district to only 1.7 percent in Meherpur district.

Figure 1.8: Percentage of Rice Farmers Using Guti Urea in 2013 by Districts in Feed the Future Zone

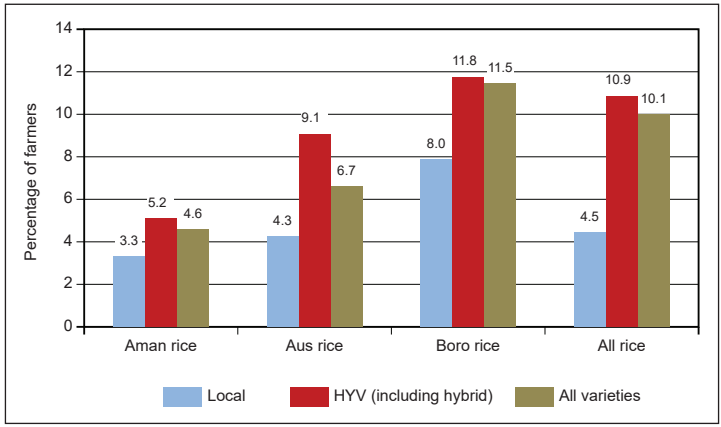


Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Figures 1.9 presents the percentages of farmers in the Feed the Future zone survey who used Guti urea at least once for cultivation of local or traditional varieties and high-yielding varieties (HYVs) of rice crops harvested in 2013. The figures reveal that rice farmers use Guti urea mainly to cultivate HYVs of rice.

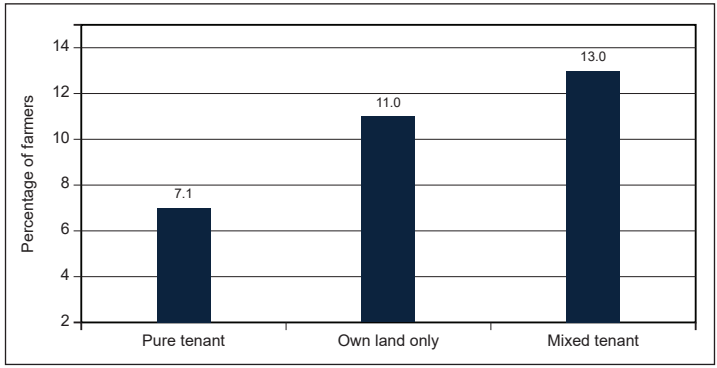
Figure 1.10 shows the use of Guti urea by types of tenancy of rice farmers for crops harvested in 2013: (a) those who do not own any cultivable land (pure tenants), (b) those who cultivate only their own land, and (c) those who cultivate their own land and also take land in as sharecroppers and/or leaseholders (mixed tenants). The rates of adoption of Guti urea are much lower for pure tenants than for those in the other two tenancy categories. In the Feed the Future survey, only 7 percent of pure tenants use Guti urea for rice cultivation whereas 11 percent of farmers who cultivate only their own land and 13 percent of mixed tenants use it.

Figure 1.9: Percentage of Rice Farmers Using Guti Urea for Different Rice Crops in 2013



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Figure 1.10: Usage of Guti Urea by Farmers in 2013 by Tenancy Categories



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.4.2 Usage of Guti Urea by Number of Rice Farmers in Feed the Future Zone

As mentioned above, the results of the survey suggest that 10.8 percent of all rice farmers used Guti urea for crops harvested in 2013. Since the Feed the Future zone level survey is statistically representative of all rice

farmers in the Feed the Future zone of influence, it is possible to estimate the number of rice farmers who used Guti urea for rice crops harvested in 2013. According to the 2011 Population and Housing Census conducted by the Bangladesh Bureau of Statistics, there are 6,277,486 rural households in 120 Feed the Future zone upazilas in 20 Feed the Future districts. IFPRI-PRSSP conducted the 2011-2012 Bangladesh Integrated Household Survey (BIHS), which is a nationally representative survey of rural Bangladesh as well as statistically representative of the Feed the Future zone of influence. From the BIHS dataset, we have calculated that 51.9 percent of all households in the Feed the Future zone cultivated rice in 2011. Therefore, the total number of rice farm households in the Feed the Future zone is 3,258,015 (that is, 6,277,486 × 0.519), of which 10.8 percent or 351,866 rice farmers have used Guti urea in 2013.

1.4.3 Coverage of Cultivated Area

Table 1.7 shows the percentage of rice farm area under Guti urea application, disaggregated by rice-crop type (*aman, aus*, or *boro*), and farm size. In the Feed the Future zone, 4.8 percent of rice farm area was under Guti urea application. The 95 percent confidence intervals of the percentage of farm area under Guti urea are from 4.1 percent to 5.5 percent for the Feed the Future survey sample. According to Bangladesh Bureau of Statistics, 2,794,571 hectares were under rice cultivation in the 20 Feed the Future districts in 2012-2013. The coverage of 4.8 percent of total rice farm area of the Feed the Future zone under Guti urea application translates into total area of 134,139 hectares (that is, 2,794,571 × 0.048).

Table 1.7: Percentage of Rice Farm Area under Guti Urea in 2013 by Farm-Size Groups

Crop	Farm-size group				
	Marginal	Small	Medium	Large	All
	(percentage of cultivated area)				
All rice	4.5	4.9	4.5	5.5	4.8
Aman	2.6	3.2	3.2	3.3	3.1
Aus	5.1	3.5	5.6	7.4	5.1
Boro	7.5	9.2	8.6	12.8	9.2

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Among the three rice crops, *boro* rice had the largest percentage of area under Guti urea application, followed by *aus* (Table 1.7). The rates of coverage under individual rice crops are often higher than the aggregate. This is because of varying rates of cultivation in the three rice seasons with only a small percentage of farmers even cultivating *aus* rice at all.

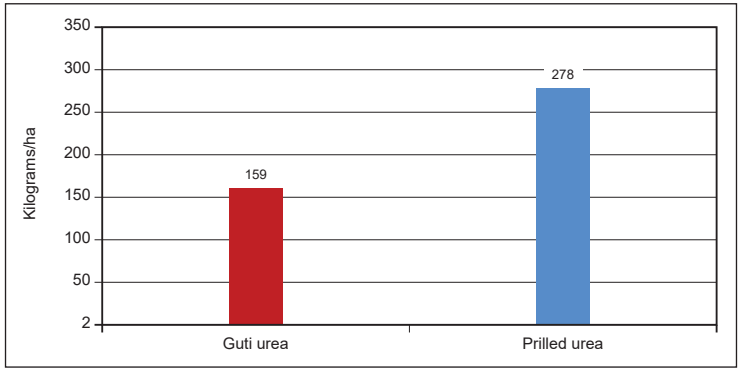
1.4.4 Amount of Guti and Prilled Urea Used by Farmers

Figure 1.11 shows the estimated amount of Guti and prilled urea applications per hectare for *boro* rice cultivation, based on plot-level survey data. Plots using only Guti urea or only prilled urea were considered for the estimations. Farmers used 42.7 percent less Guti than prilled urea (because less Guti urea is required for cultivation than prilled) for *boro* rice cultivation.

1.4.5 Effects of Guti Urea Usage on Rice Productivity

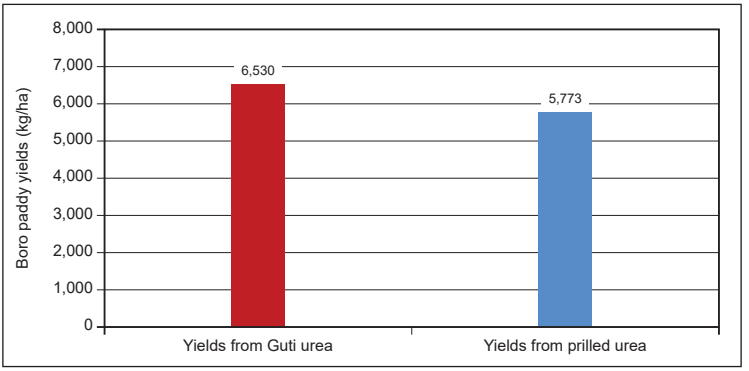
In Figure 1.12, the results of the survey suggest that the paddy yields per hectare are substantially higher for the Guti urea users compared with prilled urea users, although the quantity of application of Guti urea per hectare was considerably less than that of prilled urea. Farmers who exclusively used Guti urea for *boro* rice cultivation had 13.1 percent higher paddy yields than farmers who exclusively used prilled urea in the Feed the Future zone of influence.

Figure 1.11: Amount of Guti versus Prilled Urea Used in Boro Rice (kilograms per hectare), 2013



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Figure 1.12: Yield of Boro Paddy with Guti versus Prilled Urea (kilograms per hectare), 2013



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.4.6 Reasons for Not Using Guti Urea

If paddy yields are high with relatively low amounts of Guti urea application, why don't more farmers in the Feed the Future zone use Guti urea for crop cultivation? Farmers participating in the survey provide a variety of reasons, shown in Table 1.8. The farmers in the survey sample cited the high labor requirement as the dominant reason for not using Guti urea, followed by unavailability of Guti urea (Figure 1.13).

Table 1.8: Reasons for Not Using Guti Urea

Reason	Farm-size group				
	Marginal	Small	Medium	Large	All
	(percentage of farmers)				
Not satisfied with the results from last usage	1.7	2.3	3.1	3.1	2.4
Guti urea was is not easily available	34.7	36.4	42.3	40.6	37.7
Guti urea shop is far away	17.6	15.4	17.4	20.3	17.0
Price of Guti urea is high	15.5	14.4	15.3	14.4	14.8
It needs many laborers to apply Guti urea	54.2	54.4	58.5	47.5	54.0
It is physically inconvenient to apply Guti urea manually	28.0	28.9	30.8	22.8	28.1
Guti urea application needs line-sowing of rice seedlings	30.7	27.8	30.8	23.9	28.4

Continued

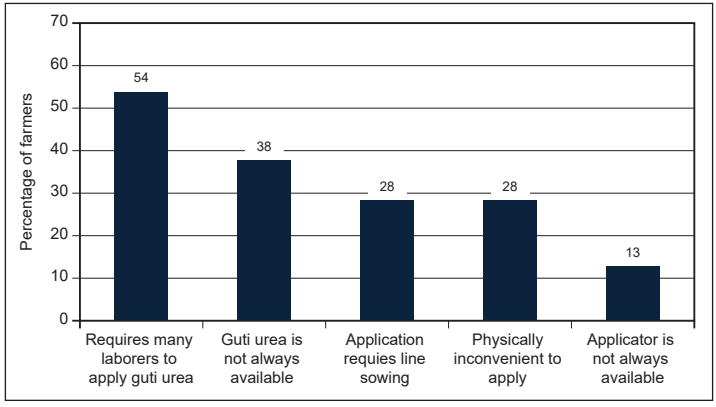
Continued from Table 1.8

Reason	Farm-size group				
	Marginal	Small	Medium	Large	All
	(percentage of farmers)				
It is physically inconvenient to apply Guti with applicator	10.0	9.1	12.0	6.9	9.5
Applicator is not easily available	14.8	12.5	13.9	10.3	12.9
Applicator is not affordable	11.9	8.4	12.0	6.1	9.5

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Figure 1.13: Major Reasons for Not Using Guti Urea (percentage of farmers)



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.5 Usage of Stress-Tolerant Rice Varieties

Since new varieties of notified crops[3] from public research institutes require official release and are subject to lengthy regulatory procedures involving multiple agencies, national and international research institutes in Bangladesh jointly adopted the strategy of pre-release seed multiplication

[3] Rice, wheat, potato, sugarcane, and jute are notified crops in Bangladesh, requiring the government to test the cultivars for performance prior to their approval.

and promotion with the aim to create awareness and generate demand for more varieties of rice seeds.

The Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural University (BAU), and the International Rice Research Institute (IRRI) produced large quantities of breeder seeds for different stress-tolerant rice varieties during the *boro* 2012, *aman* 2012, and *boro* 2013 seasons. The rice varieties promoted by the research institutes include varieties that are salt-tolerant (BRRI *dhan* 47, 53, 54, 55, and 61; BINA *dhan* 8 and 10), submergence-tolerant (BRRI *dhan* 51 and 52; BINA *dhan* 11 and 12), and drought-tolerant (BRRI *dhan* 56 and 57). Varieties with both high grain quality and high market value were also promoted, including BRRI *dhan* 50, BRRI *dhan* 61, BINA *dhan* 11, and BINA *dhan* 12. Two major approaches were adopted for varietal promotion: (1) seed production from demonstration trials and supply of seed mini-kits (2.5 kilograms of seeds) to promote awareness among farmers; and (2) improving local availability of quality seed of new varieties for area expansion and farmer-to-farmer dissemination.

This section presents the results of the Feed the Future zone level survey on the usage of the modern, stress-tolerant rice varieties by rice farmers in the Feed the Future zone of influence.

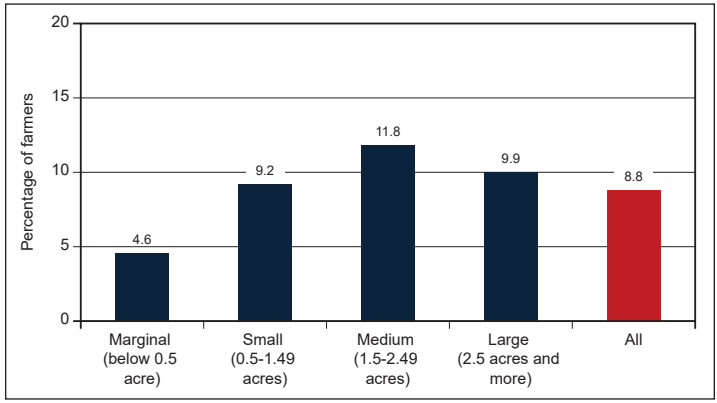
1.5.1 Usage of Modern, Stress-tolerant Rice Varieties

In the Feed the Future zone, less than one-tenth (8.8 percent) of the farmers grew at least one of the modern, stress-tolerant rice varieties promoted by the research institutes. Across the four farm size groups, adoption of these varieties is higher among the medium and large farmers. Among the marginal farmers, only 5 percent grew any of the promoted varieties (Figure 1.14).

A plausible explanation for the relatively low adoption of the stress-tolerant varieties by marginal farmers could be that these farmers are risk-averse given their lack of a diversified portfolio, which severely constrains their ability to offset any crop loss. It is understandable that these poor farmers prefer to stick to time-tested varieties with assured yields rather than experiment with new ones.

Figure 1.15 presents the geographical distribution of adoption of stress-tolerant rice varieties promoted by the research institutes in the Feed the Future zone of influence. The uptake of the stress-tolerant varieties is quite low across the 20 Feed the Future districts, ranging from less than 1 percent in Shariatpur district to 19 percent in Magura district.

Figure 1.14: Percentage of Farmers Cultivating Any Stress-Tolerant Rice Varieties by Farm Size Group, 2013



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Table 1.9: Percentage of Farmers Cultivating Top 10 Popular Rice Varieties in Feed the Future Zone in 2013

Aman		Aus		Boro	
Rice variety	Percentage	Rice variety	Percentage	Rice variety	Percentage
Guti shorna	10.23	Mala BR-2	8.18	BRRI dhan BR-28	39.07
Mukta BR-11	9.22	BRRI dhan BR-28	4.60	BRRI dhan BR-29	16.40
Dishari BR-23	7.77	Asha BR-8	2.05	Hira	9.40
BRRI dhan BR-39	5.75	Guti shorna	1.53	Asha BR-8	4.30
BRRI dhan BR-33	5.58	Lal shorna	1.79	Mini cut	4.30
Lal shorna	3.56	Biplob BR-3	1.28	BRRI dhan BR-47	2.33
Kiron BR-22	2.94	Niyamot BR-21	1.79	Kajol lata	1.60
BINA- 7	2.90	Jamaibabu	1.02	Lal teer	1.38
Progoti BR-10	2.68	Aloron 1	1.02	Mala BR-2	1.17
BRRI dhan BR-30	2.64	BRRI dhan BR-27	0.77	BRRI dhan BR-33	1.17

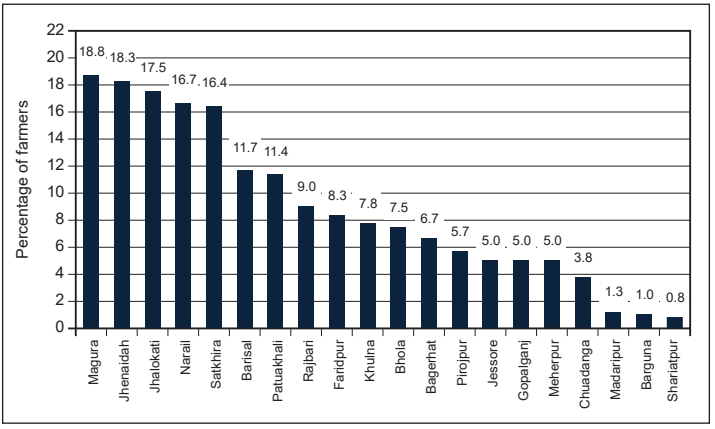
Note: Modern, stress-tolerant rice varieties are in italic and bold.

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

In the Feed the Future zone, a wide variety of paddy is grown with no overwhelming majority of any one variety over another. We identified the 10 most popular rice varieties. Table 1.9 shows the percentage of farmers

cultivating each of these 10 popular rice varieties in 2013. The highest adoption for *aman* is *Guti Shorna* (grown by 10 percent of the farmers), which is of Indian origin and may have been introduced to Bangladesh through informal cross-border exchange. This is followed by *Mukta* BR 11. In the *boro* season, 39 percent of the farmers grow BR 28 followed by BR 29 in the Feed the Future zone. Overall, BR 28 and BR 29 dominate. BR 28 and BR 29 are rice varieties that were first grown in Bangladesh two decades ago, and, despite the introduction of many varieties since then, farmers continue to grow—and often prefer—it. A reason for the continued popularity of these two varieties is their higher yields and shorter growth cycle (for BR 28), which allows farmers to increase their cropping intensity.

Figure 1.15: Percentage of Farmers Cultivating Any Stress-Tolerant Rice Varieties by Districts in Feed the Future Zone in 2013



Source: IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

Since 2000, most farmers have taken to growing BR 28 at different points of time (Table 1.10). However, it's worth noting that about 2 percent of the Feed the Future zone farmers have given up growing BR 28 during 2009-2013 (Table 1.11). The variety that the maximum number of farmers has given up since 2000, however, is BR 11 (*Mukta*), which is a first-generation high-yield variety (HYV) rice that was introduced in Bangladesh more than three decades ago. These HYVs, though effective in areas of high potential, do not perform well under stressful agro-ecologies such as soil salinity or submergence conditions. Given that a substantial part of the Feed the Future zone falls under this category, it is understandable why farmers are giving up these varieties.

Table 1.10: Percentage of Farmers Cultivating Top 10 Popular Rice Varieties in Feed the Future Zone for the First Time since 2000

Top 10 rice varieties	2009-2013	2004-2008	2000-2003
	(percentage of farmers)		
BRRI dhan BR-28	5.88	8.21	6.71
BRRI dhan BR-29	1.67	3.75	3.71
Guti shorna	5.71	2.67	1.42
Mukta BR-11	2.25	2.25	2.21
Dishari BR-23	2.21	2.25	1.88
BRRI dhan BR-33	2.79	1.67	0.96
BRRI dhan BR-39	3.63	1.29	0.42
Hira	1.58	2.71	1.00
Lal shorna	1.21	0.75	1.25
Asha BR-8	0.46	0.75	0.83

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Table 1.11: Percentage of Farmers Stopping Cultivating Top 10 Rice Varieties since 2000

Top 10 rice varieties	2009-2013	2004-2008	2000-2003
	(percentage of farmers)		
BRRI dhan BR-28	2.03	0.51	0.72
BRRI dhan BR-29	1.66	0.80	0.51
Guti shorna	0.51	0.58	0.36
Mukta BR-11	1.95	4.34	2.03
Dishari BR-23	0.29	0.29	-
BRRI dhan BR-33	0.94	0.14	0.07
BRRI dhan BR-39	0.29	0.07	-
Hira	0.72	0.72	0.29
Lal shorna	0.80	0.43	0.29
Asha BR-8	0.65	1.59	1.16

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.5.2 Usage of Stress-tolerant Rice Varieties by Number of Rice Farmers in the Feed the Future Zone

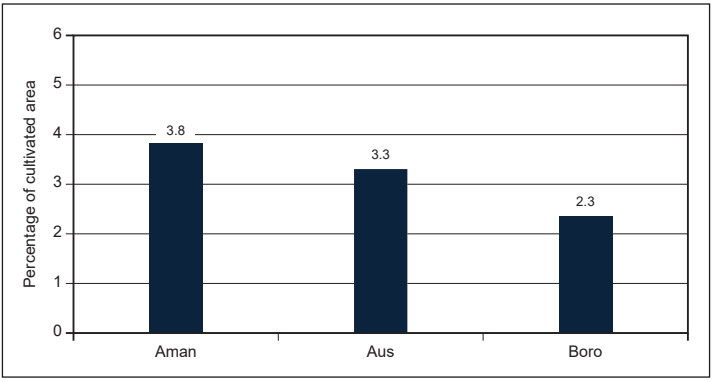
Since the Feed the Future zone level survey is statistically representative of all rice farmers in the Feed the Future zone, it is possible to estimate the

number of rice farmers who used stress-tolerant rice varieties harvested in 2013. According to the 2011 Population and Housing Census conducted by the Bangladesh Bureau of Statistics, there are 6,277,486 rural households in 120 Feed the Future zone upazilas in 20 Feed the Future districts. From the BIHS dataset, we have calculated that 51.9 percent of all households in the Feed the Future zone cultivated rice in 2011. Therefore, the total number of rice farm households in the Feed the Future zone is 3,258,015 (that is, 6,277,486 × 0.519], of which 8.8 percent or 286,705 households have grown at least one stress-tolerant rice variety in 2013.

1.5.3 Area Covered by Stress-Tolerant Rice Varieties

In terms of acreage, the surveys reveal that the coverage of area under stress-tolerant varieties promoted by research institutes is very low. As Table 1.12 shows, only 3.29 percent of the Feed the Future-zone's area under rice is cropped with these varieties. According to the Bangladesh Bureau of Statistics, 2,794,571 hectares were under rice cultivation in the 20 Feed the Future districts in 2012-2013. Therefore, the area coverage of stress-tolerant rice varieties is estimated at 91,914 hectares (that is, 2,794,571 × 0.0329) in the Feed the Future zone of influence. Figure 1.16 shows the percentage of rice area under any stress-tolerant rice variety promoted by the research institutions in the three rice seasons—*aus, aman*, and *boro*.

Figure 1.16: Percentage of Rice Area under any Stress-Tolerant Rice Varieties by Rice Season, 2013



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Table 1.12: Percentage of Feed the Future Zone Rice Area under Cultivation of Stress-Tolerant Rice Varieties, 2013

Stress-tolerant rice variety	Percentage of Feed the Future rice area
BRRI dhan BR-41 (aman)	0.34
BRRI dhan BR-43 (aus)	0.01
BRRI dhan BR-44 (aman)	0.10
BRRI dhan BR-46 (aman)	0.03
BRRI dhan BR-47 (boro)	0.35
BRRI dhan BR-48 (aus)	0.02
BRRI dhan BR-49 (aman)	0.57
BRRI dhan BR-50 (Banglar moti) (boro)	0.11
BRRI dhan BR-51 (aman)	0.16
BRRI dhan BR-52 (aman)	0.04
BRRI dhan BR-53 (aman)	0.00
BRRI dhan BR-54 (aman)	0.04
BRRI dhan BR-55 (boro/aus)	0.03
BRRI dhan BR-56 (aman)	0.01
BRRI dhan BR-58 (aman)	0.00
Bina - 7 (aman)	1.34
Bina - 8 (boro/aus)	0.06
Bina - 10 (aman)	0.04
Bina - 11 (aus/aman)	0.02
Bina - 12 (aman)	0.02
Total	3.29

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

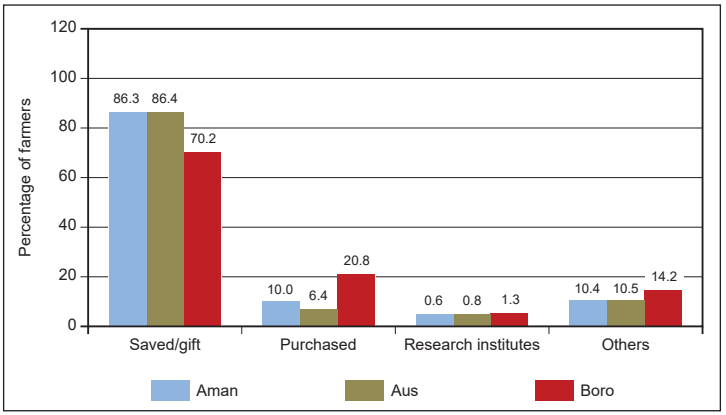
1.5.4 Patterns of Seed Use

The survey shows that 91 percent of the rice farmers in the Feed the Future survey sample make their own seedbed prior to transplantation of the paddy seedlings. In doing so, the use of saved seeds from previous harvest predominates for the summer and monsoon crops of *aus* and *aman*. For the dry season *boro* crop, a lower percentage of farmers use saved seeds and a higher percentage of farmers use purchased seed compared to farmers growing *aus* and *aman* crops (Figure 1.17).

Table 1.13 provides survey results on seed rates for preparing seed bed for top 10 popular rice varieties, and prices of seeds. Hybrid rice requires a substantially lower quantity of seed per-hectare compared to its inbred (HYV) rice but the price of hybrid seeds is much higher than HYV seeds.

The seed rate for hybrid variety *Hira* is about 41.7 kg/ha. *Hira* is grown mostly in the *boro* season. The seed rate ranges from 59 to 73 kilograms per hectare for inbreds (HYVs) in *aman* season, and from 59 to 76 kilograms per hectare for inbreds in *boro* season.

Figure 1.17: Source of Seeds for Farmers in Feed the Future Zone, 2012



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Table 1.13: Seed Rate for Preparing Seed Bed for Top 10 Popular Rice Varieties, 2013

Rice variety	Aman		Boro	
	Seed rate (kg/ha)	Average price of seed used in the seedbed (Tk/kg)	Seed rate (kg/ha)	Average price of seed used in the seedbed (Tk/kg)
BRRI dhan BR-28	69.64	32	60.69	46
BRRI dhan BR-29	61.90	38	69.22	33
Mukta BR-11	63.84	36	58.54	32
Guti shorna	59.21	27	63.43	36
Dishari BR-23	63.17	35	-	-
Hira (hybrid)	-	-	41.70	228
BRRI dhan BR-33	74.08	28	75.72	26
BRRI dhan BR-39	76.05	36	-	-
Kiron BR-22	62.59	32	-	-
Lal shorna	72.93	37	-	-

Source: IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

1.6 Determinants of Farmers' Adoption and Duration of Farm Technologies

This section presents an analysis of adoption, retention, and diffusion of both (i) urea deep placement (Guti urea) technology and (ii) a set of modern paddy varieties promoted by agricultural research institutes. It presents the cohort analysis followed by econometric analysis[4] of each technology. It is important to mention at the outset that, while agricultural research institutes have promoted many varieties within the Feed the Future zone as reported in the previous section, the analysis of adoption, retention, and diffusion that follows focuses on the top five varieties—BR 41, BR 47, BR 49, BR 50, and BINA 7—used by sample farmers.

1.6.1 Cohort Analysis and Survivor Functions of Usage of Guti Urea Technology

Table 1.14 presents the results of cohort analysis of Guti urea usage for Feed the Future survey sample. The key results are as follows:

Table 1.14: Cohort Analysis of Retention and Drop Out of Guti Urea Technology in Feed the Future Zone from 2010 to 2013

Farmers	2010	2011	2012	2013
		(number)		
Continued	-	58	100	157
New	-	157	146	102
Dropped out	-	68	115	89
Total users	126	215	246	259
		(percent)		
Dropout rate	-	54	53	36
Retention rate	-	46	47	64
Average dropout rate	-	-	-	48
Average retention rate	-	-	-	52

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Farmers dropped the Guti urea technology very rapidly. More specifically, about half of the farmers who had used the technology dropped it within one year. This is not a promising result, as it seems that the technology's

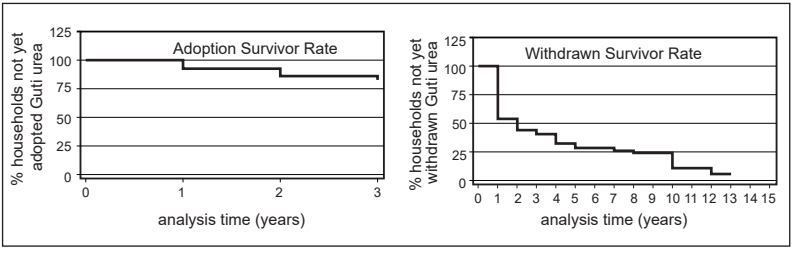
[4] Appendix B explains the economic modeling and methodology that support the econometric analysis of the adoption of new farm technologies using survival analysis.

benefits (for example, higher yields and more efficient use of fertilizer) do not outweigh its costs or the cultural-practice changes that farmers need to make in order to adopt it. An encouraging sign about this result, however, is that in 2013 the dropout rate decreased significantly to 36 percent, which might imply that farmers have grown more willing to continue using the technology beyond the first year. However, a dropout rate of 36 percent is still very high.

Just more than 20 percent of Feed the Future sample farmers used the Guti urea technology at some point during the four-year observation period (2010-2013). However, the diffusion was gradual. The left-side chart of Figure 1.18 shows the survivor function for the Guti urea adoption decision within the Feed the Future zone, which can be interpreted as the share of households that *have not* used Guti urea at a given time (*t*). The figure shows that farmers began using Guti urea soon after being exposed to the "possibility" of adoption, but the shape of the survival function might suggest high entry costs of adoption because the share of households not adopting decreased slowly.

Once farmers use Guti urea, they seem to withdraw rapidly, which confirms the results of the cohort analysis. The right-side chart of Figure 1.18 presents the survival function of the withdrawal decision over the 15-year observation period (1998-2013); it shows that the first signs of desertion occur immediately after the household has used the new technology. By the fifth year, 70 percent of the adopters have stopped using Guti urea and, at the end of the observation period, only one-tenth of the users could be classified as uninterrupted adopters.

Figure 1.18: Adoption and Withdrawal Survivor Rates of Guti Urea



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Table 1.15: Adoption and Duration Analysis of Guti Urea in the Feed the Future Zone

	Adoption	Duration
Years of education of head of household (HHH)	-0.025***	0.018*
	(0.007)	(0.010)
HHH is female	0.523	8.024
	(0.339)	(515.658)
Age of HHH	-0.002	0.008**
	(0.002)	(0.003)
HHH is married	0.074	0.610***
	(0.166)	(0.219)
Number of adults (14 to 60 years old) in the household	-0.037*	-0.009
	(0.021)	(0.039)
Total owned land in Acres	0.000	0.000
	(0.000)	(0.000)
Total operated land in acres	-0.000***	-0.000
	(0.000)	(0.000)
Output price (taka/kg)	-0.004	0.006
	(0.009)	(0.009)
Households has irrigation system	0.013	-0.033
	(0.062)	(0.100)
Households has access to credit	-0.095	0.274***
	(0.076)	(0.101)
Constant	2.441***	0.327
	(0.272)	(0.347)
Observations	6,215	586
Number of households	2,224	237
P	1.753	1.766
LR Chi^2 (8)	38.36	26.01
Prob>Chi^2	0.000	0.004

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.6.2 Determinants of Time-to-Adoption of Guti Urea and Duration

Table 1.15 shows the results of two estimated regression models explaining time-to-adoption and duration (or, time-to-withdrawal), which could be termed as "adoption spell" and "withdrawal spell," based on terminology in the existing literature. We use an Accelerated Failure Time (AFT)

transformation of the proportional hazards model; AFT coefficients reflect the acceleration and deceleration effect on time-to-adoption and time-to-withdrawal, which is an analogous interpretation of common regression models. Negative coefficients imply higher probability of adoption (or withdrawal) because they suggest that the variable they represent reduces the pre-adoption (pre-withdrawal) spell. We discuss the statistically significant results below and, in some cases, highlight the variables we expected to be significant that, in reality, were not. The likelihood ratio test of significance of the regressions (chi-squared statistics) and the *p* values associated with these statistics show the overall significance of both the adoption and withdrawal spells models to be significant at the 1 percent level.

Several results are remarkable for the determinants of time-to-adoption.

1. Farm size (determined by the amount of operated land) plays a significant role in determining adoption of Guti urea; larger operated land significantly shortens time to adoption. This is a fairly predictable result because farmers with more operated land tend to have more intensive productive systems and are therefore less risk-averse and more willing to try new farm technologies.
2. Education of the head of household reduces the time-to-adoption. This is an important result demonstrating the positive influence of education in technology adoption rates. It is also an expected result based on economic literature.
3. The number of adults in the household also reduces time-to-adoption of the Guti urea technology. Guti urea is a very labor-demanding technology, so more family labor stock eases its implementation and reduces the constraint associated with hiring more farm labor.
4. Female-headed households are found to be slower in adopting Guti urea, which is disturbing because one of the objectives of the program promoting Guti urea is to involve rural women into the adoption of new farm technologies.

Several results are salient for the determinants of Guti urea technology duration.

1. Farm size is *not* found to be a significant determinant of duration of use. This is an important finding when considered against the literature, which states a controversy (as noted above) about whether farmers with minimal land can adopt modern technologies.
2. Analogous to our finding that education reduces the time-to-adoption, we find that education also lengthens the duration of Guti urea

technology use. Access to credit plays an important role in extending duration of Guti urea use.

3. Access to credit can relax the cash constraint, which enables farmers to hire more labor—a necessary expense for adopting the technology.
4. Household characteristics related to stability lengthen duration of use. Variables such as age and marital status of the household head lead to longer Guti urea use.

1.6.3 Cohort Analysis and Survivor Functions of Stress-Tolerant Rice Varieties

Table 1.16 presents the cohort analysis results of stress-tolerant rice varieties for the Feed the Future survey sample. The main results are as follows:

Table 1.16: Cohort Analysis of Retention and Drop Out of Stress-Tolerant Rice Varieties in the Feed the Future Zone from 2009 to 2013

Farmers	2009	2010	2011	2012	2013
			(number)		
Continued	-	39	65	91	105
New	-	26	28	18	65
Dropped out	-	1	0	2	4
Total users	40	65	93	109	170
			(percent)		
Dropout rate	-	3	0	2	4
Retention rate	-	98	100	98	96
Average dropout rate	-	-	-	-	2
Average retention rate	-	-	-	-	98

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

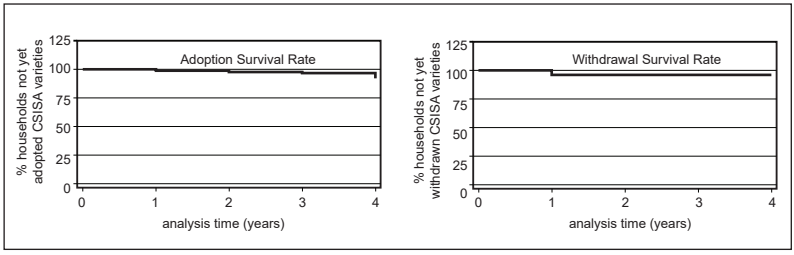
First, farmers who use the stress-tolerant rice varieties once, continue on as consistent users of such varieties. In the Feed the Future zone of influence, the average annual retention rate of the new varieties is 98 percent, which implies that once farmers adopt the new varieties, they continue to cultivate the varieties for a long period of time. This is a very encouraging result for the research institutes because it suggests a low dropout rate among farmers who adopt the new varieties. Second, 7.3 percent of farmers included in the Feed the Future sample use the stress-tolerant rice varieties at some point during the five-year observation period

(2009-2013). The diffusion is very slow, however. The left-side chart of Figure 1.19 shows the survivor function for the stress-tolerant rice varieties adoption decision within the Feed the Future zone; it can be interpreted as the share of households that have not used any of the stress-tolerant varieties at a given time (*t*). The figure shows that farmers begin using the stress-tolerant varieties soon after being exposed to the "possibility" of adoption, but the shape of the survival function shows that this process is quite slow. This result is to be expected when analyzing the adoption of new/improved crop varieties in developing countries.

Interestingly, once farmers use the stress-tolerant rice varieties, they continue using the new technology and do not withdraw rapidly. There is minimal evidence of dropout of these varieties, which supports the results of the cohort analysis.

The right-side chart of Figure 1.19 shows the survival function of the withdrawal decision, which demonstrates that there is hardly any desertion occurring after adoption of the stress-tolerant rice varieties. By the fourth year of use, more than 95 percent of the users remain as adopters of the stress-tolerant varieties uninterruptedly.

Figure 1.19: Adoption and Withdrawal Survivor Rates of Stress-Tolerant Rice Varieties



Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

1.6.4 Determinants of Time-to-Adoption of Stress-Tolerant Rice Varieties

Table 1.17 shows the results of the two regression models explaining time-to-adoption and duration (time-to-withdrawal) models. We discuss the statistically significant results below and highlight the variables we had expected to be significant that, in reality, were not. The likelihood ratio test of significance of the regressions (chi-squared statistics) and the *p* values associated with these statistics show the overall significance of both the adoption and withdrawal spell models to be significant at the 1 percent level.

Table 1.17: Adoption and Duration Analysis of Stress-Tolerant Rice Varieties in the Feed the Future Zone

	Adoption	Duration
Years of education of head of household (HHH)	-0.017*	0.013
	(0.009)	(0.014)
HHH is female	-0.418**	7.637
	(0.199)	(982.276)
Age of HHH	-0.002	0.004
	(0.003)	(0.004)
HHH is married	-0.228	0.999***
	(0.234)	(0.265)
Number of adults (14 to 60 years old) in the household	-0.000	0.023
	(0.029)	(0.064)
Total owned land in acres	0.000	0.001
	(0.000)	(0.001)
Total operated land in acres	-0.000*	0.002**
	(0.000)	(0.001)
Output price (taka/kg)	-0.017***	0.020
	(0.006)	(0.015)
Seed price (taka/kg)	0.001	-0.003
	(0.001)	(0.002)
Households has irrigation system	-0.386***	0.327*
	(0.102)	(0.184)
Households has access to credit	-0.073	0.119
	(0.097)	(0.154)
Constant	3.458***	-0.213
	(0.367)	(0.481)
Observations	9,232	384
Number of households	2346	132
ρ	2.332	2.107
LR Chi^2 (9)	32.50	55.04
Prob>Chi^2	0.001	0.000

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05.

Source: IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

Several results are noticeable for the determinants of time-to-adoption.

1. Similar to our results regarding Guti urea, farm size (determined by operated land) plays a significant role in determining adoption of

the stress-tolerant rice varieties promoted by research institutes in Feed the Future zone of influence; larger operated land significantly shortens the time to adoption. This result is to be expected because farmers with more operated land tend to have more intensive productive systems and are therefore less risk-averse and more willing to try new farm technologies.

2. Again, similar to the analysis of Guti urea results, education of the head of household reduces the time-to-adoption of the stress-tolerant rice varieties.
3. Interestingly, female-headed households are *more likely* to adopt stress-tolerant rice varieties than other sample households.

The main findings for determinants to duration of the stress-tolerant rice varieties use are presented below.

1. The size of total operated land has a positive effect on duration of use of the stress-tolerant varieties; it increases duration.
2. Having access to irrigation increases duration of time using the stress-tolerant varieties. Similar to total operated land, this result is related to production system intensification.
3. Being married also has a positive effect on duration of use of these varieties. This result is related to life cycle household stability, as discussed previously for Guti urea technology.

1.7 Summary and Conclusions

Using the data collected through a survey of rice-farm households, the IFPRI-PRSSP study analyzed two agricultural technologies promoted in USAID's Feed the Future zone of influence in the south and southwest regions of Bangladesh. The first technology assessed is urea deep placement—a relatively new fertilizer technology frequently called "Guti urea". The second technology is a set of modern stress-tolerant paddy varieties. The survey conducted in the Feed the Future zone of influence saw different results.

Guti urea: Findings and analysis

The IFPRI-PRSSP survey, which represents all rice farmers in 120 upazilas that comprise the Feed the Future zone of influence in Bangladesh, finds that 10.8 percent of all rice farmers use Guti urea for crops harvested in 2013. Overall, the percentage of farmers who use Guti urea is seen to increase when farm size increases. In total, 4.8 percent of rice farm area under cultivation in the Feed the Future zone survey sample is under Guti

urea application. Farmers use 43 percent less Guti than prilled urea (because less Guti urea is required for cultivation than prilled) for cultivating *boro* rice. Farmers who exclusively use Guti urea for *boro* rice cultivation have 13 percent higher paddy yields than farmers who exclusively use prilled urea. If paddy yields are high with relatively low amounts of Guti urea application, why don't more farmers in the Feed the Future zone of influence use Guti urea for crop cultivation? Farmers in the survey cite high labor requirements and low availability as the dominant impediments to greater Guti urea use. Ensuring enough supply of Guti urea is therefore a prerequisite for its adoption by farmers.

The rates of adoption of Guti urea are much lower for pure tenant farmers—that is, farmers who do not own any cultivable land—than for (i) those who cultivate their own land and (ii) those who cultivate their own land in addition to taking in land as sharecroppers and/or leaseholders (mixed tenants). About one-fifth of all rice-farm households in the Feed the Future zone are pure tenants that do not own the land they work. Therefore, they have insecure, prohibitive, and unstable access to land through sharecropping or land-leasing arrangements, which acts as a deterrent for technology adoption. These farmers must pay rent for the land they cultivate, which makes farming a low-profit enterprise for them.

Modern, stress-tolerant rice varieties: Findings and analysis

In the Feed the Future zone of influence, less than one-tenth (8.8 percent) of the farmers grow at least one of the stress-tolerant rice varieties.

Across farm size groups, adoption of stress-tolerant rice varieties is higher among the medium and large farms than among marginal and small farms. A plausible explanation for the relatively low adoption of the stress-tolerant rice varieties could be that small and marginal farmers are risk-averse given their lack of a diversified portfolio, which severely constrains their ability to offset any crop loss. It is understandable that these poor farmers prefer to stick to time-tested varieties with assured yields rather than experiment with new ones.

In terms of acreage, the surveys reveal that the coverage of area under stress-tolerant varieties is very low, only about 3 percent of the Feed the Future-zone's area under rice is cropped with these varieties.

Synthesis and conclusions

Although the analyses of adoption and diffusion of the two technologies show very different results, overarching conclusions emerge. First, disregarding

the type of technology, education plays a key role in new farm-technology adoption and diffusion. This is evidenced by the rate at which educated heads-of-household tend to adopt new technologies in comparison to less-educated heads-of-household. Those with more education also continue using the new technologies for longer periods of time.

Second, new farm technologies have higher probability of being adopted if farmers experience minimal changes in their production systems as a result of adoption. It is easier to change a paddy variety than it is to adopt a new fertilizer technology, which demands major adjustments in labor use at the farm level.

Third, projects and programs that promote new farm technologies should be strongly encouraged to monitor retention of those technologies. The results of this study show that a new technology can have a massive dropout rate within one year of adoption, which is a clear sign that farmers are facing challenges with it.

References

Ahmed, Akhter U., and Rajan K. Sampath. 1992. "Effects of Irrigation-Induced Technological Change in Bangladesh Rice Production." *American Journal of Agricultural Economics* 74, no. 1: 144-157.

Ahmed, Akhter U., Ahmad Kaikaus, Victoria Chou, Ricardo Hernandez, Purnima Menon, Farria Naeem, Firdousi Naher, Wahid Quabili, Esha Sraboni, and Bingxin Yu. 2013. *The Status of Food Security in the Feed the Future Zone and Other Regions of Bangladesh: Results from the 2011-2012 Bangladesh Integrated Household Survey*. Project report submitted to the United States Agency for International Development (USAID). Dhaka: International Food Policy Research Institute (IFPRI).

Ayana, I. 1985. "An Analysis of Factors Affecting the Adoption and Diffusion Patterns of Packages of Agricultural Technologies in Subsistence Agriculture: A Case Study in Two Extension Districts of Ethiopia." Unpublished MSc. thesis, Addis Ababa University.

Bangladesh Bureau of Statistics (BBS). 2011. *Report of the Household Income and Expenditure Survey 2010*. Dhaka: Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Carletto, Calogero, Alain de Janvry, and Elisabeth Sadoulet. 1999. "Sustainability in the Diffusion of Innovation: Smallholder Non-Traditional Agro-Exports in Guatemala." *Economic Development and Cultural Change* 47, no. 2: 345-369.

Carletto, Carletto, Angeli Kirk, Paul Winters, and Benjamin Davis. 2010. "Globalisation and Smallholders: The Adoption, Diffusion and Welfare Impact of Non-Traditional Export Crops in Guatemala." *World Development* 38, no. 6: 814-827. https://doi.org/10.1016/j.worlddev.2010.02.017.

Dadi, Leggesse, Michael Burton, and Adam Ozanne. 2001, September. "Adoption and Intensity of Fertilizer and Herbicide Use in the Central Highlands of Ethiopia." *Agrekon* 40, no. 3: 316-333.

Dadi, Leggesse, Michael Burton, and Adam Ozanne. 2004. "Duration Analysis of Technological Adoption in Ethiopian Agriculture." *Journal of Agricultural Economics* 55, no. 3: 613-631. https://doi.org/10.1111/j.1477-9552.2004.tb00117.x.

Hazell, P., and J. Anderson. 1986. "Public Policy toward Technical Change in Agriculture." In *Technology, Innovation and Economic Policy*, edited by Peter Hall. Oxford: Philip Allan.

Kebede, Yohannes, Kisan Gunjal, and Garth Coffin. 1990. "Adoption of New Technologies in Ethiopian Agriculture: The Case of Tegulet-Bulga District, Shewa Province." *Agricultural Economics* 4: 27-43. https://doi.org/10.1111/ j.1574-0862.1990.tb00103.x.

Mekuria, Mulugeta. 1996. "Technology Development and Transfer in Ethiopian Agriculture: An Empirical Evidence." In *Food Security, Nutrition and Poverty Alleviation in Ethiopia*, edited by Mulat Demeke, Wolday Amha, Simeon Ehui, and Tesfaye Zegeye. Proceedings of the Inaugural and First Annual Conference of the Agricultural Economics Society of Ethiopia, 8-9 June 1995, Addis Ababa.

Waktola, Aregay. 1980. "Assessment of the Diffusion and Adoption of Agricultural Technologies in Chilalo." *Ethiopian Journal of Agricultural Science* 2: 51-68.

Yirga, C., Barry I. Shapiro, and Mulata Demeke. 1996. "Factors Influencing Adoption of New Wheat Technologies in Wolmera and Addis Alem Areas of Ethiopia." *Ethiopian Journal of Agricultural Economics* 1: 63-84.

Appendix

Determinants and Effects of Farmers' Adoption and Duration of New Farm Technologies

Duration Analysis

As explained by Dadi, Burton, and Ozanne (2004), many studies in the economic literature have analyzed the adoption and diffusion of new farm technologies in many developing countries, however, most of these studies have focused on static scenarios and therefore are limited to analyzing adoption rates at specific moments in time, usually through econometric analysis that relies on the use of binary static models such as probit, logit and Heckman models (Waktola 1980; Ayana 1985; Kebede, Gunjal, and Coffin 1990; Mekuria, 1996; Yirga, Shapiro, and M. Demeke 1996; Dadi, Burton, and Ozanne 2001). These studies do not consider the dynamic process of adoption decisions; therefore they do not consider the effect of changing conditions (time varying variables), and how these conditions affect not just adoption, but also speed of adoption, how fast or slow are farmers adopting new technologies? What are the conditions that make farmers adopt new technologies sooner rather than later?

Speed of adoption and the policy implications of speed are often ignored, yet they can turn out to be very important characteristics when designing policy interventions to help smallholders adopt new technologies. As Dadi, Burton, and Ozanne (2004) points if for example, if it is thought that large farmers are more likely to adopt than small farmers, a program directed towards small farmers may be considered. However, if small farmers lag behind by only a few seasons the difference is not important and there is no good reason to target small farmers since by the time extension officers reach them, most will already have adopted. Furthermore, Dadi, Burton, and Ozanne (2004) shows that speedy adoption can be very important, as Hazell and Anderson (1986) point out, for policy makers who need rapid results in order to justify project funding since, with discounting, production increases in the early years of a project have much greater impact on the rate of return on capital investment than increases in later years. The length of time, or "duration", farmers wait before adopting a new technology may be expected to depend on a number of economic, social and institutional factors, some of which vary with time (for example, the age of the farmer, and input and output prices) and some of which do not (for example, sex of farmer, geographical location, education level).

The objective of this study is to examine the adoption behavior of agricultural technologies over time of smallholder farmers in Bangladesh using duration analysis, a statistical tool which provides numerical and graphical summaries of

duration data and allows the researcher to investigate the effects of explanatory variables on the duration of stay of an individual in a given state. Two new technologies are considered, the adoption of a new fertilizer (Guti urea) and the adoption of improved paddy cultivation varieties.

The Model

Theoretical and general implementation models

As our focus is an empirical contribution, we do not present a new theoretical model but draw heavily in this sub-section on the conceptual framework laid out in works authored by Carletto and his colleagues (Carletto, de Janvry, and Sadoulet 1999; Carletto, Kirk, Winters, and Davis 2010). While their work focused on entry in the non-traditional horticulture exports market by adoption of the crops for that market, it is directly relevant to our treatment of adoption of—entry in—and duration in the supermarket channel in the domestic food market. Thus, we merely summarize their conceptual model in this subsection.

Carletto and his colleagues specify a farm household model where a household decides the allocation of its land endowment (A) between traditional technology, A_o, and non-traditional (modern) technology (new crop variety, new fertilizer, etc.), A_1. Using the traditional technology choice is perceived as less production-risky but also has a lower expected return compared to the new modern technology choice. However, new technologies can be costly, where entry costs are perceived higher than those of traditional technology choice. With the vector of variable inputs valued at the cost w_x, the income per hectare can be written as follows:

For traditional technology (crops),

$$\Pi_0(p_0, w, z_0) + \theta_0 \tag{2.1}$$

For modern technology (crops),

$$\Pi_1(p_1, w, z_1) + \theta_1 \tag{2.2}$$

with

$$E(\theta_0) = E(\theta_1) = 0, \sum(\theta_0, \theta_1) = \left(\sigma_0^2, \sigma_1^2, \rho_{01}\sigma_0\sigma_1\right) \tag{2.3}$$

where

(1) p_o and p_1, are the expected crop prices using the traditional and modern technologies respectively;

(2) Π_0 and Π_1 are the expected incomes per hectare of the crops sold;

(3) Σ is the variance-covariance matrix of the risk terms θ_0 and θ_1; and

(4) z_0 and z_1 household assets that affect expected income.

If the household decides to allocate land using the new modern technology (A_1>0), then the household's total income is

$$Y = (\Pi_0 + \theta_0)A_0 + (\Pi_1 + \theta_1)A_1 + T - c_1, \tag{2.4}$$

where

(1) c_1 is the new technology fixed entry costs; and

(2) T is other sources of income.

Assuming that the household is risk averse, it will decide to adopt the new technology when the change in utility due to adoption (ΔU_a) is positive, given an optimal level of allocation land to the new modern technology (A_1). That change in utility is determined by the following function:

$$\Delta U_a = \frac{1}{2\phi(\sigma_0^2 + \sigma_1^2 + 2\rho_{01}\sigma_0\sigma_1)}[(\Pi_1 - \Pi_0) - \phi(\rho_{01}\sigma_0\sigma_1 - \sigma_0^2)]^2 - c_1 > 0 \tag{2.5}$$

We now proceed to the specification of the regression model and estimation procedure we use to implement the conceptual model.

We "translate" the theoretical model into an implementation model that has the general form of the equations, and the general categories of variables used by Carletto and his colleagues. Following the theoretical model presented we can rewrite equation 2.5, the change in utility from adoption, as follows:

$$\Delta U_a = \Delta U_a(p_o, p_1, w_x, FK, HK, SK, T_o, t_a, V) \tag{2.6}$$

In an analogous way the decision to withdraw is determined by the change in utility that determines withdrawal ΔU_w; initially this change is negative, but may become positive (ΔU_w>0) and encourage the household to withdraw.

$$\Delta U_w = \Delta U_w(p_o, p_1, w_x, FK, HK, SK, T_a, T_w, V) \tag{2.7}$$

Equation 2.7 is similar to equation 2.6, with the difference that the earliest time for withdrawal is the time when the household adopts the new technology (T_a) and the duration of the withdrawal spell is included as t_w.

The equations show that the change in utility from adoption or withdrawal is a function of the following:

(1) The exogenous output prices,

(2) The exogenous input prices,

(3) Household assets: human capital (*HK*); farm capital (*FK*); social capital (*SK*); and community capital (*CK*).

(4) Time, which enters the duration equations in several ways:

a. T_o, the potential earliest year for adoption which is either when the new modern technology becomes accessible to the household or when the household is formed;

b. t_a, the household's "time to adoption" which is the time period between T_o and the year the household adopted (T_a);

c. t_w, the time from adoption to the time of withdrawal, or the "duration," which is the time as a user of the new technology if they adopted; note that withdrawal may not yet (or never occur).

In most duration models, observations on t_a are of two types:

(1) The household has adopted the new technology, then the value of t_a is directly observed; and

(2) The household has not yet adopted at the time of the survey, so that we have truncated information, since the length of the duration spell (t_a) is greater than the length of the observed pre-adoption spell.

We will analyze the "time to adopt" (waiting time of the household before adoption also called in the duration literature the adoption spell) and if the household adopts, the time to withdraw (or duration). Therefore, we manipulate equations 2.6 and 2.7 to express t(a) and t(w) as functions of the explanatory variables in those equations. This will be a prelude to specifying the regression equations in the next subsection. Thus,

$$t_a = t_a(p_,, p_,, w_x, FK, HK, SK, T_o, V) \tag{2.8}$$

Since we analyze farm duration as user of the new technology (waiting time before withdrawal, also known as the withdrawal spell), it is as follows:

$$t_w = t_w(p_,, p_,, w_x, FK, HK, SK, T_a, V) \tag{2.9}$$

The estimation procedure

To estimate the adoption and withdrawal equations, we proceed as follows. Duration models are based on the implementation of hazard rates which are used to analyze decisions over time. The specification of the hazard rate can be done using both parametric and non-parametric methods. Our estimation is performed using Maximum Likelihood. We chose a parametric approach using a Weibull distribution. Drawing on Carletto, Winters, and Davis (2010) we specify the hazard function as follows:

$$h(t) = \lambda(x)^{p} pt^{p-1} \tag{4.1}$$

where

$$\lambda(x) = e^{-\beta' x} \tag{4.2}$$

(1) λ is the scale parameter, a function of the vector of covariates (x), and

(2) ρ is the shape parameter, which captures the monotonic time dependency of the event.

We use the Accelerated Failure Time (AFT) transformation of the proportional hazards model, as it yields easier results for interpretation. The AFT coefficients reflect the acceleration and deceleration effect on time-to-adoption and time-to-withdrawal, which is an analogous interpretation of common regression models. The AFT model can be written form as follows:

$$\log(t) = \beta' X + \sigma\varepsilon, \tag{4.4}$$

where

(1) t is a non-negative random variable denoting the time of the event (adoption or withdrawal),

(2) X is the vector of explanatory variables,

(3) β is the vector of coefficients,

(4) ε is the error term[5], σ is a scalar that is equivalent to the inverse of the shape parameter (σ=1/ρ).

[5] The error term, in the case of a Weibull hazard function, follows an extreme value distribution.

Chapter 2

Challenges and Opportunities for Hybrid Rice in Bangladesh[1]

David J. Spielman, Patrick S. Ward, Deepthi E. Kolady, and Harun-Ar-Rashid

2.1 Introduction

Many studies suggest that hybrid rice can contribute to food security in developing countries, especially in parts of Asia where rice production is so vital to the rural economy and where rice remains a staple of both urban and rural food consumption. The higher yields attributable to hybrid rice have the potential to increase food availability for farm households' own consumption, while also increasing farm incomes through sales of larger marketable surpluses. These larger marketable surpluses can result in increased food supplies that reduce or stabilize prices for both urban and rural food-insecure households (see e.g. Lin and Pingali 1994; Xie and Hardy 2009).

To a large degree, these touted benefits of hybrid rice have been realized in China, where widespread adoption of hybrids is credited with improving food security and feeding an estimated 60 million additional people per year (Li et al. 2010). Despite the apparent success of hybrid rice cultivation in China, however, the proliferation of hybrid rice has been much slower in many other Asian countries. While over half of total area under rice cultivation in China is used to grow hybrids, hybrid rice cultivation in other Asian countries accounts for a relatively small portion of total rice area. In India, Indonesia, and the Philippines, for example, less than five percent of total rice area is used for hybrids, while only about seven percent of total rice area in Bangladesh and ten percent of total rice area in Vietnam are under hybrids. The sluggish adoption of hybrids is particularly troubling in South Asia, where overall growth in rice yields has been slow in recent decades (Janaiah, Hossain, and Husain 2002).

---

[1] An earlier version of the chapter was published in *Applied Economic Perspectives and Policy,* 39, no. 1 (2017): 154-176. This is reproduced with the permission of the publisher.

There exist a variety of challenges constraining the widespread adoption of hybrids outside China. These challenges include not only technical challenges associated with the development of suitable hybrid rice technologies, but also institutional challenges, market failures, and policy constraints that have thus far limited the diffusion of hybrids. This study aims to address these challenges using an integrated conceptual framework that opens the "black box" of the research production function and examines the processes behind the product. Specifically, this chapter examines the factors that encourage or inhibit the discovery, development and delivery of hybrid rice in South Asia, with a particular emphasis on the Bangladeshi context. When applied to overall agricultural science, technology, and innovation policy, this integrated framework helps identify (i) key actors, assets and processes engaged in the production, exchange, and use of new technologies; (ii) actions and interactions that enable these actors to invest in process innovations; and (iii) policies and institutions that influence their actions and interactions. An analysis of the complex systems surrounding hybrid rice can provide a clear picture of the precise areas in which policy interventions can result in accelerated development and delivery.

The chapter is organized as follows. In Section 2.2, we introduce the conceptual framework that will be employed to examine the opportunities and challenges for the discovery, development and delivery of hybrid rice technologies, including an introduction of data used in the quantitative and qualitative analysis throughout the study. In Section 2.3, we provide a historical and contextual background of hybrid technologies in general and some of the specific concerns regarding hybrid rice. In Section 2.4, we review the history and patterns of hybrid rice adoption in Bangladesh, identifying several key constraints, challenges, and risks specific to the Bangladeshi experience. In Section 2.5, we discuss the technical, social, economic, and policy dimensions of hybrid rice. Finally, Section 2.6 concludes with a set of actionable policy recommendations for further research, development and delivery of hybrid rice in Bangladesh.

2.2 Conceptual Framework

While many of the benefits of hybrid rice seem obvious, there are also challenges in transforming a technology such as hybrid rice into an economically relevant production factor. Addressing these challenges requires a better understanding of the complex mechanism by which factors of technology production—scientific capital, technical know-how, breeding materials, and seed production systems—are translated into real outputs, such as marketable quantities of hybrid rice seed or hybrid rice as a tradable

commodity itself, and how these marketable outputs themselves interact with complex and diverse consumer preferences in downstream output markets.

One strategy to understand the complex issues related to technology production is to examine the processes by which science is translated into viable technologies and, ultimately, into commercial products, as well as the incentives that motivate individuals, firms, and governments to invest in these processes. This type of examination requires shifting our analytical emphasis to the question of how—rather than why—science, technology, and innovation (ST&I) policies and investments should be made, or focusing on systemic complexity and knowledge gaps rather than cost—benefit analysis.

The integrated ST&I framework used in this study addresses the "how" question by emphasizing the roles played by diverse actors in the production, exchange, and use of ST&I products and processes; the institutions and incentives that condition these actors' actions and interactions; and the precise policy interventions that are most likely to result in welfare-improving outcomes. It does so by focusing on the analysis of optimal investment, collaboration, and risk management strategies that define the critical decision-making points for investment in agricultural ST&I.

The framework examines decision points at three stages of analysis—discovery, development, and delivery. During this process, knowledge, scientific, human, and productive capital are all transformed into marketable outputs and measurable inputs through an iterative process of discovery, development, and delivery. *Discovery* describes the investment, collaboration, and risk management strategies related to scientific and technical inquiry at the earliest phase of innovation. *Development* describes the translation of science into technology and the market opportunities, regulatory hurdles, and other constraints associated with this process. *Delivery* refers to the adoption and uptake of a technology through various market and non-market distribution channels that are influenced by the economic behavior of individuals, firms, and governments.

At the nexus of discovery, development, and delivery is a series of institutional and industrial strategies involving investments, collaborations, and risk management. This iterative process of learning results in innovative technologies (e.g. interactions between discovery and delivery facilitates demand-driven innovations), innovative processes (e.g. interactions between discovery and development facilitate new methods and approaches for streamlining the research and development pipeline), and innovative dissemination (e.g. interactions between development and delivery facilitate new methods for transmitting information about the technologies or for transmitting the technologies themselves).

Table 2.1 summarizes these three stages, highlighting the clearly defined investment, collaboration, and risk management strategies that innovators and policymakers must address when making critical decisions and pursuing specific actions. Where information and analysis are limited and where public policies give little guidance in steering decisions and actions to optimal outcomes, innovators face greater levels of uncertainty. This uncertainty necessarily constrains the assessment of whether or to what degree a given technological opportunity will enhance productivity, reduce poverty, or promote equity in developing country agriculture. Efforts to bridge this information gap and design farsighted public policies are an essential contribution of any analytical work on ST&I.

Table 2.1: Key Stages and Strategies in ST&I Framework

Key stages	Product discovery	Product development	Product delivery
Key function	Basic research and upstream science	Applied/adaptive research and product introduction	Product marketing and distribution
Investment strategy	Identify or acquire relevant research assets; Identify research (technical) strategy	Transform research into a commercial product; Develop production systems and business models for commercialization	Develop marketing strategies and distribution systems
Collaboration strategy	Identify and leverage research networks and partnerships; Review intellectual property (IP) rights needs to identify licensing or collaboration priorities	Identify and leverage product development networks and partnerships	Manage in-house versus outsourced production; Identify marketing partners and partnering strategies
Risk management strategy	Identify regulatory issues associated with the research	Identify market risk issues associated with the product; Collect and manage environmental safety, human safety, and other regulatory data	Manage production and product safety; Manage market risk; Identify industry structure and concentration issues; Ensure IP protection and product stewardship

Source: Authors' estimation.

Necessarily, these differentiated stages of discovery, development, and delivery are based on overlaps and interactions, a reality that draws attention

to the fact that most innovative opportunities cannot be exploited simply on the basis of a linear process that moves from upstream science into downstream application. Instead, the process begins with a widely defined set of assets: explicit inputs, such as known stocks of scientific capital, other forms of capital, land, and labor, as well as more implicit or tacit inputs, such as scientific experience, indigenous knowledge, and managerial capacity. The application of these assets to a particular problem or production constraint leads to a non-linear progression influenced by (1) the availability of appropriate tools and technologies (the "state of the art"); (2) the capacity of agents to iterate, learn, and innovate through this progression ("innovative capabilities"); and (3) the existence of appropriate policies and investments in support of ST&I (the "enabling environment"). In short, although ST&I can contribute to solving problems in developing country agriculture, the solutions require more than just good science: they also require the right tools and technologies *plus* the right policies and investments.

This study relies on both quantitative and qualitative methods, and draws on data extracted from a range of sources, including peer-reviewed journal articles, government statistical reports, private databases and documents from industry sources. A key source of data is the Bangladesh Integrated Household Survey (BIHS) conducted by the International Food Policy Research Institute in late 2011 (Ahmed 2013). The BIHS contains data on 5,503 households drawn from 64 districts in the seven primary divisions and is representative at both the national and divisional levels. The survey covers topics that are standard to most income and expenditure surveys in developing countries, as well as topics related to agricultural production, plot utilization, input use, and post-harvest management.

2.3 Background on Hybrid Technologies

The primary characteristic distinguishing hybrids from traditional varieties is heterosis (or hybrid vigor), which describes the increase in yield, uniformity, or vigor of cultivated plants that results from genetic contributions derived from the crossing of distinct parental lines. Its economic value lies in the fact that yield gains conferred by heterosis decline dramatically after the first generation of seed (F1), thus compelling farmers to purchase new F1 seed each season in order to continually realize these yield gains. This contrasts with conventional open pollinated varieties (OPVs) or self-pollinating inbred varieties (for rice), in which harvested grains can be stored and used as seeds in the following year.

This unique characteristic has been a driving factor behind investment in crop improvement for maize and several other crops. In the early twentieth

century, public research on maize hybridization in the United States contributed to the development of a lucrative seed industry during the 1930s, including the entry of many small and medium-sized seed companies breeding and marketing hybrid maize seed to farmers. By the 1960s, almost all maize cultivated in the United States was grown from hybrid seed. Annually, maize receives more than US$1 billion in private research and development (R&D) investment in the United States—more investment than any other crop—owing largely to the incentives that hybridization provides to private breeders (see Fernandez-Cornejo 2004; Fuglie et al. 1996).

Hybrid maize cultivation has spread throughout much of the world, including into developing countries in Latin America, Sub-Saharan Africa, and Asia (Morris 1998). Hybrids of other crops, such as pearl millet, cotton, sorghum, and many vegetable crops, have also made inroads in developing countries (see, for example, Pray and Nagarajan 2010).

In spite of the benefits of hybridization to both breeders as well as farmers, there are substantial criticisms that are often raised regarding the suitability of hybrid seeds in developing country agriculture. First is the concern that seasonal or annual purchases of hybrid seed are too costly for many resource-poor, small-scale farmers in developing countries (Kuyek 2000). Several points are worth noting regarding this contention. One is that much evidence suggests that purchasing seed—both OPV (or inbred) and hybrid—is a fairly common practice among rice farmers in South Asia (Table 2.2), despite conventional narratives that argue otherwise. Data from the BIHS suggest that, although almost 45 percent of farming households in Bangladesh use saved seed, more than 75 percent purchase rice seed from private sources. This suggests that many farming households (more than 25 percent) use both saved seed and purchased seed simultaneously, and that a large percentage of farming households purchase rice seed from private sources. A related point is that although seed saving is an important crop management and livelihood strategy among the poor, it necessarily limits their access to technological improvements embodied in seed. Commercial seed markets are one among several mechanisms through which farmers can access these technological improvements—access that they might forgo if they were to depend solely on own-seed savings or exchanges with neighbors. A further point worth noting is that although hybrid rice seed is indeed significantly costlier than OPV rice seed (approximately 10 times the price), these costs are partly defrayed by a lower seeding rate.[2]

[2] Recommended seeding rates ranging from 15-30 kg/ha for transplanted hybrid rice, depending on agro-ecological conditions and other management practices. These seeding rates are generally substantially lower than rates for inbred rice. See Virmani, Siddiq and Muralidharan (1998) and Xie and Hardy (2009) for further discussion.

Table 2.2: Seed Replacement Rates for Different Crops in South Asian Countries

Crop	India, 2007 (%)	Bangladesh, 2007 (%)	Nepal, 2002 (%)	Pakistan, 2007-08 (%)
Wheat	25.23	26.46	28.5	17
Rice	25.87	24.74	11.1	34
Maize	44.24	97.97	9.2	32
Sorghum	19.87			
Millet	48.47			
Soybean	33.39			
Sunflower	62.88			39
Cotton	15.30			48

Note: Includes seed replacement rates for both open pollinated varieties and hybrids where applicable, such as for rice, maize, sorghum, millet, sunflower, and cotton.

Source: Seednet (2007) for India; BSGDMA (2007) for Bangladesh; ANZDEC Limited (2002) for Nepal; and Seed Association of Pakistan (2012) for Pakistan.

Second is the concern that hybridization leads to greater risk in the form of (i) lower in situ genetic diversity and greater susceptibility to pests and disease; and (ii) fewer management alternatives to cope with weather-related production risks. This latter concern is particularly relevant for smallholders with limited access to credit, insurance, and other services that help manage risk. Concerns over loss of genetic diversity can partially be offset by efforts to collect and catalog rice varieties, such as the International Rice Gene bank maintained by the International Rice Research Institute (IRRI), though these efforts primarily address global genetic diversity and do not directly address issues of in situ diversity. Additionally, there is the potential to incorporate both biotic and abiotic stress tolerance in hybrid rice, which may actually increase risk mitigation alternatives for credit- or insurance-constrained smallholders. The extent to which these factors are significant concerns is largely an empirical question that depends on context and situation.

A third concern is that hybridization concentrates market power in the hands of a few companies that are able to breed and market superior hybrids. Although compelling evidence suggests that seed markets for some crops are highly concentrated in some countries, and that farmer welfare may be adversely affected by corporate pricing strategies in certain instances, questions of market power are again essentially empirical, requiring careful and context-specific analyses of rice seed value chains. At present, the issue of predatory pricing behavior by monopolistic or

oligopolistic hybrid producers is not a particularly troubling concern in Bangladesh, where a majority of seed is supplied by the Bangladesh Agricultural Development Corporation (BADC), a parastatal organized under the Ministry of Agriculture.

To summarize, despite criticisms of commercially marketed hybrid seeds for smallholders, the welfare trade-off between farmer-saved seed and farmer-purchased seed, as well as the externalities associated with lost biodiversity, are not as clear-cut as suggested. The specific opportunities, challenges, and risks associated with rice hybrids are discussed in more detail throughout this chapter.

2.4 Bangladeshi Experience with Hybrid Rice

The history of hybrid rice in Bangladesh is different from that in other countries in Asia. Although hybrid rice research began at the Bangladesh Rice Research Institute (BRRI) in 1993, it did not receive high priority on the public research agenda until after 2000. Rather, it was the private sector that took a lead in the introduction of hybrid rice, initially by importing seed from China to make up for shortfalls in domestic seed supply caused by floods in 1998-1999 (Table 2.3). Subsequently, several companies expanded beyond bulk seed imports to the importation of parental lines from China from which to initiate their own seed production in Bangladesh. Several firms have also invested in adaptive research and product development for hybrid rice, as has BRAC, a large non-governmental organization (NGO) and currently a leader in the hybrid rice seed market.

Table 2.3: Hybrid Seed Use and Share of Imports in Bangladesh, 1998-2007

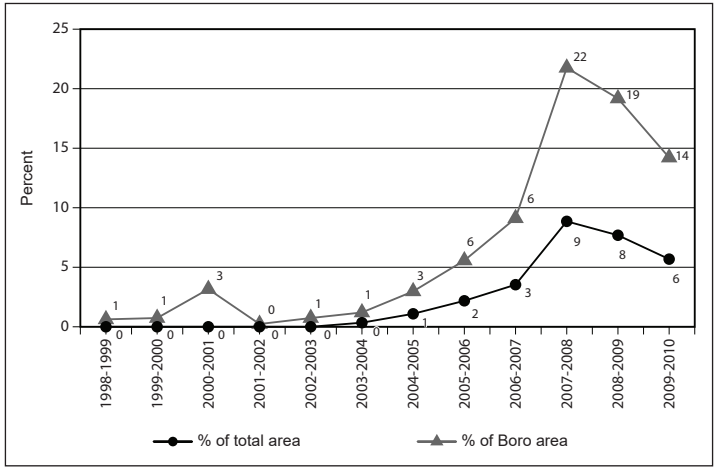
Year	Total seed used (metric tons)	Imported seed as a share of total seed used (%)
1999	150	100
2000	227	88
2001	320	67
2002	556	63
2003	803	77
2004	1,472	73
2005	2,935	77
2006	6,524	71
2007	10,026	77

Source: Hossain (2008).

Already, some companies are claiming success in expanding the hybrid rice seed market in Bangladesh. Advanced Chemical Industries Ltd. (ACI), a leading agricultural concern in Bangladesh, released Allok-93024 in 2003, a hybrid that can potentially compete with BRRI Dhan 29, one of the most popular inbred rice varieties in Bangladesh (F. H. Ansarey, Md. Shafiqul Aktar, and P. K. Bhanderi, personal communications, 2012). In addition, Bayer's latest hybrid releases are also reported to be (illicitly) making their way from India into the Bangladeshi market.

Despite the limited investment in research, hybrids represent a greater proportion of area under rice cultivation in Bangladesh than in neighboring India, despite India having more developed and well-funded hybrid rice research programmes. Hybrid rice cultivation in Bangladesh peaked in the 2007-2008 *boro* (winter) season—Bangladesh's main rice-growing season—at 22 percent of total *boro* cultivated area, or nine percent of all rice-cultivated area in the country (Figure 2.1). Hybrid rice cultivation has been mainly concentrated in Bangladesh's northern districts, particularly within the Rajshahi and Rangpur divisions (Table 2.4). This is largely due to liberalization policies that have increased the proliferation of small-scale irrigation equipment for use during the dry *boro* season (Kürschner et al. 2010).

Figure 2.1: Hybrid Rice Cultivation, Bangladesh, 1998-2010



Source: Ar-Rashid, Julfiquar, and Ali (2011), based on official figures.

Table 2.4: Hybrid Rice Adoption by Division, 2011

Division	Hybrid Rice Adoption Rate (%)
Barisal	0.00
Chittagong	6.02
Dhaka	5.35
Khulna	9.74
Rajshahi	16.08
Rangpur	15.34
Sylhet	5.62

Note: Figures represent the percentage of households cultivating land in each of the divisions that had cultivated hybrid rice from December 2010 through November 2011.

Source: Authors' calculation, based on data from Ahmed (2013).

Notably, Bangladesh has relied more on technology transfers in the form of hybrid rice seed and breeding material from China than it has on own, in-country R&D (see Arrashid, Julfiquar, and Ali 2011). This approach is significantly different from the one taken in other Asian countries such as India, where more concerted investments in public and private breeding have led to the homegrown development of rice hybrids for the Indian market. For countries such as Bangladesh, where public funding for research is limited and where few firms have the capacity to manage sufficiently large hybrid rice breeding programmes, the importation of hybrid material seems to be an attractive strategy.

However, there is some inherent risk in the strategy followed in Bangladesh. First is the risk associated with the distribution of seed that may be poorly adapted to Bangladesh's agro-ecological context, crop management practices, farming systems, and consumer preferences.[3] This last aspect appears to be especially troublesome for a heterogeneous product like rice grain, because grain not suited for the tastes and preferences of consumers often results in a thin output market and lower prices. Given higher seed costs (compared with conventional inbred varieties), higher

[3] As an example, in temperate Asia, such as Japan and China, sticky and soft rice is preferable. As such, japonica or indica/japonica hybrid varieties, which have generally low amylose content, are preferable, because these will result in grains that become soft and sticky during cooking (Kumar, Maruyama, and Moon 1994). In tropical South Asia, on the other hand, consumers prefer fluffier, non-sticky rice. Hybrids borne out of any combination with low-amylose japonica varieties (like those imported or derived from parental lines imported from China) will tend to result in grains that become soft and sticky during cooking, which consumers in those countries may perceive as being of lower quality.

expenditures on complementary inputs, and lower output prices, margins between returns and costs become increasingly narrow. We do not have adequate data to state unequivocally that this mechanism has contributed to the decline in area under hybrid rice cultivation in Bangladesh, but evidence consistent with this hypothesis does exist. Consider Table 2.5, for example, which reports farmers' perceptions about hybrid rice grain quality *vis-à-vis* grains from conventional inbred varieties. While a large share of farmers perceive that the hybrids have better appearance and aroma than the conventional varieties, only a relatively small share of farmers perceive that hybrid grain tastes better than the traditional varieties, that the stickiness of the hybrid grains after cooking is superior to that of traditional varieties, that the expansion of hybrid rice grain is superior to that of conventional varieties, or that the quality of hybrid grains can be maintained for an extended period. Some of the hybrids recently released by the private sector were designed to address some of these quality issues to make hybrid grain more comparable to other conventional *boro* varieties, such as the widely cultivated BRRI Dhan 29.

Table 2.5: Farmers' Perceptions about Quality of Hybrid Rice in Bangladesh

Quality/characteristic	Farmers reporting same or superior quality/ characteristic as compared with inbred rice (%)	
	2004	2005
Grain appearance	71	74
Taste of cooked rice	33	39
Stickiness of cooked rice	47	40
Aroma/smell	82	77
Expansion after cooking	49	45
Quality of cooked rice after long hours[a]	20	34

Note: [a] "Quality of cooked rice after long hours" relates to the taste and consistency of cooked rice when stored, cooled, and/or set aside after cooking.

Source: Azad, Mustafi, and Hossain (2008).

The second risk results from the volatile and sometimes unpredictable nature of trade policy: should Chinese exporters or Bangladeshi importers be unable to (or choose not to) ensure a continuous flow of germplasm from year to year due to tariffs, regulations, or other barriers imposed by either trading partner, then the benefits of hybrid rice cultivation could dry up quickly. Although this is not a pressing concern for either country at the moment, China's limited willingness to share its more advanced

breeding lines and systems with other countries is an indication of just how significant trade barriers can be.

Studies from Bangladesh provide further insight into hybrid rice costs, returns, and adoption. In Bangladesh, hybrid rice is grown mainly during the dry (*boro*) season.[4] Even though annual yield variations have been recorded, hybrid yields are generally 15-30 percent higher than those of traditional inbred varieties (Azad, Mustafi, and Hossain 2008). Although farmers report some production cost reductions resulting from lower seeding rates and lower irrigation costs associated with early maturation, these savings are ultimately offset by higher fertilizer and pesticide use, further suggesting that the yield gains may be partly attributable to better management practices, in addition to the hybrid seed performance itself (Hossain 2008).

Azad, Mustafi and Hossain (2008) also find that adoption rates are high among small farmers (less than 0.5 hectare farm size) in 2004; in the subsequent year, however, adoption rates have increased among large farmers (greater than 2.0 hectare farm size) and medium farmers (0.5-2.0 hectares). Despite growing adoption, farmers initially faced lower market price for both grain (4-5 percent lower than varieties during the 2004 and 2005 seasons) and straw (nine percent lower than varieties in the 2007 season). Eventually, the grain price for hybrid rice did exceed the price for a competing inbred (BRRI Dhan 29)—by four percent in 2007—indicating that better hybrids, greater consumer/miller acceptance, or improved on-farm management practices may have entered the equation. Despite growing evidence of hybrid rice's profitability in Bangladesh, the adoption rate of hybrids is still low, at four percent (Azad, Mustafi and Hossain 2008). The benefits of higher yields, higher tillering ability, shorter maturity, and increased lodging resistance seem to be offset by higher seed price, higher expenditures on other inputs (such as fertilizers and pesticides), poor cooking quality reflected in lower output prices, and high pest and disease susceptibility in Bangladesh.

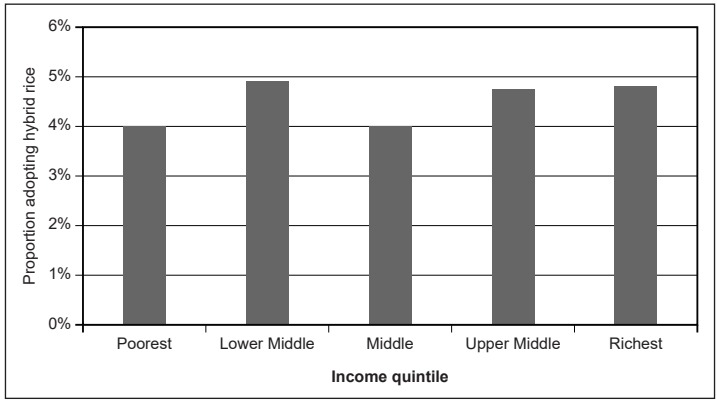
---

[4] This is somewhat a consequence of history. Hybrids were first introduced in Bangladesh during the 1999 *boro* season, after the government allowed the importation of 2,000 metric tons of hybrid seed following a 1998 flood that had destroyed a large volume of rice seeds (Azad, Mustafi and Hossain 2008). Since then, most of the hybrids and other high-yielding varieties that have been distributed in Bangladesh have been *boro* varieties. In addition, the proliferation of shallow tube wells for irrigation has made it much more affordable to cultivate rice during this dry season, which has led to dramatic increases in the volume of land under rice cultivation during the *boro* season. Consequently, this also implies that enhancements to hybrid varieties to improve tolerance or resistance to most abiotic stresses will be of limited value to Bangladeshi farmers, because the most serious abiotic stresses.

These analyses are limited insofar as they examine adoption from an *ex post* perspective. In addition, they provide limited characterization of adoption patterns disaggregated by socioeconomic characterizations. Azad, Mustafi and Hossain (2008) surveyed farmers in 2004 and 2005 on their planned use of hybrids in the following years (2005 and 2006 respectively) and disaggregated the responses by farm size, age and education. Although their study finds no discernible pattern regarding adoption patterns based on farm size, it does find that younger and more educated farmers seemed more eager to cultivate hybrids.

Data from more recent and nationally representative BIHS, on the other hand, suggest that farmers with larger landholdings are significantly more likely to adopt hybrid rice than farmers with either medium or small landholdings. Specifically, BIHS suggests that poor households (those households with per capita incomes lower than US$1.25 per day, adjusted for inflation and differences in purchasing power) are less likely to adopt hybrid rice than nonpoor households. Rather ironically, it also suggests that households that have adopted hybrid rice do not, on average, have significantly higher incomes than those households that have not adopted. According to these data, there does not appear to be any significant statistical relationship between higher income and a higher adoption rate for hybrid rice (Figure 2.2 and Table 2.6).

Figure 2.2: Hybrid Rice Adoption in Bangladesh by Income Quintiles, 2011



Source: Authors' calculations, based on data from Ahmed (2013).

Table 2.6: Hybrid Rice Adoption in Bangladesh by Income Quintiles, 2011

Income quintile	Adoption rate (%)
Poorest 20%	4.00 (0.196)
Lower middle 20%	4.91 (0.216)
Middle 20%	4.00 (0.196)
Upper middle 20%	4.73 (0.212)
Richest 20%	4.82 (0.214)

Note: Standard deviations are provided in parentheses. No statistical significance is found based on one-tail t-tests of group adoption rates among adjacent income groupings at 1 percent, 5 percent, or 10 percent levels.

Source: Authors' calculation, based on data from Ahmed (2013).

In Rajshahi and Rangpur divisions, however, where hybrid adoption rates are highest, some evidence exists that suggests household incomes are higher for hybrid rice adopters than for those households that have not adopted (though the income difference is only marginally significant in the Rajshahi sample). It should be noted that Rangpur division has the lowest per capita income among all of Bangladesh's divisions; thus, if hybrid rice cultivation does lead to higher incomes in Rangpur, increased hybrid rice adoption may prove a viable pathway for addressing poverty alleviation. For the country as a whole, however, fewer than 60 percent of hybrid rice adopters had incomes above the poverty line.

2.5 Future Scenarios and Challenges for Hybrid Rice

Despite recent declines in hybrid rice cultivation in Bangladesh, interest in the technology remains high. Yet there are significant technical and economic challenges related to hybrid rice in Bangladesh and South Asia more generally. Because of its potential for boosting stagnant yield growth, improving national food security, and raising incomes, hybrid rice remains high on the agenda of many public policy makers and corporate decision makers. Additionally, the sustainable intensification of rice production on a smaller area of land allows for greater diversification into other, higher-value crops. This section analyses the key challenges associated with hybrid rice in Bangladesh and the broader context of South Asia. To analyze these challenges, we draw on the conceptual framework described earlier. In particular, this section focuses on key constraints related to investment, collaboration, and risk management strategies associated with the stages of discovery, development, and delivery.

Scientific Discovery

The challenges surrounding the expansion of hybrid rice in Bangladesh begin at the discovery stage, which is characterized primarily by the fundamental scientific and technical dimensions of the technology. These challenges represent broad classes of problems that are generally addressed over long-time horizons and at a pre-commercial, pre-regulatory, and pre-distribution stage. We examine some of these constraints (for details, see Xie and Hardy 2009).

First, researchers have been severely challenged in their efforts to secure high levels of heterosis in hybrid rice. China has succeeded in achieving high levels of heterosis, but only for hybrids suitable in temperate regions. Much of South Asia, including Bangladesh, requires tropical hybrids, in which heterosis is only 10-12 percent over the best modern inbred varieties. One of the most important factors conditioning varietal selection is the relative yield advantage of one variety *vis-à-vis* another. In South Asia, tropical rice hybrids are not yet providing a yield gain that is attractive enough to induce farmers to switch on a large scale. An argument can easily be made that better management practices (such as early transplanting, optimal spacing, etc.) in the cultivation of inbred rice varieties—many of which also have attributes such as pest and disease resistance that are superior to the current generation of hybrids in South Asia—can generate comparable yield gains.

Second, researchers have been constrained by the limited effectiveness of the hybridization systems currently in use—in particular, the three-line male sterility system that is most commonly used in South Asia, but also the more advanced two-line system that is used in China. Further development of hybridization systems based on tools of genetic modification and (possibly) chemical hybridizing agents could accelerate hybrid rice research in the long run. In the short run, however, hybrid rice research will still depend on complex and sensitive systems of hybridization for rice.

Third—and of possibly less importance today than a decade ago—is the narrow germplasm base from which hybrid rice research is being conducted, which is in part a result of the limiting reliance on the male sterility system and in part a result of the absence of an effective heterotic genetic pool. This narrow base constrains the efficiency and output of hybrid rice breeding programmes and, further down the line, creates high levels of pest and disease susceptibility in cultivated hybrid rice populations. Because of the lack of commercially usable cytoplasmic male sterile lines, development of hybrid rice outside China has been slower than expected (Virmani 1994), which poses difficulties for breeding hybrid rice with improved abiotic and

biotic stress tolerance traits, better adaptation to different agro-ecological contexts, and better cooking and consumption qualities. Efforts to expand this narrow germplasm base are also hampered by China's implicit ban on the export or exchange of its most advanced materials for hybrid rice breeding, including female parental lines used in its superior two-line breeding system. That said, the narrow genetic diversity of female parents that plagued earlier generations of hybrid rice in South Asia is no longer viewed by researchers as the key issue, having been resolved by the creation of new female lines and new techniques for creating such lines.

Fourth, and related to this narrow germplasm base, has been the poor grain quality of hybrids, which initially led to low levels of consumer acceptance. This issue was of particular importance to farmers in high-productivity irrigated areas, who produce marketable surpluses, though possibly less so for farmers in rainfed or otherwise low-productivity areas, who produce primarily for their own consumption. Low consumer acceptance of hybrid grain implies a lower quantity demanded, which results in a lower market price for hybrid grain than, e.g. grain from traditional or modern inbred varieties. This appears to be particularly problematic in Bangladesh, due to the importation of hybrid materials from China. It is less of a concern in India, for example, where hybrid research has led to homegrown solutions. The key issue is amylose, the starch molecule that gives milled rice its specific appearance and character after cooking.[5] Although there is significant variation in consumer preferences for cooked rice across South Asia, higher amylose content (above 25 percent) is broadly reflective of generalized preferences in the region. In the past several years, researchers have been able to address this constraint, though cultivation of hybrid rice with these improved qualities is still reportedly at relatively low levels.

Most scientists agree that the current stock of scientific and technical knowledge is at a level at which many of these problems can be readily solved with sufficient time, effort, and resources. But given the time lag between research investment and product delivery, and potentially thin markets—at least initially—this also suggests that solutions will not be immediately available or remunerative in commercial markets. Thus, there is a need for both public and private investment in hybrid rice.

As with most crop research—including other hybrid crops that are potentially lucrative in downstream markets—an optimal level of upstream

[5] Higher amylose content (20-25 percent or more) gives cooked rice a high volume and dry quality with well-separated grains, whereas lower amylose content (below 20-25 percent) gives cooked rice a moister, stickier quality (IRRI 2012).

public investment is required to translate the science into a viable technology. Public investment in R&D is generally more adept at solving basic problems constraining the effective use of a technology where longer time horizons and pre-commercial application are key characteristics. In addition, where neither private firms nor sovereign governments are willing to invest in removing these constraints—where the public good is global rather than country-specific in nature—there is a case for international public investment in R&D efforts.

The international donor community, notably Asian Development Bank (ADB) and Food and Agriculture Organization of the United Nations (FAO), has financed hybrid rice R&D at IRRI, which began its research programme on hybrid rice for tropical Asia in 1979. In 1988-1989, IRRI released two cytoplasmic male sterile lines, IR58025A and IR62829A, which are still used in most hybrid rice breeding programmes in Asia today. Large-scale testing of hybrids developed from these lines followed in 1998, followed by the commercial release of hybrids in India (*Sahyadri* and CORH 2), Philippines (*Mestizo*), and Vietnam (HYT-57), among other countries.

In 2008, IRRI widened its commitment to hybrid rice research by establishing the Hybrid Rice Development Consortium (HRDC), a global platform designed to support research and share materials with public research agencies, private seed companies, and civil society organizations. Between 2005 and 2010, IRRI transferred more than 7,400 germplasm samples to other hybrid rice researchers around the world, with more than 70 percent of those transfers moving through the auspices of HRDC. Germplasm transfers have increased dramatically in recent years, with more than 80 percent of total transfers occurring from 2008 through 2010. Notably, less than 5 percent of IRRI's total germplasm transfers have gone to Bangladesh, largely reflecting Bangladesh's heavy dependence upon material and seed transfers from China. This contrasts starkly with transfers to India. Material transfers to India represent 33 percent of all transfers between 2005 and 2010, though 61 percent of the total germplasm transfers to India occurred during 2010.

IRRI has further expanded its commitment to hybrid rice research under the Global Rice Science Partnership (GRiSP), with a planned investment estimated at US$15-17 million for South and Southeast Asia over five years; this figure does not include the related rice breeding work undertaken in other GRiSP components nor other IRRI programmes that also support hybrid rice research or investments made by national

partners.[6] In addition, although national research organizations have made limited investments in hybrid rice to date (Table 2.7), they remain a necessary long-term complement to IRRI's research.

Table 2.7: Research and Development of Hybrid Rice in Asia, Selected Countries

Country	Research initiated	First hybrid rice released (number of releases)
India	1989	1994 (20)
Bangladesh	1996[a]	1999 (4)[b]
Vietnam	1992[a]	1992 (7)
Philippines	1993	1993 (3)

Note: [a] The first hybrids released in Bangladesh were imports from China and India; the first hybrids released in Vietnam were imports from China. See Janaiah, Hossain, and Husain (2002).

[b] According to Azad et al. (2008), hybrid rice research in Bangladesh was initiated in 1993 but only gained momentum in 1996.

Source: For research initiated: India: IRRI (2005); Bangladesh: IRRI (2005); Azad, Mustafi, and Hossain (2008); Vietnam and Philippines: Janaiah and Hossain (2003); for first hybrid rice released: India: DACNET (2007); Janaiah, Hossain, and Husain (2002); Bangladesh, Vietnam, and Philippines: Janaiah, Hossain, and Husain (2002); and Janaiah and Hossain (2003).

Arguably, hybrid rice research has suffered from donors' short-term outlooks and project funding cycles. Although some resources were allocated to public-sector research at both the national and international levels, there is a sense among many scientists that a large portion of the funding and scientific effort was allocated to capacity strengthening, demonstrations, and dissemination activities, all built around a limited set of hybrids and hybrid parent lines. In short, these funding commitments likely impeded early and rapid progress in addressing the technical challenges outlined above. This suggests a role for private sector investment

[6] GRiSP's long-term goals aim at the adoption of new hybrid rice with at least a 15 percent yield advantage. Specific GRiSP milestones for hybrid rice are as follows: 50 new breeding populations developed and distributed to partners in South and Southeast Asia by 2011; 5,000 new hybrid parents and hybrids test-crossed and evaluated at IRRI and other locations in South and Southeast Asia by 2013; and 10 new hybrids released for commercial production by public- or private-sector partners in South and Southeast Asia in 2015. Budget estimates are for both Southeast and South Asia based on an assumption that hybrid rice is allocated an equal (17 percent) share of funding allocated to the six subthemes under Theme 2: "Accelerating the development, delivery, and adoption of improved rice varieties." See IRRI, AfricaRice, and CIAT (2010).

in hybrid rice research, though private-sector funding of research on these upstream issues is unlikely to fill the funding gap: while private investment has been central to problem solving in the South Asian market, but such private investment in hybrid rice research is paltry compared with private investment in maize research.

Despite the constraints imposed by insufficient investment and expenditure on hybrid rice research, the collaboration strategies being formed around hybrid rice are worth noting. IRRI's HRDC is a critical platform for collaboration between public research agencies and private seed companies on various aspects of hybrid rice research. IRRI's long-standing relationship with pivotal agencies in China's national agricultural research system is also a critical input to making expertise and materials available to consortium members and IRRI's partners. In addition, IRRI's forward-looking policies on intellectual property and public-private partnerships provide an avenue for supporting effective collaborations with firms that are willing and able to invest in hybrid rice. Although more rigorous evaluations of these various collaboration strategies are needed, there are strong indications of a relevant architecture for translating hybrid rice science from the public sector into viable hybrid rice technologies in the private sector.

The risks associated with hybrid rice research at the discovery stage pertain largely to the state of the science. One such risk is related to the long-term value of hybrid rice as a practical platform for launching genetically-modified (GM) traits in rice. Hybrid rice, like other hybrid crops, provides innovators with a biological form of intellectual property rights (IPR) protection, because farmers have to purchase seed each season to realize the yield gains conferred by heterosis. Not only does this allow innovators to recoup their R&D investments in rice improvement, but it also creates an effective platform for continuous investment in developing GM rice traits, much like the experience in the hybrid and GM hybrid maize market in North America. Moreover, because firms can easily monitor their sales of hybrid rice seed, they gain a means of monitoring farmers' trait preferences, on-farm performance, and crop management practices, thus providing vital informational feedback mechanisms needed to support continued improvements and effective stewardship. However, the risks associated with the nascent or controversial biosafety regulations in some developing countries can limit the realization of this long-term value in hybrid rice.

Technology Development: Solutions to the scientific and technical problems discussed earlier would encourage more serious investment by the private sector in hybrid rice product development. However, product development itself faces several key challenges that need to be addressed if

hybrid rice is to generate welfare-improving and yield-enhancing impacts in Bangladesh or more generally throughout South Asia.

A major difficulty facing hybrid rice is the production of high-quality hybrid seed. Technical requirements for hybrid seed production are sensitive, requiring careful management of breeding materials and the seed farms themselves. Unlike varietal rice, it is difficult to outsource hybrid rice seed production to smallholders, smallholder cooperatives, or community and village seed production schemes. The technical requirements for hybrid rice seed production represent a costly constraint on the production of marketable quantities of seed for all but the largest, most technically advanced, or well-capitalized seed companies in the market.

A second hurdle related to seed production is the protection of the intellectual property embodied in the seed. Private investment in seed-based technologies is partly determined by the existence of a credible IPR policy regime. Although hybrids provide breeders, seed companies, and entrepreneurs with a biological form of IPR protection, these biological IPR protections are more effective when backed by some form of legal protection. This is particularly valuable in situations where it is easy for competitors to steal parental lines from foundation seed and production fields, as is the case in both industrialized and developing countries. By ensuring that innovators have legal recourse allowing them to appropriate a portion of their innovation rents, plant variety protection (PVP) laws can incentivize private investment in hybrid rice development. In addition, through related requirements of disclosure, certification, and labeling, PVP laws can help address information asymmetries between farmers and seed retailers. Unfortunately, few South Asian countries have sufficiently credible PVP laws. India's Protection of Plant Varieties and Farmers' Rights Act of 2001 provides the region's highest standard of protection, but other South Asian countries lag behind in this regard.

An additional regulatory issue emerges around the issue of competition and industry concentration. In most South Asian countries, the formal rice seed market is largely concentrated around the high-volume, low-margin varietal end of the business and is not what might be termed *cutting edge* in the seed industry. Only a few firms have entered the high-value, high-potential segment of the market with hybrid rice seed. With such a small number of companies in the hybrid seed market, there are concerns that large companies operating in highly oligopolistic conditions will be able to exert a high degree of market power over farmers—including small-scale, resource-poor farmers. This concern is often voiced in India—even though the hybrid rice market there is host to a fairly large number of companies

(Spielman et al. 2011)—and in other countries such as Bangladesh where the market is much thinner. Continuous and careful analysis of market conditions, including competition and concentration, backed by effective enforcement of antitrust laws are necessary to ensure that seed markets remain competitive.

The risk management issues of using hybrid rice as a platform for transgenic traits become more acute when considered at the product development stage. Risks are associated with individual traits conferred on hybrid rice (such as insect resistance or drought tolerance), stewardship of transgenic hybrid rice lines, gene flow issues to wild relatives, pollen flows to other rice varieties such as high-value *basmati,* and other such concerns. The biosafety policies and systems needed to assess and manage these risks are nascent in most South Asian countries and are the source of extensive public scrutiny and discourse. Opaque regulatory environments may significantly affect private-sector decisions on investment in transgenic traits, so creating a transparent regulatory environment to address these issues is therefore critical to the commercialization of hybrid rice containing potentially beneficial GM traits.

Product Delivery

Product delivery is possibly the weakest element in the hybrid rice innovation process. Despite accounting for 22 percent of total *boro* cultivated area as recently as 2007-2008, area under hybrid rice cultivation has steadily declined in the ensuing years. Concerns over seed quality and general perceptions of poorer grain quality *vis-à-vis* traditional varieties have no doubt contributed to this decline, with the latter largely due to the importation of seeds and genetic material poorly suited to end consumers' tastes and preferences.

Ultimately, the successful delivery and large-scale adoption of hybrid rice will depend on improvements made in the upstream discovery and development stages. Although hybrid rice has immense potential for increasing productivity and improving overall welfare for the poor in Bangladesh, the challenges are not insignificant. Important challenges include increasing both seed and grain quality and customizing varieties to various agro-ecological conditions and consumer preferences. Addressing the challenges of grain quality and customizing hybrids to consumer preferences have important implications for the output prices that farmers receive for their grains. At present, the price penalty on hybrid rice at the farm gate places it at 10-20 percent less than coarse grain rice in Bangladesh. Although breeders have made progress in increasing amylose content through conventional breeding efforts with better germplasm

and molecular markers, the new hybrids coming on the market will need to overcome this price penalty to encourage adoption. The feedback mechanisms between the delivery stage and the discovery and development stages can facilitate these improvements. Further research is required to better understand the factors that motivate or constrain farmers' adoption of hybrid rice. Understanding these factors will help not only inform future discovery and development, but will also provide insight into potential policy responses that can speed up the widespread adoption of hybrids.

2.6 Conclusions and Policy Recommendations

This chapter examines the processes and policies that encourage effective public and private investment in hybrid rice benefiting poor farmers in Asia, with a specific emphasis on the context and experiences of Bangladesh. The study identifies the roles of various organizations involved in advancing hybrid rice development and delivery and examines alternative incentives for enhancing the level and effectiveness of public and private investment in hybrid rice discovery, development, and delivery.

There is an immense stock of scientific knowledge and expertise on hybrid rice. Although much of this stock resides in China, high-quality expertise and accumulated experience also exists within the international agricultural research system, among multinational and domestic firms in the private sector, and in public research organizations in other Asian countries. More important, many of these actors are closely linked through a variety of scientific, professional, and product-related networks.

Several policy innovations could accelerate the discovery, development, and delivery of hybrid rice technology in Bangladesh. First and foremost is the recommendation for further public investment in the upstream research on hybrid rice to develop the tools and technologies needed to advance hybrid rice. While Bangladesh has heretofore relied heavily upon imported seeds and genetic materials from China, a more concerted effort in promoting a domestic hybrid rice development program may ultimately be successful in bringing to market hybrids that are more suited to consumers' tastes and preferences. International and national funding for public research that addresses improved hybridization systems, grain quality, adaptation of hybrids to local agro-ecological conditions, and germplasm diversity can provide the platform for more applied plant breeding to develop improved hybrids by both the public and private sectors.

Second is the need to improve the innovation incentives that may ultimately encourage more private investment in hybrid rice development—that is, policies and institutions needed to encourage investment in hybrid

rice by public research organizations, private firms, and farmers themselves. Stronger IPR policies and enforcement could encourage the entry of complementary private investment, while other policy incentives could accelerate the dissemination and commercialization of public research on hybrid rice that is sitting on the shelf or otherwise confined to academic use.

At the delivery/adoption end of the spectrum, careful thought needs to be given to the use of public resources to subsidize hybrid rice seed and complementary inputs. Although subsidies have strong historical precedence in encouraging the adoption of new technologies in South Asia, such interventions may ultimately work against widespread adoption and the growth of a competitive hybrid rice seed industry. South Asia's experience with input subsidies suggests that price distortions can lead to rent-seeking behavior and elite capture among certain types of farmers and industries, thus impeding market growth and efficiency in the long run.

In summary, hybrid rice has the potential to transform rice cultivation in Bangladesh despite significant challenges. The basic outcome of stable, better adapted, and commercially accessible hybrid rice could translate into a range of positive impacts: enhanced rice productivity; increased on-farm incomes for smallholders; and reductions in land required for intensive rice production, which in turn allows for reallocation to other agricultural and non-agricultural activities. Significant scientific, technical, and policy challenges exist at each stage of the innovation process—discovery, development, and delivery—and repeated iterations of research and development need to be pursued. The ability of public policymakers, corporate decision makers, scientists, entrepreneurs, and farmers to understand these challenges and anticipate solutions is fundamental to the long-term success of hybrid rice in Bangladesh.

References

Ahmed, A. 2013. *Bangladesh Integrated Household Survey (BIHS) 2011-2012* [dataset]. Washington, D.C.: International Food Policy Research Institute (IFPRI).

ANZDEC. 2002. *Agriculture Sector Performance Review*. Auckland, New Zealand: ANZDEC Limited.

Ar-Rashid, Harun, A. W. Julfiquar, and Shahjahan Ali. 2011. *A Study on Hybrid Rice in Bangladesh: History, Impact and Current Status of Hybrid Rice Research, Development and Delivery in Bangladesh*. Unpublished report. Dhaka: Agricultural Advisory Society (AAS).

Azad, Md. Abdus Samad, B. A. A. Mustafi, and Mahabub Hossain. 2008. "Hybrid Rice: Economic Assessment of a Promising Technology for Sustainable Food Grain Production

in Bangladesh." Paper presented at the Australian Agricultural and Resource Economics Society 52nd Annual Conference, Rydges Lakeside, Canberra, Australia, February 5-8.

Barwale Foundation. 2009. *Barwale Foundation Annual Report 2008-09*. Hyderabad, India: Barwale Foundation.

BSGDMA (Bangladesh Seed Grower, Dealer, and Merchants Association). 2007. "Bangladesh Seed Industry at a Glance." Asian Seed Congress 2007, Manila, Philippines, November 6-10.

DACNET. 2007. Accessed June 2010. http://dacnet.nic.in/rice/Rice%20Varieties% 20in%20 India.htm.

Fernandez-Cornejo, J. 2004. "The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets, Regulation, Industry Structure, and Research and Development." *Agriculture Information Bulletin AIB 786*. Washington, D.C.: U.S. Department of Agriculture Economic Research Service.

Fuglie, K., N. Ballenger, K. Day, C. Klotz, M. Ollinger, J. Reilly, U. Vasavada, and J. Yee. 1996. "Agricultural Research and Development: Public and Private Investments under Alternative Markets and Institutions." *Agricultural Economics Report 735*. Washington, D.C.: U.S. Department of Agriculture Economic Research Service.

Hossain, M. 2008. "Performance and Potential of Hybrid Rice Production in Bangladesh." Paper presented at the International Workshop on Hybrid Rice, Changsa, China, September 12-15.

International Rice Research Institute (IRRI). 2005. *Terminal Report of the IRRI-ADB Project: Sustaining Food Security in Asia through the Development of Hybrid Rice Technology*. Los Baños, Philippines: International Rice Research Institute (IRRI).

___. 2012. "Rice Knowledge Bank: The Chemical Characteristics That Determine the Quality of Milled Rice." Accessed August 6, 2012. www.knowledgebank.irri.org/postproductioncourse/Additional/MilledRice/1._Chemical_characteristics_determining_quality.htm.

International Rice Research Institute (IRRI), African Rice Center (AfricaRice), and The International Center for Tropical Agriculture (CIAT). 2002. "Hybrid Rice for Indian Farmers: Myths and Realities." *Economic and Political Weekly* 37, no. 42: 4319-4328.

___. 2003. "Hybrid Rice in Andhra Pradesh: Findings of a Survey." *Economic and Political Weekly* 38, no. 25: 2513-2516.

___. 2010. "GRiSP." Accessed August 7, 2011. www.grisp.net/uploads/files/x/000/ 068/9c1/GRiSP%20Full%20Proposal.pdf?1312766027.

___. 2010. *Hybrid Rice Adoption in India: Farm-level Impacts and Challenges*. Report of an ANGRAU-IRRI Collaborative Study. Los Baños, Philippines: International Rice Research Institute (IRRI); Rajendranaga, India: Acharya N. G. Ranga Agricultural University.

Janaiah, Aldas, and Mahabub Hossain. 2003. "Can Hybrid Rice Technology Help Productivity Growth in Asian tropics? Farmers' Experiences." *Economic and Political Weekly* 38, no. 25: 2492-2501.

Janaiah, Aldas, Mahabub Hossain, and Muazzam Husain. 2002. "Hybrid Rice for Tomorrow's Food Security: Can the Chinese Miracle Be Replicated in Other Countries?" *Outlook on Agriculture* 31, no. 1: 23-33. https://doi.org/10.5367/000000002101293831.

Kumar, Ish, K. Maruyama, and H. P. Moon. 1994. "Grain Quality Consideration in Hybrid Rice." In *Hybrid Rice Technology: New Developments and Future Prospects. Selected papers from the International Rice Research Conference*, edited by S. S. Virmani, 123-130. Manila: International Rice Research Institute (IRRI).

Kürschner, Ekkehard, Christian Henschel, Tina Hildebrandt, Ema Jülich, Martin Leineweber, and Caroline Paul. 2010. Water Saving in Rice Production—Dissemination, Adoption and Short Term Impacts of Alternate Wetting and Drying (AWD) in Bangladesh. SLE Publication Series. Dhaka/Berlin: Humboldt-Universitat Zu Berlin.

Kuyek, Devlin. 2000. *Hybrid Rice in Asia: An Unfolding Threat*. Manila and Los Baños, Philippines: GRAIN. Accessed November 20, 2012. www.grain.org/article/entries/34-hybrid-rice-in-asiaan-unfolding-threat.

Li, Jiming, Yeyun Xin, and Longping Yuan. 2010. "Hybrid Rice Technology Development: Ensuring China's Food Security." In *Proven Successes in Agricultural Development: A Technical Compendium to Millions Fed*, edited by David J. Spielman, and R. Pandya-Lorch, 271-293. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Lin, Justin Yifu, and P. L. Pingali. 1994. "An Economic Assessment of the Potential for Hybrid Rice in Tropical Asia: Lessons from Chinese Experience." In *Hybrid Rice Technology: New Developments and Future Prospects. Selected Papers from the International Rice Research Conference*, edited by S. S. Virmani. Manila: International Rice Research Institute (IRRI).

Morris, Michael L., ed. 1998. *Maize Seed Industries in Developing Countries*. Boulder, C.O.: Lynne Rienner.

Pray, C. E., and L. Nagarajan. 2010. "Pearl Millet and Sorghum Improvement in India." In *Proven Successes in Agricultural Development: A Technical Compendium to Millions Fed*, edited by David J. Spielman and R. Pandya-Lorch. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Seednet. 2007. "Seed replacement rates, 2007." Accessed May 2, 2010. http://seednet. gov.in/Material/SRR-08.pdf.

Spielman, David J., Deepthi Elizabeth Kolady, Anthony J. Cavalieri, and N. Chandrashekhar Rao. 2011. *The Seed and Agricultural Biotechnology Industries in India: An Analysis of Industry Structure, Competition and Policy Options*. IFPRI Discussion Paper No. 1103. Washington, D.C.: International Food Policy Research Institute (IFPRI).

United States Department of Agriculture (USDA). 1962. *Yearbook of Agriculture*. Washington, D.C.: United States Department of Agriculture (USDA).

Virmani, S. S., ed. 1994. *Hybrid Rice Technology: New Developments and Future Prospects*. Selected Papers from the International Rice Research Conference. Manila: International Rice Research Institute (IRRI).

Virmani, S. S., E. A. Siddiq, and K. Muralidharan, eds. 1998. *Proceedings of the 3rd International Symposium on Hybrid Rice, November 14-16, 1996, Hyderabad, India*. Manila: International Rice Research Institute (IRRI).

Xie, F., and B. Hardy B, eds. 2009. *Accelerating Hybrid Rice Development*. Los Baños, Philippines: International Rice Research Institute (IRRI).

Chapter 3

Agricultural Technology Potential for Rice in Bangladesh

Hua Xie, Nicola Cenacchi, and Claudia Ringler[1]

3.1 Background

Bangladesh has excellent conditions for rice production, with production possible during up to three seasons in a year. Production in Bangladesh increased rapidly during the 1960s to 1990s as a result of Green Revolution technologies fueled by short-duration varieties, irrigation, and fertilizers. Given the rapidly vanishing land base due to increased population density, urbanization, land degradation and climate change, technological change remains the key factor determining the potential for productivity growth of the agriculture sector in Bangladesh. The need for accelerated technological change was further sharpened as a result of the recent food price crises, which have led to increased calls for food self-sufficiency in the country (Asaduzzaman et al. 2010).

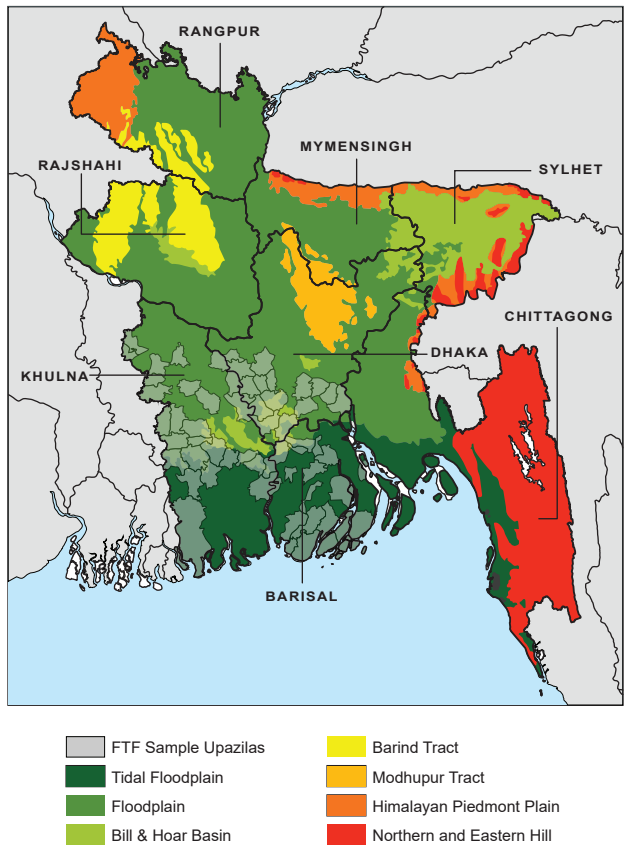
This chapter assesses the adoption potential of several promising agricultural production technologies and evaluates their impact on enhancing agricultural production in Bangladesh.[2] Specifically, the objectives of the technology assessment workshop held in April 2012 included: (i) description of the technologies in use by crop, and by Agro-Ecological Zone (AEZ) (Figure 3.1); (ii) identification of key constraints to productivity growth by

[1] This work was funded by the Bangladesh Policy Research and Strategy Support Program (BPRSSP) of the Government of Bangladesh, International Food Policy Research Institute (IFPRI), and the United States Agency for International Development (USAID). Helpful comments on an early draft were received from Zainul Abedin, Mohammad Abdul Bari and Abdelbagi Ismail of the International Rice Research Institute.

[2] The assessment was informed by a technology expert workshop, which was held on 12 April 2012 in Dhaka to gather expert insights for subsequent assessment exercises. The workshop also assessed technologies for maize and wheat, but we did not have a sufficient number of household survey observations to assess their potential with our methodology.

AEZ; (iii) identification of promising productivity-enhancing technologies/ practices, by AEZ and crop; and (iv) listing of barriers to adoption for these promising practices.

Figure 3.1: Agro-ecological Zones and Feed the Future Zones in Bangladesh



Note: Feed the Future zone is the area where USAID focuses its investments.
Source: Bangladesh Bureau of Statistics.

Table 3.1 shows a list of promising technologies identified at the workshop, and Table 3.2 shows the top ranked technology improvements by AEZ based on experts' opinions collected at the workshop. Given that the agricultural production system in Bangladesh is dominantly rice-based and given that our

data observations for non-rice crops are limited, the assessment focused on technologies related to rice cultivation. Specifically, we evaluate the remaining adoption potential of high yielding varieties (HYV) as well as for abiotic stress tolerant varieties. The workshop participants also mentioned a need for more quality seed, which relates to a demand for HYVs and also emanates from a lack of trust in seed vendors and an apparent poor adaptation of often Chinese-sourced hybrid seed to Bangladesh realities.

Table 3.1: Rice Technologies Identified by Workshop Participants by Rice Season

Sl. No.	Technologies and season	*boro*	*aus*	*aman*
1	Submergence tolerance			x
2	Salt tolerance	x		x
3	Drought tolerance	x	x	x
4	Cold tolerance	x		
5	Heat tolerance	x	x	x
6	Nutrient use efficiency	x	x	x
7	Hybrids			x
8	Pest and disease resistant varieties	x	x	x
9	Short duration varieties	x	x	x
10	New HYV	x	x	x
11	Water use efficiency in irrigation	x		
12	Integrated soil fertility management	x	x	x
13	Quality seeds	x	x	x
14	Crop rotation	x	x	x
15	Mechanized cultivation	x	x	x
16	Water harvesting	x	x	
17	Water and soil conservation	x		
18	Compressed urea	x		
19	Alternative Wetting and Drying (AWD)	x		
20	System of Rice Intensification (SRI)	x		
21	Nutrient management (USG/UDP)	x	x	x
22	Nutrient management leaf color chart (LCC)/ spade reading	x	x	x
23	Site specific nutrient management	x	x	x
24	Precision agriculture	x	x	x
25	Direct seeding/ground seeding	x	x	x
26	Postharvest technologies (drying, bagging, aflatoxin reduction, threshing, parboiling of rice, storage)	x	x	x

Source: Expert workshop on crop technologies, Dhaka, Bangladesh, April 2012.

Table 3.2: Top Ranked Technology Improvements Needed by AEZ

Agro-ecological zone	#1 Ranked technology/practice
Modhupur Tract	Quality (HYV) Seeds
Barind Tract	Drought tolerance
Beel & Haor Basin	Submergence tolerance
Floodplain	Quality (HYV) seeds
Himalayan Piedmont Plain	Cold tolerance
Northern and Eastern Hills	Water and soil conservation practices
Tidal Floodplain	Submergence tolerance

Source: Expert workshop on crop technologies, Dhaka, Bangladesh, April 2012.

The "green revolution" in the 1960s was spearheaded by the spread of modern HYV (dwarf varieties with early maturing and higher tillering capacity) (Dalrymple 1986). In addition to conventional HYVs, much of the breeding effort of modern rice varieties focuses on abiotic stress tolerant traits, which are designed to maintain high and stable yields under environments unfavorable to conventional rice varieties (Senadhira et al. 2002; Bailey-Serres et al. 2010; Kumar 2011). Based on the rice technologies suggested in the study, we include rice varieties with four types of environmental stress resistant traits in our analysis: (i) drought-tolerant varieties, (ii) cold-tolerant varieties, (iii) salinity-tolerant varieties and (iv) submergence-tolerant varieties. Bangladesh is a country prone to both droughts and floods (Islam and Sado 2000; Shahid 2008). Moreover, the coastal area in southern Bangladesh is faced with a great threat of sea water intrusion and salinity is a main barrier to expand rice production in southern Bangladesh (Haque 2006). The uptake of these abiotic stress tolerant varieties can have immediate implications for Bangladesh's food security.

The remaining sections of the paper are organized as follows. Section 3.2 details the data and methodology used in the assessment. Section 3.3 presents the key findings and Section 3.4 concludes with policy recommendations.

Overview of data and methods: We used several data sets, analytical modeling tools and other sources in the assessment of alternative rice technologies. They include (a) Bangladesh Integrated Household Survey (BIHS) and Feed the Future zone survey data collected by the International Food Policy Research Institute (Ahmed 2013); (b) Soil and Water Assessment Tool (SWAT); (c) Bangladesh soil salinity data; (d) rice submergence duration-yield function and Bangladesh flood affected extent and duration data; (e) Bangladesh national statistics of rice production; and (f) discussions with International Rice Research Institute (IRRI) scientists in Bangladesh.

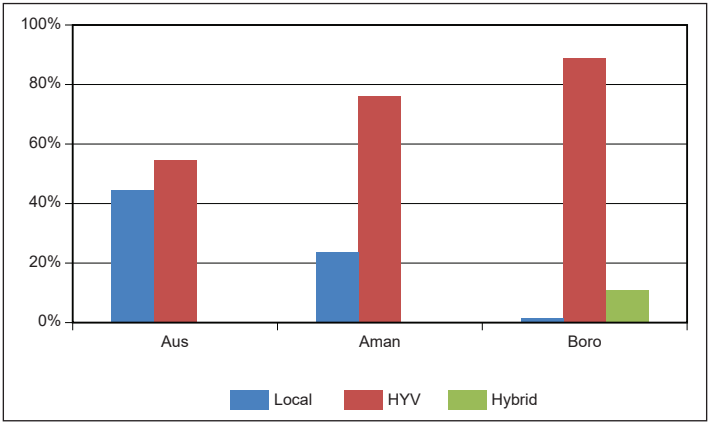
The BIHS/Feed the Future dataset (Ahmed et al. 2013) provides first-hand, comprehensive observations on agricultural production practices in Bangladesh, such as crop types, varieties (for rice), planting and harvest dates, crop yields and information on irrigation and fertilizer use. We used BIHS/Feed the Future data to assess the current status and future adoption potential of HYV rice. Rice varieties with new stress-tolerant traits have emerged as promising technologies only in recent years and their adoption levels are still low. Thus, we do not have observations on cultivation of abiotic stress-tolerant rice varieties in BIHS/Feed the Future data. Under this circumstance, we introduced the Soil and Water Assessment Tool (SWAT) and other predictive modeling tools to estimate their effects on rice yields.

3.2 Results for HYV and Abiotic Stress Tolerance Varieties

3.2.1 High-yielding Varieties

The adoption rates of HYV rice (in terms of area share) estimated from BIHS/Feed the Future data at the national level in Bangladesh are shown in Figure 3.2. As evident in this figure, the remaining potential for HYV adoption mainly exists in the *aus* and *aman* seasons. Nationwide, local varieties currently account for 45 percent and 24 percent of the rice cultivation areas in the *aus* and *aman* seasons, respectively. On the other hand, the *boro* season already has an adoption rate of HYV (including hybrid varieties) of close to 100 percent.

Figure 3.2: Area Share of High-Yielding Varieties of Rice in Bangladesh



Source: BIHS/Feed the Future dataset.

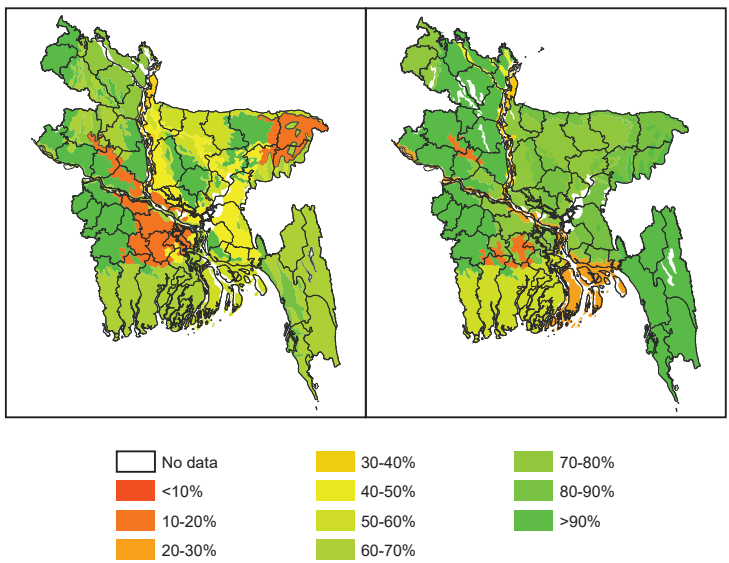
The yield statistics in Table 3.3 confirm the yield advantage of HYV rice over local rice varieties. The national averages of HYV and local varieties are 3.2 tons per hectare and 2.1 tons per hectare, respectively for the *aus* season, and 3.3 tons per hectare and 2.1 tons per hectare for the *aman* season.

Table 3.3: Average Yields of HYV Rice and Local Variety Rice (ton/ha)

	aus		*aman*		*boro*	
	Local	HYV	Local	HYV	Local	HYV/hybrid
Barisal	1.8	2.9	1.9	3.7	2.0	4.7/N.A.
Chittagong	2.1	3.4	2.1	2.7		5.1/5.8
Dhaka	2.2	3.3	2.3	2.8	4.2	5.7/6.7
Khulna	1.9	3.2	2.1	3.5		5.5/5.9
Rajshahi	2.0	2.9	2.4	3.5		6.1/7.3
Rangpur	1.3	3.6	2.1	3.4		5.8/6.3
Sylhet	2.4	2.9	1.6	2.6		4.3/6.0
All Bangladesh	2.1	3.2	2.1	3.3	4.0	5.7/6.6

Source: BIHS/Feed the Future dataset.

Figure 3.3: Area Share of HYV Rice Cultivation in Bangladesh by AEZ



Source: BIHS/Feed the Future dataset.

Figure 3.3 presents spatially disaggregated estimates of adoption rates of HYV rice by AEZ during the *aus* and *aman* seasons. The south-east region of the country, where the Feed-the-Future zone is located, has lower rates of HYV rice adoption relative to other regions, especially during the *aman* season. This might be due, in part, to the prevalence of salinity part of the year in the tidal flood plain area and flooding, in general.

Table 3.4 presents the estimated adoption rates and observed average yields of HYV and local varieties of rice in the Feed the Future zone. The rate of HYV rice cultivation in the *aman* season is below the national average.

Table 3.4: Cultivation Rates and Yields of Local and HYV Rice in the Feed the Future Zone

	aus		*aman*		*boro*		
	Local	HYV	Local	HYV	Local	HYV	Hybrid
Cultivation area (%)	39.8	60.2	40.0	60.0	1.7	78.9	19.4
Yield (ton/ha)	1.9	3.5	2.1	3.7	2.6	5.5	6.0

Source: BIHS dataset, Feed the Future sample.

The statistics of current HYV adoption rates and yield differences between HYV and local varieties noted above were combined with national statistics of rice production (You and Wood-Sichra 2012) to estimate the adoption potential of HYV rice across Bangladesh and in the Feed the Future zone. The assessed total potential for implementing HYV rice technologies across the *aus* and *aman* seasons of Bangladesh and the Feed the Future zone are shown in Table 3.5. We assume a 100 percent substitution of local varieties for HYV in the assessment.

Table 3.5: Assessed Total Potential for Implementing HYV Technologies across *aus* and *aman* Seasons in Bangladesh and Feed the Future Zone

	Harvested area ($^{\times}10^3$ ha)	Increased production ($^{\times}10^3$ ton/yr)
Barisal	238	360
Chittagong	184	225
Dhaka	358	293
Khulna	266	403
Rajshahi	133	155
Rangpur	157	113
Sylhet	107	73
All Bangladesh	1,443	1,622
Feed the Future zone	349	537

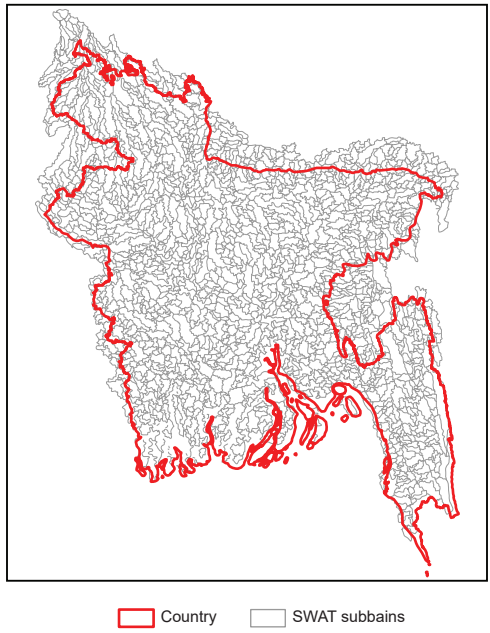
Source: Authors' compilations.

3.2.2 Abiotic stress-tolerant varieties

To assess stress-tolerant rice varieties, we assume that these varieties have yields comparable to regular HYV under normal conditions. The HYV yields calculated from the BIHS/Feed the Future dataset were taken as estimates for HYV yields in normal years and were used for the estimation of actual yield benefits brought about by the stress-tolerant traits, which are derived from predictive modeling and expressed in percentage terms in the assessment for drought-, cold- and submergence-tolerance varieties.

Potential adoption of drought and cold tolerant varieties: The assessment of adoption potential of drought- and cold-tolerant rice varieties are based on the yield responses to the new traits projected by the SWAT model (Arnold et al. 2007). SWAT is a comprehensive river basin model with proven capacity in crop simulation. The SWAT-based crop simulation is spatially disaggregated, dividing Bangladesh into 1,931 sub-basins (Figure 3.4). The data sets used in the development of the SWAT-Bangladesh model are listed in Table 3.6.

Figure 3.4: Basins in Bangladesh Defined for SWAT Modeling



Source: Authors' compilations.

Table 3.6: Main Data Sets for SWAT-Bangladesh Development

Category	Sources
Elevation	HydroSHEDS (http://hydrosheds.cr.usgs.gov/index.php)
Daily precipitation	The APHRODITE project (http://www.chikyu.ac.jp/precip/index.html)
Daily minimum/maximum temperatures, solar radiations, relative humidity, wind speed	The National Centers for Environmental Prediction (NCEP) (obtained through Global Weather Data for SWAT at http://swat.tamu.edu)
Soil data	Harmonized World Soil Database (http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/)

Source: Authors' compilations.

Considering that *boro* rice in Bangladesh is dominantly irrigated, the assessment for drought-tolerant rice focuses on rainfed *aus* and *aman* rice. By contrast, the assessment for cold-tolerant rice is focused on *boro* rice as low temperatures, which could adversely affect growth of rice plants, tend to occur in the *boro* (winter) season.

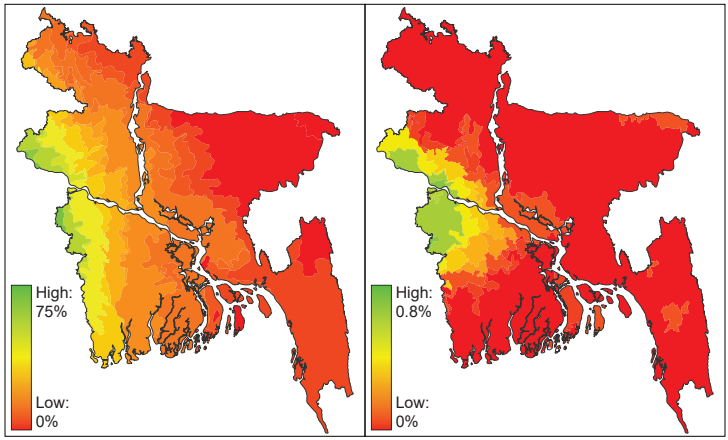
The crop simulation algorithm in SWAT originates from the Erosion Productivity Impact Calculator (EPIC) model (Williams, Jones, and Dyke 1984). The simulation is continuous and on a daily basis. The model tracks the physiological development of crop plants during the growing season. On each day of the simulation, the model first calculates the biomass accumulation, leaf area development and root development under optimal conditions and then adjusts them for water, temperature and nutrient stresses. Water stress is calculated as a ratio of water demand deficit and water demand, and temperature stress is calculated as a function of air temperature, crop's optimal temperature and base temperature. Here the base temperature refers to the minimum temperature which must be reached for crop growth to take place.

In this study, we assume that (i) the drought-tolerance trait helps reduce water stress by 30 percent; and (ii) the cold-tolerance trait helps to extend the base temperature for rice growth from 10°C to 8°C.

The estimated yield increases in the *aus* and *aman* seasons from drought-tolerance, expressed in percentage terms, are shown in Figure 3.5. The simulation results show that the rice production in the *aus* season and in western Bangladesh are more frequently affected by insufficient precipitation, and therefore more substantial yield increases are observed (note the different scale of the legend in two maps). The corresponding estimates of increased rice productions for all of Bangladesh and for the Feed the Future zone due to the adoption of drought-tolerant technologies are shown in Table 3.7.

We assess two options for increased drought tolerance adoption. In the first scenario, a substitution of drought-tolerant rice for areas currently planted to HYV varieties was assessed. In a second option we assume 100 percent adoption of drought-tolerant varieties in all areas where potential for HYV varieties exist based on our analysis of HYV variety expansion potential.

Figure 3.5: Estimated Rice Yield Increase due to Adoption of Drought-Tolerance Technology



Source: Authors' calculations.

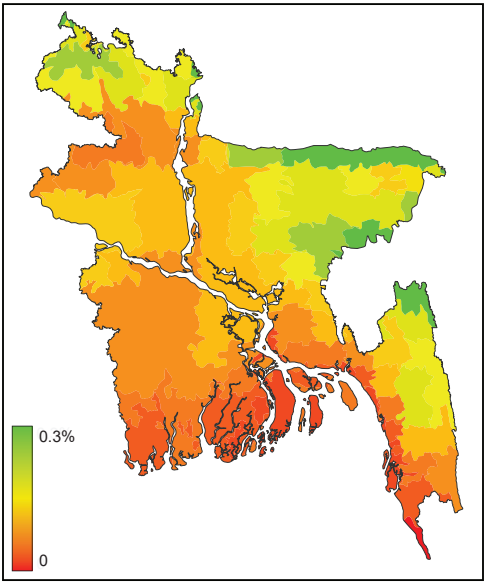
Table 3.7: Estimated Rice Production Increase due to Adoption of Drought-Tolerant Technologies ($\times 10^3$ ton/yr)

	Under current HYV adoption levels			With a 100 percent HYV adoption rate		
	aus	aman	Total	aus	aman	Total
Barisal	17.25	0.05	17.30	27.73	0.14	27.87
Chittagong	14.56	0.08	14.64	23.55	0.15	23.71
Dhaka	7.13	0.26	7.39	18.88	0.42	19.30
Khulna	36.92	1.47	38.39	50.31	1.65	51.97
Rajshahi	10.46	0.83	11.29	15.45	1.06	16.51
Rangpur	1.22	0.10	1.32	1.44	0.11	1.55
Sylhet	1.42	0.07	1.49	2.48	0.08	2.56
All Bangladesh	88.96	2.86	91.82	139.85	3.61	143.46
Feed the Future	31.42	1.08	32.50	53.50	1.83	55.33

Source: Authors' calculations.

The yield and production increases of *boro* rice estimated from the SWAT simulation for the assessment for cold-tolerant rice varieties are presented in Figure 3.6 and Table 3.8. Rice yields are more responsive to the cold tolerance trait in the northern and northeastern regions of Bangladesh, but the magnitude of the yield increase across the country is non-substantial, at less than 0.3 percent increase over current production.

Figure 3.6: Estimated Rice Yield Increase due to Adoption of Cold-Tolerance Technology



Source: Authors' calculations.

Table 3.8: Estimated Rice Production Increase due to Adoption of Cold Tolerance Technology ($^{\times}10^3$ ton/yr)

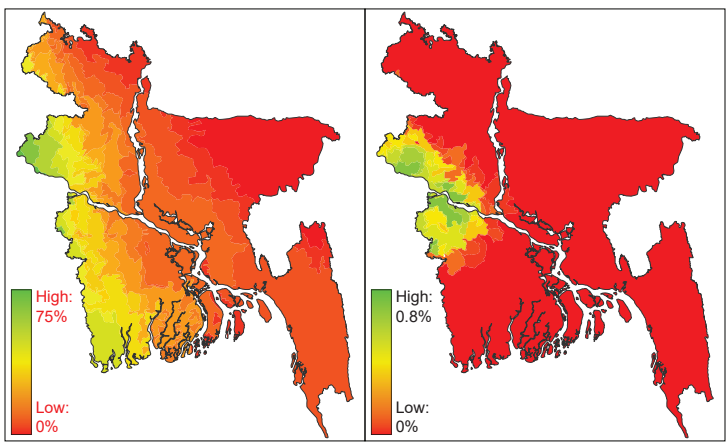
Barisal	0.2	Rajshahi	1.9
Chittagong	1.3	Rangpur	2.1
Dhaka	3.9	Sylhet	1.6
Khulna	1	All Bangladesh	12
Feed the Future	0.7		

Source: Authors' calculations.

Bangladesh is a country highly vulnerable to climate change (Yu et al. 2010). We analyzed twelve precipitation and temperature data sets downscaled from projections of General Circulation Models (GCMs) for 2050 (Jones, Thornton, and Heinke 2009). We find that climate change in Bangladesh is characterized by a warming trend and varying amounts of precipitation change. The warming trend implies a reduced impact or benefit from the cold-tolerance technology.

As for drought-tolerant varieties, the SWAT model allows us to investigate the adoption potential of drought-tolerant rice varieties under climate change. Specifically, we use the CSIRO-Mk3.0 model under the A1B scenario, which was identified as the driest scenario in an ex-ante screening analysis. Results for yield response and production increases under 2050 precipitation and temperature levels under this scenario are presented in Figure 3.7 and Table 3.9. Compared to the projected yield and production improvement shown in Figure 3.5 and Table 3.7, we find a reduced production response for drought-tolerant technologies under climate change. Thus, climate change impacts can significantly change the potential outcomes for abiotic-stress tolerant varieties. However, the current global climate change scenarios do not include adequate reflection of growing climate variability and extreme events.

Figure 3.7: Estimated Rice Yield Increase due to Adoption of Drought-Tolerant Technologies under Future Climate (CSIRO-Mk3.0 Model under A1B scenario) for 2050



Source: Authors' calculations.

Table 3.9: Estimated Rice Yield Increase due to Adoption of Drought-Tolerance Technology under Future Climate Projected CSIRO-Mk3.0 Model under A1B Scenario for 2050 ($^{\times}10^3$ ton/yr)

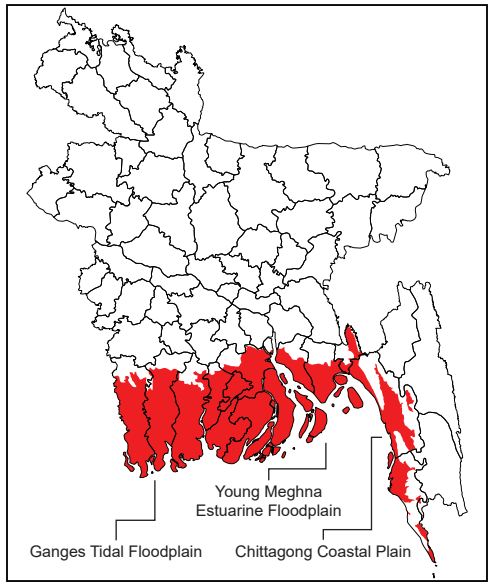
	Current HYV adoption rate			100% HYV adoption rate		
	aus	aman	Total	aus	aman	Total
Barisal	11.84	0.04	11.88	19.12	0.09	19.21
Chittagong	11.56	0.06	11.61	18.52	0.11	18.63
Dhaka	4.99	0.17	5.16	12.72	0.28	12.99
Khulna	21.70	0.98	22.68	30.28	1.10	31.39
Rajshahi	5.21	0.55	5.76	7.90	0.70	8.60
Rangpur	0.79	0.07	0.85	0.93	0.07	1.00
Sylhet	1.12	0.05	1.16	1.93	0.06	1.99
All Bangladesh	57.21	1.91	59.12	91.40	2.41	93.81
Feed the Future	19.39	0.74	20.12	33.01	1.25	34.26

Source: Authors' calculations.

3.2.3 Salinity Tolerance Variety

The growth of rice plants is sensitive to salinity and could be adversely affected when salinity is greater than 3 millimhos per centimeter (Tanji and Kielen 2002). Soil salinity data for Bangladesh suggest that soils with high salinity are primarily located in the three sub-zones of the Tidal Floodplain AEZ in southern Bangladesh: the Ganges tidal floodplain, the Young Meghna estuarine and the Chittagong coastal plains (Figure 3.8 and Table 3.10). Moreover, there is important intra-annual variability of salinity in these coastal areas (Ismail, personal communication, 2012, personal communication) with rising salinity in the *boro* season and reduced/no salinity during the rainy season. Statistics calculated from BIHS/Feed the Future samples indicate that the cultivation of *boro* rice is severely restricted in these three salinity-affected AEZs (Table 3.11). The cultivation rates of *boro* rice (share of cultivation area of *boro* rice in total cultivation area of rice) in the Ganges tidal floodplain, Young Meghna Estuarine and Chittagong Coastal Plains are 5 percent, 19 percent, and 26 percent respectively, substantially below the national average of 46 percent. In this assessment, we assume that the salinity-tolerant technology will lead to a doubling of the *boro* rice cultivation area across these affected areas. The resulting estimated rice production increase due to the adoption of salinity-tolerant technologies in all of Bangladesh and the Feed the Future zone are shown in Table 3.12.

Figure 3.8: Salinity Affected Agroecological Zones in Bangladesh



Source: Bangladesh Agricultural Research Council.

Table 3.10: Soil Salinity in Three Agroecological Zones of Southern Bangladesh

	< 2 MMHOS/cm	2-4 MMHOS/cm	4-8 MMHOS/cm	8-15 MMHOS/cm
Ganges tidal floodplain	174,338	174,338	314,057	30,429
Young Meghna estuarine Floodplain	139,014	193,292	154,955	
Chittagong coastal plain	7,228	7,228	62,121	15,465

Source: Bangladesh Agricultural Research Council.

Table 3.11: Cultivation Rates of *boro* Rice in Three Sub-zones of Tidal Floodplain AEZ of Southern Bangladesh

AEZ	Share of cultivation area (%)
Ganges tidal floodplain	5%
Young Meghna estuarine floodplain	19%
Chittagong coastal plain	26%
All Bangladesh	46%

Source: BIHS/Feed the Future dataset.

Table 3.12: Rice Production Increase due to Adoption of Salinity-Tolerant Technology ($\times 10^3$ ton/yr)

Administrative unit	Production	Administrative unit	Production
Barisal	224	Chittagong	353
Khulna	146	All Bangladesh	723
Feed the Future	162		

Source: Authors' calculations.

3.2.4 Submergence tolerance variety

Situated in the delta plains at the confluence of the Ganges, Brahmaputra, and Meghna rivers, Bangladesh is extremely vulnerable to floods. Submergence-tolerance traits can help improve the survival probability of rice plants and reduce yield losses under inundated conditions. For the assessment of the adoption potential of submergence tolerant rice varieties, we calculated the expected yield losses of regular and submergence tolerant varieties, respectively, and estimated the expected yield loss reduction that could be achieved through the submergence trait.

The expected yield losses of regular and submergence tolerant rice varieties at a given location are calculated as:

$$E(YL) = \sum_i YL(d_{i,1} \le D \le d_{i,2}) \cdot p_i$$

where $E(YL)$ is expected yield loss (%), $YL(d_{i,1} \le D \le d_{i,2})$(%) is yield loss in flood event of category i, which has a duration (D, days) between $d_{i,1}$ (days) and $d_{i,2}$ (days); and p_i is the probability of occurrence of flood event of category i.

The flood event occurrence probabilities p_i at varying locations were estimated using data from the Global Active Archive of Large Flood Events (Dartmouth Flood Observatory[3]). The data set provides information on affected area and duration of 79 major flood events in Bangladesh since June 1985.

The development of submergence duration-yield loss relationships was based on a literature review (Hussain 1995; Mackill et al. 2012) and expert interviews. The submergence duration-yield loss relationship for regular and submergence-tolerance rice varieties used in this study is shown in Table 3.13.

[3] http://www.dartmouth.edu/~floods/Archives/index.html (site disconitued).

Table 3.13: Expected Rice Loss Percentage under Different Submergence Durations

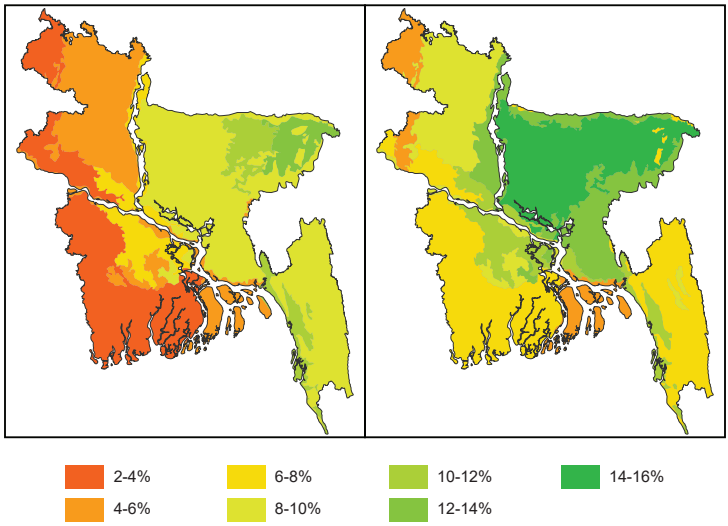
Submergence duration (days)	0-2	3-6	7-9	10-14	15-20	>20
Regular variety (%)	10	20	40	60	70	100
Submergence tolerance varieties (%)	0	0	10	20	40	95

Source: Authors' calculations.

The calculated expected yield loss reductions associated with submergence-tolerance traits by AEZ are shown in Figure 3.9.

The estimated reductions in rice production losses due to the adoption of submergence-tolerance technology for all of Bangladesh and Feed the Future zone, under both the current HYV cultivation rate and a future 100 percent HYV cultivation rate, are shown in Table 3.14.

Figure 3.9: Expected Rice Yield Loss Reduction Brought from Submergence-Tolerance Traits



Source: Authors' compilations.

Table 3.14: Estimated Rice Production Loss Reduction due to Adoption of Submergence-Tolerant Technology (×10^3 ton/yr)

	Current HYV adoption rate			100% HYV adoption rate		
	aus	*aman*	Total	*aus*	*aman*	Total
Barisal	6	41	47	10	84	94
Chittagong	33	158	191	52	186	238
Dhaka	23	314	337	41	427	467
Khulna	13	142	155	18	197	215
Rajshahi	9	198	207	13	230	243
Rangpur	2	202	204	3	238	241
Sylhet	27	109	135	42	134	177
All Bangladesh	113	1,164	1,277	179	1496	1675
Feed the Future	12	115	127	21	195	216

Source: Authors' calculations.

3.4 Policy Conclusions

Table 3.15 summarizes the major findings from the assessment.

Table 3.15: Estimated Impacts of Rice Production Technology Adoption in Bangladesh

Technology		All Bangladesh		Feed the Future zone
		Production benefit (×10^3 ton/yr)	Geographic domain with high suitability	Production benefit (×10^3 ton/yr)
High-yielding varieties		1,622	South, central flood plain and north east (for *aus* rice)	537
Stress tolerance varieties	Drought tolerance variety	92^a/143^b	West	33 ^{a}/55^b
	Cold tolerance variety	12	North and northeast	0.7
	Salinity tolerance variety	723	Coastal south	162
	Submergence tolerance variety	1,277 ^{a}/1,675^b	Northeast	127 ^{a}/216^b

Note: 'a' denotes current HYV adoption rates and 'b' assumes 100 percent HYV adoption; results do not consider climate change impacts.

Source: IFPRI Team.

The full adoption of HYV has a large impact on additional rice production in Bangladesh, increasing total production potential by 1.6 million tons, or four percent over current production levels. The yield statistics calculated from the BIHS/Feed the Future dataset confirm the yield advantage of HYV over local rice varieties. The current adoption rates of HYV are already fairly high, but there is still a large potential to increase rice production by promoting the cultivation of HYV in the *aus* and *aman* seasons. The potential is much larger in the Feed the Future zone, which has HYV cultivation rates below the national average. Here, the rice production increase could be as high as 0.5 million tons per year as a result of a 100 percent substitution of HYV for local varieties.

The stress tolerance traits may help further improve rice production in Bangladesh. The production benefits (either production increase or production loss reduction) reported in this assessment can be interpreted as indicators of the production advantages of stress-tolerance varieties over regular HYV varieties. It is noteworthy that the performance of various types of stress-tolerance varieties varies significantly across the country. Therefore, the efforts to promote the adoption of stress-tolerant varieties should target their geographic suitability domains. Measured by the production benefits, among the four stress-tolerant varieties evaluated in this study, investment priorities should go to the adoption of salinity-tolerant rice varieties and submergence-tolerant varieties, particularly in the Feed the Future zone; but benefits exist elsewhere as well. The adoption of drought-tolerance and cold-tolerance seem to have less production benefits. Simulations under climate change also cast uncertainty regarding the potential benefits of these two technologies. Thus, more care needs to be taken regarding the investment decision for the adoption of the drought-tolerance and cold-tolerance varieties. However, these climate change scenarios do not take account of growing variability or climate extremes.

References

Ahmed, Akhter U. 2013. *Bangladesh Integrated Household Survey (BIHS) 2011-2012.* Washington, D.C.: International Food Policy Research Institute (datasets). http://hdl.handle.net/1902.1/21266.

Ahmed, Akhter U., Ahmad Kaikaus, Victoria Chou, Ricardo Hernandez, Purnima Menon, Farria Naeem, Firdousi Naher, Wahid Quabili, Esha Shraboni, and Bingxin Yu. 2013, April. *The Status of Food Security in the Feed the Future Zone and Other Regions of Bangladesh: Results from the 2011-2012 Bangladesh Integrated Household Survey*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Arnold, Jeffrey G., Raghavan Srinivasan, Rajan S. Muttiah, and J. R. Williams. 2007. "Large Area ydrologic Modeling and Assessment Part 1: Model Development." Journal of the American Water Resources Association 34, no. 1: 73-89. https://doi.org/10.1111/j.1752-1688.1998.tb05961.x.

Asaduzzaman, M., Claudia Ringler, James Thurlow, and Shafiqul Alam. 2010, May. *Investing in Crop Agriculture in Bangladesh for Higher Growth and Productivity, and Adaptation to Climate Change*. In *Bangladesh Food Security Investment Forum*. Dhaka: Bangladesh Food Security Investment Forum. https://bangladeshfoodsecurity.files.wordpress.com/2010/05/investing.pdf.

Bailey-Serres, Julia, Takeshi Fukao, Pamela Ronald, Abdelbagi Ismail, Sigrid Heuer, and David Mackill. 2010, August. "Submergence Tolerant Rice: SUB1's Journey from Landrace to Modern Cultivar." *Rice* 3, no. 2-3: 138-147. https://doi.org/10.1007/s12284-010-9048-5.

Dalrymple, Dana G. 1986. *Development and Spread of High-yielding Rice Varieties in Developing Countries*. Washington, D.C.: Agency for International Development. http://books.irri.org/9711041596_content.pdf.

Haque, S. A. 2006, December. "Salinity Problems and Crop Production in Coastal Regions of Bangladesh." *Pakistan Journal of Botany* 38, no. 5: 1359-1365.

Hussain, Sk. Ghulam. 1995, December. Decision Support System for Assessing Rice Yield Losses from Annual Flooding in Bangladesh. PhD Dissertation submitted to the Graduate Division of the University of Hawaii. http://hdl.handle.net/10125/9274.

Islam, Md. Monirul, and Kimiteru Sado. 2000. "*Development of Flood Hazard Maps of Bangladesh using NOAA-AVHRR Images with GIS*." *Hydrological Sciences Journal* 45, no. 3: 337-355. https://doi.org/10.1080/02626660009492334.

Jones, Peter G., Philip K. Thornton, and Jens Heinke. 2009, August. Generated Characteristic Daily Weather Data using Downscaled Climate Model Data from the IPCC's Fourth Assessment. Project report. Nairobi: International Livestock Research Institute (ILRI). https://cgspace.cgiar.org/handle/10568/2482.

Kumar, A. 2011. *Bangladesh Releases Two Drought Tolerant Varieties*. STRASA News 4(3).

Mackill, David James, A. M. Ismail, Uma Shankar Singh, Romeo V. Labios, and T. R. Paris. 2012. "Development and Rapid Adoption of Submergence-Tolerant (Sub1) Rice Varieties." *Advances in Agronomy* 115 : 299-352. https://doi.org/10.1016/B978-0-12-394276-0.00006-8.

Senadhira, D., F. J. Zapata-Arias, Glenn B. Gregorio, M. S. Alejar, H. C. de la Cruz, T. F. Padolina, and A. M. Galvez. 2002. "Development of the First Salt-Tolerant Rice Cultivar through Indica/Indica Anther Culture." *Field Crops Research* 76, no. 2: 103-110. https://doi.org/10.1016/S0378-4290(02)00032-1.

Shahid, S. 2008, June. "Spatial and Temporal Characteristics of Droughts in the Western Part of Bangladesh." *Hydrological Processes* 22, no. 13: 2235-2247. https://doi.org/10.1002/hyp.6820.

Tanji, Kenneth K., and Neeltje C. Kielen. 2002. *Agricultural Drainage Water Management in Arid and Semi-arid Areas.* FAO Irrigation and Drainage Paper no. 61. Rome: Food and Agriculture Organization (FAO). http://www.fao.org/3/a-ap103e.pdf.

Williams, J. R., C. A. Jones, and P. T. Dyke. 1984. "A Modeling Approach to Determining the Relationship between Erosion and Soil Productivity." *Transactions of the American Society of Agricultural Engineering* 27, no. 1:129-144. https://doi.org/ 10.13031/2013.32748.

You, L., and U. Wood-Sichra. 2012. *Spatial Production Allocation Model (SPAM) 2005 Version 1 Release 1.* Personal communication. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Yu, Winston, Mozaharul Alam, Ahmadul Hassan, Abu Saleh Khan, Alex Ruane, Cynthia Rosenzweig, David Major, and James Thurlow. 2010. *Climate change risks and food security in Bangladesh*. Routledge.

PART 2

INPUT USE AND AGRICULTURAL PRODUCTIVITY

Chapter 4

Rice Productivity in Bangladesh: What Are the Benefits of Irrigation?[1]

Andrew Reid Bell, Elizabeth Bryan, Claudia Ringler, and Akhter Ahmed

4.1 Introduction

Agricultural production in Bangladesh has undergone dramatic changes over the past several decades. Green Revolution technologies transformed the agriculture system in the country through the introduction of high-yielding rice and wheat varieties, chemical fertilizers and pesticides, and the expansion of tube well-irrigated area, enabling crop production during the dry season (e.g. Hossain 1988; Sen, Mujeri, and Shahabuddin 2004; Timmer 2005). As a result, yields of key staples, namely rice but also wheat, have increased as has food availability. However, serious challenges continue to plague the agriculture sector. These include scarcity of land due to high population density, unbalanced use of fertilizers and pesticides, great variation in water supply across seasons from drought to stagnant flood conditions, resource degradation due to over-application of chemicals and intensive year-round cultivation of rice, climate change and related extreme climatic events.

The expansion of irrigated areas contributed to the gains in production during the Green Revolution, and further expansion of irrigated area—including through the continued development and improvement of surface water systems—is being eyed by Bangladesh's Ministry of Agriculture to address many of the remaining challenges facing the country (Asaduzzaman et al. 2010). However, such expansion is not without risks or consequences, including reduced water availability and quality (Alauddin and Quiggin 2008), waterlogging, and exacerbation of income inequality, when poor farmers face disproportionate barriers to adoption of irrigation technologies

[1] An earlier version of the chapter was published in *Land Use Policy* 48: 1-12, November, 2015. This is reproduced with permission of the publisher.

(Smith 2004). While there may yet be potential for irrigation development to improve livelihoods across Bangladesh, a careful analysis of who benefits from irrigation, and how, must guide development priorities.

This chapter examines the relative contribution of agricultural inputs, including irrigation, to rice productivity across Bangladesh by cropping season, using linear least-squares crop production functions. Particular attention is paid to outcomes for rich and poor farmers, which have been divided into those residing in northern (Dhaka, Rajshahi, Rangpur, and Sylhet) and southern (Barisal, Chittagong, and Khulna) divisions of the country, due to differences in agro-ecological conditions and production systems. The data used for the analysis were collected as part of the Bangladesh Integrated Household Survey (BIHS), which was implemented from late 2011 to early 2012. The next section provides background on agricultural production in the northern and southern parts of the country and on the role of irrigation. Section 4.3 describes the data and methods used for the analysis and Section 4 presents the results of our production function analyses. Section 4.5 discusses the implications of the findings for Bangladesh's farmers and policymakers.

4.2 Agricultural Production in Bangladesh and Role of Irrigation

Agriculture remains a key economic sector in Bangladesh, accounting for 18 percent of GDP (gross domestic product) in 2011 (World Bank 2012) and more than half of total employment as recently as the early 2000s (World Bank 2005). Intensification has led to major changes in cropping patterns. In particular, the area under irrigated, short-duration, high yield varieties (HYV) of staple cereals, such as rice and wheat, has increased, while production of other non-rice crops such as pulses and oilseeds, as well as fisheries, has declined (Husain, Hossain, and Janaiah 2001; Rahman 2010). Changing cropping patterns have been accompanied by an increase in intensive cultivation of rice over the entire year and an accompanying rise in input use (fertilizer, pesticide) intensity (Hossain and Kashem 1997; Rahman 2010). Rice production now covers 77 percent of total agricultural lands and rice is grown in up to three growing seasons: *aman*, *boro*, and *aus*. *Aman* grows during the monsoon season and is mainly rainfed; *boro* is grown during the dry season and requires irrigation; and *aus* production takes place during the spring rains before the monsoon and generally requires supplementary irrigation (Ruane et al. 2013).

Intensive cultivation of rice takes place in the northern part of the country, particularly the northwest where *boro* rice is the main cultivated crop. In the coastal south, where intrusion of saline sea water occurs during high tides

and storm surges, continuous crop production is hindered by soil salinity. A common farming system in this region involves rice cultivation during the rainy season followed by aquaculture, namely shrimp, during the dry season. However, the flooding of crop lands for shrimp production reduces yields of rice in subsequent seasons and has contributed to a reduction of agricultural land over time. In addition, the poor are increasingly excluded from engaging in this livelihood activity as open fisheries are converted into aquaculture using enclosed water bodies. This exacerbates income inequality in the region as income from paddy rice production is only a small fraction of the income earned from shrimp farming.

Irrigation is one key input that has contributed to large increases in agricultural productivity across the country (Ahmed and Sampath 1992; Asaduzzaman et al. 2010; Hossain, Naher, and Shahabuddin 2005; Palmer-Jones 2001). The share of cultivated area equipped for irrigation has expanded rapidly from 16 percent in 1978 to 58 percent in 2008 (FAO 2012). Area expansion was closely tied to the spread of groundwater irrigation using both shallow and deep tube wells—in 2008, more than 5 million hectares of land were irrigated during the dry season (of an estimated 7 million ha of irrigation potential) and 79 percent of this irrigation from groundwater (World Bank 2005; BADC 2012; FAO 2012). Groundwater aquifers are hydraulically connected to major waterways and are replenished during the monsoon (Chowdhury, 2010), with recharge potential greatest in the northern parts of the country (Shamsudduha et al. 2009). However, withdrawal of surface water in the upstream reaches reduces groundwater levels and increases the salinity of the shallow aquifers in the coastal region. Moreover, groundwater in areas receiving less recharge can dry up during the *boro* season.

The majority of irrigation schemes are small-scale in nature; only 10 percent of all irrigation is delivered via large-scale surface schemes, which generally suffer from lack of maintenance and investments (Asaduzzaman et al. 2010). Surface water systems also depend on water from transboundary rivers which makes the quantity available for irrigation more uncertain. Groundwater irrigation is generally more flexible than surface water irrigation, given that farmers tend to have more control over its use than surface water. Moreover, groundwater can be used in conjunction with surface water and often increases water use efficiency given that farmers bear the costs of groundwater extraction (Asaduzzaman et al. 2010).

At the same time, there are downsides to heavy dependence on groundwater. First, groundwater is very costly, with pumping costs typically greater than surface water pumps and requiring diesel or electricity. Furthermore,

while groundwater development has been smallholder-driven and therefore has been relatively equitable, there are still significant gaps between relatively richer smallholders who have been able to draw down groundwater sources and smallholders who cannot afford deeper tube wells or to maintain surface water irrigation systems.

While Bangladesh has made significant progress over the past several decades in terms of economic growth, poverty reduction, and human development, an estimated 35 million people still live in extreme poverty and are highly vulnerable to livelihood shocks (World Bank 2012). Several studies have shown that agricultural growth is key to reducing poverty in the country (Irz et al. 2001; Loayza and Raddatz 2010; Thirtle, Lin and Piesse 2003; Timmer 2005). However, as mentioned above, the poor also face greater challenges to improving agricultural productivity and increasing their income from agricultural production given difficulties in accessing key inputs, such as irrigation equipment, and water and land resources (Namara et al. 2010; Smith 2004).

4.3 Data Collection and Methodology

The study uses data from the Bangladesh Integrated Household Survey (BIHS) conducted from October 2011 to March 2012. The BIHS sample is statistically representative at the following levels: (a) nationally representative of rural Bangladesh; and (b) representative of rural areas of each of the seven administrative divisions of the country: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet. The total BIHS sample size is 5,500 households in 275 primary sampling units (PSUs). BIHS follows a stratified sampling design at two stages—selection of PSUs and selection of households within each PSU—using the sampling frame developed from the community series of the 2001 population census. In the first stage, a total sample of 275 PSUs were allocated among the seven strata (divisions) with probability proportional to the number of households in each stratum, which resulted in the following distribution: 21 PSUs in Barisal, 48 in Chittagong, 87 in Dhaka, 27 in Khulna, 29 in Rajshahi, 27 in Rangpur, and 36 in Sylhet. In the second stage, 20 households were randomly selected from each PSU, for a final BIHS sample of 5,500 households. Sampling weights were adjusted using the sampling frame of the 2011 population census.

This study relied primarily on data collected using the module on agricultural production and costs, which captured plot-level data on land and soil quality, crops grown, area planted, crop yields, input use and costs, agricultural technologies used, and access to agricultural extension services, among other information. The survey covered the agricultural production

year from 1 December 2010 to 30 November 2011. Analyses based on this dataset suffer from two key limitations. The first, common to any cross-sectional (single time point) analysis, is that there may be unresolved endogeneity issues in the data—i.e., to what extent a positive coefficient for a particular input reflects the benefit of using that input, and to what extent it reflects higher motivation or efficiency on the part of the farmer that tends to use that input. The other and more significant limitation of BIHS data specifically is that while crops grown, area planted, irrigation use, and crop yields are reported for all plots, non-irrigation inputs and costs are only recorded for the main plot of the household. The main plot was defined as the largest plot cultivated by the household, with two exceptions. If two or more plots had the same cropped area then the plot with non-rice cultivation was used as the main plot. Additionally, if the respondent had rented plots in addition to those he or she owned, then separate "main" plots were selected from both those owned and those rented.

A lack of agricultural input data across all plots precludes an econometric analysis of production at the household level; the analysis in this study, therefore, is based on a dataset that consists almost exclusively of a single main plot per household, with clustering applied at the household level in the cases that multiple main plots per household were collected. This limitation prevents us from integrating aquaculture (a key activity in Bangladesh, examined in detail within the BIHS, but not linked reliably to the main plots of our analysis) into the household-level analysis of production. However, analysis at the plot level does allow an analysis of plot production as a system across three annual seasons. Analysis at the plot level has previously yielded econometric studies on the adoption of soil and water management practices (e.g. Bekele and Drake 2003), as well as on crop-specific input use (e.g. Qaim and Traxler 2005) and the role of specific inputs across specific demographic groups (e.g. Holden and Lunduka 2010); our study approaches data most similarly to this last example as we examine the relative roles of different inputs on production, across higher and lower income groups, with particular interest in the role of irrigation for crop productivity.

4.3.1 Analytical Method

All variables in our analysis are constructed directly from the BIHS dataset. Labor is reported on a cost basis by multiplying the person-days of both hired and family labor with the average daily wage reported for that labor task in the survey. Our analysis focuses on inputs, costs, and production specific to a particular rice crop in a particular season, while non-rice crops are excluded from the analysis (descriptive statistics are presented in Table 4.1).

Table 4.1: Descriptive Statistics—Weighted Mean and Standard Deviation

Variable	Aman						Boro						Aus					
	Full Sample		Low Income		High Income		Full Sample		Low Income		High Income		Full Sample		Low Income		High Income	
	n = 2001		n = 746		n = 1255		n = 1976		n = 708		n = 1268		n = 383		n = 164		n = 219	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Production	2955.37	1222.93	2900.85	1222.44	2989.17	1222.51	5517.10	1559.14	5374.67	1596.12	5599.95	1531.79	2648.75	1084.04	2601.30	1066.04	2684.58	1098.53
HHHead_Age	45.87	12.99	44.61	12.98	46.65	12.94	45.34	12.83	43.67	12.44	46.30	12.96	46.59	13.89	46.34	13.24	46.77	14.39
HHHead_Literacy	2.75	1.25	2.48	1.21	2.91	1.24	2.71	1.24	2.41	1.20	2.89	1.23	2.72	1.25	2.56	1.21	2.84	1.26
HHHead_Education	3.46	4.04	2.26	3.26	4.20	4.30	3.31	3.95	2.10	3.13	4.01	4.19	3.25	3.78	2.42	3.22	3.87	4.04
HHTotal_Assets	56.63	366.69	23.60	83.51	77.10	460.92	66.79	411.85	28.22	169.45	89.22	500.30	34.80	203.31	19.30	46.81	46.50	265.92
ExtensionVisitYN	0.08	0.27	0.04	0.21	0.10	0.30	0.08	0.27	0.05	0.21	0.10	0.30	0.09	0.28	0.05	0.22	0.11	0.32
HHSumExtensionVisits	0.24	1.31	0.19	1.59	0.27	1.10	0.22	1.03	0.12	0.77	0.28	1.15	0.31	1.75	0.23	1.34	0.38	2.00
Loans_Banks	0.23	0.42	0.19	0.39	0.25	0.43	0.22	0.41	0.17	0.38	0.25	0.43	0.28	0.45	0.23	0.42	0.32	0.47
Loans_Lenders	0.11	0.31	0.13	0.33	0.10	0.29	0.11	0.31	0.12	0.32	0.10	0.30	0.10	0.30	0.12	0.33	0.08	0.27
Loans_NGO	0.29	0.46	0.32	0.47	0.28	0.45	0.31	0.46	0.35	0.48	0.29	0.46	0.36	0.48	0.44	0.50	0.29	0.46
Loans_Kin	0.25	0.43	0.23	0.42	0.27	0.44	0.25	0.43	0.22	0.41	0.26	0.44	0.22	0.41	0.16	0.37	0.26	0.44
Feb_May_2010	360.14	218.76	353.45	208.55	364.28	224.84	387.24	226.34	384.71	228.73	388.71	225.02	345.68	234.93	360.66	255.17	334.37	218.33
Jun_Sep_2010	1159.40	398.39	1170.70	387.10	1152.40	405.23	1156.46	371.38	1176.84	374.08	1144.60	369.44	1129.97	427.55	1139.53	450.28	1122.76	410.46
Oct_Jan_2010	239.77	109.76	234.39	115.29	243.11	106.09	225.64	80.20	215.06	79.10	231.79	80.22	302.48	153.83	297.67	152.08	306.11	155.39
Feb_May_2011	361.02	90.87	355.42	86.40	364.49	93.40	372.04	91.59	370.82	88.55	372.76	93.34	366.57	114.11	366.40	111.85	366.70	116.05
Jun_Sep_2011	1573.04	373.96	1576.75	360.97	1570.74	381.92	1512.52	290.44	1509.94	268.26	1514.02	302.69	1658.69	470.46	1679.43	509.07	1643.03	439.62
Labor	25438.56	23893.32	25283.66	15119.50	25534.56	27988.74	32599.89	24587.54	31841.20	19925.69	33041.17	26928.21	25289.56	21659.56	23284.57	13947.98	26803.32	25941.16
Pest_Herb_Insecticide_Costs	1199.56	1524.68	1158.79	1364.15	1224.82	1616.21	1747.59	1567.39	1646.67	1431.35	1806.29	1639.04	1492.01	1695.27	1244.56	1298.45	1678.83	1923.86
Fertilizer_Costs	6273.45	5030.72	6449.10	5339.97	6164.58	4828.17	11829.86	6167.20	11614.08	5983.63	11955.37	6270.47	6719.03	4993.05	6226.81	4545.33	7090.65	5286.04

Continued

Continued from Table 4.1

Variable	Aman						Boro						Aus					
	Full Sample		Low Income		High Income		Full Sample		Low Income		High Income		Full Sample		Low Income		High Income	
	n = 2001		n = 746		n = 1255		n = 1976		n = 708		n = 1268		n = 383		n = 164		n = 219	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
ToolsAnimalCosts_Total	5136.89	3236.23	5083.85	2820.72	5169.76	3469.57	5386.27	4840.28	5196.84	3765.25	5496.45	5365.78	5857.91	4970.83	5740.63	4526.22	5946.46	5290.36
Per_Area_Total_Seed_Cost	4463.69	4323.72	4456.13	3435.23	4468.37	4793.76	5416.57	4315.85	5601.77	5079.09	5308.85	3800.27	4356.16	3480.64	3845.08	2718.58	4742.02	3922.27
SouthOwnGroundwater	0.02	0.15	0.02	0.14	0.02	0.15	0.02	0.15	0.02	0.13	0.03	0.16	0.07	0.26	0.06	0.23	0.08	0.28
SouthOwnPlot	0.16	0.37	0.12	0.32	0.18	0.39	0.10	0.30	0.06	0.23	0.13	0.33	0.29	0.45	0.19	0.39	0.36	0.48
NorthOwnGroundwater	0.04	0.21	0.03	0.18	0.05	0.22	0.08	0.27	0.06	0.23	0.10	0.30	0.01	0.09	0.00	0.05	0.01	0.11
NorthOwnPlot	0.37	0.48	0.32	0.47	0.39	0.49	0.40	0.49	0.35	0.48	0.42	0.49	0.20	0.40	0.19	0.40	0.20	0.40
Rice_Type_aman_hybrid	0.02	0.12	0.01	0.11	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice_Type_aman_local_1	0.23	0.42	0.24	0.43	0.22	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice_Type_aman_local_2	0.04	0.20	0.04	0.20	0.04	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice_Type_boro_hybrid	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.29	0.08	0.27	0.10	0.31	0.00	0.00	0.00	0.00	0.00	0.00
Rice_Type_ropa_aush_hyv	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.33	0.09	0.29	0.15	0.36
Rice_Type_aush_local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.38	0.20	0.40	0.16	0.37
Rice_Type_aush_local_develop	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.35	0.15	0.36	0.14	0.35
NorthXSW_M_FE	0.01	0.09	0.01	0.10	0.01	0.08	0.05	0.23	0.06	0.23	0.05	0.22	0.00	0.00	0.00	0.00	0.00	0.00
NorthXGW_M_D_FE	0.09	0.29	0.09	0.28	0.09	0.29	0.15	0.36	0.16	0.37	0.15	0.36	0.07	0.25	0.09	0.29	0.05	0.23
NorthXGW_M_S_FE	0.23	0.42	0.26	0.44	0.22	0.41	0.55	0.50	0.59	0.49	0.52	0.50	0.08	0.28	0.07	0.26	0.09	0.29
SouthXSW_M_FE	0.03	0.16	0.02	0.14	0.03	0.17	0.06	0.23	0.05	0.22	0.06	0.24	0.11	0.31	0.09	0.29	0.13	0.33
SouthXGW_M_D_FE	0.00	0.04	0.00	0.03	0.00	0.05	0.01	0.11	0.02	0.13	0.01	0.09	0.01	0.09	0.01	0.09	0.01	0.10
SouthXGW_M_S_FE	0.06	0.23	0.05	0.22	0.06	0.24	0.14	0.35	0.10	0.30	0.17	0.37	0.10	0.30	0.06	0.24	0.13	0.33

Source: Authors' calculations.

All analyses are weighted for sample selection at the division level, clustered at the household level to account for cases where more than one rice crop was reported by the household, and recursively filtered to remove outliers greater than three standard deviations away from the mean. The form of our production function in the least squares analysis is given by:

$$Y_i = \beta_{i,0} + \beta_{i,X}X + \beta_{i,I}I + \beta_{i,F}F + \beta_{i,I2}I^2 + \beta_{i,IF}IF + \varepsilon_i \quad (1)$$

where Y_i is the total production (yield) per acre for household i, X is a vector of household and environmental control variables; I is a vector of labor, chemical, and other inputs costs; F is a vector of dummy variables describing characteristics of the particular rice plot (including variety and water source); the vectors I^2 and IF represent any quadratic terms or interaction terms of interest (in our case, diminishing marginal returns on fertilizer inputs, and the interaction of irrigation method with fertilizer use); and ε_i is a residual error term implicitly incorporating both random disturbance and any technical inefficiencies. The coefficients β_i in the least squares analysis thus represent the marginal effect of a unit change in the variable of interest.

4.4 Results

We present results on the production intensity (kilograms/acre) of rice across the three rice cropping seasons (Table 4.2). Variable descriptions can be seen in Table 4.3. Table 4.2 shows results for the full sample, filtered for outliers, as well as results for the data subsets of poor and wealthy households. Relatively poorer and wealthier households are defined by per capita expenditure quintiles. The lower two expenditure quintiles represent the poorer households and the upper three expenditure quintiles represent the richer households. While the definition of these two groups is based on expenditures, we refer to these groups below as poorer and wealthier households (Table 4.4).

Several factors shape rice production (measured as per-acre yields) similarly across all seasons. For example, plots managed by older farmers tend to have lower production (*aman* and *boro*), as do plots managed by farmers relying on informal loans from kin (all seasons). In the latter case, informal borrowing may be an indicator of lack of access to formal credit (and possibly to other inputs critical to production). Further, as expected, hybrid and high-yielding varieties greatly out-produce local varieties across all three rice-growing seasons.

Table 4.2: Multivariate Regression Results

Variables	Aman			Boro			Aus		
	Full	Low	High	Full	Low	High	Full	Low	High
HHHead_Age	-5.634***	-6.505*	-5.589**	-5.743*	-6.588	-7.623**	-2.704	1.964	-7.108
HHHead_Education	-5.470	-9.889	-10.13	17.49*	22.78	7.121	-12.17	0.453	-27.40
HHTotal_Assets	-0.00965	-1.017**	0.00881	0.184**	0.935***	0.126**	0.0332	-0.180	-0.0233
ExtensionVisitYN	64.65	76.44	44.60	16.71	-53.49	-4.404	170.7	-62.70	238.5
Loans_Banks	91.22	71.88	94.01	161.0*	69.54	189.2*	157.9	46.01	213.1
Loans_Lenders	-82.32	21.89	-137.9	-123.9	-314.0	-19.12	-341.6*	-248.3	-487.3*
Loans_NGO	27.78	-21.50	66.38	22.73	98.95	-1.116	35.83	23.02	-24.52
Loans_Kin	-264.7***	-369.2***	-226.7***	-186.2**	-191.6	-221.6**	-0.902	-485.5**	285.5*
Feb_May_2010	-0.141	-1.055**	0.303	-0.198	-0.0775	-0.559	0.514	0.171	0.815
Jun_Sep_2010	0.0331	0.580**	-0.289	-0.428	-0.296	-0.443	-0.153	0.298	-0.649
Oct_Jan_2010	-0.473	0.745	-1.139**	-0.0704	-0.0114	-0.510	-1.812**	-1.401	-1.952*
Feb_May_2011	-0.583	-0.294	-0.560	0.122	-0.640	0.645	1.008	0.661	1.821*
Jun_Sep_2011	0.0156	-0.200	0.143	-0.241	-0.0413	-0.257	0.496	0.233	0.810*
Labor	0.00158	0.00891	0.000757	0.00311	0.00776	0.00354	-0.000322	-0.0106	0.00534
Pest_Herb_Insecticide_Costs	0.108***	0.0754	0.129***	0.0632	0.0582	0.0243	0.142*	-0.0589	0.310***
Fertilizer_Costs	0.0706***	0.0718***	0.0740***	0.0215	0.000417	0.0242	0.0354	0.101	0.00821
ToolsAnimalCosts_Total	0.0162*	0.00667	0.0178*	0.00943	-0.0134	0.0129*	0.00122	0.0115	0.00347
Per_Area_Total_Seed_Cost	-0.00178	0.00329	-0.00473	0.000294	0.0109	-0.00349	0.0140	0.0207	0.00950
SouthOwnGroundwater	-326.7	-381.5	-244.9	-180.1	-1,360***	243.7	-726.0**	-1,364**	-667.3*
SouthOwnPlot	198.3**	-1.336	268.0***	-38.56	220.6	-176.9	-17.33	-164.5	70.62
NorthOwnGroundwater	-41.71	-264.7	65.46	-36.28	-85.91	6.811	-218.4	-1,386**	560.5
NorthOwnPlot	32.31	42.89	30.47	118.9	100.4	101.8	-475.2***	-502.0**	-490.7**

Continued

Continued from Table 4.2

Variables	Aman			Boro			Aus		
	Full	Low	High	Full	Low	High	Full	Low	High
Rice_Type_aman_hybrid	-63.47	-245.7	-23.43						
Rice_Type_aman_local_1	-747.7***	-921.6***	-660.6***						
Rice_Type_aman_local_2	-682.9***	-537.6***	-800.1***						
Rice_Type_boro_hybrid				861.6***	997.5***	734.9***			
Rice_Type_ropa_aush_hyv							329.3*	648.8**	377.5
Rice_Type_aush_local							-550.5***	-688.8**	-269.7
Rice_Type_aush_local_develop							-223.5	-396.1	-143.8
FertSquared	-1.55e-06***	-1.28e-06**	-1.75e-06***	-2.07e-07	6.73e-08	-2.07e-07	-3.54e-07	-3.03e-06	2.21e-07
Pest_Herb_Insect_Squared	-3.35e-06**	-3.16e-06	-4.06e-06***	-2.14e-06	1.10e-05	-8.65e-07	-4.23e-06	3.57e-05	-2.21e-05*
LaborSquared	-8.37e-10	-5.74e-08	-2.26e-10	-7.08e-09	-4.35e-08	-7.18e-09	-8.94e-09	5.69e-09	-1.92e-08
NorthXSW_M_FE	-544.9	-1,184***	133.6	220.2	-182.5	307.6			
NorthXGW_M_D_FE	323.8***	477.7**	201.1	240.0	-349.5	449.5*	154.8	297.7	-263.3
NorthXGW_M_S_FE	-36.74	-110.1	-4.794	325.1*	-196.5	468.2**	634.0***	866.7**	277.7
SouthXSW_M_FE	-173.5	-244.9	-233.3	-537.5*	-1,285***	-236.8	420.4	865.2	364.3
SouthXGW_M_D_FE	-6.388	23.45	-95.01	-692.8***	-1,173**	-414.6	-4.753	-1,920**	1,280
SouthXGW_M_S_FE	118.9	93.02	114.1	-27.00	-933.2**	251.2	637.8**	353.5	769.1***
Constant	3,162***	2,822***	3,323***	5,868***	6,223***	6,019***	1,740***	1,766**	1,383**
Observations	2,001	746	1,255	1,976	708	1,268	383	164	219
R-squared	0.229	0.259	0.245	0.114	0.138	0.128	0.343	0.395	0.444
Robust standard errors in parentheses									
*** p<0.01, ** p<0.05, * p<0.1									

Source: Authors' calculations.

Table 4.3: Variable Descriptions

Variable	Unit	Notes
Production	kg/acre	
HHHead_Age	Year	Age of Household Head
HHHead_Literacy		Literacy of Household Head (1 - Cannot read or write; 2 - Sign only; 3 - Can read but not write; 4 - Can read and write)
HHHead_Education	Year	Education of Household Head
HHTotal_Assets	Tk	Total household assets, calculated as sum (Qty * % ownership by household * Current market value) for all assets
ExtensionVisitYN		1 if Household has been visited by Extension Services
HHSumExtensionVisits		Number of visits in recall period
Loans_Banks		Fraction of HH loans granted by Banks
Loans_Lenders		Fraction of HH loans granted by Lenders
Loans_NGO		Fraction of HH loans granted by NGOs
Loans_Kin		Fraction of HH loans granted by Kin/Friends
Feb_May_2010	mm	Sum of rainfall over season
Jun_Sep_2010	mm	Sum of rainfall over season
Oct_Jan_2010	mm	Sum of rainfall over season
Feb_May_2011	mm	Sum of rainfall over season
Jun_Sep_2011	mm	Sum of rainfall over season
Labor	Taka/acre/season	Imputed total cost of family and hired labor for all production purposes
Pest_Herb_Insecticide_Costs	Taka/acre/season	Total cost of pesticides, herbicides, insecticides
Fertilizer_Costs	Taka/acre/season	Total cost of fertilizers
ToolsAnimalCosts_Total	Taka/acre/season	Total cost for rental/purchase of tools, machinery, or animals
Per_Area_Total_Seed_Cost	Taka/acre/season	Total cost for seeds
SouthOwnGroundwater		1 if irrigation method is owned by respondent (South)
SouthOwnPlot		1 if plot is owned by respondent (South)
NorthOwnGroundwater		1 if irrigation method is owned by respondent (North)
NorthOwnPlot		1 if plot is owned by respondent (North)

Continued

Continued from Table 4.3

Variable	Unit	Notes
Rice_Type_aman_hybrid		1 if plot crop is hybrid aman rice
Rice_Type_aman_local_1		1 if plot crop is local aman rice (1st type)
Rice_Type_aman_local_2		1 if plot crop is local aman rice (2nd type)
Rice_Type_boro_hybrid		1 if plot crop is hybrid boro rice
Rice_Type_ropa_aush_hyv		1 if plot crop is hybrid aus rice
Rice_Type_aush_local		1 if plot crop is local aus rice (1st type)
Rice_Type_aush_local_develop		1 if plot crop is local aus rice (2nd type)
NorthXSW_M_FE		1 if plot relies on mechanical surface water irrigation (North)
NorthXGW_M_D_FE		1 if plot relies on deep tubewell irrigation (North)
NorthXGW_M_S_FE		1 if plot relies on shallow tubewell irrigation (North)
SouthXSW_M_FE		1 if plot relies on mechanical surface water irrigation (South)
SouthXGW_M_D_FE		1 if plot relies on deep tubewell irrigation (South)
SouthXGW_M_S_FE		1 if plot relies on shallow tubewell irrigation (South)

Table 4.4: Mean Production Intensity (kg/acre/season) across Regions, Income Classes and Rice Crops

		Aman			Boro			Aus		
		n	Mean	S.E.	n	Mean	S.E.	n	Mean	S.E.
Full	North	1366	2860.23	32.36	1558	5521.34	39.52	159	2621.69	80.68
	South	635	2923.24	50.11	418	5117.17	75.91	224	2612.08	74.73
Low-income	North	529	2812.88	52.91	589	5422.58	63.94	78	2583.41	111.57
	South	217	2870.77	81.59	119	4719.99	144.05	86	2530.02	121.19
High-income	North	837	2890.16	40.86	969	5581.37	50.20	81	2658.55	116.88
	South	418	2950.48	63.28	299	5275.24	87.79	138	2663.23	95.01

However, most of the key determinants of successful production (i.e., those that explain variance in production across the sample) differ by growing season. For *aus* rice (early *kharif*, April-August), which is rainfed, only the use of pesticides helps explain yields, and then only for plots

managed by the wealthier households. For that season, we also see a clear influence of the strength and shape of the monsoon. More rainfall over the period February-May for the *aus* season covered by this study (2011) led to improved production, while more rainfall over the preceding period (October-January) had a significant negative impact on production. This latter result may reflect a disruption in the start of the *aus* season due to flooding or some other conditioning effect of rainfall on land. Though we see a significant effect of shallow tube wells for *aus* production, this effect needs to be considered jointly with the negative effect of irrigation ownership, and it should be noted that there is no theoretical expectation for groundwater irrigation to have significant effect during the monsoon season. Taken together with the small sample size for *aus*, we do not place strong weight on this finding in our analysis.

For *aman* rice (late *kharif* season, July-December), we observe that labor, tools/animals, and chemical inputs significantly shape rice yields. Specifically, *aman* yields from plots managed by poorer farmers depend directly on labor and fertilizer inputs, with diminishing returns observed to fertilizer inputs. In contrast, among plots managed by wealthier farmers, labor is insignificant in explaining variation. Rather, expenditure on pesticides, tool and animal rentals, and fertilizers are all significant, with diminishing returns observed to both pesticides and fertilizers. The consistent diminishing returns to fertilizers across all income groups in the sample likely suggests that adequate quantities of fertilizer are used by even the poorer households due to available subsidies for urea, which reached nearly BDT 50 billion in expenditure in 2010, or 0.7 percent of GDP (Mujeri et al. 2012).

Turning to the irrigated *boro* season, we observe no significant effects of rainfall nor chemical agricultural inputs in explaining variation across our sample, apart from the weak positive impact of tool and animal rental among wealthier farmers. Irrigation access has the greatest role in explaining rice production outcomes, but only in the south of Bangladesh. This finding indicates that in the northern districts of Bangladesh, access to irrigation is performing its intended function of smoothing out production and insuring against climate risk. However, in the lower-lying coastal south, plots reliant on surface water irrigation fare significantly worse than those reliant on groundwater irrigation, especially for low-income farmers. This pattern occurs weakly for the *aman* season as well, during which supplemental irrigation may be applied during flowering in October.

As with the *aus* and *aman* analyses, the baseline category includes rainfed plots and plots using non-mechanical surface irrigation, which

account for a very small component of the sample for *boro* rice. In order to compare production outcomes for plots irrigated with surface water with plots irrigated by shallow or deep tube wells more directly, we conducted an additional analysis for the *boro* season that drops the small number of rainfed plots and plots using non-mechanical surface irrigation and compares groundwater directly against a baseline category of surface water. In addition, we ran the analyses separately for the northern and southern divisions to tease out differences in terms of the effectiveness of irrigation sources in these two regions.

This additional analysis demonstrates that irrigation performs much better in the north than in the south, with no significant differences among irrigation sources in northern divisions (i.e., surface water, shallow or deep tube wells). This result is not surprising given the pattern of *boro* cultivation, with most *boro* production taking place in the north (79 percent of *boro* plots in our sample). Rather, what appears to matter for *boro* outcomes in the north is the wealth of the household—*boro* yields are higher for plots managed by farmers with a greater level of household assets, which may enable these farmers to invest in maintenance of irrigation equipment and infrastructure.

Among households cultivating *boro* rice in the south, most irrigate using shallow tube wells or surface water and there are no differences in *boro* yield outcomes between these two sources of irrigation water across the full sample. However, for wealthier households, shallow tube wells perform much better than surface water. The results also show that households using deep tube wells in the south fare much worse; possibly because they have difficulty coping with the cost of extracting water from deep tube wells or because these tube wells do not provide freshwater reliably. This result is true particularly for poorer households, while there is no difference between deep tube wells and surface water for the rich.

A final observation from our results is that in neither the *boro* nor *aman* seasons (when it would matter) do we see a significant effect of ownership of the irrigation system. That is to say, plots managed by farmers who rent in their irrigation water (by renting pumps/shallow tube wells, or contractual arrangements between irrigation equipment owners and non-owner farmers for water sharing in exchange of cash or crop share) fare no worse than those managed by farmers who own, and thus have preferred access to irrigation water. A possible interpretation of this is that in the Bangladesh context (where groundwater is ample), markets in groundwater irrigation may act to improve access and equity. We do observe significant negative effects of ownership of irrigation systems in the *aus* season as well,

as discussed above, but dismiss these from our discussion since there is no reason to expect groundwater to have significant impacts during the monsoon season, nor is there a mechanistic explanation for a negative impact of having preferred access (via ownership).

4.5 Implications of Findings

Early in 2013, the Bangladesh Ministry of Agriculture launched its Master Plan for Agricultural Development in the Southern Region of Bangladesh, jointly with the Food and Agriculture Organization of the United Nations (FAO) (MOA and FAO 2013), outlining (among other things) prioritized spending across the agricultural sector, including water management and drainage for the coming decade. Across a total of BDT 578 billion in spending (approximately USD 7.4 billion), the plan allocates about BDT 75 billion (13 percent of the total) to water management. This includes BDT 41 billion for surface water augmentation mainly canal excavation and rehabilitation in Barisal and Khulna as well as BDT 34 billion for increased irrigation capacity, mainly on-farm water management and double lifting technologies focusing on Barisal and Chittagong. This is to say, most spending over the next decade in southern Bangladesh on agricultural water development will be for enhancing surface water irrigation.

Our results suggest that the coastal south may not be well-suited for *boro* rice production. Currently, there is very little *boro* production in the area compared to the north, while other livelihood activities, such as aquaculture, are more prominent. Given the limitation of *boro* production in the south, it is unclear whether significant gains may be had from the planned massive investment in surface water irrigation. A recent study suggested that with good governance, storage of surface flows in polders could increase planted *boro* area by around 15 percent in at least 50 percent of years (depending on climate); this increases to 40 percent with investments in surface water infrastructure (Sharifullah et al. 2009). However, the pre-condition of good governance in water management is itself an area requiring research and development. Outside of the *boro* season, access to surface water does not appear to offer benefits in terms of *aman* or *aus* yields compared to rainfed plots, while access to groundwater shows some positive benefits. This result is not surprising, as *aman* and to some extent *aus* production is typically rainfed with groundwater used for supplemental purposes when needed. However, any current benefits from groundwater may be ephemeral, with a rising sea level expected to raise water tables in the coastal south with concomitant degradation in groundwater quality (Shamsudduha et al. 2009).

Our observation that groundwater markets appear to be functioning well across the country—in the north and the south— may have divergent implications for these two different areas. Coupled to the observation that groundwater recharge rates improve with abstraction (Shamsudduha et al. 2011) an implication for the north is that groundwater markets may be a means of equitable and sustainable development in agriculture. However, we acknowledge that seasonal depletion of shallow groundwater has also become more common. For the south, an expected decline in availability of good-quality groundwater may mean that any current success stories in groundwater reflect only a capacity to hold on marginally longer to an agricultural practice that is and will become increasingly difficult.

In the context of our findings, we must view the plans for development in Bangladesh's coastal south in one of two ways—either they are well-targeted investments to correct the problems facing *boro* production in the region, or they are large-scale spending capable only of temporarily propping up a livelihood strategy that is headed towards collapse due to pressures from both natural (via sea level rise) and social (via the rise of shrimp aquaculture) pressures. The structure of our data precludes us from comparing the relative roles of aquaculture and agriculture in the households in our survey. Our production data is complete only at the plot level, precluding comparative analysis at the household level. It is clear however that a deeper understanding of the interplay between these two important livelihood strategies in the coastal south—and how benefits from either are shared across rich and poor households—is critical to judging the potential for Bangladesh's planned investments in coastal surface water irrigation to address agricultural and livelihoods challenges in the region.

4.6 Summary and Conclusions

We examined plot-level data for rice production across a nationally-representative household survey in Bangladesh. We observe some results common to all three seasonal rice crops—*aus, boro,* and *aman*; namely, that plots tend to have higher yields if they are managed by younger farmers, by farmers not relying on informal loans, and if they are planted with improved or hybrid rice varieties. We also observe a range of results particular to each cropping season.

For *aus* rice, pesticide is the only significant direct input explaining variation across the sample, and then only for wealthier households; overall, rainfall is the most important factor explaining variation in *aus* production. For *aman* rice, labor and fertilizer use explain variation in yields for plots managed by poorer households; pesticides, fertilizer, and the

use of mechanical inputs and animals explains variation in plots managed by the wealthy. Across all households, significant and diminishing returns to fertilizer application is observed, possibly demonstrating that even poor households have sufficient access to subsidized urea.

Our findings for *boro* rice have perhaps the greatest policy significance. Rather than inputs, access to different forms of irrigation has the greatest role in explaining variation in *boro* yield, particularly in the coastal south region of Bangladesh. Rising sea levels, flooding, and lack of access to high quality groundwater have hampered agricultural production in this region in recent decades, with brackish shrimp aquaculture becoming an increasingly important part of rural livelihoods. In response, the government of Bangladesh is planning massive investments in the region for improved provision of surface water irrigation. Our results show generally poor returns to *boro* rice production in the south, with some exception in the case of plots fed by shallow tube wells. The expected decline in groundwater accessible from these sources, coupled with our econometric findings, suggests that *boro* production in the south may not be a good strategy to promote for the region. Whether the emerging alternative of brackish shrimp aquaculture can provide an equitable and sustainable alternative should continue to be a focus of research for the region.

References

Ahmed, Akhter U., and Rajan K. Sampath. 1992. "Effects of Irrigation-Induced Technological Change in Bangladesh Rice Production." *American Journal of Agricultural Economics* 74, no. 1: 144-157.

Alauddin, Mohammad, and John Quiggin. 2008. "Agricultural Intensification, Irrigation and the Environment in South Asia: Issues and Policy Options." *Ecological Economics* 65, no. 1 (March): 111-124. https://doi.org/10.1016/j.ecolecon.2007.06.004.

Asaduzzaman, M., Claudia Ringler, James Thurlow, and Shafiqul Alam, 2010. "Investing in Crop Agriculture in Bangladesh for Higher Growth and Productivity and Adaptation to Climate Change." Paper presented at the conference Bangladesh Food Security Investment Forum, 26-27 May 2010, Dhaka. https://bangladeshfoodsecurity.files.wordpress.com/2010/05/investing.pdf.

BADC (Bangladesh Agricultural Development Corporation). 2012. *Minor Irrigation Survey Report 2011-12*. Dhaka: BADC.

Bekele, Wagayehu, and Lars Drake. 2003. "Soil and Water Conservation Decision Behavior of Subsistence Farmers in the Eastern Highlands of Ethiopia: A Case Study of the Hunde-Lafto Area." *Ecological Economics* 46, no. 3 (October): 437-451. https://doi.org/10.1016/S0921-8009(03)00166-6.

Chowdhury, Nasima Tanveer. 2010. Water management in Bangladesh: an analytical review. *Water Policy*, 12: 32-51.

FAO (Food and Agriculture Organization of the United Nations). 2012. "AQUASTAT Main Country Database." Accessed April 17, 2012. http://www.fao.org/nr/water/ aquastat/ dbase/index.stm.

Holden, Stein Terje, and Rodney Lunduka. 2010, September. *Too Poor to be Efficient? Impacts of the Targeted Fertilizer Subsidy Program in Malawi on Farm Plot Level Input Use, Crop Choice and Land Productivity*. Noragric Report No. 5. Ås, Norway: Norwegian University of Life Sciences. https://doi.org/10.13140/RG.2.2.16252.18560.

Hossain, Mahabub. 1988. *Nature and Impact of the Green Revolution in Bangladesh*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Hossain, Mahabub, Firdousi Naher, and Quazi Shahabuddin. 2005. "Food Security and Nutrition in Bangladesh: Progress and Determinants." *Electronic Journal of Agricultural and Development Economics* 2, no. 2: 103-132.

Hossain, S. M. A., and M.A. Kashem. 1997. "Agronomic Management to Combat Declining Soil Fertility in Bangladesh." Presented at the 6th Biennial Conference of the Bangladesh Society of Agronomy, Dhaka.

Husain, A. M. Muazzem, Mahabub Hossain, and Aldas Janaiah. 2000, December. Hybrid Rice Adoption in Bangladesh: A Socio-economic Assessment of Farmers' Experiences. *Economic Studies* XV: 154-206. Dhaka: Research and Evaluation Division, BRAC. http://hdl.handle.net/10361/12492.

Irz, Xavier, Lin Lin, Colin Thirtle, and Steve Wiggins. 2001. "Agricultural Productivity Growth and Poverty Alleviation." *Development Policy Review* 19, no. 4: 449-466. https://library.fes.de/libalt/journals/swetsfulltext/12093119.pdf.

Loayza, Norman V., and Claudio Raddatz. 2010. "The Composition of Growth Matters for Poverty Alleviation." *Journal of Development Economics* 93, no. 1 (September): 137-151. https://doi.org/10.1016/j.jdeveco.2009.03.008.

MOA (Ministry of Agriculture), and FAO (Food and Agriculture Organization of the United Nations). 2013. *Master Plan for Agricultural Development in the Southern Region of Bangladesh*. Dhaka: MOA and FAO.

Mujeri, Mustafa K., Siban Shahana, S., Tahreen Tahrima Chowdhury, and Khondoker Tanveer Haider. 2013, June. *Improving the Effectiveness, Efficiency and Sustainability of Fertilizer Use in South Asia*. GDN Working Paper no. 67. New Delhi: Global Development Network (GDN).

Namara, Regassa E., Munir A. Hanjra, Gina E. Castillo, Helle Munk Ravnborg, Lawrence Smith, and Barbara Van Koppen. 2010. "Agricultural Water Management and Poverty Linkages." *Agricultural Water Management* 97, no. 4 (April): 520-527. https://doi.org/10.1016/j.agwat.2009.05.007.

Palmer-Jones, Richard. 2001. Irrigation Service Markets in Bangladesh: Private Provision of Local Public Goods and Community Regulation? Paper presented at the Workshop on Managing Common Resources, Department of Sociology, Lund University, Sweden.

Qaim, Matin, and Greg Traxler. 2005. "Roundup Ready Soybeans in Argentina: Farm Level and Aggregate Welfare Effects." *Agricultural Economics* 32, no. 1 (January): 73-86. https://doi.org/10.1111/j.0169-5150.2005.00006.x.

Rahman, Sanzidur. 2010. "Six Decades of Agricultural Land Use Change in Bangladesh: Effects on Crop Diversity, Productivity, Food Availability and the Environment, 1948-2006." *Singapore Journal of Tropical Geography* 31, no. 2 (July): 254-269. https://doi.org/10.1111/j.1467-9493.2010.00394.x.

Ruane, Alex C., David C. Major, Winston H. Yu, Mohazarul Alam, Sk. Ghulam Hussain, Abu Saleh Khan, Ahmadul Hassan, Bhuiyan Md. Tamim Al Hossain, Richard Goldberg, Radley M. Horton, and Cynthia Rosenzweig. 2013. "Multi-factor Impact Analysis of Agricultural Production in Bangladesh with Climate Change." *Global Environmental Change* 23, no. 1 (February): 338-350. https://doi.org/10.1016/j.gloenvcha.2012.09.001.

Sen, Binayak, Mustafa K. Mujeri, and Quazi Shahabuddin. 2004, November. Operationalising Pro-Poor Growth: Bangladesh as a Case Study. A World Bank Study. Washington D.C.

Shamsudduha, M., R. E. Chandler, R. G. Taylor, and K. M. Ahmed. 2009. "Recent Trends in Groundwater Levels in a Highly Seasonal Hydrological System: The Ganges-Brahmaputra-Meghna Delta." *Hydrology and Earth System Sciences Discussions* 6, no. 3 (June): 4125-4154. https://doi.org/10.5194/hessd-6-4125-2009.

Shamsudduha, Mohammad, Richard G. Taylor, Kazi M. Ahmed, and Anwar Zahid. 2011. "The Impact of Intensive Groundwater Abstraction on Recharge to a Shallow Regional Aquifer System: Evidence from Bangladesh." *Hydrogeology Journal* 19, no. 4 (April): 901-916. https://doi.org/10.1007/s10040-011-0723-4.

Sharifullah, Abul Kalam, To Phuc Tuong, Manoranjan K. Mondal, and Danielito T Franco. 2008, September. "Assessing Water Supply and Demand for Dry Season Rice in Coastal Polders of Bangladesh." In *Increasing the Productivity & Sustainability of Rainfed Cropping Systems of Poor Smallholder Farmers: Proceedings of the CGIAR Challenge Program on Water and Food International Workshop on Rainfed Cropping System, Tamale, Ghana, 22-25 September 2008*, edited by Elizabeth Humphreys, and Ruvicyn S. Bayot, 199-206. Colombo, Sri Lanka: The CGIAR Challenge Program on Water and Food.

Smith, Laurence E. D. 2004. "Assessment of the Contribution of Irrigation to Poverty Reduction and Sustainable Livelihoods." *International Journal of Water Resources Development* 20, no. 2: 243-257. https://doi.org/10.1080/0790062042000206084.

Thirtle, Colin, Lin Lin, and Jenifer Piesse. 2003. "The Impact of Research-Led Agricultural Productivity Growth on Poverty Reduction in Africa, Asia and Latin America." *World Development* 31, no. 12 (December): 1959-1975. https://doi.org/10.1016/j.worlddev.2003.07.001.

Timmer, C. Peter. 2005, July. *Agriculture and Pro-Poor Growth: An Asian Perspective*. Working Paper Number 63. Washington D.C.: Center for Global Development. https://www.cgdev.org/sites/default/files/2986_file_WP63_1_0.pdf.

World Bank. 2005. *Bangladesh: Country Water Resources Assistance Strategy*. Report No. 32312-BD. Washington, D.C.: World Bank. http://hdl.handle.net/10986/8402.

___. 2012. "World Development Indicators." Accessed March 30, 2013. http://data.worldbank.org/data-catalog/world-development-indicators.

Chapter 5

Fertilizer Policy in Bangladesh: State Intervention in Markets and Prices

Nurul Islam and Mustafa K. Mujeri

5.1 Introduction

Bangladesh has achieved commendable progress in agriculture especially in increasing food grains production over the past few decades. Three mutually supportive mechanisms have operated in different degrees for expanding agricultural (food) production in Bangladesh during the period: first, the increase in efficiency of use of farm inputs and technologies; second, using more productive inputs; and third, adopting improved technologies. Among the three, the first two have helped the small and marginal farmers (who form the overwhelming majority in Bangladesh agriculture) to experience the immediate benefits of higher farm outputs, contributing to an increased income and better living conditions. The third has been particularly important in enhancing the welfare of the consumers (resulting from lower real food prices) including the largest segment of the poor households in both rural and urban areas who are net buyers of food in Bangladesh (Mujeri, Shahana, Chowdhury, and Haider 2013).[1]

In the coming decades, Bangladesh needs to build on these gains through diversification and value addition, along with new technologies. This will require policy mechanisms that encourage farmers to move out from traditional cropping patterns towards new, high-value crops, promote investment in increasing productivity through using new and improved technology, improving market support services and better rural infrastructure, and eliminate policy distortions causing over-use and destruction of natural

[1] One reason for this is that income and price elasticities of demand for food tend to be low. The broad capacity of productivity growth in agriculture to benefit even the poor consumers who are not involved in farming gives agriculture a strong fighting power against poverty relative to other sectors.

resources, such as over-extraction of groundwater, and salinity in irrigated areas. Policy reforms are also needed to strengthen agricultural technology and innovation systems, and refocus on domestic trade, agro-processing, and land and credit markets to support private investments in the farm sector. In this context, a key challenge to steady growth in crop yields is the diminishing marginal returns to agricultural inputs, particularly fertilizer. Farmers can improve their net returns from agriculture with lower cost inputs and enhanced efficiency of fertilizer use.

The period since the 1970s witnessed a significant increase in both food grains production and fertilizer consumption establishing a significant association between the two. The government also implemented various policies and adopted other measures to promote an effective fertilizer distribution system with the ability to deliver quality fertilizers to the farmers at affordable prices. However, fertilizers have often not been as effective as they should have been in Bangladesh for many reasons, such as low quality, incorrect or sub-optimal use of fertilizers and lack of complementary inputs such as improved seed varieties and adequate water and similar factors. Despite these limitations, rapid expansion of irrigation, spread of high yielding variety (HYV) and hybrid seeds, distribution of fertilizers to the farmers at subsidized prices, expansion of dealers' network, improvement in fertilizer availability and relative stability in farm gate fertilizer prices have contributed significantly towards increasing fertilizer consumption in the country.

Recognizing the importance of fertilizer in agriculture and its potential for bringing about desired technological transformation, successive governments in Bangladesh have pursued active policies since the country's independence to improve adoption and productive use of fertilizer in Bangladesh agriculture. These policies have covered all major aspects of the fertilizer sector especially prices, marketing channels, and distribution of fertilizers. These policies have also undergone significant changes over the last five decades.

Fertilizer was first introduced in Bangladesh in the 1950s at heavily subsidized rates. The agriculture input management system was government-dominated, and the procurement and distribution of fertilizers were under the control of the government. Since then, a significant part of the fertilizer marketing and distribution system has remained under control of the government. Consequently, demand and supply—and hence prices—of fertilizers are not determined by market forces; rather these are set by the government. Annual demand for fertilizers is estimated by the government, based on which availability is determined and the prices to be paid by farmers

are also set by the government. In case of imports, private agents are allowed to procure a pre-determined amount of fertilizer along with the two public sector organizations—Bangladesh Chemical Industries Corporation (BCIC) and Bangladesh Agricultural Development Corporation (BADC). The allocation of fertilizer over different geographical regions is done through a chain of registered dealers and sub-dealers under the supervision of the administration.

In practice, the fertilizer market is less integrated in terms of both location and over time especially due to the nature of demand of the input. The price difference between the wholesale (e.g., point of origin) and retail markets is also high. The farmers, who are mostly credit and storage constrained, cannot take advantage of lower prices during the slack season and are forced to purchase fertilizers at the peak season when delaying purchases is not possible as the fertilizers have to be applied to crops at the right time. Obviously, this is the time when fertilizer prices are the highest.

The distribution of fertilizers takes place through a network of registered dealers and sub-dealers under the overall supervision and monitoring of the administration at different tiers through several committees. Obviously, if there is any mismatch between the estimated demand and supply, scarcity emerges and impacts prices. While these are features of imperfect markets, speculation by the dealers plays an important role in the process. For instance, the dealers may delay the lifting of fertilizers from the warehouses to affect supply in the local markets in anticipation of earning higher profits. Often, it is alleged that the dealers form "syndicates" to collectively influence the market to their advantage.

The above features of the fertilizer markets are contrary to the characteristics of the rice market, which is considered to be fairly integrated, both spatially and temporarily (see Mujeri, Shahana, Chowdhury, and Haider 2013; Chowdhury, Farid, and Roy 2006; Dawson and Dey 2002). It is reported that fertilizers are often sold at prices higher than the administered price through which the dealers earn "rent" from fertilizer trade (see Hossain, Jones, Mandal, and Asaduzzaman 2009). One factor that influences the working of the market in favor of the dealers is the small number of dealers in relation to the size of the market. This also creates a condition in which "personalized" factors and local informal support systems influence market transactions, especially in times of shortages in the availability of fertilizers.

This chapter provides a historic review of the fertilizer policy in Bangladesh, largely in terms of state interventions in markets and prices and their consequences for the agriculture sector. The analysis differentiates among

different phases of fertilizer market intervention and examines the nature of state intervention along with implications on market forces and prices.

5.2 Role of Fertilizer in Bangladesh Agriculture

In Bangladesh, HYVs of crop production brought about a significant change in production and productivity in agriculture. Besides HYVs of seeds, the technology requires two complementary inputs—water and fertilizer. Nearly three-quarters of the total cultivable land in Bangladesh are now irrigated, which contributed to the growth of HYVs of rice, particularly in the *rabi* season. Given the objective of ensuring food security, the government's policy focuses primarily on ensuring the availability of two crucial inputs, fertilizer and water, necessary for the production of modern varieties of rice.

The importance of fertilizer in crop production in the modern system of agriculture in Bangladesh is reflected in the fact that fertilizer has been contributing around half of the crop yield increases in recent years, and its importance keeps rising over time (Table 5.1). Agronomic research indicates that it is still possible for the farmers to achieve a better yield per hectare through applying recommended doses of fertilizer to different crops.

Over the decades, with rapid expansion of production technology and availability of yield-raising inputs, agriculture in Bangladesh has become increasingly dependent on chemical fertilizers for raising crop production. The average rice yield was 1.05 tons per hectare (ha) in 1971-1972, which increased to 2.52 tons in 2005-2006 mainly due to the spread of water-seed-fertilizer technology. The application of fertilizer increased significantly during the period.[2] In 1975-1976, fertilizer application was 0.36 kilograms (kg) per ha of agricultural land, which rose to 298 kg per ha in 2007 (Basak 2011). Despite these increases, the contribution of fertilizers to crop production is still considered low as the farmers use relatively low doses of nutrients in their crop-fields, mainly due to financial constraints of farmers and/or lack of knowledge about the recommended doses of fertilizers for specific crops at different locations.

[2] Total fertilizer consumption in the country rose from 0.8 million tons (of which 68 percent was urea, 26 percent TSP and 6 percent MP) in 1981 to 2.7 million tons (of which 89 percent was urea, 3 percent TSP and 8 percent MP) in 2010. It is argued that continuous higher application of Nitrogen (N) in relation to Phosphate (P) and Potash (K) has adverse effects on soil fertility, crop productivity and sustainability of agriculture in the long-run. For best results, the ideal ratio of 4:2:1 of NPK is often recommended.

Table 5.1: Contribution of Fertilizer to Crop Yields in Bangladesh

Crop	Average yield (ton/ha)		Contribution of fertilizer (%)
	Without fertilizer	With fertilizer	
Rice (*boro*)	2.4	5.2	53.8
Rice (transplanted *aman*)	2.8	4.4	33.3
Jute	1.1	3.5	45.7
Wheat	1.4	3.6	61.0
Mustard	0.6	1.7	64.1
Potato	9.6	10.2	59.1
Sugarcane	0.4	80	51.3
Groundnut	1.1	2.5	56.0

Note: The yield figures represent outcomes of scientific experimentation, not what the farmers actually get.

Source: BARC (1997).

In the above context, long-term fertilizer experiments show that the continuous use of N alone cannot produce sustained high yields without addition of adequate P, K and other deficient plant nutrients.[3] This is evident from relatively higher P and K fertilizer use efficiencies and relatively lower N use efficiency during the 1980s and 1990s as compared with the 1970s.[4] The disproportionate use of N, P and K fertilizers occurs mainly due to relatively low price of urea, and ignorance about the importance of balanced use of fertilizers among the farmers. The excessive use of nitrogenous fertilizers and unbalanced supply of crop nutrients also increase the acidity and deteriorate the physical condition of the soil. It further increases the emission of nitrous oxide, which is one of the major gases responsible for global warming, and results in deterioration of the quality of underground water in many parts of Bangladesh (Mujeri, Shahana, Chowdhury, and Haider 2013).

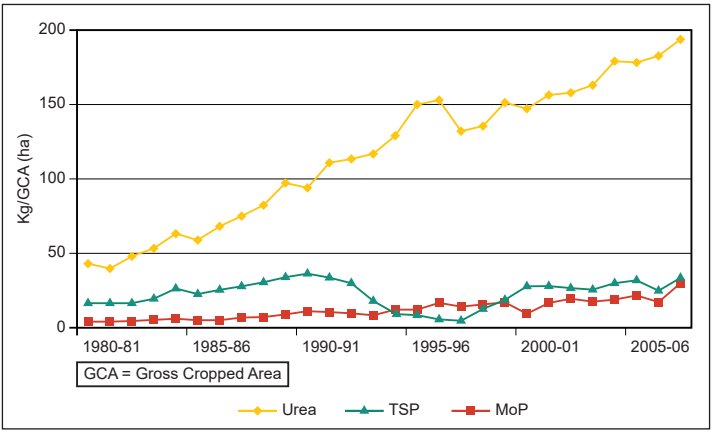
It is also reported that the yield response to fertilizer is declining in Bangladesh in line with declining yield response in South Asia as a whole. The amount of food grains produced per kilogram of NPK fertilizer has

[3] In this context, one of the policy options is to promote widespread use of USG popularly known as 'guti' urea. The use of USG minimises the need of applying urea in high doses and increases efficiency including environmental benefits.

[4] For example, in India the yield response to different nutrients in case of rice indicates that the yield response to N has reduced from 2,905 kg/ha in 1977-1978 to 2,640 kg/ha in recent years while the yield increased from 500 kg/ha to 925 kg/ha for P and from 50 kg/ha to 231 kg/ha for K during the same period. (See Tiwari, Sharma, Singh, Dwivedi, and Shukla 2006). It supports the argument that all three major nutrients N, P and K are essential to achieve sustained yields of crops.

declined from 14.3 kg in 1971-1980 to 11.7 kg during 1981-1990, and further to 10.9 kg in 1991-1998 (Katyal and Reddy 2005). The efficiency of fertilizer use is also relatively low so that improving efficiency, rather than raising the levels of application, is crucial to raising yields in Bangladesh.

Figure 5.1: Trend in Per Hectare Use of Fertilizers in Bangladesh



Source: Hossain, Jones, Mandal, and Asaduzzaman 2009.

The current pattern of fertilizer use, with a heavy reliance on nitrogenous fertilizer along with poor nutrition management, absence of complementary inputs, declining soil fertility, and weak marketing and distribution systems are all constraining the effectiveness of fertilizer use in Bangladesh, while the agronomic efficiency of fertilizer has also been falling.[5] The low efficiency and effectiveness of fertilizer use has also raised questions around sustainability as fertilizer nutrients applied but not taken up by the crops contribute to environmental ills ranging from nitrate leaching to greenhouse gas emission.

Irrigated crops account for the lion's share of the total fertilizer application compared with rain-fed crops.[6] Overall, fertilizer application has rapidly

[5] Over the last five decades, nutrient use has increased significantly in Bangladesh while total food grain production increased by a much lower rate. This shows that the input use efficiency is declining at a fast pace, posing a threat to food security which mainly affects the poor and underprivileged population.

[6] The lower use of fertilizers in rain-fed crops is attributable to several other factors besides the lower application rate and uncertainties in availability of critical inputs like water. Other factors include, for example, shrinking acreage of *aus* and lower availability of HYVs

increased in case of the irrigated crop production system. Moreover, there are different implications for the response rates of crops to fertilizer application between irrigated and rain-fed production systems. Non-irrigated crops have a lower rate of response, due mainly to low rates of fertilizer application and uncertainties in availability of critical inputs, especially water. On the other hand, response rates in the case of irrigated crops (especially rice and wheat) are also dropping, but mainly because of factors such as application of unbalanced doses of fertilizer, micronutrient deficiencies, lack of proper management, declining soil fertility, and similar deficiencies. In addition, the use of fertilizer varies significantly over different crops, with more than 75 percent of all fertilizers applied to rice.[7]

In Bangladesh, fertilizer use does not differ much by land size (Abdullah 1996; Asaduzzaman and Islam 2008), indicating that poor and marginal farmers are not using lower levels of fertilizers in their farms irrespective of relative distribution of benefits of fertilizer subsidy between large and small farmers (Table 5.2).

The gap between demand and supply of fertilizers has been increasing in recent years. Fertilizer supplies come from both domestic production and imports in Bangladesh, but the capacity to meet demand from domestic production has been steadily declining over the past two decades. The share of imports has gone up from 28 percent in 2002-2003 to 56 percent in 2008-2009. In the case of urea, Bangladesh imported only 8 percent of urea from the world market in 2002-2003, a figure which rose to nearly 50 percent in 2008-2009. In the case of Muriate of Potash (MOP), it is entirely imported. Although Bangladesh has two Diammonium Phosphate (DAP) plants, they are unable to meet the rapidly rising local demand. The total amount of fertilizer supplied to farmers thus often falls short of what is demanded in different locations.[8]

---

of *aus* compared with *aman* and *boro* HYVs. Besides, erratic pattern of rainfall during the *aus* season is another factor. Conversely, if there is excess rainfall, there is sprouting leading to lower yield. Further, there is a distinction between the yields of T-*aus* and B-*aus*. T-*aus* is more likely to be HYVs with higher yield than B-*aus*. In T-*aus,* fertilizer is used along with some water for irrigation. The government recently adopted a policy to promote rain-fed rice*, aus* and *aman*, for which the Ministry of Agriculture provided incentives to the farmers through free distribution of inputs like fertilizer and HYV seeds. The gains achieved, however, are modest.

[7] It is so because rice occupies nearly 70 percent of the total cropped area in the country. Besides, fertilizer doses for rice are higher than those for other crops.

[8] One should, however, note that the gap between demand and supply is usually reported in micro studies. The findings from such studies cannot probably be applied to the macro level or for different regions. Besides, a careful examination of the figures shows that for

Reliable estimations of fertilizer use efficiency and informal import of fertilizers are lacking in Bangladesh. However, the nutrient supply gap is at least partly filled through the use of other sources of crop nutrients such as organic manures, soil content, symbiotic and non-symbiotic natural fixation of plant nutrients to the soil. Overall, it can be surmised that most of the soils in Bangladesh are being heavily mined through continuous crop production, and the lack of proper nutrient replenishment and soil conservation measures and practices will adversely affect soil health and nutrient reserves in the long run, leading to yield reduction and desertification.

Table 5.2: Land Ownership and Fertilizer Use in Bangladesh

Land Ownership status	Urea		TSP		MOP		DAP		Total	
	N	%	N	%	N	%	N	%	N	%
Landless	580	36.7	513	32.5	459	29.1	27	1.7	1,579	100
Marginal	35.1	487	32.0	447	29.4	53	3.5	1521	534	100
Small	282	35.2	250	31.2	234	29.2	35	4.4	801	100
Medium	362	35.3	322	31.4	306	29.9	35	3.4	1025	100
Large	69	35.0	62	31.5	57	28.9	9 4.6	197	?	100

Source: Barkat, Faridi, Wadood, Sengupta, and Hoque 2010.

5.2.1 Trends and Volume of Fertilizer Use by Types

Agriculture in Bangladesh has witnessed a remarkable increase in consumption of fertilizers. From the late 1960s, the consumption of fertilizers increased dramatically, exceeding 4 million tons in 2011. It is interesting to note that although fertilizer was used as an important input even before the introduction of the Green Revolution, the level of use of fertilizers use was very low during the pre-Green Revolution period. During the period, although rice occupied more than 70 percent of the gross cropped area, the farmers hardly applied

major fertilizers like urea, TSP and MOP, the reported gaps are not significant except for MOP. It is usually seen that MOP is used less than TSP and still lesser than urea. This is consistent with the recommended dose. Further, relatively low supply of MOP may be due to its higher price compared with urea or TSP which existed during most periods. In 2010-2011, the prices of TSP and MOP were lowered by the government leading to higher availability and supply. In this respect, some explanation for Single Super Phosphate (SSP) vis-à-vis Triple Super Phosphate (TSP) is relevant. In 1997-1998, the use of SSP (which was imported and some were substandard) was banned as the farmers mistakenly opted for SSP in place of TSP without realising that, in order to gain similar yield response, three times higher doses of SSP would be needed than TSP. The limited availability of SSP is from the government-owned TSP factory which was outside the purview of the ban. The BCIC TSP Factory has since stopped the production of SSP.

any chemical fertilizers since the traditional varieties of rice grown during the time was not responsive to chemical fertilizers.

The HYVs of rice and wheat introduced as part of the Green Revolution were very responsive to increased use of fertilizers. Since then, fertilizer use in the country has been rising continuously. Since the introduction of reforms in the fertilizer sector in the early 1990s, the country has witnessed a significant increasing trend in fertilizer use. It has been observed that the rapid expansion of irrigation, spread of HYV seeds, distribution of fertilizers to the farmers at affordable prices, expansion of the fertilizer dealers' network, and improvement in fertilizer availability were the major reasons for increase in fertilizer consumption since the 1990s.

With increasing fertilizer consumption, per hectare consumption of total fertilizer in terms of nutrients also increased. The entire period since the 1970s has witnessed continuous increase in the use of fertilizers per hectare. However, per hectare use of different fertilizers indicates that the nitrogenous fertilizer is predominantly used by the farmers. The recommended balanced use of fertilizer is generally in the ratio of 4:2:1 for N, P and K respectively. In percent terms, balanced fertilizer should contain 58 percent of nitrogen, 28 percent P and 14 percent K. Thus, there seems to persist imbalances in fertilizer use in the country. The percentage of N fertilizers has been around 57 percent of the total fertilizer consumption, whereas the share of P has been 17 percent and the share of K 15 percent over the years. However, although imbalances in fertilizer use ratio persist, there has been some improvement in recent years.

5.3 Fertilizer Marketing and Distribution System in Bangladesh

The management and use of fertilizer have been the focus of fertilizer policy of Bangladesh during the past few decades. Considering the importance of application of fertilizer for raising agricultural production, much effort has been expended on designing an efficient, undistorted and non-discriminatory fertilizer distribution system in Bangladesh.

The evolution and major changes in the fertilizer marketing and distribution system are summarized in Table 5.3. Overall, the liberalization of the fertilizer sector affected the domestic market in a number of ways. There are many positive features of liberalization, but several inefficiencies also persisted in the input market. Despite the reforms especially with respect to the privatization of sale, distribution and import of fertilizers, sudden and unexpected price hikes, unbalanced use of fertilizers, adulteration of fertilizers and other problems continued to affect the efficient operation of the fertilizer market in the country. As a consequence, timely supply of

quality and required quantity of fertilizers remained as a major concern for the country's fertilizer sector. Major 'fertilizer crises' occurred on several occasions in recent years (e.g., 2005, 2007 and 2008) creating heightened public concerns regarding the functioning of the fertilizer market. In view of these developments, the government decided to introduce several direct control measures, which curtailed the flexibility of the open market system in the fertilizer market of the country.

Table 5.3: Evolution and Major Changes in Fertilizer Marketing and Distribution System in Bangladesh

Time Frame	Main features
Late 1950s	Chemical fertilizers were introduced. Fertilizer procurement, storage, distribution and retail sale were entrusted to the Department of Agriculture (DAE) under the Ministry of Agriculture.
1951	Urea fertilizer was introduced.
16 October 1961	The Bangladesh Agricultural Development Corporation (BADC) was established.
1962-1978	BADC played a vital role in fertilizer distribution. Private dealers got license to sell fertilizers in a restricted area. All dealers had to maintain registers. Urea crisis happened in 1974.
Mid 1970s	Phasing out of fertilizer subsidies.
1 December 1978-1 July 1980	The New Marketing System (NMS) widely known as Fertilizer Distribution Improvement (FDI-1) was introduced. The NMS was formally initiated first in Chittagong Division and gradually expanded to all over Bangladesh by July 1980.
1978-1983	The BADC withdrew from retail and wholesale markets at thana (upazila) levels which were the primary distribution points.
1982-1983	Licensing requirement was withdrawn and restriction on movement removed (with the exception of 8 km border zones with India).
1982-1984	Deregulation of fertilizer price took place in April 1983. Farm level prices and retail prices were decontrolled.
Mid-1980s	A competitive fertilizer market started to function and the process was almost completed by mid-1990s.
1985-1986	Wholesaling and dealership were freed from BADC.
March 1987-August 1994	FDI-2 was started concentrating less on BADC and more on strengthening the role of the private sector.
July 1987	Liberalization of fertilizer trade was started. The Transport Discount Points were established.
1988-1989	Private traders and distributors were allowed to make bulk purchases and import TSP and MP.

Continued

Continued from Table 5.3

Time Frame	Main features
1989	Urea crisis occurred. The private dealers/distributors were allowed to lift urea first time from the Urea Fertilizer Factory Limited (UFFL) since March 1989. They also lifted imported fertilizers directly from the vessels and ports.
June 1989	Commercial Credit Programme was started for the private sector dealers.
July 1990	Use of Inland Letter of Credit (ILC) started.
1990-1991	Private dealers were permitted to import all kinds of fertilizers.
1992	End of public sector role in fertilizer distribution. Subsidy was introduced on TSP and MP. Unrestricted import from the world market began.
December 1992	Completion of deregulation in fertilizer marketing.
06 December 1992	Full removal of explicit subsidy on fertilizer. The private dealers were permitted to import urea. Import prices were liberalized.
1994	Completion of privatization of fertilizer market.
December 1994-March 1995	Urea crisis (supply and distribution) was observed resulting in partial reversal of reform.
1996	Re-introduction of fertilizer subsidy.
2005-2006	Subsidy was introduced on imported fertilizer for the first time.
2005, 2007 and 2008	Urea crisis was observed.
2007	Introduction of slip system.
2008	The Dealership Policy 2008, by cancelling Upazila-based system, provision was made for appointing at least one dealer in each union.
2009	Under the new dealership policy introduced on 1 October 2009, a modified dealership system was developed by invigorating union-wise dealer appointment. Under the modified dealership system 'Farmers' Register', 'Fertilizer Distribution Card' and 'Fertilizer Distribution Register' were introduced.
2010	The 'Fertilizer Distribution Card' and 'Fertilizer Distribution Register' were abolished and open-market sale was re-introduced. Farmers could purchase urea from the sub-dealers at a price fixed by government, but non-urea fertilizers from the open market at prevailing market price.
2012	Non-urea fertilizer was highly subsidized. The price of TSP became BDT 22/kg from BDT 80/kg; MP BDT 15/kg from BDT 70/kg and DAP BDT 27/kg from BDT 90/kg.
25 August 2013	A provision was made for providing BDT 6,800 million yearly subsidies for urea. Accordingly, the price of urea was re-fixed at BDT 16/kg from BDT 20/kg.

Source: Adapted from Barkat, Faridi, Wadood, Sengupta, and Hoque 2010; Jaim and Akter 2012; Mujeri, Shahana, Chowdhury, and Haider 2013.

5.3.1 State Intervention in Fertilizer Market: 1970-1992[9]

The introduction of fertilizer in Bangladesh agriculture in the early 1960s coincided with the introduction of high-yielding seed varieties and modern irrigation equipment. The government established the Bangladesh Agricultural Development Corporation (BADC) in 1961 to procure and distribute key agricultural inputs to farmers at a time when other agricultural input marketing channels did not exist. A system was established to sell fertilizer to small retailers at fixed prices. To begin with, the BADC appointed approximately 460 wholesale dealers, including central cooperative associations which were licensed by BADC to sell fertilizer to the retailers. Approximately, 43,000 retail dealers were also licensed and were not permitted to sell beyond their respective local government or union boundaries (an average area of 12 square miles). During 1962-1978, BADC had a total monopoly on the procurement and distribution of fertilizer to the *thana* (now upazila or sub-district) level. BADC procured fertilizer from both domestic and external sources and brought it to the lowest administrative level, i.e., *thana* level. Prices were fixed at all levels and largely subsidized. Dealers were paid on the basis of distance to cover their transportation, storage, and other incidental costs, and a profit margin. In view of the inefficiencies of the old distribution system, such as the time-consuming process of the government appointing such a large number of wholesale and retail traders all over the country as well as erratic and uncertain supplies, a new modified system was introduced with a view to reducing the role of the public sector and expanding the role of the private sector. The system of procurement as well as the organization of marketing and distribution of fertilizer in these early days was heavily dependent on foreign assistance. The most dominant donor at the time was the USAID, which played the key role on advising on the new system and provided technical and financial support for the implementation of the new policy.

Under the new system called the New Marketing System (NMS), the BADC, instead of operating 423 *thana* sales centres, limited its role to 97 wholesalers strategically located in major commercial centers, which were later reduced to 75, known as Primary Distribution Points (PDPs) at different places of the country (see, Barkat, Faridi, Wadood, Sengupta, and Hoque 2010). Under the new marketing system, BADC still had the monopoly in the procurement and distribution of fertilizers to PDPs (Figure 5.2).[10] Any individual, group of

[9] This section draws on materials from Renfro (1992).

[10] M. A. Quasem, *Impact of the New System of Distribution of Fertiliser and Irrigation Machines in Bangladesh—Survey Findings* (Dhaka: Bangladesh Institute of Development Studies, 1987a). The change in the marketing system was linked with USAID financing of fertilizer import and contribution of warehouses for holding stocks of fertilizer.

farmers, or cooperative society was allowed to purchase fertilizers from any PDP after nominal registration with BADC. Dealers were no longer appointed by the government. Moreover, wholesalers and dealers were allowed to buy, sell, and transport fertilizer freely anywhere in the country, except within a five-mile border belt. In order to encourage wholesalers (discourage the retailers), a minimum quantity restriction on fertilizer (at least 3 metric tons at any lifting) to be lifted from PDPs was imposed. With the introduction of NMS, the number of traders (including seasonal operators) increased by about 50 percent over those under the Old Marketing System (OMS). Under this new system, BADC distributed fertilizer from the factories and ports to PDPs for sale to licensed private-sector wholesalers at fixed prices. The wholesale price at which the wholesalers in their turn could sell was deregulated in April 1982. The decontrol of prices was first introduced in one area on an experimental basis and price differentials between regulated and deregulated market areas showed no consistent pattern, and fertilizer supply variability and distributional efficiency of the marketing system accounted for most of the variation.[11]

Government fears that deregulation might lead to price increases by private traders by allowing traders to raise prices seemed unfounded, and prices remained close to official prices except at times of national supply scarcity. Between 1978 and 1988, there was a 35 percent increase in sales outlets to farmers in a 10-year period. USAID and IFDC (International Fertilizer Development Centre) estimated that farmers had access to an average of nine retail fertilizer dealers in their villages, and regularly bought from 2-3 dealers. Retail price deregulation signaled the true beginning of NMS. Whatever increase in fertilizer prices occurred during this period was due primarily to inflation and reduction in subsidies. This system continued up to 1987.

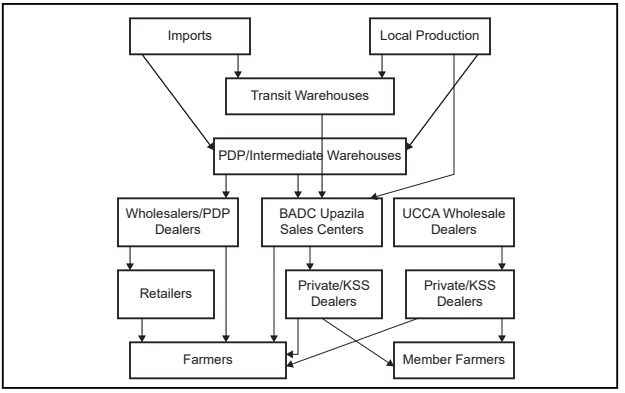
M. A. Quasem, "Supply and Distribution of Fertiliser in Bangladesh," in *Fertiliser Pricing Policy in Bangladesh*, ed. Bruce Stone (Washington, D.C.: International Food Policy Research Institute, 1987b). Retrieved from IFDC, *Third Evaluation of the New Marketing System* (Muscle Shoals, A.L.: IFDC, April 1982).

Note: UCCA = Upazila Central Cooperative Association; KSS = Krishi Samabaya Samity (Agricultural Cooperative Society). An *Upazila* is an administrative unit smaller than a district (previously called a "thana").

11 Bangladesh continued to be characterized by low spatial variability in prices. Analysis of International Fertiliser Development Center's (IFDC) monthly survey data of fertilizer prices and availability between remote and non-remote areas showed that even during periods of high demand and scarcity, spatial price differences were not significant. Remote areas were defined as less accessible by water and road infrastructure, and more distant from fertilizer sales outlets. Prices were slightly higher in remote areas because of higher transportation costs, but there was little evidence that farmers in remote areas were adversely affected by policies of deregulation.

By that time, an evaluation of this system revealed a few shortcomings such as failure of the BADC distribution system to make fertilizer available in an adequate, timely, and convenient manner (IFDC 1980; 1982). The procurement procedure by the dealers was complicated and time-consuming involving 3-5 days of a dealer's time. It did not work very well in underdeveloped areas with poor transportation and communications and suffered from limited fertilizer supplies (Jabbar 1981).

Figure 5.2: Fertilizer Distribution under the New Marketing System, 1983-1984



In January 1988, a new system of Transportation Discount Points (TDPs) was introduced along with the PDP system. The TDP concept was based on the supposition that, if fertilizer was sold by BADC from fewer wholesale outlets (i.e., six TDPs versus 46 PDPs), it would reduce the cost incurred by the BADC in transportation, handling, and overhead, allowing price discounts to private wholesalers procuring large amounts from TDPs which in turn could pass on the lower prices to the farmers in view of lower marketing margins. Private wholesalers purchasing from TDPs tended to be larger than wholesalers procuring from PDPs, and had more extensive marketing networks of smaller wholesalers and retailers. The market area served by a TDP averaged 6,000 square miles, over six times greater than the average area served by a PDP. Consequently, there were lower marketing margins and enhanced price competition (IFDC, TDP Monitoring Reports, 1988-1989). As experience with the private traders accumulated, further movement towards privatization took place.

The main argument in favor of privatization of fertilizer trade in Bangladesh was that the private sector responded quickly to market signals

and could operate more efficiently than the government bureaucracy, which was to respond to changes in supply and demand. Since fertilizer was a key agricultural input, whose effectiveness depended on its timely application on the crop, delayed actions had adverse effects on crop production. Under the government-controlled system, it was also necessary to maintain large inventories of fertilizer (three months requirement for urea, and five months for TSP and MOP) in order to minimize the risk of delays or disruption in supplies on account of the bureaucratic delays. All the above factors resulted in the cost of marketing being higher under the public compared to the private distribution system. It was also expected that competition among private traders would eliminate abnormal profits and ensure fair prices to the farmers (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010; Hossain 1996).

An important step associated with the privatization of fertilizer marketing was the decontrol of prices at the retail and farmer's level so that the traders were empowered to sell at any price they could fetch in the market. The farm-level prices and retail prices were decontrolled from 1982-1983 onwards. Along with the decontrol of price and withdrawal of restrictions on retail fertilizer trade, wholesaling and dealerships were made free from the grip of BADC. The BADC's role in fertilizer distribution was gradually confined to only 75 PDPs (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010).

The next stage in the privatization and deregulation of the fertilizer market in 1987 was to allow private dealers/wholesalers to obtain fertilizer directly from the factories at ex-factory prices at which BADC also procured its supply of fertilizer. Initially, BADC and private dealers were allowed to compete in the purchase of fertilizer from the factories. To start with, the government allowed the private distributors to procure urea directly from factories on a 50:50 quota with BADC, but BADC failed to compete with the private sector and the government decided to discontinue the quota systems. From December 1989, factories started supplying on a "first come first serve" basis (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010).

BADC began direct sales of imported fertilizers to private distributors from sea ports in 1990 instead of transporting supplies to inland sales points. This also resulted in improvements in timely supply of imported fertilizers through the private sector to farmers. From 1990-1991, the private companies/dealers were allowed to directly import all kinds of fertilizers. For some time, BADC and private companies/dealers both imported fertilizers from external sources. Later on, due to high competition with the private companies and high prices of fertilizers imported by BADC, it withdrew from importing activity (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010).

As a result of deregulation, the market structure underwent a radical transformation. The share of private distributors in the urea market steadily increased. A parallel reduction took place in ex-PDP sales by BADC from 77 percent of total national sales (all products) in March 1989 to less than 30 percent by January 1990. Under the open market mechanism in the post-1992 period, there were about 40 importers/distributors, 1,345 wholesalers, and 112,000 dealers/retailers in the fertilizer marketing network serving the farmers (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010).

The effect on farm-level fertilizer prices was positive. The competitive pressure led the distributors, dealers, and retailers to economize on costs, reduce marketing margins, and offer lower prices to farmers. Before deregulation in marketing, the cost of distribution of fertilizer by the BADC was estimated at US$25-30 per ton, while the cost of distribution of the private sector was about US$15 per ton (Ahmed 1996; Sidhu 1992). As a result, farm-level urea prices steadily declined. Farmers also received better customer services in the shape of correct weight and better bags as well as in terms of credit extended by the private wholesale distributors to dealers and retailers which in turn facilitated trade in fertilizer (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010).

5.3.2 Market Liberalization and Fertilizer Crisis, 1994-1995

Thus, a few major policy decisions were implemented by 1992-1993 such as the complete elimination of subsidy on fertilizer, and freedom of the private sector to import fertilizer with access to foreign exchange resources necessary to import fertilizer on a full-cost basis, and engage in its marketing and distribution. The deregulation in fertilizer marketing was completed in December 1992. It should be noted that the reforms in the marketing and distribution systems for fertilizer were gradual, starting in early 1970s and proceeding one step at a time; the results of each step on reform were evaluated before the next step was undertaken. When fertilizer was first introduced in the 1960s, Bangladeshi farmers were not familiar with the use of fertilizer. There was no market for fertilizers. The government had to intervene to create demand, i.e., a market, for fertilizer by directly undertaking its marketing and distribution along with extension and training of farmers in the use of fertilizers. In fact, it also undertook the training of the traders, who were not familiar with trade in fertilizers, i.e., how to deal with purchase and sale of fertilizers.

Sequencing in policy changes took place not only with respect to timing but also in different regions in the country. For example, the first major reforms were introduced in a big region/district where the market for fertilizer was large

and demand was strong, and the effects of new policies were evaluated before they were extended to other areas. Again, while the government agency BADC continued to import fertilizers from abroad as well as procure fertilizers from the government-owned factories, and carry them to the local government sales centers (thana centers), as a first step in the reform process, the private dealers were simultaneously allowed to lift fertilizers from local government centers and sell at the retail level to the farmers. In the second step, BADC brought the supplies to what were called "primary distribution points (PDPs)" which were fewer in number than the *thana* centers so that the area of operations of the private dealers expanded to a larger geographical area than was covered before; in the next stage, the state agency brought supplies to an even fewer distribution points called TDP (Transportation Distribution Points), each of them covering even a larger area than PDP, from where the private dealers were to pick up their requirements of fertilizers; any private individual trader or groups of traders combined together, could lift supplies from these regional distribution points, each of which covered a much larger area, and hence provided considerable economies of scale for traders. Further, the dealers could sell supplies so obtained anywhere and any amount in their area of operation. Thus, the geographical range of operation or coverage of the private dealers was widened in a step-wise fashion, allowing them to reap economies of scale and reduce costs.

Until 1983-1984, prices at which the dealers were to sell to the farmers were fixed by the government. In cases of shortage of supplies, market demand exceeding supply at the government-fixed prices, the market prices rose above the government-fixed prices. After 1983-1984, the retail price was no longer fixed by the government, they were allowed to sell at any price they could get in the market. In the next stage, the state withdrew completely from the marketing and distribution of fertilizers inside the country, allowing the private dealers to lift their supplies from the factory gate in the case of domestically-produced fertilizer (mostly urea) and from the import point in the case of the non-urea fertilizers. However, imports from abroad were until then left in the hands of the government agency (BADC). It was to be noted that the domestic factories which were engaged in producing urea and, in only one case, i.e., TSP were, however, state owned. The non-urea fertilizers were imported from abroad. In 1992-1993, the private traders were allowed to import directly from abroad, without the intervention of any government agency.

Therefore, the complete withdrawal of the government from the marketing and distribution of fertilizer in the domestic market as well as from imports took place over many years, i.e., starting 1977-1978 and completing in 1992-

1993—a period of 15 years or so. At each stage in the process of privatization, both private dealers and government agency operated simultaneously so that there was competition between the private dealers and the state agency (BADC). This allowed the policymakers to evaluate the relative efficiency of private and state marketing. Also, as the market for fertilizer expanded, the number of private dealers expanded, thus rapidly allowing competition among the private dealers, and allowing the state agency to reduce its scale of operations. As the retail prices were decontrolled after 1983-1984, the possibilities of price manipulation by a relatively few private sectors were sought to be reduced in the first stage, by the competition by the state agency with the private trader and later on, by an increase in the number of dealers competing from the stage of wholesale to that of retail sale. As the process of privatization proceeded, the objective was to ensure a competitive distribution system (Chowdhury and Uddin 2009).[12]

The lessons of the experience in Bangladesh are as follows: when farmers are unfamiliar with modern inputs, such as fertilizers and there is no market, the market has to be created. Secondly, the shock therapy approach versus gradual approach in the market liberalization process is much debated. Bangladesh has chosen the gradual approach. Sequencing of marketing reforms is considered critical. The phasing which is chosen is to introduce in gradual steps a system of competitive private trading at the various layers of the marketing channel, starting from grassroots retailing to wholesaling to the apex. Efficiency in marketing and distribution is enhanced as the public sector withdraws from retail trade at first, then from the wholesale and the apex. This is because retail trade is likely to be more competitive since each retailer is likely to have a small sale of operations or a small volume of sales to deal with; as one moves from the retail to the wholesale, there is likely to be a few dealers in view of the fact for each wholesaler the scale of operations is likely to be large and at the apex stage, i.e., purchase from the factory gate or the import point, there are likely

[12] See, Barkat, Faridi, Wadood, Sengupta, and Hoque (2010). Cited in Titumir and Sarwar (2006). The whole process of transition from public sector to open market mechanism was completed with the adoption of the following policies in fulfillment of the agreement signed with donor agencies like the World Bank and the Asian Development Bank and the Government of Bangladesh during 1989-1990: (i) Public-sector PDPs began closing from July 1989; (ii) Allowing direct procurement of urea, TSP, and MOP from factories and ports by the private sector from July 1989; (iii) Transferring of BADC warehouses to the private sector began from July 1989; (iv) Commercial credit programme for private-sector fertilizer dealers implemented from June 1989; (v) Allowing direct import of fertilizers by the private sector from July 1991; (vi) Closing down of public-sector fertilizer distribution system from December 1992; and (vii) Complete elimination of subsidies on TSP and MOP from December 1992.

to be even fewer dealers. Given the size of market which is small to start with, there is likely to be no room for a large number of dealers at higher stages of marketing. Under the circumstances, the degree of competition in private trade generally diminishes as one moves from the retail to the wholesale, and to the apex. This is how in Bangladesh the sequencing has been undertaken, i.e., to privatize the retail market first, then wholesale, and gradually move to the apex market.

Similarly, gradualness in the market liberalization in one geographical area at a time provides opportunity to avoid or minimize (a) the risks which might be faced in the process of implementation; or (b) side effects which might follow when reforms are into effect. By limiting the reforms within a geographical area, i.e., by experimenting in a limited area, lessons can be learned to avoid unintended side effects or difficulties in implementation so that they can be avoided when the reforms are extended over the country as a whole.

There was an important incentive or pressure behind the process of privatization and liberalization of fertilizer trade in Bangladesh. This was the "conditionality" attached by the donors to the aid for the import of fertilizers as well as for the overall agricultural-sector development assistance. Importantly, the donors and national researchers did produce empirical evidence on the relative costs incurred by the private dealers and the government agency in fertilizer marketing to demonstrate that the private sector was likely to be less costly and could avoid the bureaucratic delays.

It is to be noted that, in the process of implementation of the process of liberalization, there were transitional adjustment problems. Import liberalization was designed to reduce fertilizer prices (especially of TSP and MOP) by increasing private imports of these fertilizers. This objective was not realised as prices did not fall. Following the withdrawal of subsidies in December 1992, the prices of urea, TSP, and MOP at the source of procurement source increased by 13 percent, 35 percent, and 47 percent, respectively, during the 2nd quarter (October-December). Fertilizer sales in FY1992-1993 decreased as a consequence. During the 4th quarter (April-June), sales declined again by 14 percent due to the confusion surrounding the effective date of BCIC's new urea price, which dealers expected any time after newspaper reports in May that such a reduction was imminent.[13]

With liberalization, fertilizer distribution was opened to the wholesalers at the district levels. The majority of the wholesalers at the district level,

[13] However, economies were expected to be achieved in the import of fertilizers as the average price of TSP imported by the private sector was reported to be about US$16/metric ton lower than the price of the BADC imports and the price of private MOP imports to be lower by approximately US$11.45/metric ton.

which were licensed as traders, were linked to the political parties in power and socially influential persons, as reported by the farmers.[14] Often they were not regular dealers (did not trade in fertilizer throughout the year as they had other businesses) and were only active during the peak seasons. It was suggested that they raised prices through hoarding and syndication to make quick profit and the regular dealers followed suit.

Moreover, there were complaints by the farmers that they were often victims of fertilizer adulteration which occurred at the storage and distribution points, such as fertilizer sacks containing less than the specified amount. In addition, low-grade fertilizers imported mainly from India and China entered the market.

A severe fertilizer crisis occurred in 1994-1995 following liberalization. Throughout the period from the 1970s to 1990s, Bangladesh witnessed occasional fertilizer shortages due to the absence of coordination between relevant agencies involved in the fertilizer distribution chain or consequences of policy changes. For example, during the fall of 1984, Bangladesh experienced a severe fertilizer shortage starting the second half of 1984, with prices rising 60-100 percent above the normal level. This was primarily due to the restriction on quantity that each dealer could procure at PDPs as well as restrictions on inter-district movement.

The crisis of 1994-1995 related to the domestically-produced urea. There was a seasonal (*boro* season) shortage of fertilizer during December 1994 to March 1995. The proximate cause of the crisis was the steep rise in the urea price in the period July to December 1994, following a shortage in supply. With the introduction of irrigation and high-yield variety of seeds in the cultivation of *boro* crop, the January-March period emerged as the period of steep rise in demand for fertilizer. The rise in the price of urea in this period therefore resulted in hardship for the farmers, leading to unrest and agitation among the farmers. This led to peasant demonstrations, attempted looting of fertilizer godowns and of trains carrying urea; police had to resort to firing to restore peace, and in the process killed at least two demonstrators.[15]

This phenomenon of shortfall in fertilizer supply, steep rise in its price, and consequent fallout in respect of peasant's revolt/reaction was much analyzed at that time. The rise in the ex-factory and retail price of urea

[14] The import subsidy was introduced for the first time in 2005-2006 in the backdrop that the prices of imported fertilizers like TSP and MOP was spiky relative to that of the domestically-produced urea during the reforms period and aftermaths. See, Titumir and Sarwar (2006).

[15] As a serious fallout of the incidents, the chief of the Bangladesh Chemical Industries Corporation (BCIC) which managed the state-owned urea factories was replaced in January 1995 and in April the Industries Minister tendered his resignation.

in several preceding years was slow. This period included the years before complete decontrol of retail price in 1992-1993. The marketing margin, i.e., difference between ex-factory prices and retail prices started to increase from 1992-1993, i.e., years of market liberalization. This was more evident in the case of urea rather than in the case of TSP. While the ex-factory price of urea was unchanged during 1991-1992 and 1992-1993 followed by a small fall in 1993-1994 and a steep fall in 1994-1995, the farm-gate price registered a steep rise in 1992-1993; small fall in 1993-1994 and a very steep rise in 1994-1995. The average farm-gate prices during 1992-1993 and 1994-1995 were much higher than during the preceding years, with resulting increase in the average level of marketing margin. Thus, 1994-1995 (July to December) recorded the highest rise in farm-gate price and in the marketing margin, whereas the ex-factory price fell below the average of the preceding four years.[16] The ex-factory price was fixed by the government whereas the retail and farm gate prices were determined by the market supply and demand.

Table 5.4: Trends in Prices and Marketing Margin of Fertilizer (BDT per ton)

Year	Issue prices to traders from factory/ports		Farm gate price		Marketing margin	
	Urea	TSP	Urea	TSP	Urea	TSP
1989-1990	4,030	4,325	4,610	4,950	14.4	14.5
1990-1991	4,030	4,325	4,780	5,400	18.6	24.9
1991-1992	4,175	5,403	4,803	6,459	15.0	19.5
1992-1993	4,175	6,645	5,662	7,798	35.6	17.4
1993-1994	4,040	6,860	5,123	8,268	26.8	20.5
1994-1995 (Jul-Dec)	3,720	6,860	5,418	8,658	45.6	26.3

Source: International Fertiliser Development Centre and Directorate of Agricultural Marketing, quoted in Hossain and Dhaly 1991; and Abdullah, Hassanullah, and Shahabuddin 1995.

[16] It is to be noted that since 1984, subsidy in urea has been virtually eliminated and the subsidy on TSP and MOP was gradually reduced over time, until 1992, when the latter was also eliminated. There was an increase since 1991-1992 in the issue price of MOP and TSP which was freely imported by the private traders from 1992 onwards. This was due to increase in international prices of TSP and MOP. However, from 1992-1993, the marketing margin between import issue price and the farm-gate price was much less than in the case of urea. The ex-factory price of urea in the post-1994 period, in fact, registered s steep fall in 1994 from the level 1992-1993 or 1993-1994 whereas the marketing margin rose very sharply in 1992-1993. In the face of a steep fall in ex-factory prices in 1994, the marketing margin rose even higher with retail price being 50 percent higher than ex-factory price.

What were the reasons for this steep rise in the marketing margin in 1994-1995, resulting in steep rise in farm-gate price? Several reasons were provided for this phenomenon:[17]

- There was a fall in urea production—about 2.5 percent and a rise in exports in spite of a fall in output resulting in 15 percent fall in the availability in domestic market.
- The combined result of a fall in production and an increase in exports was a fall in stocks in urea factories. This coincided with a demand for caused by an expansion of the *boro* crop. This was a serious case of faulty assessment of the supply situation.
- BCIC under the Ministry of Industries was in charge of management of the state-owned urea factories but was not authorised to make its own estimate of demand. There was a lack of coordination between the relevant ministries. Therefore, the urea factories which were run by BCIC operated in response to the demand forecasts by the Ministry of Agriculture.

The market demand for fertilizer was seasonal, with peak and slack seasons, so that the factories could not adjust their production schedule according to varying demand because reduction in capacity utilization during slack seasons would increase the unit cost of production. To hold large stocks was expensive. The traders did not hold adequate stocks for fear of increasing inventory costs. The factories had an incentive to get rid of the surplus of production over expected domestic scales by exporting, and even more so, if domestic price fixed by the government was lower than the world price (export price). This policy, at the same time, ran the risk of shortage if there was an unexpected upsurge of demand or mistake in estimates of market demand by the Ministry of Agriculture. In fact, there was an upsurge of domestic demand due to sudden and significant reduction of ex-factory price in 1994-1995 which was not anticipated by the BCIC management. That the reduction in price would have led to an increase in demand was not taken into consideration by them; they should not have exported/depleted stocks.[18]

[17] There are varying perceptions of the causes of the crisis. It appears that a favorable international price led the government to indulge in excessive exports of urea, depleting domestic stock to only 73,000 tons on 31 October 1994-1969 percent less than 235,000 tons of stock a year back. The government did so at a time when domestic demand for fertilizer shot up to 2 million tons, as the farmers received better price. See Dowlah (2001).

[18] Anecdotal evidence about factory management as well as collective bargaining agencies (trade unions) extracting bribes from traders for their allotment of urea quotas to favored insiders instead of on "first come, first serve" basis point to the scarcity being a natural consequence of the rigidities of public sector production and of the creation of artificial

The bureaucratic process of decision-making was slow. There was no system for the coordination of the flow of information and its follow-up action by different agencies/ministries. A freely functioning market system would have caused the prices to change in response to imbalance between supply and demand. Insofar as production, as well as determination of the ex-factory price, remained in the hands of the state-owned factories, their slow bureaucratic decision-making process did not allow the adjustment of supply to demand, even if the latter was estimated correctly. Moreover, there was an information asymmetry between the state-owned factories, on the one hand, and of the traders, on the other, regarding the forecast of demand and planning of inventories, which tended to create instabilities in market supplies and prices. Thus, the market mechanism did not or could not contribute to the adjustment of supplies and prices over the seasons/years. The benefit of subsidy in the issue/ex-factory price could not be transferred to the farmers because the marketing margin did go up, and instead the traders received the benefit of subsidy by raising retail price.

The increase in marketing margin in the sales price of urea could partly be attributed to imperfections in the market, i.e., control of supplies and prices by few traders. There could be two possible reasons for the phenomenon. This would have been the case even if there was no appointment of dealers/traders by the state fertilizer factory. First, the size of the market was not big enough to allow room for a very large number of traders, each with optimum size of business operations. Second, the lack of access to finance or lack of experience could have limited the free entry of traders to domestic and import trade in fertilizer. The small importers did not have the experience in undertaking large-scale operations, which could have enabled a few large businesses to control the market. There was no way to examine this counter-factual scenario. As it happened in practice, during 1994-1995 the appointment of the dealers/wholesalers by the BCIC was not governed entirely by commercial criteria but was influenced by political considerations, which restricted the selection of dealers to a few politically-favored dealers. It was alleged that there was a new breed of "politically chosen" dealers elbowing out genuine traders, who were extracting rent through "paper sale" of fertilizer allocation (Hossain 1996).

The widespread and extremely adverse reaction to rise in fertilizer price in 1994-1995 seemed extraordinary when it was considered that the retail price of urea in 1994-1995 was not much higher than that in 1991-92, i.e., 8 percent higher and, in fact, was lower than as in 1992-1993. Two reasons

rents through public sector under pricing due to sudden and steep reduction in ex-factory prices), See Abdullah 1996, 147.

might be suggested. One, it was plausible to conclude that the farmers were getting used to rising prices of fertilizers in the earlier years as evidenced from the fact that, in spite of rising prices of both urea and TSP from 1991-1992 onwards, they were using increasing amount of fertilizers due to profitability of fertilizer. The rising prices of fertilizer were absorbed even though there was a sharp rise in fertilizer/rice price ratio for both urea and TSP in 1991-1992. Second, the years 1992-1993 or 1993-1994 preceding the crisis year 1994-1995 were not characterized by shortage in the supply in relation to demand. The availability of fertilizer in adequate quantity at the right time was not a problem in those years. It became a problem in 1994-1995. There was yet another reason for the extraordinary reaction of the farmers in 1994-1995. The steep reduction in issue price in 1994-1995 was widely publicized by the government and the farmers naturally expected that the retail prices would reflect this reduction in ex-factory price and would fall correspondingly. Rather than declining, the retail price rose above the level of the 1993-1994 price. This created a serious disappointment among the farmers who felt a sense of betrayal by the middlemen/traders who were collecting such high rents.[19] This happened in the context of a strong demand for fertilizer further stimulated by a significant drop in urea/rice price ratio which increased the profitability of the use of urea in rice production.

Table 5.5: Trend in Fertilizer-Rice Price Ratio, 1977-1994

Year	Farm level price (BDT/kg)			Fertilizer/rice price ratio	
	Un-milled rice	Urea	TSP	Urea	TSP
1973-1974	1.74	0.80	0.53	0.46	0.30
1977-1978	2.19	1.60	1.28	0.73	0.58
1984-1985	4.72	4.58	4.67	0.97	0.99
1989-1990	5.84	4.65	5.0	0.80	0.86
1990-1991	6.33	4.73	5.32	0.75	0.84
1991-1992	6.64	5.0	6.25	0.75	0.94
1992-1993	5.70	5.38	7.71	0.94	1.35
1993-1994	4.95	4.91	8.17	0.99	1.65
1994-1995 (Jul-Dec)	7.04	5.41	8.66	0.77	1.23

Source: Hossain (1987); and Abdullah, Hassanullah, and Shahabuddin (1995).

[19] The farmers could have received the benefit of subsidy if supply constraint did not exist and/or if a competitive marketing and distribution system prevailed.

5.3.3 Policy Reversal: Reintroduction of Controls and Unresolved Inefficiencies

The urea crisis of 1994-1995 (July to December 1994) marked a landmark in the evolution of the fertilizer policy in the country; it heralded the end of free market in fertilizer distribution and pricing. In the aftermath of the crisis, the government, in consultation with the Bangladesh Fertilizer Association (BFA), decided to change the system of appointment of the fertilizer dealers in 1995. The responsibility of dealer selection/scrutiny at both the district/*thana* (upazila) levels was handed to the District Fertilizer and Seed Monitoring Committee. This Committee was headed by Deputy Commissioners, i.e., the district administrators (general administrators). The BFA, and the local Chambers of Commerce and Industries had their representation in the Selection Committees. A total of about 4,000 dealers were appointed to enable easy access of the farmers to fertilizers and also to serve areas where there were previously no dealers. Later, the dealer network was extended to the *thana* level and the number of fertilizer dealers was limited to a maximum of 10 in each *thana*. The number of dealers/wholesalers appointed in the post-crisis period was considerably higher than the number before the crisis even though there were very large number of retailers in previous period.

The government also introduced a buffer or public intervention stock system in 1995, mainly in the northwest, as well as parts of southwest of Bangladesh.[20] This was done to ensure availability of urea in these areas even during the dry season, when regular transport of urea was not possible due to inability of the railway to ensure ferry crossing because of shallow water levels. An additional reason for buffer stock center was that many of the districts in the northwest were remote from domestic factories as well as from ports. In 1995, BCIC established and operated buffer stock from 15 locations, a figure which increased to 29 by 1996, containing about 500,000 MT of buffer stock of urea in 21 districts.

Like urea, TSP and SSP fertilizer produced by BCIC were also distributed and marketed through dealers who could lift urea as well as TSP and SSP

[20] See Barkat, Faridi, Wadood, Sengupta, and Hoque 2010. The concept of buffer stock was developed at least 20 years back. In 1990, two committees appointed by the government recommended that buffer stock of fertilizer be maintained. The Low Cost Intervention Study (1990) of FDI-II also made the same recommendation. The urea maintained in the buffer stock was normally offered for sale during January to March which was the highest peak period of demand mainly for the *boro* crop. During this period, about 52 percent of the annual demand of urea was consumed. To meet this demand, ex-factory sales volume needed to be maintained at a minimum of 11,000 mt per day. Surveys at different times corroborated that the adequate availability of urea, especially during the *rabi-boro* peak season, ensured that the urea price 'remained normal and within the purchasing capacity of the farmers'.

from BCIC factory gates, or purchase urea from buffer stock centers. The government had control over sale/issue prices (ex-factory price or buffer stock price) of urea, as well as of TSP and SSP produced by BCIC, but not over the retail prices. The sale price of urea at the BCIC factory gate and sale price of urea in buffer stock were fixed by the government. The buffer stock sales price was fixed in July 1997 at BDT 265 per 50 kg bag, which approximately covered BCIC's cost of distribution (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010).

During the years 2007 and 2008, there was a shortage of fertilizer and spike in prices. In the first instance it occurred in the northern region while in latter year it was in the country as a whole. However, its impact in both cases was felt more acutely in the northern region.[21] The farmers blocked highways demanding additional supply of the urea fertilizer. The 2007 crisis was due to disruption in the transport network, and the 2008 crisis was partly attributed by observers to the introduction in 2007 of the "slip system" under which the "allotment slips" were issued to the farmers by the chairman and members of the Union Parishads and sub-assistant agricultural officers (SAAOs) in their respective unions, specifying the amount of fertilizer each farmer could receive. The sale system was controlled; for example, urea was sold in 4-5 days a week in the presence of SAAOs. There were as many as 4,500 dealers at the upazila level, whereas the government appointed additional sub-dealers, i.e., three sub-dealers in each union. Thus, the fertilizer shortage during 2006-2008 in Bangladesh were largely "management problems". For example, at times there were large quantities of fertilizer (urea in particular) stocked in different fertilizer warehouses and godowns at different places of the country, while shortages occurred in some other areas. There were inordinate delays in approving the fertilizer sale by the respective upazila executive officers (UNOs) and union agricultural officers (UAOs); and there was often considerable delay and sometimes harassment involved in farmers obtaining "recommendation slip" to buy fertilizers from UP members, chairman and block supervisors. The supply of fertilizer to the dealers was sometimes less than the approved allotment to the dealers/farmers. Moreover, limiting the area to Union Parishads for fertilizer sale by the listed fertilizer dealers caused inflexibility.

All these factors caused inflexibilities and bottlenecks in the distribution system.[22] In 2008, the dealership policy was again modified in that the

[21] Unforeseen factory shutdown could also lead to a disruption in supply and further on to a crisis. Also, delays in obtaining imports on occasions led to shortages.

[22] The farmers had to show the slips to the dealers. In this system, some farmers managed to get more fertilizers by collecting more slips and some others were deprived of getting required amount of fertilizers making the distribution more discriminatory. This aroused indignation by the majority of farmers and, as a result, the system was abolished in 2008.

dealers were appointed not on the basis of upazila but on the basis of union, which was the lowest local administrative unit, so that at least one dealer was appointed for each union. Priority was to be given to the selection of new union/municipality dealers from among the residents of the respective unions/municipalities. The union was made the focal point for fertilizer distribution in 2008. Moreover, fertilizer could be sold by opening fertilizer sales centers and appointing one sales representative for each block/municipal ward in the area specified for the dealer. The appointment for dealership at the level of unions/municipalities was first scrutinized by the Upazila Fertilizer and Seed Monitoring Committee, and then by the District Fertilizer and Seed Monitoring Committee; subsequently on the basis of recommendation by the latter, BCIC finally appointed the dealers.

The District Fertilizer and Seed Monitoring Committees was to monitor the overall fertilizer situation such as (i) the supply of urea and other fertilizers in each district, including their procurement and storage; (ii) the selection of fertilizer dealers and the evaluation of the dealers' performances; and (iii) movements in prices. This was intended to help coordinate the policies and actions by multiple agencies involved in managing production, imports, and distribution of fertilizer. Fertilizer produced in the factory as well as imported were supplied directly to the buffer godown. Fertilizer was to be distributed from the factory/buffer godown nearest to any district. Equal amounts of fertilizers were to be allotted to every dealer depending on the actual timeline-based demand for such fertilizers.

In early 2009, a further modification was made in the system of fertilizer distribution. The Sub-Assistant Associated Officers (SAAOs) conducted household surveys and prepared a "Farmers' Register" containing data of each household, including crops they cultivated as well as areas under different crops in different seasons. Each household was then provided with a printed "Fertilizer Distribution Card" with records of their crops and cultivated area by season. Fertilizer was distributed based on the information recorded in the card, along with the recommendations of the SAAOs. On the day of fertilizer distribution, each farmer had to go to dealers' shops, where an SAAO checked the Fertilizer Distribution Card and the Fertilizer Distribution Register with the dealer, and gave each farmer the specified allotment of fertilizers on the spot. This therefore meant that farmers had no opportunity to purchase fertilizer in excess of their requirements and the sales of fertilizer outside the union were prohibited. The District Fertilizer and Seed Monitoring Committee (DFSMC) was assigned with determining the "maximum" indicative retail price of fertilizers for each district in early 2009, so that farmers were able to get fertilizer at prices indicated by the government.

However, farmers expressed dissatisfaction with this system on two counts: (i) the process was time-consuming; and (ii) farmers needed cash to purchase fertilizer on the spot which they did not always have, and under this system they could not buy on credit. Farmers usually preferred to purchase fertilizers from the open market. Moreover, it was found that, due to the controlled sale of fertilizers, all dealers could not sell their previous consignment, and therefore had to forgo some of their current allotments (Barkat, Faridi, Wadood, Sengupta, and Hoque 2010) In 2009, a large amount of imported non-urea fertilizers was found to remain unsold in the country. Early in 2009, fertilizer distribution through the farmer's card system was abolished and free sale of fertilizer in the market was restored. The salient new features of the fertilizer policy at the end of 2009 were as follows:

- The retail sellers were to be appointed at the union level by a union selection committee headed by the Union Parishad (UP) Chairman with six committee members, out of which four were to be nominated by the local MP. As regards the mechanism in selecting retail sellers, an ID card (identification card) of the fertilizer retail dealership was instituted. The Upazila Agriculture Office (UZAO) was to provide the ID cards to the retailers for the sale of fertilizer. The involvement of the political representative, i.e., members of parliament, in the process of the selection of retailers resulted in politicization of the system.
- The local retailers, with their ID cards, were allowed to purchase fertilizer from the authorized dealer, who acted as wholesaler in effect and sell it to the farmers. However, in case of insufficient stock of fertilizer with the dealer, the retailer could purchase fertilizer from any dealer in the upazila using his own valid ID card.
- The District Fertilizer and Seed Monitoring Committee (DFSMC) was to monitor the overall fertilizer situation. It was reorganized to include all the parliament members (MPs) of a district as advisers to the DFSMC. Besides, the MPs in an upazila were advisers to respective UFCMC.
- The government was to set "indicative prices" for all types of fertilizer sold at the retail level.

As seen in the foregoing analysis, the reaction to the 1995 fertilizer crisis which was marked by shortage and high prices of urea was to reintroduce the government's detailed direct control over the marketing

and distribution of fertilizer.[23] In fact, the control or regulation in some ways was more extensive than in the pre-liberalization period, i.e., 1978-1993. As seen before, a whole range and types of regulations were tried from 1996 onwards, involving the appointment of dealers for domestically produced and imported fertilizers, regulating farmers' access to purchase of fertilizers and prices at which dealers could sell. The process of marketing and distribution of fertilizer as it stood in 2009 changed the system of appointment of sellers of fertilizer, i.e., wholesalers/dealers at the union level, by the upazila committee consisting of officials, their appointment by the union level committee consisting of local government chief executive and four members of parliament from the local area.

Secondly, the district and upazila fertilizer and seed monitoring committees who were monitors of the fertilizer supply and price developments by 2009 had the members of parliament in the district and upazila respectively as their advisers. Thus, the government control over the entire process of supply as well as marketing and distribution was not only greatly tightened in 2009, but also by including the role of the members of parliament in the process was politicized. The system prevailing in 2010 at the end of a long period of experimentation and policy changes continued to be plagued by a variety of problems as follows:

i. Inaccurate assessment of the demand for fertilizer as well as unanticipated disruptions in supply resulted in frequent imbalance between supply and demand putting upward pressure on prices. Frequently, the estimation of expected production on the part of BCIC, i.e., government-owned and managed fertilizer factories was faulty. The fertilizer factories were old and often suffered from a lack of replacement or modernization of equipment, with the result that frequent interruptions occurred in the production of urea. Further, there were interruptions in the supply of gas for fertilizer production, adding another reason for unpredictable shortfalls in domestic production and supply of urea, which was the most widely, used fertilizer in Bangladesh. There were also delays in procurement and distribution of imports. The process of deciding on the quantity of imports and allocating them to BFA (Bangladesh Fertilizer

[23] In the light of subsequent policy changes, it was reasonable to argue that the market liberalization policy followed in the preceding years was not so much a matter of conviction on the part of the policymakers as the result of pressure by donors, who were heavily involved in financing the agricultural development expenditures, including the financing of imports of agricultural inputs and technical assistance for improvement of the marketing and distribution of inputs.

Association) and to their constituent members/importers involved delays.[24] This was compounded by inadequate and poor storage facilities. In some districts, fertilizers were only sold once a week so farmers had to queue for days, losing valuable work hours and often failing to get their allocation despite the wait, meaning they then had to buy fertilizer at high prices from private sources. BCIC's operating practices were bureaucratic and consisted of a command-and-control culture, not conducive to business behavior.[25] On occasions, there were illegal exports of fertilizer to the neighboring countries, i.e., India and Myanmar, where prices might be higher. In mid-2000s, urea fertilizer was priced at 85 percent higher in Myanmar and 10-15 percent higher in the neighboring Indian provinces.

ii. There was no effective mechanism of coordination among urea factories, importers, dealers, extension staff, and operators of the intermediate fertilizer storage points, as there was no clearly designated body responsible for coordination. The Market Monitoring Information System (MMIS) under the Ministry of Agriculture (MOA) only collected and updated the fertilizer distribution data. The National Fertilizer Distribution Coordination Committee (NFDCC) usually issued allotment for non-urea imported fertilizers. These fertilizers were mainly imported by private sector and a small portion by BADC. Unlike the urea fertilizer which was dealt by the Ministry of Industries, Ministry of Agriculture dealt with non-urea fertilizers. The private-sector importers were supposed to sell/distribute through the BCIC-appointed dealers, even though in reality they sold to other agents as well. The same BCIC dealers were to lift the non-urea fertilizers from factory gate of the domestic producers of TSP. There was a limited number of BADC-appointed dealers across the country who procured non-urea fertilizers exclusively from BADC godowns. Farmers were allowed to buy non-urea fertilizers from BCIC and BADC dealers and retailers. The smooth or rapid adjustment of supply to demand, even when supply was available country-wide, was hindered by the requirement that dealers could sell only within the designated area

[24] Usually, delays take place in the planning and implementation of imports due to bureaucratic processes in relation to finance and release of funds for imports. See, K. A. Toufique, *Proving the Effectiveness, Efficiency, and Sustainability of Fertiliser Use in Bangladesh*, Dhaka: South Asia Network of Economic Research Institutes, June 2012, p. 11.

[25] The procedure for the dealers to procure their supplies from the factories or from warehouses of BCIC and BADC was complicated and time consuming; it frequently required 3 to 5 days for a dealer to get the delivery of individual consignments.

such as an upazila, and were not allowed to sell in other areas in case there was an excess supply in one upazila. Again, in the same district, fertilizers were sold to the farmers once a week and the farmers had to queue up for obtaining their supplies. There were occasions when having failed to obtain from the dealers they had to buy fertilizers from private sources (not officially appointed dealers) at higher prices.[26]

iii. The same fertilizer type was distributed for all farmers irrespective of the crops grown and the soil type due to the lack of information on the part of the farmers. A few specific features of the urea fertilizer were noted: intensive management requirements of urea as well as its handling and storage characteristics tended to create "spikes" in demand or, conversely, narrow windows of opportunity for efficient and effective use.[27] Since production facilities were highly concentrated on the eastern side of the country and major consumption areas were located in western Bangladesh, the vagaries of river transportation in Bangladesh acted as a constraint on the system in adequately delivering urea to the domestic market at the right time. If high price and shortage of fertilizer in relation to demand occurred during February-April months, i.e., period of *boro* crop, it had an immediate and direct impact on the production of the most important crop and hence on farmer's income.

iv. Politicization of the procurement and distribution processes involving interference by influential private persons and public sector employees created distortions in the market. Civil administrators such as District Commissioners reported spending over half their work in fertilizer distribution at the expense of usual activities. Moreover, the agricultural extension service with its heavy involvement in the administration of fertilizer distribution was left with little time to do their normal work of providing farmers with technical advice.

---

[26] See Barkat, Faridi, Wadood, Sengupta, and Hoque (2010). It has been suggested that a unit should be established to: design a rational fertilizer pricing policy; monitor fertilizer price, supply, and demand situations in the market; keep information on market behavior at import levels and on distribution network; strengthen market information and monitoring; and ensure price stability through maintenance of buffer stock.

[27] Since the domestic urea market was a 100-percent bagged market, the lag between bulk availability, bagged availability, and market delivery was a severe constraint. Available data indicate that slightly over 50 percent of the retail purchase of urea was in loose form and as a result, the dealers were required to carry 50 kg bags to the retail stage of the distribution channel.

There were two issues which have been constant in the course of the debates/discussions over the years on fertilizer marketing and distribution system. One is the occurrence of periodic shortages and high prices of varying intensity in the post-1995 period, i.e., in 2004, 2006, and 2008. In the 2006 *boro* season, the shortage of fertilizer was serious enough to cause demonstrations by farmers in scattered locations, and they were widely reported in the daily newspapers, even though the shortage was neither as widespread nor serious as in 1994-1995. The causes of these crises remained disputed. The predominant view among the government policymakers was that these incidents were due to market failures, i.e., the manipulation of supplies and prices by few traders/dealers. There were others outside the government who held that these incidents to be mainly state failures, i.e., a lack of coordination among different government agencies involved in estimating demand, on the one hand, and providing supplies, especially managing domestic fertilizer factories as well as programming of imports of right amount at the right time, on the other.

The second issue relates to fertilizer being sold at higher than prices fixed by the government at retail level whenever fixed or indicated by the government. The existence of high scarcity margins or rents earned by the dealers meant that the full benefit of the subsidies was not passed on to the farmers when the level of scarcity margin absorbed the entire subsidy. In 2009, the prices for urea actually paid by the farmers in most cases were reported to be 50 percent higher than official prices. It was unclear whether the excess of prices at the farmers' level was due to scarcity margins resulting from the imbalance between supply and demand, i.e., supply shortfalls or to the manipulation of the supplies or shortages created by the oligopolistic dealers, or collusion among dealers. In view of the uncertainty in supplies, including production and imports, one can argue that there was a scope for speculation by the dealers. For example, the dealers might delay lifting fertilizer from the warehouses (BCIC and BADC) in anticipation of insufficient demand—leading to shortages in the market. In support of the hypothesis of oligopolistic characteristics of the fertilizer trade, it was stated that, since dealers were appointed by the BADC/BCIC, i.e., the government institutions, there was no free entry to the fertilizer trade on the part of the dealers. It was also suggested that the dealers (who were large traders with big warehouses and investment of their own) were influential persons and frequently linked to the political party in power, and thus could maintain their entrenched position in trade. To make matters worse, there were instances where many of the selected dealers were not professional traders without any experience in fertilizer

trade, and they were active only in the peak seasons. The prospects of high profits at times of shortage attracted such persons to the dealership in the distribution of fertilizers. They had no long-term interest in trade and hence in holding stocks to meet seasonal variations in demand. The debate continued unabated between the protagonists of two views in the absence of systematic analysis of the structure of fertilizer trade, comprising factories, importers, dealers, and retailers, etc. There was no analysis of the presence or otherwise of monopolistic elements/market manipulation by collusion among the traders, including the extent to which prices at various stages of the marketing chain related to each other.[28]

Did the small/marginal farmers pay more for fertilizer than large farmers? There was no conclusive evidence on this. One empirical study in 2010 suggested that the small and marginal farmers paid, in the case of urea, higher prices than the medium and large farmers; no evidence was collected on the non-urea prices. But the price differences were not significant; for example, average price paid by the marginal farmers was BDT 12.59 per kilogram as against BDT 12.54 and BDT 12.43 per kilogram paid respectively by the medium and large farmers.[29] However, it was suggested that non-price factors add to the cost of fertilizers to the farmers; the proportionate burden was heavier for the poor since they were less able to bear the burden. The monetized value of the non-price factors such as their opportunity costs of having to go to the dealer on the specific days, as well as waiting for a long time to get fertilizer, for example, imposed a heavier burden on them in terms of per unit cost.

---

[28] See Mudahar and Ahmed (2010). No reliable assessment of the complaints about market manipulation by traders and consequent imperfections in the market was made. The credibility of frequent complaints about the operation of the market including their lack of competitiveness, and their causes and extent had not been subject of serious investigation. The government did not and does not have as yet an effective monitoring and regulatory mechanism. At the same time, the farmers were both credit- and storage-constrained, and therefore could not take advantage of low prices in the market for use in the later period. Hence, they could not hold stocks to be able to adjust the use of fertilizer to seasonal variations in requirement.

[29] Barkat, Faridi, Wadood, Sengupta, and Hoque (2010). The integration of the fertilizer market in Bangladesh was hampered by two important factors: one that was already mentioned was the restriction on the dealers to operate within designated areas, i.e., upazila or union where they are assigned; second factor was the high transport costs. The government set the price uniformly across the country but the distance between the warehouses from where the dealers acquired fertilizers and the locations where they sold fertilizers varied. The commission granted to the dealers was adjusted accordingly but whether it was adjusted adequately is not known. The transport costs for the dealers in the outlying areas of Bangladesh from the center constituted 76 percent to 82 percent of the marketing costs. See Toufique (2012).

From the early years, two particular aspects of the fertilizer market were notable, and have been increasing in importance in recent years. One was the quality of fertilizers and the second was the closely related phenomenon of the adulteration of fertilizers. Imports from China and India were reputed to be low grade and highly adulterated, with the extent of adulteration ranging from 25 to 50 percent. The adulteration took place as well in the locally-produced fertilizer, i.e., such elements as cadmium and lead were found in high proportion. The use of adulterated fertilizers was believed to cause a rapid depletion of nutrients from the soil and reduce crop yields. This was indeed a very pronounced case of market failure, i.e., asymmetry of information available to the buyers, on the one hand, and sellers, on the other, calling for government intervention. There was no effective mechanism for quality control and consumer protection in particular. The Ministry of Agriculture did not and even today does not have the infrastructure, resources and technical capacity to undertake such a task (Toufique 2012).

5.4 Evolution of Fertilizer Pricing and Subsidy Policy: Magnitude and Rationale of Subsidy

The evolution of the policy of subsidy for fertilizer was closely associated with the evolution of the system of marketing and distribution of fertilizer. The fertilizer market started with a state monopoly in trade and ended up in gradual stages in the almost total privatization by 1992-1993, excepting that the government continued to exercise varying degrees and types of regulations including the appointment of the dealers at both wholesale and retail levels. The liberalization process was reversed in 1994-1995 in the wake of shortage in the market supply and a spike in prices, and was followed by a revival of state intervention in the fertilizer marketing and distribution. In the same vein, the provision of the subsidy first went down and up again. A distinction may be made between the economic subsidy on the one hand, i.e., the extent to which the retail price at the farmer's level was below import parity price, defined as import price plus the cost of transport and distribution to the level of the farmer, and on the other, on the budgetary/nominal subsidy defined as the excess of procurement cost of the Bangladesh Agricultural Development Corporation (BADC) of the private dealers plus the distribution cost over the sales price.[30] Table 5.6 shows how

[30] See Barkat, Faridi, Wadood, Sengupta, and Hoque (2010). In the case of urea fertilizer in the early years when most imports were aid financed, the cost of aid-finance imports was differently estimated; it was higher than the border price, because the aid-imports were tied to source and were not competitively procured in the world market. When BADC in the early years procured fertilizers from both domestic factories as well as from imports, the excess of its cost which was then an average of (a) import cost and (b) the purchase price

both the rates of budgetary subsidies and economic subsidies have changed over the years. It is important to emphasize that the domestic cost out of production of urea included subsidy to the price of gas which was the raw material for the production of fertilizer. The rate of nominal (budgetary) subsidy for all fertilizers varied between 67 percent and 43 percent during the years 1970 to 1980, and between 33 percent and 12 percent during 1980 and 1990. The rate of economic subsidy varied between 74 percent to 41 percent and 39 percent to 10 percent during the same periods, as seen in Table 5.6. The domestic wholesale price of urea was considerably below the import price and generally above the export parity price, i.e., 32-50 percent below import parity price during 1970s and 1980s and 50 percent below the export parity price during 1990-91 and 2009-2010.[31]

---

from the domestic factories plus (c) the distribution cost up to the farmers/traders over its sales price was the estimated budgetary subsidy. In the case of non-urea fertilizers which were imported, an excess of import cost plus distribution cost over sales price was the budgetary subsidy. In 2009, the salient features of the system and method of payment and allotment of subsidy (which was introduced in 1996) for imports of TSP, DAP, and MOP fertilizers were as follows: import of TSP, DAP, and MOP of specific quality as per annual demand and in coordination with the Bangladesh Fertiliser Association (BFA); subsidy to be given only when the amounts of imported TSP, DAP, and MOP were equivalent to their demands estimated by the government; and subsidy was to be paid for each fertilizer by type and source of fertilizers; selling price of fertilizers was to be determined by incorporating 15 percent subsidy with total import value; release of the subsidy money on the basis of documents evidencing amounts of fertilizer sold by the importer and lifted by the dealers. The subsidy in the case of urea, in fact, did have two elements which determined the ex-factory price. The first element is the subsidised gas price which is the raw material for the production of urea. The gas price paid by the urea factories was less than the export price of gas. Therefore, the cost of production of urea was already subsidised to the extent that gas price was less than the market price. The second element of subsidy was the excess of the domestic cost of production (what is already subsidised) over the ex-factory price at which urea was supplied to the purchasers, including both BADC and private dealers. To add to the complexity of the problem was the fact that the different urea factories widely differed in their efficiency and costs of production. The subsidy was offered to cover the costs of the most inefficient factory. It rewarded the inefficient factories because the higher cost factories got higher subsidies since the subsidy was provided to compensate for the excess of the cost of production of a factory over the ex-factory price fixed by the government. Therefore, the system provided incentive for increasing inefficiency. While some factories produced 1 ton of urea for 30 million cubic feet of gas, others used 50-59 million cubic feet for the same output. In addition, while gas consumption in fertilizer production was rising at 3 percent per year, the corresponding urea output for sales was increasing at the rate of 2.7 percent per year, indicating an increasing inefficiency in the production of fertilizer.

31 Including the subsidy to the gas price (in the case of urea) and excluding the marketing and distribution costs, the excess of the purchase price of fertilizer over the sales price (at the import or factory gate) in the estimation of economic subsidy, the economic subsidy was estimated at BDT 57.5 billion ($839 million) whereas the budgetary subsidy was BDT 32.0 billion ($872 million) in 2009. Mudaha and Ahmed 2010.

Table 5.6: Nominal and Economic Fertilizer Subsidies, 1970-1990

Bangladesh FY	BADC nominal procurement cost* (Million BDT)	Import (border) cost⊕ (Million BDT)	Total BADC distribution cost (Million BDT)	Total sales revenue⊗ (Million BDT)	Total nominal subsidy∅ (Million BDT)	Nominal unit subsidy (BDT/MT)	Rate of nominal subsidy** (%)	Total economic subsidyθ (Million BDT)	Economic unit subsidy∂ (BDT/MT)	Rate of economic subsidy** (%)
1970	120	75	38	66	92	326	58	46	164	41
1971	129	106	50	73	107	346	60	83	268	53
1972	119	167	57	58	118	476	67	166	670	74
1973	270	291	96	176	190	486	52	211	541	55
1974	362	732	103	263	202	523	43	572	1,482	69
1975	718	738	116	333	501	1,762	60	521	1,835	61
1976	940	1,321	269	531	678	1,457	56	1,058	2,276	67
1977	1,166	1,130	260	728	697	1,338	49	661	1,270	48
1978	1,837	1,714	335	1,009	1,163	1,590	54	1,040	1,423	51
1979	2,142	2,088	336	1,209	1,269	1,704	51	1,215	1,632	50
1980	2,744	2,934	464	1,728	1,479	1,736	46	1,670	1,960	49
1981	2,773	3,079	542	2,221	1,094	1,251	33	1,401	1,601	39
1982	2,986	3,095	649	2,763	872	1,050	24	981	1,182	26
1983	3,645	3,650	931	3,478	1,097	1,134	24	1,102	1,139	24

Continued

Continued from Table 5.6

Bangladesh FY	BADC nominal procurement cost* (Million BDT)	Import (border) cost⊕ (Million BDT)	Total BADC distribution cost (Million BDT)	Total sales revenue⊗ (Million BDT)	Total nominal subsidy∅ (Million BDT)	Nominal unit subsidy (BDT/MT)	Rate of nominal subsidy** (%)	Total economic subsidyθ (Million BDT)	Economic unit subsidy∂ (BDT/MT)	Rate of economic subsidy** (%)
1984	4,788	4,532	943	4,123	1,608	1,424	28	1,352	1,197	25
1985	5,386	5,041	945	5,568	763	606	12	418	332	7
1986	4,986	4,556	1,265	5,241	1,010	874	16	580	502	10
1987	5,312	5,043	1,026	6,000	338	256	5	69	52	1
1988	6,910	7,025	1,156	6,909	1,158	765	14	1,272	840	16
1989	7,540	7,249	1,168	7,070	1,638	1,059	19	1,347	871	16
1990	5,692	4,722	942	4,464	2,170	2,228	33	1,200	1,233	21

* BADC procurement cost = purchase price x quantity procured.

⊕ Total import cost = border price x quantity procured.

⊗ Total sales revenue = BADC sales prices x quantity sold.

∅ Total nominal subsidy = BADC procurement cost + distribution cost – sales revenue.

θ Total economic subsidy = import cost + distribution cost – sales revenue.

∂ Unit subsidy = total subsidy ¸ total quantity sold.

** Rate of subsidy = total subsidy ¸ (total procurement or import cost + distribution cost) x 100.

Source: Renfro (1992).

The subsidy was abolished in 1991-1992, and it was reintroduced in 1996, when the amount was BDT 1 billion. Since then, there had been an increase in the amount of subsidy; the significant acceleration took place starting 2004-2005, as seen in Table 5.7.

The rationale for subsidy evolved/changed over the years. In 1973, the official policy in favor of input subsidy including that for fertilizer was stated as follows (Islam 1977). As a new technology, it constituted a radical departure from traditional practices. Even though it was profitable, there was a period of experimentation, education, and training required of the farmers for the use of a new input. During the learning period, returns were lower than potential yield. Second, there were always uncertainties relating to the yield of a new input like fertilizer which added to the risks of low yield; they arise from fluctuations in weather, particular such as floods and droughts. In addition, farmers were uncertain about the impact of fertilizer use on soil nutrient.

Table 5.7: Fertilizer Budgetary Subsidy during 1996-2009

Year	(BDT billion)
1996-1997	1.0
2001-2002	1.0
2002-2003	2.0
2003-2004	3.0
2004-2005	6.0
2005-2006	12.0
2006-2007	15.4
2007-2008	22.5
2008-2009	57.9
2009-2010	49.5

Source: Mujeri and Shahabuddin 2012.

The possibility of high profits due to the subsidized price of fertilizer was deemed to overcome or offset the farmers' perception of high risks arising from a variety of above-mentioned factors. Thirdly, administrative failures relating to the procurement and distribution of inputs such as fertilizer in right time, in right quality and quantity added to further risks of its adoption. The presence of all of the above factors enhanced the risks of adopting new methods. Therefore, the prospects of very substantial returns

were necessary in order to offset the risks and uncertainties and probability of low yield to induce farmers to adopt a new and unfamiliar input such as fertilizer.

The next important argument advanced was the imperfection in the rural credit market, constraining the access of the farmers, especially the small farmers, to credit. During the 1970s and 1980s, fertilizer constituted 30 percent of the material cost of all crops and over 50 percent of the transplanted *aman* group in early 1980s. Fourteen percent of the farmers' received institutional credit in 1980-1981 and 11 percent in 1981-1982 (Osmani and Quasem 1985). Credit constraints affecting farmers' use of fertilizer had several aspects. Fertilizer-intensive production often had high cash requirements relative to net farm income, so that farmers had difficulty in raising cash to pay for fertilizer. Most farming was seasonal, often with one growing period in the early years, so that resources invested in fertilizer were tied up for significant amount of time. Many farmers had limited collateral to secure loan; property rights on land were poorly defined, hampering its use as collateral; contract enforcement was difficult and administrative costs for small loans were high.[32] Moreover, an increasing proportion of such loans went to the large farmers. The same farmers had to borrow at exorbitant rates of interest; they were frequently obliged to cut down essential consumption at times in order to buy fertilizer. Subsidy under the circumstances was a way of offsetting the high cost of credit.

Moreover, a high priority was attached to the increase in food production; heavy reliance on food imports often ran the risk of having to pay high food prices in the world market, not to speak of ban or restrictions on food

[32] See Dorward (2009). Credit was, therefore, long recognised as a priority to support input purchases and agricultural intensification (see, for example, Feder et al. 1985) and state provision of subsidized seasonal credit services was a significant part of the bundle of subsidized services, along with input provision, in successful green revolutions. Severe (and justifiable) criticism of agricultural credit programs as fiscally unsustainable (with a large subsidy component and major repayment problems), and regressive (with the majority of loans going to well-connected, wealthy borrowers and limited benefits to poor households) led to their demise. The abolition of these programs had not, however, led to their replacement by private sector and micro-finance services for staple food crop production, although there had been and continued to be successful models for delivery of seasonal finance to non-staple producers (where higher value crops gave limited numbers of buyer's incentives to invest in smallholder production). The absence of complementary financial services allowing farmers to access credit to finance the significant costs of purchasing fertilizer meant that only if subsidies led to sufficiently large reductions in fertilizer prices, this leads to increased access to fertilizers by poorer farmers. If subsidies led to smaller reductions in fertilizer prices which did not make them affordable by poorer farmers, then they were likely to mainly benefit less poor farmers whose use of unsubsidized fertilizer was less constrained by lack of knowledge of how to use fertilizers.

exports by the food-exporting countries at times of the world food shortage, as had happened in several instances in the 1970s and 1980s. Under such circumstances, the required amount of food imports might not be available for purchase in the world market at any price. For a food-aid dependent country like Bangladesh during 1960s and 1970s, there was the risk of food aid being reduced at times of shortage in world markets. Experience confirmed that the food exporting and aid providing countries frequently reduced food aid at times of high prices of food in the world market. The fertilizer subsidy was a way of reducing the cost of domestic food production to reduce import dependence and thus diminish the impact of risks or uncertainties involved in dependence on the world market.

However, starting late 1980s, there was a change in attitude and a willingness, but as yet slow and hesitant, in the policymaking circles to accept a reduction in input subsidy. This was done in gradual stages and at the end by 1992-1993, there was an elimination of the fertilizer subsidies. This was the period, i.e., decade of 1980s and early 1990s, which was marked by a generally comfortable food supply situation, improving the sense of food security. A substantial increase in food production resulted in a downward trend in real price of rice as well as in a significant reduction in imports of rice.[33] The real price of rice fell from BDT 8.20 per kg in 1980-1981 to 1984-1985 to BDT 7.50 per kg in 1985-1986 to 1989-1990 and to BDT 5.60 and BDT 5.50 per kg respectively in the periods 1990-1991 to 1994-1995 (Chowdhury 2010). Moreover, the demand for urea fertilizer was strong, in spite of a decline in subsidy. This was because the increase in the use of fertilizer was greatly facilitated by the extension of irrigation and HYVs during the 1980s and 1990s. By this time, the farmers were long familiar in the use of fertilizer and had gotten accustomed to the high yield from the use of fertilizer so that the earlier fears of uncertainty and risks from the use of fertilizer were gone. It was also felt that the credit availability had increased somewhat, and in any case, it was felt that at the same time institutional reforms to expand agricultural credit should deserve high priority.

It may be recalled that, during this period, there was no unanimity among policymakers and economists/analysts regarding the reduction or elimination of subsidy (Osmani and Quasem 1985). In fact, beginning

[33] This is evidenced by trends in food imports and rate of increase in food production, and growth in fertilizer use over the years. Imports of rice declined from 277,000 tons in 1980-81 to 1984-1985 to 249,000 tons in 1985-1986 to 1998-1990 and to 191,000 tons in 1990-1991 to 1994-1995. See Mujeri and Shahabuddin 2012, Table A3 and A4). There was a drop in the ratio of import to total availability of food grains from an average of around 11.2 percent during 1980-1981 to 1984-1985 and 1985-1986 to 1989-1990 to 8.4 percent during 1990-1991 to 1994-1995 (Table 5.5).

in the 1980s, there were vigorous debates in the policy-making circles, including the economists and policy analysts, regarding the pros and cons of the fertilizer subsidy. A very important factor in tilting the argument in favor of market liberalization and reduction of subsidy, as discussed in the earlier chapter, was the pressure from the donors who were at that stage financing a large part of development expenditures of the government. The large budgetary burden of subsidies, it was argued, should be reduced to allow for an increase in the high-priority investments in agriculture such as research, extension, education, irrigation, training, and extension, etc. Over time, those who were in favor of reduction and eventual removal of subsidy, supported by the strong pressure from donor countries had won the argument but only temporarily as is seen below.

During the middle of the 1990s, i.e., 1994-1995, there was a fertilizer crisis marked by very high prices and shortage of fertilizer due to multiplicity of factors, which led to the reintroduction of the state intervention in the marketing and distribution of fertilizer. About the same time, the subsidy was also reintroduced and the new state-controlled distribution mechanism served as the vehicle for the provision of subsidies to the farmers. A number of external circumstances relating to the food supply situation at the end of 1990s encouraged a reconsideration of the policy of fertilizer subsidy. Towards the latter part of the 1990s, the near self-sufficiency in rice that was reached in the early 1990s was gradually being reversed. The food imports were on the rise; as increase in domestic demand exceeded the growth in domestic production. Imports of food grains contributed 11.9 percent of total availability during 1995-1996 to 1999-2000 (9.3 percent excluding abnormal imports due to massive floods) and 9.5 percent during 2001-2002 to 2004-2005. The downward trend in real price of rice stopped and in fact it was reversed; the real price of rice increased from BDT 5.5 per kg in 1995-1996 to 1999-2000 and BDT 6.0 per kg in 2000-2001 to 2002-2003 to BDT 7.4 per kg during 2006-2007 (Mujeri, Shahana, Chowdhury, and Haider 2013). There was a shift in the political climate of opinion in favor of more vigorous attempts for achieving self-sufficiency; it was argued that shortfalls from weather-induced variations in the context of a substantial increase in domestic production would be easier met or absorbed. Also, it was argued that with a larger domestic food output, it could be possible to build up large stocks in good years to meet the unexpected shortfalls in bad years and to moderate the extent of rise in prices. Furthermore, credit constraint for the farmers persisted; not much improvement took place over the years in credit availability for the small farmers. 45 percent

of the marginal and small farmers could not get access to the institutional credit and had to obtain credit from informal sources paying higher rates of interest than those paid by the medium and large farmers, about 70 percent to 85 percent of whom had access to the institutional credit at rates several times cheaper than those paid by the small and marginal farmers. A recent study found that small farmers suffered from a larger deficit in supply of fertilizer in relation to their demand as well as "requirements" (as suggested by Barkat, Faridi, Wadood, Sengupta, and Hoque 2010).

It was believed that the use of fertilizer per acre in Bangladesh was sub-optimal in the sense that the prevailing amount of fertilizer used per acre did not replace the soil nutrient which was lost through an increase in the crop intensity of land use in Bangladesh over the years. The loss of soil nutrient did not enter into the private cost calculation of the farmers; hence, they did not increase the use of fertilizer in order to maintain and preserve nutrient content of the soil. Thus, fertilizer subsidy by correcting for sub-optimal use of fertilizer could offset some of the disadvantages of the insufficient use of fertilizer. Fertilizer use reduced soil erosion by supplying soil nutrients (nitrogen, phosphate, and potassium), increased soil fertility and hence productivity of land; it obviated the need for bringing new land under cultivation by deforestation, for example, in order to compensate for the loss in productivity of land already under existing cultivation. To the extent that the reduction in deforestation reduced the emission of greenhouse gas in the atmosphere, it restrained environmental damage.[34]

If there were competitive markets and prices, various types of fertilizer, i.e., such nitrogen/urea fertilizer, phosphate, and potash, and if the farmers were knowledgeable about their relative productivity, the proportion in which they would be used would be determined by their relative profitability. In the presence of information asymmetry, however, it was possible that the excessive use of one type of such fertilizer, determined by its relative lower price due to higher rate of subsidy, might cause the

[34] However, it may be added in this context that, in the ultimate analysis, the problem of inadequate or sub-optimal use in given circumstances was due not only to the price of fertilizer but also to a number of factors which affect the profitability of use of fertilizer, the value of additional output resulting from the application of fertilizer in relation to the cost of supply to the farmer, i.e., yield response of fertilizer. In addition to fertilizer price, potential profitability of the use of fertilizer also depended on the price of the inputs that substitute for or complement the use of fertilizer and price of output resulting from the use of fertilizer. Response of crop yield to fertilizer application depended on the requirements of fertilizer for different crops in specific agroecological circumstances as well as on soil and water management techniques. This, in turn, depended on the quality and quantity of agricultural research as well as the quality of extension and training services for the farmers. Nonetheless, price of fertilizer in one important factor in helping to correct the sub-optimal use of fertilizer.

loss of soil salinity or soil nutrients. In other words, the social costs of this particular variety of fertilizer exceeded the social benefits and, therefore, its use needed to be restricted.[35] The share of urea in the total use of fertilizers remained more or less the same, i.e., about 67 to 69 percent between 1992-1993 and 2004-2005. This period covered the years of market liberalization as well as controlled and regulated market from 1995-1996 onwards. The relative price of urea was low in relation to the other fertilizer. The N-P-K ratio increased from 10-3-7 in 1988-1989 to 10-1.7-1.0 in 1996-1997.[36] The relative price of urea compared to other fertilizers fell from 1999 to 2007. As a result, Nitrogen-Phosphorous-Potassium (N-P-K) ratio increased from 10.6/1.6/1.0 in 1981 to 14.6/0.4/1.0 in 2008-2009. The recent increase in the subsidies on non-urea fertilizer prices sought to correct the imbalances.[37]

[35] In Bangladesh, urea fertilizer was being subsidized for many years, while non-urea fertilizers such as potash and phosphate, etc., were unsubsidised or subsidized very little with the result that there was an excessive or overuse of urea in relation to other fertilizers leading to adverse effects on soil nutrients. Recent subsidies on non-urea fertilizers were expected to, therefore, help a more balanced composition of three types of fertilizer, i.e., increase the use of non-urea in relation to urea fertilizer by increasing relative uses of non-urea fertilizer.

[36] When a comparison between actual and recommended levels was made, the actual ratio in 1996-1997 was 1.0 / 0.24 / 0.25 and the recommended ratio was 1.0 / 0.50 / 0.58 (Ahmed 1987, 252).

[37] The relative prices of urea and other fertilizer (BDT per kg) changed between 2008 and 2009 as follows:

Fertilizer	Before June 2008	After June 2008	From November 2009	From October 2010
Urea	6	12	12	18
TSP	30	80	22	22
MOP	36	75	25	15
DAP	28	85	30	27

The recent change in the ratio of urea to non-urea in response to increasing subsidy of non-urea fertilizer was as follows:

N-P-K ratio after the reduction in the price of non-urea fertilizers		
Crop	2008	2009
Boro	3.4 / 0.4 / 1.0	3.6 / 0.4 / 1.0
Aman	9.8 / 0.5 / 1.0	6.4 / 0.4 / 1.0

Source: Toufique 2012, 14-19.

The price change had a limited impact on the N-P-K ratios. In fact, the use of urea relative to other fertilizers for *boro* production continued to increase even after the increase in the price of urea and fall in the price of non-urea fertilizers. However, for the *aman* crop, the consumption of urea declined which was possibly compensated by some increase in the proportion of phosphorous-based fertilizers.

It is worth noting here that the 1995 fertilizer crisis described earlier related to the supply of urea fertilizer and less to the supply shortage of phosphatic and potassic fertilizer. The farmers were more agitated by the short supply of urea rather than that of other fertilizers because urea's effect on crop growth was more immediate and sharper than the effect of other fertilizers. This behavior of the farmers was considered illusory even though the yield effect from a marginal increase in the use of other fertilizers was often higher than that for urea. It was argued that this perception fostered by the failure of the agricultural extension services to inform and train the farmers in the productive use of non-urea fertilizers. The illusory attraction of urea to the farmers caused by such factors has been partly responsible for this significant imbalance.

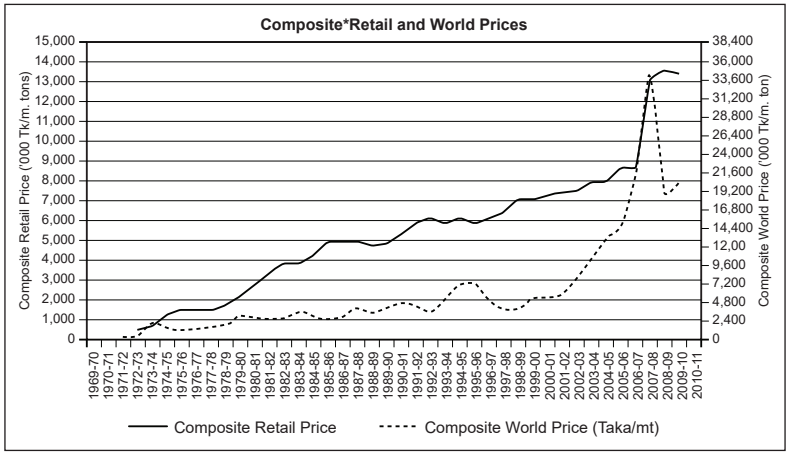
An argument for fertilizer subsidy was linked to its role in moderating the risks and losses caused by fluctuating crop output. Rain-fed agriculture was highly variable which was translated into exaggerated price swings because markets were thin and price elasticity of demand was low. There were no insurance markets to compensate for such risks.[38] With highly fluctuating crop prices, farmers had difficulty in assessing potential benefits of fertilizer use resulting in its sub-optimal use. Precipitous price falls increased the severity of losses in years of surplus production and reduced the use of fertilizers and other inputs since risk adverse farmers reduced the use of purchased inputs. Subsidies on fertilizers to these farmers affected by crop failures-induced losses could help them recover severe income losses as well as could build up and maintain demand for fertilizers. Until such time when credit facilities were built up and insurance schemes were devised, it was argued that fertilizer subsidy was a way to promote optimum fertilizer use.

For countries depending on the international market for fertilizer products, the volatility of their prices and the availability was an important concern. It aggravated the fluctuations in domestic food production. In years of high prices of fertilizer, unless it was offset by high price of food, both fertilizer use and food production would decline and this would jeopardize food security. Under the circumstances, subsidy on fertilizer

[38] Weather-induced insurance schemes that issue policies which pay out depending not on the performance of crops grown by individual farmers, but on a readily measured and subjectively verifiable index, such as rainfall in a specified area, were not commonly available. Moreover, the introduction of such schemes was handicapped by the lack of reliable rainfall and yield data in many regions; even if data were available, there must be strong correlation between typical on farm yields and rainfall levels for such a scheme to work.

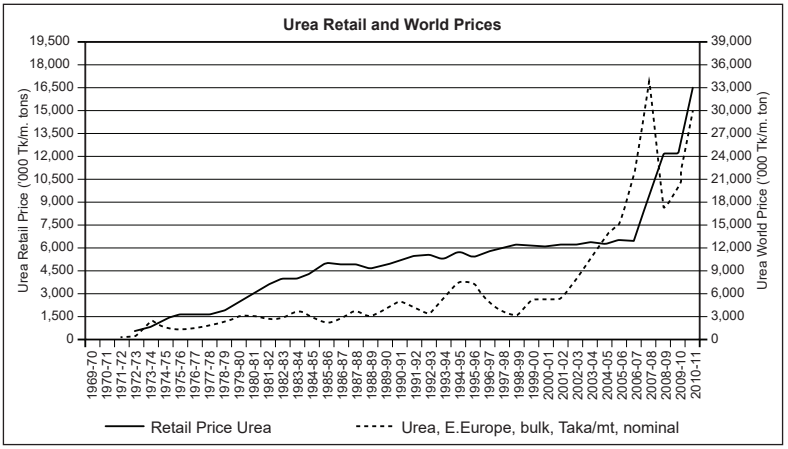
could maintain the incentive for food production. The converse would be the case, however, when fertilizer price declined. Thus, fertilizer subsidy could serve as a component of a combined tax-cum-subsidy policy to stabilize fertilizer price over time. Similarly, in the absence of food price stability over time, variable fertilizer tax cum subsidy might be used as an instrument for stabilizing the profitability of food production over time.[39] The fertilizer subsidy in Bangladesh did indeed contribute to the greater stability of domestic prices of fertilizer as seen in Figure 5.3, except in the years of 2007-2008/2008-2009 where there was a crisis in the world market for food and fertilizers caused by a combination of circumstances such as rise in oil price, increase in bio-fuel production, depletion of food stocks, and adverse weather conditions. In those years, the extent of increase in subsidy in fertilizer that could have been necessary to fully offset its rise in world price was not financially feasible.

Figure 5.3: Composite Domestic Retail and World Prices



[39] See, Dorward (2009). Fertilizer suppliers/traders might also be adversely affected by volatility of fertilizer prices. Traders with large stocks would gain if increasing fertilizer prices allowed them to increase sales prices of existing stocks. However, they might suffer from reduced sales volumes if higher prices led to reduced demand by farmers and they might also find it difficult to raise the working capital to buy more expensive fertilizer stocks. Traders might also suffer from falls in fertilizer prices if they had bought when prices were high and held high priced stocks while competitors could bring in lower priced supplies.

Figure 5.4: Urea Domestic Retail and World Prices



The overriding argument for fertilizer subsidy since the policy of no-subsidy was revised in 1995-1996 was that by reducing the cost of fertilizer and thus encouraging the farmers to increase the use of fertilizer, the domestic food production could be increased.[40] As stated before, the priority attached to domestic food production was accentuated by food crisis of 2007-2008, and heightened the sense of food insecurity. However, fertilizer subsidy had to be combined with measures to increase the supply of fertilizer.[41] Unless the supply of fertilizer responded to the increase in

40 However, increase in food production due to the lower price and greater use of fertilizer would not reduce the domestic food price if food is a tradable commodity, because price would be determined by the import parity price and increase in domestic production reduces imports and not price. However, domestic price of rice in Bangladesh was frequently lower than the import parity price and higher than export parity price in Bangladesh so that domestic price fluctuations could occur within the wide gap between the import and the export parity prices. Under the circumstances, increase in domestic production caused by lower cost of fertilizer might reduce the domestic price so long as it was below the import price. However, to the extent that fertilizer subsidy led to increased use of fertilizer but a reduction in the use of other inputs such as seeds, pesticides, and water, in view of the fall in relative price of fertilizer vis-à-vis the prices of other inputs, there might not be any increase in food output. It may lead to an over use of fertilizer and under use of other inputs reducing the production efficiency and with adverse impact on soil.

41 In a study of variations in the price of fertilizer and associated variations in the use of fertilizer between 2007 and 2008, it was found that in 2007 use of urea was close to the ideal usage (recommended dose per acre), but in 2008, with increase in price, it fell from the 2007 level as well as below the level of the recommended dose. In the case of non-urea fertilizers, prices rose very sharply and level of this use was already less than the recommended dose

demand, the benefit of subsidy would accrue to the suppliers/traders of fertilizer as the scarcity margins generated by the limited supply would be absorbed by them.[42] There are at least three complicating issues relating to the use of fertilizer subsidy to increase the production of rice. If fertilizer was used for other crops as well, it would have unintended consequences of subsidizing other crops, implying a larger budgetary cost of subsidy. Even if subsidy could somehow be exclusively directed towards say, for instance, rice or wheat producers, it might not be still feasible to confine it to food crops only, if the same farmers produced multiple crops. Second, in many cases such fertilizer was often used as a substitute for industrial chemicals with the result that those industries would substitute fertilizer for other chemicals and earn windfall profits. Thirdly, there was a possibility of cross-border trade with the neighboring countries if trade was not effectively banned with them. If fertilizer subsidy cheapened its price relative to that in the neighboring countries, it would be exported and thus added to the budgetary costs of the government. This was especially relevant in the case of illegal trade of Bangladesh with Myanmar and India.

Recently, in course of the ongoing debates on fertilizer subsidy in late 2000s, the earlier argument of credit constraint facing the small and marginal farmers was reemphasized. There were many who recommended that subsidy should be targeted towards the poor rather than provided to all farmers in

in 2007 and in 2008 with the rise of prices, their use fell further. The government decided to cut down the prices of non-urea fertilizers—muriate of potash (MP) and diammonium phosphate (DAP)—by 40 and 3 percent, respectively, as an incentive to farmers to grow more winter crops. At the farmers' level, MP would be sold at BDT 15/kg, which now sells at BDT 25, while DAP was to be sold at BDT 27/kg, which now cost BDT 30. At a dealers' level, the new price of MP was to be BDT 13/kg and DAP BDT 25/kg. "We want the farmers feel encouraged to produce more winter crops, especially potato and reduce their dependence on urea only. It is important to ensure balanced use of fertilizer, which would also help sustain soil fertility," the government press release said. Prices of all non-urea fertilizers were almost halved on January 14, 2009; and later on November 3, 2011, the government again slashed the prices. The government would subsidize BDT 22 million for these fertilizers this fiscal year, said an official at the agriculture ministry (*The Daily Star*, October 23, 2010).

42 If the wholesale and/or dealers received the fertilizer at subsidized prices and if they were free to sell to the retailers at price that the market would bear; in case of excess demand, there will be a scarcity margin which would accrue to the wholesale dealers. If the distribution system was so designed that the retailers would procure fertilizer at subsidized price, the scarcity margin would be obtained by the retailers in case of excess demand. Frequently, because of resource limitation, the amount of subsidised fertilizer supply in Bangladesh fell short of demand at the subsidized price, with the result that open-market price was higher and there was a leakage of supplies from the public distribution system to the open/unsubsidiszed market.

general.[43] For example, even at the end of 2012, the predominant clients/borrowers of such sources of credit as (a) friends and relatives, and (b) NGOs, were the marginal and small farmers, i.e., 51 percent and 56 percent of their borrowers respectively. The persistence of credit constraint for the small farmers was due to the failure of past efforts to expand credit supply to them and remained a serious concern. The cheaper and more convenient sources of credit such as specialized agricultural banks and commercial banks had a very small percentage of borrowers from among the marginal and small farmers, i.e. 15-17 percent of their borrowers were from the ranks of marginal and small farmers (Ahmed 2013). The marginal and small farmers in Bangladesh (with farm size of less than 0.5 acres and 0.5-1.49 acres respectively) constituted 80.8 percent of the farming households and cultivated 47.4 percent of total land, whereas the medium farm (between 1.5 and 2.49 acres) constituted 11 percent of the households and cultivated 21.6 percent of the total land. The large farmers (with 2.5 acres and above) constituted 7.3 percent of the farming households and cultivated 31.1 percent of the land.[44] It was expected that the provision of fertilizer subsidies to the small and marginal farmers would enable them to increase fertilizer use by a greater percentage than in the case of medium and large farmers, who were already using about the optimum amount of fertilizer. Hence, the fertilizer subsidy to them would contribute to a larger additional increase on output than in the case of large farmers in view of diminishing returns to the use of fertilizer. In this sense, the increased access on the part of the small and marginal farmers to fertilizer would not only increase output but also help reduce poverty. The growth-accelerating impact of the access of the small farmers to subsidy might also be deduced from the fact that they did adopt the Green Revolution technology (irrigation

[43] Moreover, subsidy might be justified to offset the disadvantages of the farmers in distant or remote areas who suffer from lack of easy accessibility and high cost of transports. In the long run, the solution to the latter is to improve the transportations link with and accessibility to the distant and remote areas, including subsidies to the development of transport rather than might subsidizing one input. With generalised subsidy provided to all farmers, unless subsidies can be related to the provisions of individual farmer's requirements based on area under cultivation and cropping pattern, some farmers can buy more than they need and emerge indirectly as dealers and this adds to the cost of fertilizers to the actual users of fertilizers.

[44] The rice yields per acre for different farm sizes are as follows: marginal – 2.90 tons, small – 2.87 tons, medium – 2.83 tons, and large – 2.81 tons). In many countries, agricultural sector was the means of existence of the largest and the poorer section of the population. Farmers benefited little from other subsidized goods and services provided by the public utilities or social services such as health and education services. Hence, it was argued by some that a case for agricultural subsidies could possibly be made for those with significant implications for increased production (Osmani and Quasem 1985).

and HYV seeds) from 1980 onwards as new technology spread, roughly at the same rate as the larger farmers, even though they had to pay higher cost for the purchased inputs (Table 5.8).

Table 5.8: Coverage of Irrigation and Adoption of Improved Varieties, 1988 and 2004

Farm size (hectares)	Irrigated area as percent of cultivated land		Area under modern varieties as percent of rice-cropped area	
	1988	2004	1988	2004
Up to 0.20	29.4	73.9	52.2	71.4
0.21 to 0.40	26.3	77.4	45.2	70.0
0.41 to 1.00	24.9	70.2	35.6	68.1
1.01 to 2.00	22.5	74.6	27.7	62.9
2.01 and above	24.0	77.7	15.8	59.5
All farms	24.0	72.2	29.0	65.6

Source: Shahabuddin and Islam 2009, Ch.13.

The task of targeting subsidy only to the marginal and small farmers was not without problems. The first challenge related to the design of a mechanism of delivery of subsidy to the targeted farmers. The second problem was how to devise the rate of subsidy which was just sufficient to compensate for the high-risk aversion and credit constraint. This involved a process of trial and error along with constant monitoring of the impact of subsidies so that it could avoid unintended consequences.

There were two ways of delivering subsidy to the targeted groups. One was the direct government intervention in the marketing and distribution of fertilizer as Bangladesh was doing for years during the past decades, with various degrees of participation by private traders selected and approved by the public institution concerned. The alternative was not for the government agencies to undertake direct marketing and distribution but to use the private marketing system to deliver fertilizer to the targeted groups at subsidized prices. This would lead to the development of the private market for fertilizer with all its attendant characteristics, i.e., warehouses, storage facilities, and transportation, etc. The basic idea was to subsidize the targeted group of farmers rather than the input, i.e., fertilizer. Instead of lowering the cost of input through a certain amount of subsidy, the producer can be provided with the equivalent subsidy.[45]

[45] It is suggested that the distribution of cash equivalent of the subsidy through banks or through coupons or through the new technology of mobile phones, now rapidly spreading

This system of providing input subsidy, called "smart subsidies", has been much discussed in recent years. Under the system, there was no attempt to determine the market price of fertilizer or price of fertilizers to be received by targeted beneficiaries. Subsidy was to be administered through a system of vouchers linked to the purchase of fertilizer to be distributed to the farmers; the value of the vouchers would specify (a) the amount of subsidy and (b) the amount of fertilizer that the recipient farmer could buy from the private input dealer. The latter, on presentation of the voucher, could deduct the value of subsidy as indicated in the voucher from the price that he would charge the farmer. In other words, the dealers would sell the farmers at market price but would charge the farmers market price minus the value of the voucher. The private input dealer would get the vouchers redeemed by the government. The designation of beneficiaries and the administration of vouchers was to be done by a government agency which would be different from and independent of the retailers or distributors of fertilizer, even though collusion between the two was not ruled out with a view to undermining the targeting system. The voucher system could be used not only to distribute fertilizer but also other associated inputs such as seeds and pesticide, etc. in appropriate combinations with fertilizer to promote a greater output response; also, it could be combined with the training of the farmers as well as the input suppliers in the efficient use of fertilizer. Second, the system could facilitate an "exit" strategy by reducing the value of voucher over time or by converting it, for example, to a crop production credit to be repaid at harvest time.

One way of targeting poor households is to make the vouchers conditional upon the poor households participating in, for example, public works programs. The better-off farmers were unlikely to provide such labor in order to be eligible for vouchers. However, the individual beneficiaries in a locality could sell vouchers to others, and not use the fertilizer themselves; to the extent this resulted in the poor households selling to those not so poor, there was still a net income transfer to the poor. Effectiveness and efficiency of a program of subsidy could be improved by expanding extension and training of the farmers as well as by implementing other policy instruments in ways that were complementary. Subsidy entitlements might be linked

in any rural economies of the developing world, could be an alternative to fertilizer subsidy. If the latter could be implemented successfully, then the choice of appropriate amount of use of fertilizer could be left to be determined by the farmers on the basis of respective price (cost) on the one hand, and output gain (benefit) on the other. However, objectives for subsidy such as to offset (i) fluctuations in crop prices, (ii) preserve or restore soil fertility, and (iii) promote optimum use of fertilizer and fertilizer market development and cost reduction would not be realised by the alternative method of cash transfer.

as incentives to investments in soil and water conservation, etc. All these measures cumulatively would enhance agricultural production. As knowledge of the farmers regarding optimum ways of using fertilizer improved, as risk aversion was reduced, and credit constraints was removed, and as increased use of fertilizer replenished soil nutrition, subsidy may be phased out in a systematic manner.

It is interesting to observe that in recent years, a report by the World Bank on its response to the Global Food Crisis (2007-2008), recognized with approval the role of input subsidy, especially fertilizer subsidy, in stimulating food production in the context of rising fuel and fertilizer prices in world markets starting 2007. It was argued that rising fertilizer prices discouraged food production by raising the costs of food production (World Bank 2008, 4, 19, and 31-33). While the development of efficient agricultural input markets is a long-term process, the World Bank assistance in 2008 was intended to promote rapid support to "countries facing immediate and near-term constraints related to seed and fertilizer availability, distribution, affordability, and utilization." (World Bank 2008, 90). Subsidy schemes needed to be placed within "context of developing more viable and sustainable input supply system". It recommended "improved linkages between its input subsidy and social safety nets to enhance production assets of the poorest and promote their potential access to inputs."[46]

In line with this thinking, several countries in recent years have modified their approach to input subsidies, defining their role as more of a broader productivity enhancement strategy and as temporary interventions that support private investment in input production and distribution rather than substitute them. To be "market smart", input subsidies: (i) should be targeted at poor farmers to encourage incremental input use by those who would not otherwise use them; (ii) should not displace existing commercial sales; (iii) should utilize vouchers, matching grants or other instruments and utilize (and strengthen) existing private distribution systems; and (iv) be introduced for a limited period, with a clear schedule for phasing out

[46] "Many countries have employed input subsidies at one time or another, either geared toward reducing the costs of input production and distribution operations or directly reducing the prices paid by farmers. The experiences of direct price subsidies for seed and fertilizer have been mixed, although in most cases the costs of the subsidies have proven to be high and unsustainable, while the relatively modest benefits have tended to be captured primarily by larger farmers. Despite this record, input subsidies have continued to garner strong support—both from farmers and governments—as a means of encouraging technology adoption, overcoming existing market weaknesses, and supporting an important constituency. Input subsidies have also been used as a social welfare instrument, although alternative safety net approaches are generally more cost effective."

once their purpose has been achieved.[47] In its progress report in 2012 on the program, the Bank notes that effective institutional mechanisms for delivery of inputs are essential to ensure that input subsidy schemes in all government-supported programs should be harmonized to make these free from political consideration, to recover input credits, and to make effective linkages between markets, financial institutions, and the private sector (World Bank 2012, 23-23).

Thus, it appears that the World Bank makes a case for input subsidies under circumstances requiring a rapid response to the challenge of meeting a food crisis by increased food production in the short run. The Bank report recognizes that such schemes could be costly and they offered opportunities for substantial captures of rents by a variety of stakeholders (program administrators, input suppliers, traders, and less poor farmers). If subsidies were not set up with clear time limits and continued for long periods there is a risk of it being entrenched due to the persistence of vested interests.

5.5 Intervention in Food grain Market: Fertilizer Subsidy Versus Food Price Support

A question had been raised as to whether a policy of support of output prices was not a better or more efficient alternative than input subsidy such as fertilizer subsidy, in terms of achieving the objective of increased food production. Since price incentive for the farmers could be improved either by raising the price of output or by lowering the price of input, or by a combination of the two, a choice between the two policies would obviously depend on the relative costs and benefits associated with each alternative. It might be recalled throughout the 1980s and 1990s that the donor community, especially the World Bank, as the leader and coordination of aid to Bangladesh expressed its strong support in favor of output price support program (see, World Bank Food Policy Reports on Bangladesh during the 1970s and 1980s).

The output price support provides a direct incentive which gives producers complete flexibility to choose the least-cost combination of inputs and hence to increase productivity. It benefits all producers, whereas input subsidy only helps those who use a particular input. A subsidy on an input, however, was a more indirect incentive that distorted the relative intensity of use of different inputs away from their economically optimal level, thus leading to inefficiencies such as the encouragement of an excessive use of

[47] See World Bank framework document: http://documents1.worldbank.org/curated/en/717381468137698947/text/438410BR0REVIS10and0IDAR20081016212.txt

the subsidized input.[48] It was often suggested that output price support policy can be so designed as to achieve a stability of product price—an additional benefit which is not provided by input subsidy. However, a policy of output price support does not necessarily involve a policy of price stabilization.

Whether the elasticity of production with respect to a change in output price was greater than that with respect to a change in input price, and whether the costs of the output price policy was lower than the cost of input subsidy policy, remain controversial. If the objective was to achieve self-sufficiency in food grain, in the sense of substituting current imports by domestic production, the critical question is to examine the relative costs of achieving this objective through the alternative options of price support and input subsidy. This issue can be resolved only in course of an empirical exercise based on actual parameters in a particular country. Different studies, however, came to different conclusions in Bangladesh (Bayes 1984). The different results were due to the different assumptions regarding the (a) the methods of procurement and sales of output by the government agency; (b) price elasticity of demand for fertilizer as well as yield response of fertilizer; (c) price elasticity of demand for food/output; (d) different years for which exercises were undertaken by different authors, when subsidy rates for fertilizer were very different; and (e) substitution possibilities of principal food crop for other crops. Moreover, the way in which output price support was implemented, i.e., the way in which the purchase and sales by government agency were carried out, was also an important factor in determining the outcome.[49]

In order to improve incentive for increased food production, it was not *a priori* clear in the light of the above whether from the point of efficiency

[48] It was also argued that input subsidy program did not encourage farmers to use more labor and provides better managerial care for the crops, implying that a price support program was able to do so. However, their argument did not hold when labor was complementary to subsidized inputs, as was indeed the case with inputs like fertilizer and irrigation. See Timmer, Falcon, and Pearson (1983).

[49] Such farmers, who were mostly deficit farmers, could lose out on two counts if input subsidy is replaced by output price support: first, by being deprived of input subsidy with no compensation from price support since they did not have any marketable surplus to sell; and secondly, by having to pay a higher price of food when they would enter the market as consumers. This double squeeze might have under certain circumstances an important bearing on production itself. While the loss of subsidy would raise their requirement for working capital, the need to pay a higher price for food grain in the face of an inelastic demand would reduce their wherewithal from which to supply the needed working capital. The consequent tightening of the credit constraint would either force them to reduce production, or increase their indebtedness in the informal credit market.

or equity, one policy, i.e., raising food price, was better than the other, i.e., lowering the price of input, even if both the policies were efficiently implemented. However, price support could also play a complementary role to input subsidy. Even when input was subsidized, the farmers needed to be assured that the price they received at the harvest time was remunerative enough to cover the cost of production and yielded at least a minimal surplus. In the years of abundant harvests, a price support could serve as a means of defending a floor price.

Thus, the food grain procurement and price policy can be conceived to have three interrelated aspects, which were not often clearly distinguished. First was to prevent price hikes during the lean seasons, or during a year when there was a production shortfall compared to the average or trend production over the years. The second objective was to prevent a fall in price below a minimum level in the harvesting season (after the crops were harvested), which would otherwise drive prices below the costs incurred by the farmers and cause distress. This would discourage them to maintain their current/previous level of production and hence lead to a fall in output in the next season. The first two objectives were therefore intended to stabilize food grain prices over the seasons in a year or over the years in the medium term. The third objective was to provide incentive to the farmers to increase production over the average of the past years with a view to encouraging a long-run increasing trend in food production. This might imply ensuring a price which not only did not fall below the average annual price during the previous seasons or years, or even to raise the price above it during the harvesting season in such a manner that the average price over the medium/long term was higher than average in the preceding few years.

In an open economy, this would require that domestic price is maintained above the import parity price in the medium term with a view to encouraging import substitution.[50] If the procurement policy was to provide an incentive price, the success of the program was to be judged by the impact of the government procurement price on the market price. If the market price was higher than the procurement price in a particular year and if this higher price was anticipated by the farmers at the time of sowing, then ostensibly there was no problem of incentive and the provision of an incentive price scheme was redundant that year. If the objective was to obtain enough food grain to meet the requirements of the public distribution system, then the concern

[50] In terms of implementation of a support price policy for food grains, if the policy was to provide a floor price in the harvesting season the price for procurement by the government could be announced at the time of harvesting. If, on the one hand, the objective was to provide incentive to increase production in the next season or next year, the procurement price needed to be announced ahead of the harvesting season.

was whether the volume of procurement met the specified target. With a high market price, the government would then require to buy at higher than its pre-announced procurement price in order to meet the procurement target and incur a high cost. On the other hand, if in the harvesting season, market price remained depressed and the procurement program failed to push it up to the level of floor price, then the policy can be judged to be a failure. In this case, the criterion of a successful procurement policy would be the ability to keep market price in the vicinity of guaranteed price in years of good harvest.

The procurement price was intended to provide incentives to producers in the sense that it reduced price risks, and ensured farm income to producers since small farmers generally sold immediately after harvest to meet their consumption needs and to pay for production inputs as well as debt. If the procurement price was set at a level higher than the prevailing market price, farmers benefitted, provided the farmers, especially small farmers, sold directly to government procurement centers but not to the intermediaries who reaped the benefit of the high prices. Moreover, this could have pushed the market price up to the procurement price, if the volume of procurement was high enough to affect the balance between demand and supply in the market. However, there were serious shortcomings in the procurement system which tended to limit the access of farmers so that they were obliged to sell to the private traders at a lower price.[51] Lack of purchase centers, limited financial resources of the government, institutional impediments to timely purchase from and payment to small sellers, and collusion between officials and traders were often cited as the major reasons for limited access. Over the years, the performance of the procurement system did not record much improvement. Moreover, the amount of procurement was not large enough to affect the market prices.[52] The share of procurement of rice and wheat in output fluctuated over the years.

---

[51] In two out of the three good harvest years since 1975-1976 (the year from which the procurement program was geared towards price support), grower's price in the market remained substantially below the guaranteed price. It should be noted that the volume of procurement was also the highest in these years. In 1980-1981, a record 6 percent of gross production (or 20 percent of marketed rice, assuming a marketing ratio of 30 percent) was procured by the government. Yet the grower's price was 11 percent below the procurement price.

[52] The effect of domestic net procurement on market prices was estimated by treating net procurement as a reduction in net private supply (including both sales and own consumption), and then using an assumed own-price elasticity of demand for rice. For example, in 1996, if the net procurement of 150,000 metric tons did not take place, net supply would have been 1.9 percent greater. Assuming an elasticity of demand of – 0.2, the market price would be 9.5 percent lower in the absence of procurement. Alternatively, using the simulated no-procurement price as a base, procurement raised market prices by an estimated 10.5 percent.

Price stabilization was an important, but somewhat ambiguous, policy objective of the government, since procurement price and open market sale (OMS) prices were not, respectively, truly effective floor and ceiling prices. The government's mechanism of preventing hikes in the market prices was to sell in the open market from the public stocks with a view to adding to the market supply and dampen price rise. As the volume of procurement was too small to affect market prices in good harvest years or seasons, so also the volume of open market sales was inadequate to prevent price hikes during lean season. In view of its limitations, the state intervention in the food grain market thus did not contribute, much to price stability.[53]

5.6 Conclusions

Increasing food production was recognized by the government from the early years as one of the prime objective of economic development policy. Over the years, Bangladesh had gone through food crises of varying proportions. The worst case was in 1974 when due to a major shortfall in domestic food production and unusually high international prices, the country faced a famine, just two years after independence, which claimed 1.5 million lives. Since then, all successive governments in Bangladesh, irrespective of their ideological differences, have strived for self-sufficiency in rice. The consistent emphasis on food security was important in Bangladesh, with its small land area and comparatively large population, with very high population density per cropped area. The policy emphasis on food security resulted not only in a significant increase in per capita food production but also in a decline, at least until recently, in intra-year/inter-year variations on food supply and prices, largely because of an increasing dependence on groundwater irrigation contributing to more stable water supply as well as multiple cropping spreading over different seasons.

[53] The inter-year variability of rice price increased from 8.13 (1988-1989–1992-1993) to 20.19 (2005-2006–2009-2010). The reasons for the difference in the degree of variability between 1970s and 1980s, on the one hand, and 1990s and 2000s, on the other, are not clear and need further investigation. Among possible hypotheses could be (a) an increase in the variability of weather, i.e., frequency and intensity of floods/cyclones, as a result of the impact of climate change; and (b) the extension of cultivation to fragile lands and coastal areas. Moreover, it may be hypothesized that the stockholding behavior of the private traders/farmers was more relevant to intra-year (seasonal price variability) rather than to inter-year variability of prices. Thus, while the coefficient of monthly variation of food grain prices was much lower than the inter-year variation. This could be to the farmers/traders behaving rationally based on price expectations, i.e., buying, and building stocks when prices were low and getting out of stocks when prices are high. Since private stocks increased over time, their operation could have affected market prices.

The key role of the fertilizer distribution system is to ensure the timely availability of adequate fertilizer for the millions of farmers in the country, meaning an efficient distribution system is an important pre-requisite. Since independence, the government has adopted policies related to price, marketing, and distribution of fertilizers which have undergone significant changes over the last four decades.

Overall, the past liberalization of the fertilizer sector affected the domestic fertilizer market in a number of ways. There are many positive features of liberalization but several inefficiencies also persist in the input market. While privatization has taken place across several aspects of sale, distribution and import of fertilizers, sudden price hikes, unbalanced use of fertilizers, adulteration of fertilizers and other problems continue to affect the efficient operation of the fertilizer market in the country. As a consequence, timely supply of quality and required quantity of fertilizers still emerges as a major concern for the country's fertilizer sector.

During the late 1990s and early 2000s, food production has reemerged due to more frequent and intense weather shocks, exacerbated by the expansion of agricultural cultivation into more ecologically fragile areas because of population pressures and rising demand. The 2007-2008 food crisis resulting from significant domestic production shortfalls combined with significant increases in world food prices was made worse by restricting access to world market due to export ban/restrictions in food exporting countries, which emphasized once again the risk of dependence on world markets.

The role of the state in the marketing and pricing of inputs and outputs in Bangladesh has to be seen in the evolving context of changes in world market. There was a gradual shift of policy towards the decontrol and liberalization of markets starting in the 1980s and was accelerated during 1990s and 2000s. This policy change not only affected the markets for inputs such as fertilizer, but also the provision of irrigation which was a crucial supplement to other inputs. For example, the irrigation system shifted towards private enterprise ownership as opposed to initial systems of state-operated large-scale irrigation projects. First, there were the low-lift irrigation pump drawing on rivers, owned and operated by a farmer or a group of farmers; second, privately-owned small-scale deep and shallow tube-well irrigation relying on groundwater became popular. However, the trend towards the market liberalization of the import markets did not last very long and by late 1990s there was a reversal of policy.

The government intervention in Bangladesh in the market for food grains, on the one hand, and production inputs, on the other, was historically

interrelated.[54] However, during the late 1990s and early 2000s, there was a significant shift towards intervention in input markets to ensure adequate input supplies at low prices, rather than in output markets. The low prices for inputs increased profitability for the farmers while keeping consumer prices low, thus helping reduce the tension between "remunerative" prices for producers and "affordable prices" for consumers. Moreover, public stock management remained a tricky or a difficult task. It was often compounded by the mismatch between production, imports, and domestic procurement, on the one hand, and the requirements of pubic distribution system, on the other. The management of public food stocks not only involved high costs but also risks of spoilage and of deterioration in quality. Therefore, the need to rollover stocks by buying and selling in the market in such a manner as not to destabilize the food grain market was a substantial challenge. In this context, to determine the appropriate size of public stocks obtained from imports and domestic procurement involved a very hard choice which was fraught with a certain degree of uncertainty of its impact on food prices.

During the late 1990s, as a result of increasing reliance on private imports, on the one hand, and the decline in the generalized food distribution to the consumers at subsidized prices, on the other, there was a trend towards a decline in public food stocks by mid-2000s. Thus, the public stock of wheat in 2006-2007 became almost one-third of its level in 2001-2002. The total public stock of cereals declined from its level of 944,000 metric tons in 2001-2002 to 607,000 metric tons in 2006-2007 (Raihan 2013). However, the crisis of 2008-2009 led to an increase in public stocks in view of the difficulties experienced in getting access to food supplies in the world market, and consequent hardships imposed on the consumers, especially the poor. However, the focus of the policy of public stock management was much less on ensuring a support or minimum price for farmers and much more was on moderating spikes in food prices caused by major production shortfalls. Moreover, a targeted public food distribution system to meet the needs of the poor and the vulnerable groups received an increasing emphasis.[55]

---

[54] See, Islam (2014). It needs to be stressed that while input subsidy and output price support may be considered as alternatives for stimulating production, input subsidy cannot directly contribute towards stabilization of prices nor it cannot prevent a fall in output prices. They can be considered complementary; for example, input subsidy could stimulate the use of yield-enhancing input by reducing uncertainty and reducing cost.

[55] Government of Bangladesh, *National Food Policy Plan of Action, 2008-2015*, 2008. The objective of ensuring support prices and preventing a fall in prices at harvest times was to be met principally by the farmers and traders through the operation of private stocks in the markets. There were those who argued that increase in private stocks should be facilitated by the construction of warehouses, either private warehouses with public assistance such as

It is important to observe that priority attached to state intervention in input marketing and pricing policy was partly due to the periodic crises marked by high prices and shortages that occurred in the fertilizer market leading to public protests and demonstrations by the farmers, countrywide or localized. These led in several instances to the breakdown of law and order. The government, in apprehension of wider consequences, social and political, had a tendency to react to such incidences with direct intervention in the fertilizer markets. For example, following the major fertilizer crisis in 1994-1995 as well as during other crises that occurred during the period 2006-2008, the government tried experimenting with various alternative ways of intervention in the marketing and pricing of fertilizer. In fact, there were frequent policy changes during the period between 2008 and 2010, directed towards a greater role of the state in fertilizer marketing and pricing.

Obviously, fertilizer prices in the international market can exhibit widely fluctuating trends over which Bangladesh does not have control. Bangladesh, however, can undertake systematic reform that reduce the marketing costs of fertilizer through more efficient distribution systems and better infrastructure. Financial, administrative and technical challenges such as deliberate delays, indifference amongst duty-bearers and corruption and collusive mechanisms can be reduced. Similarly, given the prevalence of small and marginal farmer in Bangladesh, timely and adequate credit through commercial and specialized banks and microfinance institutions is key to optimal use of fertilizer at the farm level.

The role of fertilizer subsidy needs to be seen in the context of a wider range of input subsidies in the agricultural sector—all of which were directed towards reducing the cost of food production in order to encourage increased production. For example, there were subsidies for diesel oil and electricity for irrigation pumps. The shallow (small) tube wells which accounted for 94 percent of the irrigated land received diesel oil at subsidized price. There have been debates over time regarding whether the objective of stimulating food production was best-served by input subsidies or by further research and development, and investment in education and extension, as well as flood control and drainage projects in irrigation. However, over time, agricultural subsidies have taken up an increasing proportion of public expenditure on agriculture, while public investment in research, extension, and flood control

credit or public warehouses to be rented to the private sector. In this role, the public stocks designed for the targeted food distribution to the poor and the vulnerable were to work as stocks in transit as the food grains were to pass from imports or domestic procurement to the various target groups.

and water control has fallen by almost half between 1999 and 2007. Even though estimates of rates of return on competing investments compared to input subsidies in Bangladesh were not available, based on evidence from other developing countries, it seemed that returns were higher in other investments (Mudahar and Ahmed 2010). Furthermore, there were other options to reduce farmers' costs in the short run besides input subsidies, such as expanding credit facilities targeting small and marginal farmers, lowering tariffs on imports of agricultural implements, etc.[56] There was a critical need for evidence-based research on relative cost/benefit analysis of alternative public expenditures in the agricultural sector to inform policy decisions and generate discussion among public intellectuals, different interest groups, and the relevant ministries/departments of the government.

The speed and pattern of policy reforms or changes over time in respect of state intervention in input and food grains markets were affected by often divergent and evolving views of the social scientists and economists, on the one hand, and the competing/complementary views of various government ministries and agencies involved in policymaking and implementation on the other. There was disagreement among the experts as to the (a) relative importance of market failures in input/output markets and (b) the usefulness or effectiveness of government intervention or control in correcting the market forces. There were differences of opinion, for example, regarding the rationale for input subsidies; there were continuing controversy on the extent to which input subsidies were passed on to the farmers or were usurped by the middlemen and traders engaged in oligopolistic practices or collusion, or how far the excess of prices paid by the farmers over the subsidized prices were due to scarcity margins caused by the shortages. The balance of opinion among the specialists/experts shifted over time; during the early 1990s, the balance of opinion among the specialists moved in favor of reduction, if not total elimination, of subsidies as happened in 1992-1993. Again, following the 2008 crisis, there was a rethinking on the part of many among them in favor of subsidies at least for a short period.

The donors played an important role in the liberalization of both the input and output markets and prices. They pressed frequently for the

[56] The cost of fertilizer per acre was about 11 to 13 percent of cost per acre for *aman* and *boro* rice crops. The ratio of cost of fertilizer to the total cost of production has declined over the years; it was higher in 1980s and 1990s.It is worth noting in this context that more than 31 percent of the borrowing by the farmers was intended for the purchase of fertilizer. Therefore, directly reducing the cost of fertilizer was preferred to the reform of institutional credits system which to date has not been very successful, See IFPRI, BIHS Survey 2012.

withdrawal of the state from the input markets, as well as for the reduction of subsidies. However, they had also changed their recommendations from time to time. They argued until recently in favor of an output price support program as against input subsidy program.

Thus, the influences shaping the output price and input subsidy policies in Bangladesh emanated from a multiplicity of sources—opinion makers and interest groups at both home and abroad. At the same time, the examples/experiences of the developed and other developing countries also had an impact—developed countries had a variety of both input and output subsidies for the agricultural sector, e.g., in the United States and Europe, which were often discussed by policymakers in Bangladesh. The question naturally arose why developed countries who themselves resorted to agricultural subsidies objected to Bangladesh following their example.

However, the balance of opinion seems to be veering towards a judicious combination of input subsidy and output support in the short run depending on the particular circumstances and the political compulsions at the time. However, the bias in favor of input subsidy remains strong for various reasons, both economic and political, described in the foregoing pages.

In the long run, a movement towards the reduction of subsidy and of intervention in the marketing and distribution of inputs and outputs may be further encouraged by an accumulation of evidence on the inefficiency of state intervention in the markets for inputs like fertilizer. However, the empirical evidence on efficiency of input markets in Bangladesh so far remains controversial, partially due to the absence of readily available counterfactuals. Such a comparison between state intervention and markets would evoke strong confidence if the conditions for competitive input markets such as free entry and exit of intending market participants were assured. At the same time, the limitations posed by the presence of economies of scale in the input market and by information asymmetry among market participants need to be resolved in order to reduce or eliminate state intervention in marketing. The role of appropriate regulatory mechanism and regulations that are necessary in lieu of direct intervention have to be defined at least to achieve a second best solution in search of efficiency of resource allocation; the objective of poverty alleviation/equity should be dealt with, to the maximum extent possible, by direct income support and safety net programs food-based and otherwise. There has been significant movement until to date in this direction following the liberalization of the market for food grains. Moreover, a substantial increase in food production achieved by a widespread use of productivity enhancing technology and

associated measures which would produce a comfortable food supply situation would create opinion favorable towards reforms especially of the input market, i.e., state intervention and subsidy.

References

Abdullah, A. 1996. "The Urea Market in Bangladesh, 1994-1995: The Anatomy of a Crisis." In *State Market, and Development: Essays in Honour of Rehman Sobhan*, edited by Abu Abdullah and Azizur Rahman Khan. Dhaka: The University Press Limited.

Abdullah, A., M. Hassanullah, and Q. Shahabuddin. 1995. "Bangladesh Agriculture in the Nineties: Some Selected Issues." *In Experiences with Economic Reform: A Review of Bangladesh's Development 1995*, edited by R. Sobhan. Dhaka: Centre for Policy Dialogue (CPD).

Ahmed, J. U., et al. 1980. *Paddy/Rice Procurement System*. Report to the Ministry of Agriculture. Dhaka: Government of Bangladesh.

Ahmed, Kafiluddin. 2008. "Fertiliser Distribution, Subsidy, Marketing, Promotion, and Agronomic Use Efficiency Scenario in Bangladesh." Presented at the IFA Crossroads Asia-Pacific 2008, Melbourne, Australia, December 16-18, 2008.

Ahmed, Raisuddin. 1979. *Food Grain Supply, Distribution, and Consumption Policies within a Dual Pricing Mechanism: A Case Study of Bangladesh*. Research Report No. 8 Washington, D.C.: International Food Policy Research Institute (IFPRI).

___. 1987. "Structure, Dynamics and Related Policy Issues of Fertiliser Subsidy in Bangladesh." In *Fertiliser Pricing Policy in Bangladesh*, edited by Bruce Stone. Washington, D.C.: International Food Policy Research Institute (IFPRI).

___. 2010. *Government in Rural Transformation: Role of Public Spending Policies in Bangladesh*. Dhaka: The University Press Limited.

Ali, A. M., M. S., Ishrat Jahan, Akhter Ahmed, and Shahidur Rashid. 2008. "Public Food Distribution System in Bangladesh: Successful Reforms and Remaining Challenges." In *Farm Parastatals to Private Trade: Lessons from Asian Agriculture*, edited by Shahidur Rashid, Ashok Gulati, and Ralph Cummings Jr., 103-134. Dhaka: International Food Policy Research Institute (IFPRI).

Asaduzzaman, M., and N. Islam. 2008. *Distribution of the Benefits of the Diesel Subsidy to Framers and Its Effectiveness*. Mimeo. Dhaka: Bangladesh Institute of Development Studies (BIDS).

BARC (Bangladesh Agricultural Research Council). 1997. Fertilizer Recommendation Guide. Dhaka: BARC.

Barkat, Abul, Rushad Faridi, Syed Naimul Wadood, Subhash Kumar Sengupta, and S. N. M. Ehsanul Hoque. 2010, December. *A Quantitative Analysis of Fertilizer Demand and Subsidy Policy in Bangladesh*. NTNFPCP Final Report PR#9/08. Dhaka: Manob Sakti Unnayan Kendro (MSUK).

Basak, J. 2011. *Future Fertiliser Demand for Sustaining Rice Production in Bangladesh: A Quantitative Analysis*. Dhaka: Unnayan Onneshan – The Innovators.

Bayes, A. 1984. "An Evaluation of Combined Price Support and Fertiliser Subsidy Policies for Increasing Rice Production in Bangladesh." Unpublished PhD Dissertation, University of New England, Armidale.

Chowdhury, N., N. Farid, and D. Roy. 2006. *Food Policy Liberalization in Bangladesh: How the Government and the Markets Delivered*. MTID Discussion Papers No. 92. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Chowdhury, M. I., and A. M. F. Uddin. 2009. *Agrarian Transition and Livelihoods of the Rural Poor: Agricultural Input Market*. Dhaka: Unnayan Onneshan – The Innovators.

Chowdhury, N. 2010. *Price Stabilisation Market Integration and Consumer Welfare in Bangladesh*. Report No. 6107 NFPCSP. Dhaka: Government of Bangladesh, USAID and FAO.

Dorward, Andrew. 2009. *Rethinking Agricultural Input Subsidy Programmes in a Changing World. Rome: Trade and Markets Division*. Rome: Food and Agriculture Organization of the United Nations, and London: Centre for Development, Environment and Policy. School of Oriental and African Studies, University of London.

Dawson, P. J., and P. K. Dey. 2002. "Testing for the Law of One Price: Rice Market Integration in Bangladesh." *Journal of International Development* 14, no. 4: 473-484. https://doi.org/10.1002/jid.888.

Dowlah, C. A. F. 2001. "Agriculture and the New WTO Round Economic Analysis of Interests and Options for Bangladesh." Workshop Paper, New Delhi, January 11-13, 2001.

Government of Bangladesh. 2008. *National Food Policy Plan of Action, 2008-2015*. Dhaka: Ministry of Food and Disaster Management, Government of the People's Republic of Bangladesh.

Hossain, M. 1987. *Green Revolution in Bangladesh: It's Nature and Impact on Income Distribution.* BIDS Working Paper No. 4. Dhaka: Bangladesh Institute of Development Studies.

___. 1996. "Agricultural Policies in Bangladesh: Evolution and Impact on Crop Production." In *State, Market, and Development: Essays in Honour of Rehman Sobhan*, edited by Abu Abdullah and Azizur Rahman Khan. Dhaka: The University Press Limited (UPL).

Hossain, M., and M. R. Dhaly. 1991. *Tracer Study on Recent Agricultural Policies in Bangladesh*. Mimeo. Dhaka: Bangladesh Institute of Development Studies (BIDS).

Hossain, Mahabub, Steve Jones, M. A. Sattar Mandal, and M. Asaduzzaman. 2009. *Rice Technologies, Strategic Choices and Policy Options.* BIDS Policy Brief No. 0903. Dhaka: Bangladesh Institute of Development Studies (BIDS).

IFDC (International Fertiliser Development Centre). 1980, July. *Second Evaluation of the New Marketing System*. Prepared by John M. Hill and Robert D. Benton for USAID/Dhaka under the BADC/IFDC contract, July 1980. Muscle Shoals, A.L.: IFDC.

___. 1982, April. *Third Evaluation of the New Marketing System*. Muscle Shoals, A.L.: IFDC.

IFPRI (International Food Policy Research Institute). 2012. *Bangladesh Integrated Household Survey 2012*. Dhaka: IFPRI.

Islam, N. 1977. *Development Planning in Bangladesh: A Study in Political Economy*. London: C. Hurst and Company.

___. 2014. *Political Economy of State Interventions in the Bangladesh Food-grain Sector*. IFPRI Discussion Paper 1404. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128884.

Jabbar, M. A. 1981. "Supply, Distribution, and Pricing of Chemical Fertilizer in Bangladesh." *Journal of Social Studies* 13: 48-69. https://ageconsearch.umn.edu/record/208704/files/1981-Supply%20of%20fertilizers-JSS.pdf.

Katyal, J. C., and M. N. Reddy. 2005. "Fertilizer Use in South Asia." In Agricultural Science. Vol. II of Encyclopedia of Life Support Systems (EOLSS). http://www.eolss.net/Sample-Chapters/C10/E5-24-08-05.pdf.

Mujeri, Mustafa K., and Q. Shahabuddin. 2012. Food Security: Bangladesh—An Overview of Major Challenges, Australian Centre for International Agricultural Research, University of Queensland, September 2012.

Mujeri, Mustafa K., Siban Shahana, Tahreen Tahrima Chowdhury, and Khondoker Tanveer Haider. 2013, June. *Improving the Effectiveness, Efficiency and Sustainability of Fertilizer Use in South Asia*. GDN Working Paper no. 67. New Delhi: Global Development Network (GDN).

Osmani, S. R., and M. A. Quasem. 1985. *Pricing and Subsidy Policies for Bangladesh Agriculture*. Dhaka: Bangladesh Institute of Development Studies (BIDS).

Quasem, M. A. 1980. "Government Procurement of Paddy/Rice and Farmers' Participation in Bangladesh." *Asian Profile*18, no. 4.

___. 1987a. Impact of the New System of Distribution of Fertiliser and Irrigation Machines in Bangladesh — Survey Findings. Research Report No. 62. Dhaka: Bangladesh Institute of Development Studies (BIDS).

___. 1987b. "Supply and Distribution of Fertiliser in Bangladesh in Fertiliser Pricing Policy in Bangladesh." In *Fertiliser Pricing Policy in Bangladesh*, edited by Bruce Stone. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Raihan, Selim. 2013. *The Political Economy of Food Price Policy: The Case of Bangladesh*. Working Paper No. 2013/002. Helsinki: UNU World Institute for Development Economics Research (UNU-WIDER). https://www.wider.unu.edu/sites/default/files/wp2013-002.pdf.

Renfro, Raymond Z. H. 1992. "Fertiliser Price and Subsidy Policies in Bangladesh." *World Development* 20, No. 3 (March): 437-455. https://doi.org/10.1016/0305-750X(92)90034-S.

Samad, A. 1987. "National Fertiliser Supply and Adjustment Planning in Bangladesh." In *Fertiliser Pricing Policy in Bangladesh*, edited by Bruce Stone. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Selim, Raihan. 2013. *The Political Economy of Food Price Policy: The Case of Bangladesh*. WIDER Working Papers No. 2013/002. Helsinki: UNU-WIDER.

Shahabuddin, Q., and R. Islam. 2009. *Development Experience and Emerging Challenges: Bangladesh*. Dhaka: Bangladesh Institute of Development Studies (BIDS).

Shahabuddin, Q. 1996. "Public Intervention in Food Grain Market in Bangladesh: An Appraisal." In *State, Market, and Development: Essays in Honour of Rehman Sobhan*, edited by Abu Abdullah and Azizur Rahman Khan. Dhaka: The University Press Limited.

Sidhu, S. S. 1992. *Development of a Competitive Free Market Structure for Fertilisers in Bangladesh: IFDC Experience in Policy Reform*. Muscle Shoals, A.L.: IFDC.

Stone, R. 1987. *Fertiliser Pricing Policy in Bangladesh*. Washington, D.C.: International Food Policy Research Institute (IFPRI), and Dhaka: Bangladesh Institute of Development Studies (BIDS).

Timmer, C. P., Walter P. Falcon, and Scott R. Pearson. 1983. *Food Policy Analysis*. Baltimore and London: Johns Hopkins University Press.

Titumir, R. A. M., and G. Sarwar. 2006. *Failing Farmers: Liberalisation in Agriculture and Farmers' Profitability in Bangladesh*. Dhaka: Unnayan Onneshan—The Innovators.

Tiwari, K. N., Sanjay Sharma, Vinod K. Singh, Brahma S. Dwivedi, and Arvind K. Shukla. 2006. *Site Specific Nutrient Management for Increasing Crop Productivity in India: Results with Rice-Wheat and Rice-Rice System*. PDCSR (ICAR)–PPIC, India Programme.

Tolley, G. S., Vinod Thomas, and Chung Ming Wong. 1981. *Agricultural Price Policies and the Developing Countries*. Baltimore: Johns Hopkins University Press.

Toufique, K. A. 2012. *Proving the Effectiveness, Efficiency, and Sustainability of Fertiliser Use in Bangladesh*. Dhaka: South Asia Network of Economic Research Institutes (SANEI).

World Bank. 2008. *Framework Document for Global Food Crisis Response Programme*. Washington, D.C.: World Bank.

___. 2012. *Final Report on Global Food Crisis Reverse Programme*. Washington, D.C.: World Bank.

Chapter 6

Economics of Water Resources Management in Bangladesh

Quazi Shahabuddin, Mohammad Yunus, and K.M. Nabiul Islam

6.1 Introduction

In Bangladesh, the dry season of October to March is characterised by falling water tables, reduction in the discharge of major rivers, drying water channels, and salinity intrusion, particularly in the southwest coastal region. Demand for groundwater is at its highest during this season. Although groundwater has powered the expansion of cereal production over the last two decades or so, the sustainability of groundwater-based agricultural production has been questioned by many researchers. The tension between water supply and demand during the dry season thus has become a critical one.

So far, water resource development in Bangladesh has been geared towards the expansion of irrigation to promote food grain production even during the lean season. However, with conflicts intensifying as supplies of water become even more limited, there is a need to shift focus from water resource development towards water resources management. This need only becomes more urgent when considering the parallel phenomena of population growth, urbanization, and industrialization, which are all putting massive stress on existing water resources, and pose a serious threat to the economy and environment if current practices continue (Finger and Allouche 2002).

However, when considering the issue of water resource management, it should be noted that there is a major difference between estimates of groundwater availability made by the National Water Plan (NWP 1991) by Master Plan Organization (MPO) and the National Minor Irrigation Development Programme Report (1997) by the Ministry of Agriculture. If the National Water Plan estimates are correct, then Bangladesh will have

to face an increasingly higher cost of extracting groundwater as it switches from suction-mode to forced-mode technology. In contrast, if National Minor Irrigation Development Programme estimates are correct, then irrigation can be sustained by the cheaper and more efficient suction-mode technology. Given these contrasting views, future planning for irrigation development must make use of accurate data on groundwater availability.

In future, it may become imperative to establish priorities for the provision of water services during the dry season. The plan will have to examine the water needs of various sectors and determine priorities based on national objectives. Water for domestic consumption should obviously receive top priority. Water supplies in municipalities are mostly derived from groundwater sources, but overexploitation may exhaust aquifers in some areas. At present, there are critical shortages of water especially in large metropolitan areas such as Dhaka. Investment in surface water treatment plants and exploitation of deep artisan aquifers should be considered to meet the growing demand in municipal areas.

Industries in Bangladesh are concentrated around the major cities. Rising industrial demand for water for both processing and effluent disposal is likely to become a problem. In rural areas, the demand for safe drinking water is mostly met from groundwater extracted through hand-pumped tube wells. However, as irrigation is facing some limitation with the rapid expansion of shallow tube wells, Bangladesh will have to rely increasingly on manually operated forced-mode tube well to provide safe drinking water to the rural population in some areas.

Preservation of natural habitat of fisheries, which meet the protein requirements of the rural poor, must be weighed against development of surface water irrigation and flood control/drainage as they have affected river and open water fisheries in many places in Bangladesh. Dams and diversion of water for irrigation (drainage as well) also affect navigability of the river system and hence their relative importance has to be determined by policymakers. Similarly, water for environmental has to be considered in order to mitigate salinity and deforestation, particularly in the southwest region of Bangladesh.

Although agriculture at present consumes the bulk of water resources, Bangladesh will be under increasing pressure to reallocate water from irrigation to other competing uses. The increased demand for food may have to be met largely through higher yields using less water, which would be possible with better on-farm water management and by switching to food crops that require less water such as wheat and maize. Changes in the national diet away from staple grains and towards vegetables, fruits, fish, and livestock,

coupled with the increasing cost of irrigation, which discourages production of water-intensive crops such as rice, will make Bangladesh agriculture much more diversified in the twenty-first century.

Given this context, an examination of the relationship between economics and water management, focusing particularly on irrigation using ground and surface water, is needed to guide Bangladesh towards improved agricultural productivity. This examination would need to include an analysis of the balance of water use across difference regions in the country, particularly the challenges to water resources development in the southwest region, to ground appropriate policy interventions. Finally, farmers' response to water scarcity is an unknown factor, and needs to be explored given its potential implications for sustained growth of crop production in Bangladesh.[1]

The chapter is organized as follows. Section 6.2 reviews the existing policy and regulatory framework and identifies the policy gaps. The regional dimension of water resources development has been explored in section 6.3, with an analysis of barriers to water resources development in the southwest and appropriate policy recommendations. The economics of irrigation in general and the financial as well as economic rates of return to alternative modes of ground and surface water irrigation are analyzed in section 6.4. Section 6.5 analyzes how farmers cope with and respond to water scarcity, and implications for crop production in the dry season. Finally, some concluding remarks are made in section 6.6.

6.2 Water Resources Management: Policies, Rules and Regulations

Water resource planning in Bangladesh needs to take into account a variety of geographic, economic, and environmental factors. Bangladesh, being a lower riparian country, faces huge inflows of water over which it has no control. The flow is often unpredictable with too much or too little water at different times due to variability in rainfall and withdrawals by the upper riparian countries.

National water planning in Bangladesh dates back to the mid-1960s when the first Master Plan with 58 large-scale flood control, drainage, and irrigation projects was prepared. The World Bank undertook the Land and Water Sector Study in 1972 advocating the development of smaller-scale irrigation facilities, thereby indicating a major shift in strategy (World Bank 1972). During the 1970s and 1980s small-scale irrigation (also known as minor irrigation) spread rapidly, initially under public investment programmes and later through private sector initiatives.

[1] See https://www.ifad.org/en/web/latest/speech/asset/39026109.

By the early 1980s, the need for a long-term, more comprehensive water resources development plan became apparent and the MPO was established in the Ministry of Water Resources. In 1986, MPO produced the first National Water Plan (NWP-I) and the NWP-II was completed in 1991. However, the National Water Plan fell short of being comprehensive and the MPO was restructured as the Water Resources Planning Organization (WARPO) in 1991 to develop national policies and strategies for utilizing and conserving water resources. With the formulation of Bangladesh Water and Flood Management Strategy (1995), National Water Policy (1999), and National Water Management Plan (2004) by the government, the vision of long-term and sustainable system of water management has been adopted.

6.2.1 Evolution of Water Policies in Bangladesh

The system of development of irrigational facilities and the marketing of irrigation water has undergone a gradual evolution through several steps: public ownership with bureaucratic management, public ownership with cooperative management, and private ownership for development of competitive water markets (Osmani and Quasem 1990). In the late 1950s when modern irrigation was at its infancy, the government leaned heavily towards large-scale surface water development projects. However, over time, the emphasis has shifted to small-scale projects such as fielding power pumps to lift surface water and tube wells for extraction of groundwater (Hossain, Lewis, Bose, and Chowdhury 2003). Groundwater extraction through shallow tube wells (STWs) and deep tube wells (DTWs) now accounts for about 70 percent of the area irrigated by modern methods, while gravity irrigation through large-scale surface water development projects accounts for less than 15 percent of total irrigated area.

Until 1979-1980, various types of minor irrigation equipment were procured and distributed by the Bangladesh Agricultural Development Corporation (BADC) and Bangladesh Krishi Bank (BKB), the former dealing with all types of irrigation equipment and the latter limiting to sales of STWs to interested farmers with credit support. In early 1980s, the private sector was permitted to import and trade in STWs.

The evolution of the pricing policy for irrigation has been governed by two principles: (a) reduction of subsidy over time; and (b) impetus to private ownership of irrigation equipment. Although the government pursued a policy of increasing rental charges for pumps and tube wells, and selling the equipment to cooperatives and private owners, there remained a large implicit subsidy on irrigation till late 1980s because of the widespread failure

to collect water charges from the managers of irrigation groups and to recover credits from financial institutions with which the irrigation equipment was purchased from the government. However, the government eliminated restrictions on the import of agricultural machinery and reduced import duties in 1988, encouraging farmers to invest their own resources to but STWs, thus reducing the implicit subsidies on minor irrigation equipment through agricultural credit substantially.

The privatization in irrigation equipment was promoted to (i) mobilize private savings for investment in irrigation; (ii) eliminate delays in installing of equipment and repair and maintenance due to bureaucratic procedures and rent seeking in the public sector; (iii) avoid problems in the management of irrigation cooperatives; and (iv) increase in capacity utilization of the machines. With unrestricted private sector imports, farmers could avail lower prices for minor irrigation equipment by choosing Chinese or Indian-made options instead of Japanese or Korean makes for pumps and motors, and using plastic pipes instead of metal pipes. With these price reductions, medium-sized farmers could afford such investments from their own resources. Ending the requirement for standardized equipment and other restrictions contributed to a massive expansion of private markets in irrigation services.

As in other countries in South Asia, informal water markets are common in Bangladesh. Typically, the practice involves a farmer selling surplus ground or surface water to another for a specified period. This allows for water to be reallocated to users who require greater quantities without formalizing existing water rights. Informal water markets have the added benefit of incentivizing the conservation and rational use of water in order to maximize the surplus available for selling. Moreover, they can also facilitate increased access to water for some of the poorest farmers.

With the rapid expansion of groundwater irrigation, especially due to the extension of privately owned STWs purchased at unsubsidized prices, informal water markets for irrigation have quickly developed in Bangladesh, where farmers without wells can attain access to irrigation through purchasing groundwater from farmers owning wells. As the water market has expanded in the private sector, the pricing system has also changed to meet the needs of the farmers. Initially, in-kind payments were the most common practice, with a farmer sharing one-fourth of the harvest with the owner of the equipment for water. This evolved to a flat seasonal fee, with the rate set by the availability of electricity and the price of diesel. More recently, the market has moved towards charging fees per hour of tube well operation, the rate depending on whether the receiver of

the service brings fuel for running the machine (Kumar 2012). The hourly charge provides incentives to adopt supplementary irrigation during the *aman* season in times of drought, and has encouraged cultivation of modern varieties in the wet season.[2] However, in many parts of the country, the in-kind payment system still prevails as an innovative way to shift the burden of irrigation cost to the water sellers (or suppliers) for about four months, when at the beginning of the irrigation season the water-buying farmers have cash constraints and they also have to pay for fertilizers, seedlings and labor.

A key concern in the development of a private sector water market was that irrigation equipment would become concentrated in the hands of the large farmers, potentially creating a situation conducive to differential pricing and limited or inequitable access for small and marginal farmers. A large-scale panel survey conducted by BIDS indicates that irrigated area has increased substantially over the 1987-1994 period, more so for the relatively large farmers than for the medium and small ones.[3] The difference in access to irrigation between the small and large farmers remained the same over this period. However, the unit cost of irrigation for large farmers was only half of that for small and marginal farmers, and about 25 percent lower than that for medium farmers. The inequity increased marginally during the 1987-1994 period. It is important to note however, that during this private water market expansion, irrigation charges paid by farmers did not increase. The average water charge in fact declined by 4 percent, while the price of rice increased by nearly 30 percent, meaning irrigation water has become substantially cheaper in real terms after liberalization of the water market (Hossain 1996).

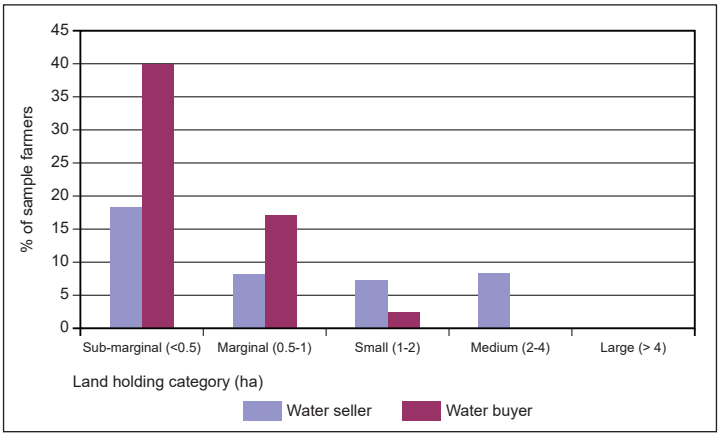
The widespread expansion of tube wells also contributed to competitive pricing in the water market. It is quite likely that the dominance of the so-called "water lords" would dissipate with the presence of thousands of water-sellers entering the market with small irrigation equipment. The water market is more competitive now than before (Hossain and Bayes 2009). According to 2008 Agricultural Census, 48 percent of the irrigation equipment was owned by small farms (up to 1 hectare), 42 percent by medium farmers (1 to 3 hectares) and 10 percent by the large farmers

[2] The hourly rate has been conducive to more efficient use of water and a decline in unit cost of irrigation. However, it may be mentioned that the machines are being used not only for irrigation but also for earning income from non-farm activities i.e. for running country boats in the rainy season.

[3] The sample of the panel survey was drawn from 62 villages randomly selected through a multi-stage sampling method. The number of sample households was 1208 in 1987 and increased to 1,293 by 1994 (see Hossain, Quasem, Jabbar, and Akash 1994).

(above 3 hectares). This implies that the small and medium farmers have been dominating the water market in the country. Zahid, Haque, Islam, and Hasan (2009) show that sub-marginal and marginal farmers with small landholdings (land holding size <1 hectare) are mostly water buyers, while the small and medium farmers (with landholding between 1.01 and 4.0 hectares) mostly own the STWs and sell water from the same (Figure 6.1).

Figure 6.1: Distribution of Water Sellers and Buyers by Land Holding Sizes



Source: Zahid, Haque, Islam, and Hasan (2009).

However, policy reforms in trade and marketing of inputs can only have a "once-and -for-all" effect through influencing the price mechanism. When these effects become fully adjusted, it requires non-price factors such as infrastructure and innovative technology to drive the sustainability of agricultural growth. The drastic deceleration in growth in crop production in the early 1990s suggests that the positive effects of policy reforms may have run out of steam. Bangladesh therefore needs to shift focus towards research for the development of new technologies in general and food security in particular if the country is to achieve further gains in sustainable agricultural growth (Hossain 1996).

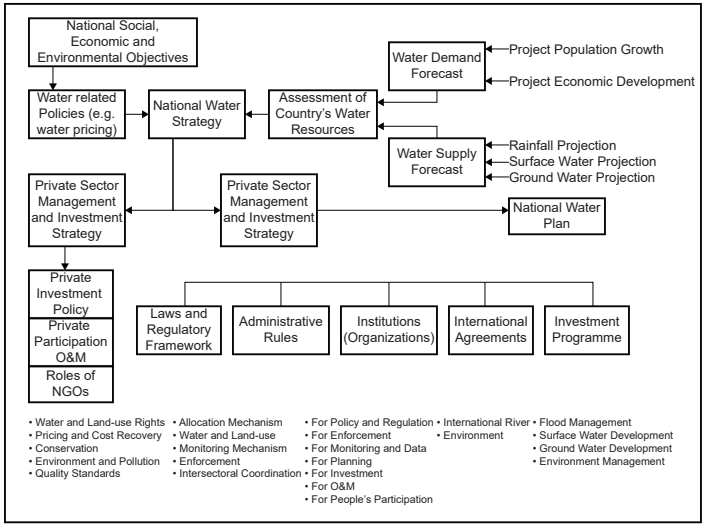
6.2.2 Legal and Regulatory Framework for Water Resource Management[4]

Figure 6.2 presents a schematic framework for water policy and management relevant for a country like Bangladesh. The National Water Strategy (NWS),

[4] This section draws heavily on Faruquee and Chowdhury (1998).

which lays down the short, medium and long-term programmes for the sector, is at the center of the framework.[5] Essential inputs into the NWS are: (i) social, economic and environmental objectives; (ii) priorities for provision of water services to different sectors and users; and (iii) an assessment of the country's net water resources based upon supply and demand projections (which, in turn, are based on projected population growth, rate of economic growth, rainfall, and projected surface and groundwater availability).

Figure 6.2: A Framework for Water Resource Management in Bangladesh



Source: Faruquee and Chowdhury (1998).

Private Sector Water Management and Investment Principles

In the water sector, the private sector can play a role in increasing efficiency if it provides investment and management resources. An example of this is a private leasing arrangement, whereby a competitive bidding process is followed to lease out a facility to a private operator for the long-term. The lessee then provides investment for improvement of the facility and for its operation and maintenance (O&M). This has been observed in Cote d'Ivoire, Guinea, Macao, Portugal, Spain and Argentina (World Bank

[5] The proposed programmes were presented in the Bangladesh Water and Flood Management Strategy designed by the Flood Plan Coordination Organization, with assistance from the World Bank in March 1995.

1993). Many countries in Latin America are adopting similar approaches. In Bangladesh, private sector participation has been particularly significant in the sale and operation and maintenance of tube wells, especially shallow tube wells. Privatization can also take other forms such as transfer of facilities to beneficiary groups like water user associations. This arrangement exists in many countries, such as Argentina, Mexico, Philippines, Indonesia, Nepal, Sri Lanka, and Pakistan.[6]

A large number of NGOs in Bangladesh are operating in various areas of socio-economic development, such as employment generation, poverty reduction, health and sanitation. These organizations can play an important role in the development of private water markets, such as facilitating formation of user groups, enhancing information exchange or providing funding to small entrepreneurs. They can also contribute significantly to environmental protection activities, including educating the public, monitoring environmental hazards, and mobilizing people to undertake appropriate measures for improved management of water resources.

Public Sector Water Management and Investment Principles

Legal and Regulatory Framework: The state owns all the natural resources including water, and the government tacitly authorizes the use of it. Legislation, however, does not always clearly indicate priorities, and altogether ignores some areas, such as in the environmental aspects of water use. Other principal areas that need to be regulated include water rights and allocation, service standards, water quality and environmental protection, watershed management, soil and water conservation, utility tariffs, and ease of entry into water service industries.[7] However, regulation in Bangladesh is highly inadequate across many of these areas, and what regulation exists is poorly administered. One reason behind this is the existence of multiple agencies, each following its own agenda without any coordination or rationalization of its activities with the others. For example, the plans for

[6] It may be noted here that large-scale investment may not be expected and/or forthcoming from the private sector, and also may not be desirable. BWDB, on the other hand, has experience of management transfer of secondary and tertiary canals for operation and maintenance of major surface water irrigation projects. Also, there is a serious policy debate regarding the operation and maintenance of sluice gates in the Southwest region where conflict of brackish water shrimp with fresh water based livelihood issue exists. There is a need for proper coordination of the role of public agency, local government institutions and the private sector.

[7] Legal instruments may shed light on who owns water in the river and who owns floodplains since it is associated with water congestion in times of high rainfall situation in most of the cities/towns and in the low-lying areas.

groundwater irrigation of the Ministry of Agriculture may conflict with those of the Department of Public Health Engineering for use of groundwater for drinking purposes. Furthermore, pricing policies are also inconsistent; for example, the price of irrigation water is well below municipal water rates. Under these conditions, the need for centralized policies for water resources becomes imperative[8] (Faruquee and Chowdhury 1998).

Administrative Rules: Legislation around water rights needs to be backed by appropriate rules for administration, both to ensure fair allocation of water in the market as well as to protect government and private sector investment. In countries with efficient water administration, the source of water, geographical restrictions on its use, quality restrictions on source and return flows, and rules for any transfer of rights by the holder are all well-defined.

Formulating such well-defined rules of administration requires a wide range of activities, from clarifying legislation to preparing manuals and guidelines. The participation of civil society and the wider public in such activities is important to ensuring practicality of objective and approach. The rules also need to address what constitutes a violation and the associated penalties, which should be duly imposed and enforced. Well-administered service standards and regulations needed to sustain good water services and ensure a high quality of service so beneficiaries are more able and willing to pay.

The principal elements of a water sector management system, discussed above, could be used to prepare a strategic approach for Bangladesh to improve its water management. Some of the elements are already present in the system, and how these specific improvements can increase efficiency are examined below (Faruquee and Chowdhury 1998).

Formulating National Water Policy: This is the first step towards adopting a comprehensive water management program.[9] There have been many *ad hoc* directives from the government in the past, but these were uncoordinated and often contradictory. All existing policies must be reviewed in conjunction with the objectives and strategies for: (i) development of agricultural, industrial, energy and power, fisheries, livestock, forestry, navigation, and public health sub-sectors; (ii) flood and drought management; (iii) environmental protection; (iv) poverty alleviation and women-in-development; (v) decentralization; and

[8] However, it should be recognized that the centralized policy for all hydrological zones may not be practical.

[9] In fact, a National Water Policy covering different aspects of water management policies and programs in Bangladesh was formulated in 1999. However, the Policy needs to be updated keeping in view the latest developments and emerging challenges in the water sector.

(vi) private use of water. A policy review of this nature would reveal any inconsistencies between existing water policies and the needs of different sectors. It would also identify the new policies needed for a harmonized and integrated framework that brings together the objectives of different development agencies and the private sector.

Policy on Water Pricing and Cost Recovery: Cost recovery is critical to the sustainability of water supply. If cost recover is inadequate, the private sector will not be interested to invest, and the public sector will have to run their water supply operations at a loss that is eventually passed on to the general public, who also have put up with service gaps. This entails both economic and social costs.[10] Cost recovery is relative simpler in urban and industrial supply where metering is prevalent, and appropriate government policy and administrative mechanisms can ensure cost recovery based on opportunity cost. For the urban poor, the government can adopt a policy of graduated volumetric pricing, where heavy users pay more for consumption above a certain level. In rural areas, there are alternative methods to at least partially address these problems, such as cost recovery through user groups, and levying water charges on the basis of cultivated hectare of land and type of crop (a rough indication of the volume of water consumed).[11]

Pricing policies can also promote water conservation. In urban areas, fees and fiscal incentives could encourage industrial consumers to adopt water-efficient technologies, including re-use systems. Similarly, in rural areas, water fees could incentivize farmers to switch to crops that consume less water. This would help achieve crop diversification objectives as well.[12]

---

[10] Farmers are heavy users of water and also paying cost for water use. Hence, rather than increasing efficiency of water use such as AWD technology, conservation agriculture, buried pipe systems, growing short maturity rice etc. should be expanded.

[11] See Faruquee and Chowdhury (1998). It may be noted here that formation of user group was introduced during the early sixties for low-lift pumps (LLP) using surface water. BADC's record and World Bank evaluation would show that recovery was good. However, when the same user group approach was adopted for deep tubewells (DTW) during the eighties, the recovery was not so good. In other words, the user group approach for cost recovery worked for LLP using surface water during the sixties but not for DTW using groundwater during the eighties. This calls for some explanation. The main reason for the failure of the user group in the eighties was internal dispute within the group regarding leadership. Another reason might be the failure of the Managing Committee to work properly to collect the rents. Yet another reason may be that most of the DTWs became dysfunctional due to declining water table following privatization policies during the eighties which led to proliferation of STWs on a large scale. So there was no point in continuing with the user groups for DTW.

[12] Pricing of water may, however, promote but not guarantee crop diversification since it is associated with and depends on a number of other factors such as storage, marketing etc.

Fiscal incentives could also encourage the private sector to invest in in small-scale water processing technologies, such as community-based water supply or sewage systems.

Laws and Regulatory Framework: Bangladesh could experiment with the licensing system currently widely used in developed countries, for its surface water. Under such systems, licenses are awarded either on the principles of riparian rights or first-in-time and first-in-use or legal authorization. The merit of a licensing system is that it achieves multiple objectives within a single system, including allocating and controlling water use and quality; charging for water services; protecting investments and other user interests; and transferring rights through legal mechanisms (Faruquee and Chowdhury 1998).[13]

Along with water-use rights, land-use rights also need to be examined. The two areas are closely linked across issues such as land zoning in urban areas for meeting environmental objectives, settlement on floodplains, uptake of land for flood control and flood proofing facilities, siting restriction on industries to control pollution, and restricting high water users' access in times of shortage.[14]

Framing of Administrative Rules: Rules and procedures for the administration of water legislation and regulations should be simple and easily implementable, with a flexible allocation mechanism. The first priority should be domestic use, followed by industry and agriculture, subject to the limits imposed on in-stream flows for navigation, fisheries, and environmental protection. The allocation mechanism may vary. If licensing is used, the licensee obtains a legal right, but if no legal title is given, or is difficult to enforce, public control is the alternative instrument of enforcement of water rights.

In Bangladesh, as in many countries of the world, there is inadequacy in the enforcement of the water codes and laws. Hence, indirect methods, such as taxes and subsidies, might encourage compliance. Sometimes, the lack of

---

[13] It may be recognized that introducing licensing system for surface water is difficult since this may not work being unacceptable to the (political) policy makers because customary law dictates that people have a common right over surface water (common property resources). Moreover, since a number of diversified stakeholders are involved, this may require public debate and critical review before the licensing system is formally introduced. However, some form of licensing exists over surface water for fishing purposes, the most common form being the annual leasing to the highest bidder.

[14] It may be mentioned here that Land Use Policy (2001) does provide for land zoning. However, draft legislation for land zoning was almost finalised but did not see the light of the day for some unknown reasons.

connection between the quantity of water and quality poses administrative problems: water quantity regulations and incentives are administered by different water-related ministries while quality standards are set, monitored, and enforced by the Ministry of Forestry and Environment.

Institutions and Organizations: Besides laws and regulations, the institutional aspects of water management in the public sector are organizations, enforcement, monitoring and data collection, planning investment, and operation and maintenance. It is important to ensure public participation in as many aspects of these activities as possible. The major water sector organization in Bangladesh is the Ministry of Water Resources. Other sub-sector institutions are the Department of Public Health Engineering (DPHE), Local Government Engineering Department (LGED), Water and Sewerage Authority (WASA), Department of Fisheries (DoF), Bangladesh Inland Water Transport Authority (BIWTA), Department of Environment (DoE), and respective municipal corporations.[15] The National Water Council presides over all these institutions in matters of water policy and legislation. The Ministry of Water Resources has the Water Resources Planning Organization (WARPO), Bangladesh Water Development Board (BWDB), River Research Institute (RRI), and Surface Water Modeling Centre (SWMC) under it.

The small-scale water resources development projects implemented by LGED in Bangladesh take a participatory approach across planning, design, implementation and maintenance. Such interventions can significantly enhance income and asset for the beneficiary households, although non-poor households appear to benefit more (Islam 2014). It should be noted that the performance of the projects is highly dependent on the performance of the Water Management Cooperative Associations (WMCAs). Efforts should, therefore, be made to improve the performance of WMCAs to ensure proper operation and maintenance for the sustainability of such projects.

[15] The Ministry of Water Resources is responsible for overall water sector planning and policy formulation. As for implementation and monitoring, its functions are limited to surface water major irrigation projects. For development of minor irrigation, on the other hand, the Ministry of Agriculture through Bangladesh Agricultural Development Corporation (BADC), Barind Multipurpose Development Authority (BMDA) and to some extent, LGED is involved in surface water minor irrigation projects, not exceeding 1000 hectares. BIWTA is responsible for regulating water of large rivers for transportation purposes. Also, the reference to municipal corporations has to be seen in the context of WASA which is responsible for supply of drinking water in big city corporations of Dhaka and Chittagong, over which city corporations have no control.

Water codes generally specify the following: the rights, powers, and duties of individual users and the government with respect to water; ancillary power over land; registration and licensing of rights to water; and the administrative structure to implement the code. However, existing laws and regulations in Bangladesh do not cover all these areas; many laws are outdated or are overlapping (Table 6.1, Box 6.1). The system lacks cohesiveness, which exacerbates the conflicts inherent in the water sector.

Table 6.1: Laws, Regulations, and Administrative Procedures for Water Sector Management

Title	Status	Purpose
The Bengal Irrigation Act, 1876	Act	Levy of water rates
Bengal Tank Improvement Act	Act	Regulates public and private water rights
Bangladesh Irrigation Water Rate Ordinance, 1983	Act	Levy of water rates
East Bengal Embankment and Drainage Act, 1952	Act	Construction, operation, and maintenance of embankment and drainage structures
Groundwater Management Ordinance, 1985	Ordinance	Siting and installation of minor irrigation equipment
Acquisition and Requisition of Immovable Properties Ordinance, 1982	Ordinance	Acquisition of land in the public interest
State Acquisition and Tenancy Act, 1950	Act	Regulates land ownership and declares those subsoil resources belonging to the state
Transfer of Properties Act, 1882	Act	Provides for disposal of immovable properties by gift, sale, mortgage, or lease
Registration Act, 1908	Act	Registration of properties and agreement between contracting parties
Local Government Ordinance, 1983	Act	Structure, composition, and function of local government institutions
National Water Bodies Policy, 2009	Act	Regulation of rights to water use for fisheries
Water Act, 2013	Act	Provides for punishment and penalty for non-compliance

Source: World Bank (1998), updated.

Box 6.1: Assessment of Water Laws and Regulations in Bangladesh

The three basic principles of natural water rights recognized by most countries are declaration of state title, declaration of water subject to administrative control, and declaration concerning private rights. The first principle relates to the French doctrine of public domain. Under this doctrine, certain resources cannot be owned or managed by private individuals because of their overwhelming public significance. The second principle flows from English common law. It recognizes neither total state ownership of water resources nor total private ownership. It reserves powers to the state to control water for specific purposes. The Northern Indian Canal and Drainage Act of 1873 and the Bengal Irrigation Act of 1876 exemplify this principle. The third principle relates to private rights over water resources. In effect, it mixes public and private rights. South Korean laws illustrate the application of this principle.

The water laws designed in colonial British India, embracing Bangladesh, established the right of government to control and regulate water for specific purposes. They also limited private control over water resources through such legislation as the Indian Easement Act of 1882. With the passing of the East Bengal State Acquisition and Tenancy Act in 1950, the common law treatment of the issue officially ceased and state rights over subsoil was formally established. But this was never enforced, and regulation of water has continued along traditional (colonial) lines.

The current laws, regulations, and administrative rules for water management in Bangladesh were framed in response to the needs of individual sectors and of specific situations. The laws are inconsistent and outdated, hampering enforcement. The task of revising old laws to suit present conditions has to be undertaken after framing the national water policy. That policy should reflect the principles of water rights and the extent of state and private ownership. As it stands now, only groundwater has been declared under the State Acquisition Act to be a subsoil resource belonging to the state. But the Ground Water Management Ordinance, framed to regulate the use of groundwater for irrigation, is functionally dead. There are also laws governing particular aspects of water use, such as water rates, that need to be consolidated.

Source: World Bank (1998)

6.3 Regional Dimension of Water Resources Development Potential

The northwest region of Bangladesh is characterized by temperate climate along with dry weather most of the year. These particular characteristics of the region have different impacts on agricultural productivity compared

to that of other regions, especially during the dry season. The issue of balanced development of water resources in Bangladesh, including the northwest region, has thus become a critical one. To deal with this issue, the potential for water resource development potential in the northwest region of Bangladesh needs to be explored first.

The northwest region, which includes 16 districts of Rajshahi Administrative Division, is the largest irrigated area of all regions (WARPO 2001c).[16] The region's total net cultivable area is 2.35 million hectares. Water resources in the northwest region include rivers, canals, rainwater, groundwater, etc. The region is bounded by the Brahmaputra and the Ganges rivers. Average annual rainfall in this region is about 1,700 millimeters, but its south western part, the Barind zone, is one of the driest in Bangladesh, with average rainfall below 1,400 millimeters.

The major source of water for irrigation of agricultural land in the northwest region is groundwater, which accounts for about 75 percent of water resources for irrigation (Bari and Anwar 2000). About 70 percent of the groundwater is extracted using shallow tube wells and the rest by deep tube wells (WARPO 2001c). It has been observed that while the contribution of groundwater has increased from 41 percent in 1982-1983 to 77 percent in 2006-2007, that of surface water has declined. These changes mean that the ratio of groundwater to surface water use is much higher in northwestern districts relative to the rest of the country (BRAC 2013).

There is a concern that groundwater table in the northwest is gradually declining due to over-extraction, poor water management, below average rainfall etc. Water resources need to be developed in this region to facilitate expansion of irrigation to increase food grain production. As groundwater level is declining, emphasis should be given on surface water development along with the development of groundwater resources in the region. However, with groundwater development, fluctuations will amplify; but as long as rainfall recharges aquifers, and proactive water saving strategies are put in place, a steady and sustainable state can be achieved (IWMI 2010).

The government aims to develop main rivers (the Brahmaputra and the Ganges) and also manage those for multi-purpose use through a system of barrages as well as other structural and non-structural measures (WARPO 2001d). The government also has a plan to work towards international river basin so that the potential benefits of the main rivers of the northwest

[16] The sixteen districts include Rajshahi, Dinajpur, Rangpur, Bogra, Pabna, Natore, Kurigram, Panchagarh, Thakurgaon, Nilphamari, Lalmonirhat, Gaibandha, Joypurhat, Naogaon, Nawabganj and Sirajganj.

region can be realized. These rivers, unlike that of southwest regions, are good sources of fresh water in the dry season for irrigation. The potential of Meghna river to serve the needs of this region by means of a barrage and/or by river pumping needs to be studied inter-regionally. The augmentation of the Dhaleswari, also integrated development of the Brahmaputra, Ganges and Padma rivers, and updated assessments of the Brahmaputra barrage are among the key areas of further study and research. There is also a Master Plan for erosion control in the Brahmaputra river. In the northwest, the identified risks in the long run can be managed through the development of barrages on the Brahmaputra, the Ganges and the Padma rivers.

Sixteen programmes have been undertaken to benefit the northwest region of Bangladesh, of which five are exclusive to the region (WARPO 2001c). These are targeted at fulfilling Rajshahi's need for water supply, sanitation, sewerage, storm water drainage, and public deep tube well irrigation. The shared programmes will involve river abstraction, improved surface water distribution, erosion and flood control, river dredging, and arsenic mitigation. These programmes will help the development of both types of water resources—groundwater and surface water. To rectify the problem of arsenic contamination of groundwater, short-term interventions are being tested including arsenic filters and household removal facilities, while research on medium-to-longer term solutions is underway to access safe deeper aquifers below 250-300 meters.

Flood-proofing (rather than flood control) of the rural population in the *haor* basin and in the *char* lands are high priority activities to be completed within the medium-term. Alongside, a drought forecasting and warning system will be developed as a short-term measure, and once established and proven, it will be supplemented by dissemination programmes that promote supplementary irrigation for *aman* and *aus*. The government will also promote cheaper force-mode pumps to encourage future growth of tube well irrigation.

Where groundwater is less accessible and costly to attract private investment, and surface water is not available, the government can consider developing subsidized deep tube wells (DTW). These may be implemented in and around the high *Barind* area where groundwater layers are deep, and in the far northwest where drilling costs are high due to the rocky soil layer. The government can provide direct subsidies to private investors, or initiate development along the lines of the Barind Integrated Area Development Project (BIADP).

Alongside, development of effective institutions and legal and regulatory measures as well as efficient and equitable management of the water sector

as a whole are essential to develop water resources in the northwest region of Bangladesh.

6.3.1 Water Resource Development Potential in Northwest Region

The potential of development of water resources in the northwest region cannot be fully realized due to the existence of some constraints and impediments. These impediments have to be identified and need to be addressed properly to realize the development potential of water resources in the region.

Among the key impediments, the first one is over-exploitation of groundwater in the region. Although irrigated areas have rapidly expanded over the last two decades, poor performance and low water-use efficiency still prevail (Dey, Bala, and Hayakawa 2006). In most cases, farmers cannot accurately gauge how much water their crops need, and rice farmers everywhere have the tendency of keeping continuous standing water in rice fields. This has multiple negative impacts, including wastage of the scarce water resource, increasing cost of irrigation, and uplifting excess groundwater causing environmental degradation (Alam and Islam 2009). These in turn have an impact upon the interlinked sources of the water table, which is declining alarmingly. Although groundwater dominates the total irrigated area, its sustainability is at risk in terms of quantity in the northwest region (Simonovic 1997; Shahid 2011).

According to a study conducted by BRAC (2013), the groundwater table has a declining trend over the last 30 years (1981-2011), implying the lack of sustainability of groundwater use in the study areas (Rajshahi, Dinajpur, Rangpur, Bogra and Pabna in Northwest region of Bangladesh). According to a recent study, groundwater levels in some areas are falling between 5-10 meters in the dry season, and most of the tube wells are unable to lift sufficient water (Dey and Ali 2010). Rajshahi is the most severely depleted district compared to the other four. All the rivers and canals in the area become dry during the dry season, thus further intensifying dependence on groundwater (Shahid 2008; Shahid and Behrawan 2008).

Drought is another constraint in this region. In the last 40 years, the region has suffered eight major droughts (Paul 1998), which has also contributed to increasing groundwater dependence for irrigation. The continued increase in groundwater extraction for irrigation without any concomitant increase in rainfall have caused groundwater levels to fall to the extent that they are no longer fully replenished in the recharge season. The problem is becoming more acute with the growth of population and expansion of irrigated agriculture.

Boro is a low value crop requiring more water for irrigation compared to other crops such as lentil, wheat, potato, etc. Cultivation of *boro* rice has increased significantly over time mainly due to the expansion of groundwater irrigation facilities. The area *boro* rice cultivation has increased around 17 times in 2010-2011 as compared to that in 1980-1981, compared to just three times for the ten major crops. *Boro* area has increased most in Rangpur relative to the four other districts of the northwest region. Total area under irrigation increased around four-folds during the 1981–2008 period primarily because of rapid expansion in *boro* rice cultivation. With the declining groundwater table in the northwest region, the production of the dry season rice crop, which is heavily dependent on irrigation, is posing a threat to sustainable groundwater irrigation in this region.

Considering the criteria of selected indicators, the BRAC analysis (Table 6.2) shows that most of them do not satisfy the criteria to ensure sustainability of groundwater use for irrigation in the northwest region of Bangladesh (BRAC 2013).

The practice of multiple-cropping throughout the year requires supplementary irrigation—to sustain this practice the water resources must be adequately recharged. But Table 6.2 indicates that river water contribution to groundwater, precipitation (amount of rainfall added to the groundwater storage), conservation of rainwater and wetland area have decreased while depth of groundwater table, well intensity, groundwater withdrawals, introduction of crops requiring high irrigation frequency have increased. These clearly indicate that the groundwater extraction exceeds groundwater recharge, which constitutes an impediment towards sustainable groundwater use for irrigation. The changes in the environmental indicators are reinforced by the changes in the social indicators, where it is observed that the percentage of people practicing groundwater recharge methods, using alternative sources of water for irrigation and knowing the harmful effects of stagnant water in the field have declined although these were supposed to increase. This is very alarming because if the users of groundwater are not conscious about the consequences of over-extraction and does not practice recharge methods properly then ensuring sustainability of groundwater for irrigation will be very difficult. Hence, there is an urgent need for developing awareness among the people and also for exploring alternative cost-effective methods/technology to abstract groundwater in the northwest region.

Table 6.2: Sustainability of Groundwater Use for Irrigation in Northwest Bangladesh

Sl. No.	Indicators	Measurement	Study findings	Criteria to ensure sustainability	Remarks
Environmental/Technological					
1.	River water contribution to groundwater	Change in river water contribution to GW over time	Decrease	Increase	Not satisfied
2.	Precipitation	Amount of rainfall added in the GW storage	Decrease	Increase	Not satisfied
3.	Groundwater table	Depth of groundwater table	Increase	Decrease	Not satisfied
4.	Groundwater withdrawals	Volume of water used for irrigation	Increase	Decrease	Not satisfied
5.	Well intensity	Nos. per square km	Increase	Decrease	Not satisfied
6.	Excess water	Crop water requirement	Decrease	Increase	Not satisfied
7.	Land use change: Information of major crops and areas	Change in crop area	Increase	Increase	Satisfied
8.	Wetland area	Change in wetland	Decrease	Increase	Not satisfied
9.	Change in crop type	Introduction of crop types requiring high irrigation frequency	Increase	Decrease	Not satisfied
10.	Conservation	Conservation of rainwater, SW and GW artificial recharge	Decrease	Increase	Not satisfied

Continued

Continued from Table 6.2

Sl. No.	Indicators	Measurement	Study findings	Criteria to ensure sustainability	Remarks
Economic					
11.	Cost of GW use for irrigation	Direct cost of groundwater	Increase	Decrease	Not satisfied
12.	Financial Profitability	Cost and return analysis	Increase	Increase	Satisfied
13.	Economic profitability	Shadow pricing of inputs and outputs	Increase	Increase	Satisfied
Social					
14.	Percent of people practicing groundwater recharge methods	Groundwater recharging method	Decrease	Increase	Not satisfied
15.	Percent of people using alternative sources of water for irrigation than before	Surface water use for irrigation	Decrease	Increase	Not satisfied
16.	Percent of people know about harmful effect of stagnant water in the field than before	Harmful effect of stagnant water	Decrease	Increase	Not satisfied

Source: BRAC 2013.

Some Policy Implications

The barriers to development of water resources in the northwest region of Bangladesh need to be removed, especially for sustainable use of groundwater for irrigation purposes. Some policy recommendations to this effect are provided below.

- To address the problem of overexploitation of groundwater use, monitoring organizations should be strengthened to track groundwater recharge and use, and also contribute to the improvement of water quality. The organizations should also do the same for surface water resources.
- The Water User Association (WUA) should fix the rate of irrigation cost from private tube wells, which is much higher compared to public tube wells. The price of water, particularly for the purpose of irrigation, should be determined as a rule on volumetric basis to ensure efficient and equitable use of water. This would also help to minimize the use of excess water for irrigation purpose.
- High value crops that require less water for irrigation, such as lentil, wheat, mustard, potato, etc. should be encouraged in place of *boro* rice. The cultivation of lentil should be emphasized in Pabna district, and wheat (except in Bogra), mustard and potato (except in Rajshahi and Pabna) in the other four districts of the study areas, namely Dinajpur, Rangpur, Rajshahi and Bogra, considering higher returns from these crops.
- An estimated water budget should be prepared that would include recharge, extraction and change in storage in the aquifer(s). Managed aquifer recharge should also be undertaken as a national program. In addition, local planners should identify and consider the recharge areas, while making land use planning decisions that could reduce recharge or pose a threat to groundwater quality.
- Research and development (R&D) on modern water management practices such as alternate wetting and drying (AWD), and water-saving technologies like hose pipe irrigation or drip irrigation, along with climate change adaptive technology such as drought-tolerant crop varieties etc. needs to be intensified.
- Awareness creation and advocacy on sustainable water management concepts, principles and methods are much needed. Department of Agriculture Extension (DAE) can take a lead in this respect.

- Alternative power sources, especially that of solar energy driven pumps for STW and DTW irrigation, should be examined to ensure environmental sustainability.
- The scope of using pre-paid meters in pumps for DTW irrigation to reduce irrigation cost and water wastage should be explored on a broader scale.
- In view of the increasing trend of environmental costs of irrigation over time, it could be said that expanding irrigation 'irrationally' might have substantial direct costs and adverse social as well as environmental impacts. Therefore, acceptable levels of the direct and indirect costs involved in sustaining irrigated agriculture needs to be determined. A structured approach based on zoning of potential areas may also be adopted for effective groundwater development and discontinuation of irrigation in some areas and reallocation of water to non-agricultural uses can be considered.

It is clear that some new strategies, institutions, technology and awareness creation on sustainable water management concepts, principles and methods are needed to remove barriers to development of water resources, especially for sustainability of groundwater irrigation in the northwest region of Bangladesh.

6.3.2 Water Resources Development Potential in the Southwest Region

The southwest region of Bangladesh is large (26,200 km^2) with a population of 18.3 million in 13 districts.[17] Two distinct zones comprise the southwest region, namely the inland zone and the coastal zone. The inland zone extends from the Ganges and the Padma rivers to the south to around Khulna district. The coastal zone consists of the parts of land near the Bay of Bengal. Total net cultivable area of the southwest region is 1.38 million hectares. Average annual rainfall is around 1700 millimeters, with comparatively low rainfall area in the west along the Indian border (WARPO 2001c). The northern and southern parts of the southwest region have several distinctive features. Almost all the northern inland zone is under shallow tube well irrigation and unlike the coastal zone, the surface water remains fresh rather than saline during the dry season.

The water resources in the southwest region have potential for development. For environmental and other purposes, there is a potential for restoration

[17] The thirteen districts in the Southwest region includes Khulna, Jessore, Kushtia, Bagerhat, Chuadanga, Jhenaidaha, Meherpur, Rajbari, Magura, Narail, Gopalganj, Satkhira and Pirojpur.

of dry season freshwater inflows to the region from the Ganges through the Gorai River, and possibly through other channels. Among the issues relating to development potential, maintenance, rehabilitation, and where necessary, improvement of the coastal embankment system are emphasized in the National Water Management Plan (NWMP). The Plan also includes alleviation of its associated drainage congestion. There is an ample scope of flood-proofing in the Ganges river *char* lands for the development of water resources in this region.

According to the NWMP (2001), 14 programmes are critical to the development of water resources in the Southwest region. Five among those are exclusive to the region. These are targeted at supplying Khulna's water supply, sanitation, sewerage, flood protection and storm-water drainage demand, as well as salinity control in the Sundarbans. Shared programmes are similar to those for the northwest region, addressing river abstraction, surface water distribution, drainage, dredging, arsenic mitigation and flood proofing of key infrastructure.

The southwest region is among the most seriously arsenic affected regions in Bangladesh. Therefore, short-term interventions are being tested including arsenic filters and household removal facilities, and medium to longer term solutions are being studied to access safe deeper aquifers below 250-300 meters. In arsenic affected areas, alternative sources of drinking water such as surface water have to be considered.

In addition to addressing the issues of the existence of iron and boron in groundwater, other challenges to water supply include the seasonal draw-down of groundwater causing shortfalls in potable water in the rural areas, saline encroachment in ground and surface water sources in the coastal belt, and inequitable access to safe water sources (WARPO 2001d).

The evolution of policies around water management in coastal zone vis-à-vis the southwest region from the 1950s to date and their trends are summarized in Box 6.2. We see several shifts in water policy. For example, the 1960s saw a shift from small-dynamic community '*bandhs*' to structural solutions through the polderization of the region, and also top-down engineering solution through mega-projects with little local participation. The 1970s witnessed a shift away from large-scale projects to small-scale projects due in large part to change in donor focus. In the 1980s, small-scale projects were combined with a more pro-poor approach to generate employment for the marginalized through Landless Cooperative Societies and Target Groups. There was, however, hardly any involvement of communities for day-to-day management of water infrastructure as the government used to employ gatekeepers (called *khalashi*s) entrusted with the job of operating sluice gates. In the 1990s, participation

of the community including women's empowerment emerged significantly. The 2000s witnessed a genuine community participatory water management approach through creating Water Management Cooperative Associations (WMCAs). In the process, LGED played a prominent role in promoting innovative participatory water management, although the participatory management model is yet to be fully developed.[18] The 2010s focused increased attention to sustainability and income generation.

Box 6.2: Timeline of Evolution of Coastal/SW Region Water Policy in Bangladesh

Decades	Key policies related to water management
1950s	Construction of small mud embankments managed by communities with the help and direction from landlords (zamindars)
1960s	Polderization emerged through shifting away responsibility from Zamindars to Government initiated structural engineering and mega-projects approach. Top-down engineering solution encouraged with few local participation
1970s	Shift from mega-structure to small-scale water resources development with a little community participation through farmers' cooperatives under the Green Revolution
1980s	Focused on pro-poor approach, targeting landless and marginalised populations, with institutionalization of Labor Contracting Societies LCS), with focus on local ownership, involving local people in project planning and design for the first time
1990s	People's participation as a priority by donors in all water projects—paradigm shift of participation as 'end in itself' to 'means to an end'
2000s	Formalization and standardization of participatory water management—gave water management responsibilities to communities through Water Management Organizations increased role of LGED in water resources development.
2010s	Increased attention to sustainability and income generation

Source: Adapted from Dewan and Mukherji (2013).

[18] Recently, LGED in its first phase implemented a number of small scale water sector projects in SW districts such as Patuakhali, Barguna and Satkhira. An evaluation (Islam 2014) indicates that lack of true participatory management, ownership and O & M funds are among the major constraints. The study also observed that such constraints have gradually been addressed by LGED (e.g., in its subsequent phases). In fact, in order to make them more efficient WMCAs can function as a taskforce of Union Parishad on water management (Karim 2013).

Development Potential in the Southwest Region

There are a number of constraints and/or impediments regarding water resources in the southwest region which prevents the development potentials from being fully realized (Mainuddin et al. 2013). These have to be addressed for sustained development of the region. The first problem that can be identified regarding water resources in the southwest region is the arsenic problem. There is existence of arsenic throughout the region, but it is most concentrated in the groundwater areas adjacent to the main rivers. But the presence and attendant risks of arsenic in the shallow aquifer are well-recorded compared to the safety of the deeper aquifer. Research about the impact of arsenic-contaminated water on food safety is being carried out, but no valid conclusions have yet been reached. If it turns out to be unsafe, then the implications will be shaped by the extent to which health hazards apply to different crops, and whether treatment is a viable option. However, if there is a need to ban irrigation from groundwater in these areas, the impacts would be mitigated to some extent by the fact that most STW irrigation is not in areas of high arsenic contamination (WARPO 2001b). Arsenic is, however, not the only contaminant of groundwater. For example, iron is commonly found in the water of this region and frequently cited by people as a problem. Nevertheless, research results show that this is more of a public health concern than a serious threat to crop health.

In the coastal zone of the Southwest region, there are more impediments compared to the northern inland zone. Salinity of shallow groundwater and surface water is a major problem, which has severe adverse implications for both domestic water supplies and irrigation. Besides, coastal flooding adversely affects the modern agricultural system because of the salinity in the flood water.

Another major problem is drainage congestion in the coastal polder zone. Drainage congestion occurs due to high outfall water levels that prevent drainage flows, regardless of any other impediments. Another constraint is impeded drainage that is caused by insufficient drainage capacity through road embankments, blocked drainage channels due to siltation, cross-dams or unplanned fishing activities, structures built on the drainage channels and inadequately sized drainage sluices. Drainage congestion and impeded drainage are connected and can affect each other.

The Sundarbans, situated in the southwest region of Bangladesh, are at risk due to the diminished upland flows. Apart from these, the extensive development of brackish water *Bagda* (Tiger shrimp) without zoning or separating the water resource may serve as impediment to development of the region. Besides, the quality and extent of the mangrove forest has been

significantly damaged by the construction of Farakka Barrage in India in 1975 (WARPO 2001c).

Although the people of southwest region are mainly dependent on surface water to meet all their needs, they use groundwater for irrigation as well. A comparison of potential demands on groundwater availability indicates that deficit may arise in some areas of the southwest region where recharge tends to be less (WARPO 2001b).

The southwest region is in serious need of augmentation due to multiple demands and the low flows entering the region when the Gorai is cut off in the dry season. However, this deficit could be made up by diversion from the Ganges, and the Gorai River Restoration Project (GRRP) and Options for Ganges Dependent Area (OGDA) studies are exploring this option. The Ganges flows secured under the 1996 Treaty are thus critical to the sustenance of the southwest region (WARPO 2001b).

Climate models indicate that the dry season will become significantly drier over the next 50 years, with a noticeable increase in crop water requirements. By 2050, this increase may be as much as 25 percent above current requirements, meaning farmers will need more water. However, as the cost of water increases, farmers might also be shift towards non-rice crops, thus partially off-setting an overall rise in water demand. Similar changes will take place throughout the Ganges river basin, but overall pressure on the Ganges dry season flows is likely to increase despite some mitigatory moves away from rice crops.

Rainfall in the peak monsoon period may be even higher than for the season as a whole, with predictions of 29 percent increase above current levels by 2050. This will mean an associated increase in drainage requirements and flood duration. While from a socio-economic perspective, this will adversely impact people's livelihoods, there may be benefits in environmental terms for coastal sedimentation and overall salinity ingression. However, such impacts are hard to predict at present.

Other impacts in the coastal belt include sea-level rise due to global warming, continued sedimentation of the rivers and flood plains and subsidence of the Ganges Basin, which all affect sea levels with respect to land levels. The situation is further complicated by an increase in tidal amplitude caused by reduction of tidal flows due to polders in the southwest region. By 1995, the tidal range had increased to about 3.0 meters from about 1.8 meters in 1960, and can be expected to increase further. The combined effect of both sea-level rise and increased tidal range will have a substantial impact over much of the coastal areas (WARPO 2001b).

Vulnerability of the Coastal Zone vis-à-vis Southwest region[19]

The southwest coastal floodplain region of Bangladesh belongs primarily to agro-ecological zone of Ganges Tidal Floodplain. The tidal floodplain is characterized by numerous, often interconnecting, tidal rivers and creeks. Under natural conditions, the land is subject to flooding during high tides. The river networks bring enormous silts to the floodplains through their tidal process. The southwest coastal area suffers from various types of disasters such as cyclones, tidal surges, floods, droughts and sea level-induced hazards.

The coastal and southwest region lags behind other parts of the country in many respects, such as land use, irrigation, crop yields, cropping intensity, production levels and livelihoods. Agriculture in the region reflects this backwardness in terms of nature of technology used, lack of environment-tolerant and modern varieties of crops, and lack of improved water management (although in some areas, saline tolerant, short-duration and submergence tolerant crop varieties are available). The areas are subjected to flooding in the monsoon season[20] and water logging in parts of basin areas in most of the dry season.[21] Tidal flooding is another challenge in the coastal context.

While discussing about backwardness of the areas, of course, one has to first mention the salinity conditions relating to both soil and water in the area.[22] Out of 2.86 million hectares of coastal and off-shore arable lands, about 1.1 million hectares are affected by varying degrees of salinity (SRDI 2012). Farmers mostly cultivate low yielding, traditional rice varieties during the wet season. Many lands remain fallow in the dry season because of soil salinity, lack of irrigation water and proper drainage. Recent increases in the degree of salinity in some areas, and the risk of further intrusion of saline water, mean normal crop production will become even

[19] In complying with NWMP (2001) definition, the present analysis considers 13 districts to consist of SW Region although some do not possess typical southern-district characteristics in respect to soil and water conditions.

[20] For example, about 50 percent of the coastal lands face different degrees of inundation, thus limiting their effective use (SRDI 2012).

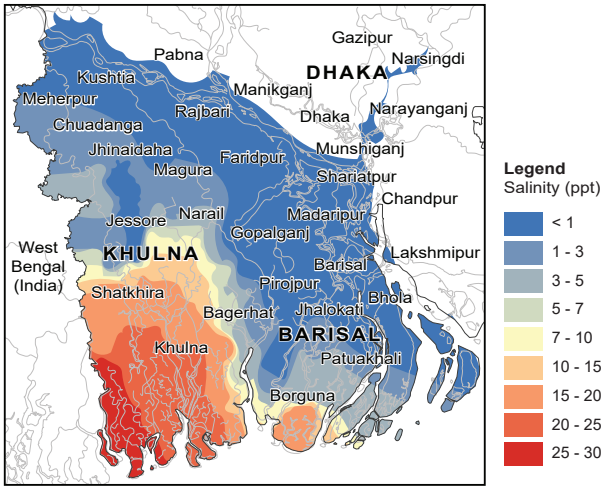
[21] Introduction of brackish water for shrimp cultivation, lack of maintenance and faulty management of the sluice gates and polders are some of the contributing factors.

[22] While soil salinity is relatively less difficult to manage (Kabir et al. 2011), water salinity is not. Naturally, rainfall contributes to leach salt from soil surface but in dry season when rainfall is insufficient, the artificial process or irrigation is needed. Sometimes, deep-water irrigation is also required.

more challenging.[23] Despite these threats, agriculture remains the mainstay of the economy.

The upstream withdrawals of trans-boundary rivers, particularly in the dry season, cause very low flows in the distributaries of the delta, resulting in the intrusion of saline water into the distributaries of the western part of the delta in southwest Bangladesh (Figure 6.3). The saline intrusion is further exacerbated by the decline in dry season flows in recent years.

Figure 6.3: Salinity Intrusion in Southwest Bangladesh (CSIRO-IWM 2014)



For both surface and ground, water quality generally degrades from the wet to dry season and spatially from the north to the south and south-western parts of Bangladesh (CSIRO-IWM 2014). In the coastal areas especially in south-west, salinity intrusion poses a serious challenge to sustain dry season agricultural production (Chowdhury 2012). This is why southwest region is considered among the most vulnerable regions in Bangladesh.

Water management through polders

The southwest coastal floodplain is particularly prone to natural hazards such as cyclones, tidal surges, floods and droughts. Over the last four decades, a

[23] In fact, people face risks in almost all their livelihood options, be it in agriculture, fisheries or livestock due to natural disasters, diseases and pests (Khan and Afroz 2011).

cluster of 125 polders, covering an area of about 13,000 square kilometers, has been constructed (Mainuddin et al. 2013). The primary purpose of this polderization was to increase agricultural production and productivity through reducing flood damages by protecting the land from salinity intrusion. The polders currently consist of about 5,000 kilometers of embankment, 6,000 kilometers of drainage channel. and 2,500 water control structures.

However, the purpose of polderization has not been fulfilled as expected for many reasons. Shrimp farming and salt cultivation, undertaken largely by wealthy and powerful sections of society, have undoubtedly caused great harm to the agriculture and environment, apart from creating social conflicts in the coastal region.[24] In fact, the situation is gradually reaching an alarming stage. The salinity intrusion has caused decline in soil fertility, resulting in decline in agricultural lands and lower yields than what was envisaged. The inaction of concerned national and local departments has also contributed to these alarming conditions and deprivations.

Waterlogging is a major concern for the coastal farmers.[25] Waterlogged areas have significantly increased from 62,000 hectares in 1975-1976 to 148,000 hectares in 2008-2009 due to seasonal submergence, tidal surges, construction of roads and embankments, faulty sluice gates, shrimp farming and the naturally heavy clays in the coastal region (Miah 2010).

The changing coastal conditions, exacerbated by global warming and climate change, requires a redesign of most of the embankments, along with their sluice gates (O'Donnell et al. 2012).[26] Without proper water management, the huge investments in polders in the coastal areas will not yield desired results.

To maintain the polders in good conditions and/or to avoid further degradation, there is no alternative to redesigning, proper coordination among agencies involved (e.g., BWDB and LGED) and regular maintenance.[27]

---

[24] It is, however, noted that shrimp cultivation has also some significant positive effects through generating linkage activities.

[25] In coastal area, most rainfalls occur in the month of July and August when most of the land operations are done. During this period, the provision for adequate number of sluice gates in the embankment system could remove excess water and prevent ingress of saline water during high tide.

[26] The existing serious conditions of the polders and embankments in SW Bangladesh, especially after Aila and Sidr, can be mentioned.

[27] Both poor structure and inadequate maintenance of the constructed polders lead to severe physical and economic losses for the villagers, as observed by SRDI (2012). The polders have been constructed in a hazardous and uncoordinated way. The concerned authorities do not take care of the polders properly.

Emphasis is now often given to people's contribution to maintaining them, but some of the major maintenance and repair needs, resulting from natural hazards for example, have to be recognized as primarily a responsibility of the government. There are research studies (e.g., Islam 2014) which show that the performance of water management projects is highly dependent on the performance of the related water management associations. Efforts are thus needed to make the associations more operational and functional, particularly in terms of their improved operation and maintenance.[28] Besides, associations also contribute towards conflict resolution in respect of land and water resources.

Barriers to crop cultivation

Salinity is a major constraint to crop production, but all areas are not saline at all times. Embankments and polders are built surrounding the saline areas in the southwest region but occasionally high tidal surge cause saline water to enter into polders and destroy standing crops.

Groundwater salinity is a limiting factor in parts of the southwest region, although freshwater is generally available in some parts of the region. Surface water salinity has been accentuated by the reduction in dry season flows entering the Gorai distributaries, following the diversion of the Ganges flow upstream by the neighboring country. Water salinity now is reaching an alarming stage in parts of southwest region such as Khulna, Bagerhat and Satkhira districts (Mainuddin et al. 2013).

Water resources management is a big challenge in the region. The most critical challenge is excess water in the wet season and water shortage in the dry season. In some places like the northern part of Khulna, Bagerhat and Satkhira, groundwater is used for irrigation at a small scale. But in other areas, there is no scope for groundwater irrigation because of salinity.

Two-thirds of the net cropped area in the southern region is poorly drained. The dominance of poorly drained soil indicates that the removal of salinity from soil is a major constraint for land reclamation. Soil texture of the southwestern areas is mostly clay to clay loam, which are not favorable for dry land crops in the Rabi/dry season.

A large part of the southwest region is under low level of available moisture, except perhaps some parts such as Meherpur, Jhenaidah and Jessore. Soil salinity is also a major constraint for crop production in the southwestern region. Soil salinity is high in parts of Satkhira, Khulna and Bagerhat districts. The plants cannot absorb sufficient amount of water due

[28] The participatory approach clearly leads to increased agricultural production and income, associated, however, with unequal distribution between poor and non-poor (Islam 2014).

to high salt concentration. Only a few stress-tolerant varieties (e.g., saline and drought-prone variety) have been developed so far for the southern region. Due to empoldering, natural inundation outside polders has been obstructed by embankments which has led to higher elevation of land outside, thereby hampering drainage capability and resulting in waterlogging.

The coastal zone, in general, and southwest, in particular, has the greatest exposure to arsenic, salinity and storm surges, while also facing serious challenges with storage of surface water and poor quality of groundwater. It is therefore very vulnerable to water related issues and is most at risk from sea level rise (CSIRO-IWM 2014). The coastal zone also has amongst the lowest irrigation levels and crop yields. Solving these problems will be an immense challenge, but if crop yields in this region could be improved, this would have positive impacts on wider Water resource management, such as easing pressures on groundwater use in the northwest and north-central regions.

The use of groundwater should be environmentally-friendly and based on sound recharge policies developed on the principles of conservation and community participation. This requires a focal organization at the national level to plan and implement concerned activities. It is also imperative to follow best irrigation management practices and climate change adaptation techniques for sustainable use of groundwater (BRAC 2013).

Attention should be given to policies towards increasing aquifer recharge through adopting activities such as harvesting and storing of surface water and rainwater, and excavating canals, ponds, and other water bodies. Such activities will subsequently address the problem of soil degradation and water contamination. It is important to strengthen appropriate monitoring mechanisms for tracking groundwater recharge, surface and groundwater use, and improvement in surface and groundwater quality and soil quality.

There has hardly been any effective mechanism in place for monitoring, compliance and enforcement of relevant acts, laws, rules and regulations in protecting land and water from degradation. Land use planning should be implemented, particularly with respect to unplanned shrimp farming, and enforcement mechanisms of relevant acts and laws should be strengthened. The poor performance in terms of enforcement of such legislations has made the coastal environment worse than ever.[29]

[29] For example, in response to a writ petition the High Court in 2012 directed the authorities concerned to take effective steps to sustain the fertility of land and protect water quality to save the environment in coastal zone. It also ordered to formulate a policy within three months to determine separate land for shrimp farming to protect agriculture land from salinity intrusion. Field investigation shows hardly any progress in this regard even two years after the verdict.

For the removal of barriers to the development of water resources in the southwest region of Bangladesh, some policies can be suggested:

- The southwest region mostly relies on the use of surface water. Therefore, it is of utmost importance to ensure optimal and judicious use of surface water under the Indo-Bangladesh 1996 Treaty on the basis of the studies of the Gorai River Restoration Project and of the Ganges Barrage.
- In arsenic-affected areas, alternative sources such as surface water and rainwater should be considered.
- To remove the problem of drainage congestion in the coastal polder zone, remedial actions are needed for the existing Flood Control, Drainage and Irrigation (FCDI) schemes.
- The cyclone-proofing program needs to be accelerated, along with complementary measures to improve the management of the coastal embankment system.
- Development of comprehensive and sustainable solutions are required that can address the interaction between tidal and upland flows on the water regime.
- Zoning of *bagda* shrimp production should be introduced as early as possible. That would help to remove the problems of land-use conflict and soil salinization resulting from saltwater shrimp (*bagda)* production.[30]
- A program concerning the increased future inflows of fresh water through the Gorai River System need to be developed in order to maintain and/or improve the productivity and biodiversity of Sundarbans.
- Due to the effects of climate change, competing demands for water amongst the co-riparian countries will increase in the future. Hence, the co-riparian states should have a shared long-term view of how these changes will be managed. Crop water productivity and enormous water loss in the process of irrigation are pertinent issues which need to be addressed.
- Finally, in line with Integrated Coastal Zone Management (ICZM) plans, which offer means of balancing the competing demands to optimize the benefits, it is important to work through the local government institutions in managing resources such as water (Karim 2013).

Apart from these policies, institutional and financial reforms are crucial to adopt in order to remove the barriers towards development of water

[30] However, it may be difficult to implement this for various reasons.

resources in Bangladesh, especially in the southwest region. Important issues to address are: (i) the pace and focus of institutional change; (ii) widening private sector participation in the provision of water and sewerage services, and (iii) setting tariffs that appropriately reflect real resource costs.

6.4 Financial and Economic Analysis of Alternative Modes of Irrigation

This section examines the financial and economic viability of alternative modes of irrigation for crop production. The modes of irrigation are analyzed using three alternative criteria viz. benefit-cost ratio (BCR), internal rate of return (IRR) and net present value (NPV). While BCR and IRR will demonstrate the viability of the modes of irrigation, the NPV will reveal the extent of net worth of investment. Thus, analyzing any particular mode of irrigation using all three criteria simultaneously will provide a comprehensive view of the particular mode. Furthermore, a comparison across various modes will reveal their comparative performance in terms of both financial and economic viability.

6.4.1 Benefits of Irrigation

Availability of water through irrigation brings about positive impacts in the form of changes in the input-output coefficients of the same crop and/or the choice of crop on the same plot, and/or the cropping intensity per unit of land. In contrast, changes in fish production due to increased use of chemical fertilizers and pesticides, soil fertility etc. are some of the negative impacts. Often, these factors work simultaneously in the different directions and ultimately contribute to the increase in net crop income per unit of land (Young 1996). Due to data constraints, negative impacts are not considered.

Following Hussain and Bhattarai (2004), the change in net income method is used in deriving the imputed benefit of water. The quantum of net benefits is translated to net monetary value through the prevailing prices of inputs and outputs and by-products, where applicable. For the purpose of analyses, harvest time market prices of 13 major crops are calculated as a five-year average between 2008-2009 and 2012-2013, after indexing the series at 2012-2013 constant prices. The input prices are estimated from the cross-sectional data on costs and returns of different crops collected from a survey of 700 farm households in 2014. These sets of data are deflated to 2012-2013 prices to make them comparable to output prices. Given the markets for both inputs as well as outputs are subject to various types of distortions and imperfections, the market prices are adjusted using the appropriate conversion factors.

Using the input and output coefficients and the corresponding input and output prices thus derived, gross returns, total costs and net returns of each of the crops per hectare of land are estimated with and without irrigation. The shares of non-irrigated land in total agricultural land across different flood depths used in the present exercise are: 35.5 percent non-flooded, 39.1 percent shallow flooded, 15.1 percent medium flooded, and 10.3 percent deeply flooded (derived from the figures of land elevation published by Bangladesh Bureau of Statistics). The differences of net returns between non-irrigated vis-à-vis irrigated lands at different flood depths are weighted with the above distribution of non-irrigated land to arrive at the national average benefits of modern irrigation per hectare of land (Table 6.3). The economic benefits are about 19 percent higher than financial benefits as most of the conversion factors used are greater than unity.

Table 6.3: Annual Increase in Net Crop Income per Hectare from Modern Irrigation by Flood Depths

Flood depth	Area weight (%)	At market price (BDT)	At shadow price (BDT)
Non-flooded	35.50	44,129	54,326
Shallow	39.10	37,107	43,635
Medium	15.10	43,857	50,092
Deep	10.30	26,431	29,931
Weighted average	-	39,519	46,994

Source: Authors' calculation.

In applying the method, a number of assumptions need to be made about the situation such as intensity of land use, cropping intensity, types of crops grown, and productivity per unit of land in the absence of irrigation. Another issue is in relation to the contribution of other inputs such as fertilizers and improved seed varieties to increased productivity. These inputs are complementary to each other in irrigated agricultural production. While intensity of land use, cropping intensity, types of crops grown can be attributed to irrigation, increased amount of fertilizers and use of improved varieties of seed cannot be attributed to irrigation. Hence, the estimates of increased productivity may be regarded as an upper bound of the benefits of irrigation (Young 1996).

The benefits of irrigation across modes were estimated under the current state of irrigation. and drainage efficiency as well as the varieties of crops farmers grow at present. Apparently, an increase in efficiency of irrigation

will entail benefits both in the form of increased area of land irrigated with the same amount of water, and costs in the form of alignment and re-alignment of distribution channels and measures to minimize seepage of water. Thus, it is uncertain about the extent and direction of change in the net benefits. In contrast, use of new improved varieties of crop will definitely increase net benefits.

6.4.2 Costs of Irrigation

The costs associated with irrigation can broadly be classified into three categories: resource costs, social costs, and environmental costs. Again, these may be direct costs such as costs associated with the provision of irrigation infrastructures and services, or indirect costs such as the costs associated with the secondary effects of the intervention. Major resource costs of irrigation include: (i) capital (infrastructures) costs, and (ii) O&M costs. While the infrastructure costs include costs of the machineries and associated materials, and the costs of the drainage and channel works, the O&M costs include costs incurred in maintaining and managing the irrigation system. The above categories of costs may be classified as financial costs. In order to calculate economic costs, the market distortions and/or imperfections of these goods and services need to be taken into account. Thus, the capital costs and O&M costs are converted into economic costs using the respective conversion factors. For the brevity of analysis, the capital costs and O&M costs of six dominant modes of irrigation were considered. A summary of the capital costs and O&M costs per hectare of irrigation is presented in Table 6.4.

Table 6.4: Capital Costs and O&M Costs of Irrigation Water by Modes

(BDT/hectare)

Modes	At market price		At shadow price	
	Capital costs	O&M costs	Capital costs	O&M costs
STW (diesel)	12,064	7,197	8,134	5,682
DSSTW (diesel)	19,324	6,692	13,355	5,288
DTW (electricity)	77,071	5,333	57,125	4,196
LLP (diesel)	56,091	4,808	39,030	3,795
LLP (electricity)	52,727	3,515	38,945	2,748
Primary pump/gravity distribution	72,931	2,194	59,981	2,113

Source: Authors' calculation.

While O&M costs across the modes, except primary pump/gravity distribution scheme, are by and large similar, there is large variation in terms of capital costs per hectare. These costs are as low as BDT 12,000 for diesel-operated STW and as high as BDT 77,000 for electricity-operated DTW.

6.4.3 Benefits and Costs

The cash flows of benefits and costs are assumed to happen over a period of 24 years for each mode of irrigation. While the command area or the net benefitted area of the shallow tube wells (STW)/deep sunk shallow tube wells (DSSTW) are assumed to be 4 hectares, that of deep tube wells (DTW) and low lift pumps (LLP) (diesel/electricity) are assumed at 25 hectares and that of the primary pump/gravity distribution system at 10,000 hectares. These command areas are reduced by one percent to account for land used for distribution channels, except for primary pump/gravity distribution system. The conversion factors are applied only to the local components of costs; the foreign exchange component have same values at both market prices and shadow prices. Finally, the land acquisition costs are not included in the costs since the value of land is subtracted from the net income in deriving the benefits.

All costs are assumed to be private in the case of STWs and DSSTWs, while all costs are public in the case of primary pump with gravity distribution systems. Depending on the type of irrigation mode, there is a time when capital investment is made and the building up of benefits to their full potential is achieved. The phasing vectors of costs and benefits for the six modes are taken from MPO (1985). Finally, a 12 percent discount rate is used in this analysis.

The results of financial and economic analyses are presented in Table 6.5. In calculating the IRRs, BCRs, and NPVs the conventional assumption was made that all payments and receipts occur simultaneously in each year. This prevents calculation of IRRs for the STW and DSSTW as benefits exceed costs every year during the project life. It may be noted that the rates, ratios or values based on financial prices are lower than those based on economic prices. This apparent paradox may be attributed to the fact that most of the specific conversion factors used in converting financial benefits into economic benefits are greater than unity, while the factors used for converting financial costs are less than unity.

All six irrigation modes considered in this exercise appear to be financially and economically viable, judged by three criteria, BCR, IRR and NPV (in the sense that the estimated BCRs are greater than unity, estimated IRRs are greater than social rate of discount and estimated NPVs are greater

than zero). It has also been observed that for all three criteria, the estimates based on economic values are higher than those based on financial values. This is true for all six irrigation modes.

Table 6.5: Financial and Economic Viability of Modes of Irrigation

Modes	Type of Valuation	IRR (%)	BCR	NPV (BDT)
STW (Diesel)	Financial	nncf	4.13	889,898
	Economic	nncf	6.46	1,179,889
DSSTW (Diesel)	Financial	nncf	3.77	862,556
	Economic	nncf	5.94	1,161,140
DTW (Electricity)	Financial	41.91	2.20	3,603,599
	Economic	74.94	3.46	5,594,469
LLP (Diesel)	Financial	47.82	2.30	3,585,765
	Economic	83.41	3.78	5,556,749
LLP (Electricity)	Financial	52.76	2.60	3,913,206
	Economic	85.44	4.14	5,728,099
Primary Pump/ Gravity Distribution	Financial	32.08	2.82	1,786,641,735
	Economic	41.85	3.97	2,463,558,732

Note: nncf stands for non-negative net cash flow.

Source: Authors' calculations.

It is observed that ranked in terms of BCR (economic), diesel-operated STW (6.46) occupied the top position followed by diesel-operated DSSTW (5.94), electricity-operated LLP (4.14), major irrigation (primary pump—gravity distribution, 3.97) and diesel-operated LLP (3.78). Ranked in terms of BCR (financial), diesel-operated STW (4.13) still occupies the top position, followed by diesel-operated DSSTW (3.77), major irrigation (2.82), electricity-operated LLP (2.60), diesel-operated LLP (2.30), and electricity-operated DTW (2.20).

Ranked in terms of economic IRR (EIRR), it is observed that electricity-operated LLP (85.44 per cent) occupies the top position, followed by diesel-operated LLP (83.41 per cent), electricity-operated DTW (74.94 per cent) and major irrigation (primary pump/gravity distribution, 41.85 per cent).[31] Ranking remains unchanged when it is done in terms of financial IRR (FIRR). Thus, minor irrigation technologies such as LLP (both diesel-operated and electricity-operated) and electricity-operated DTW appear to

[31] IRR (both financial and economic) could not be estimated for STW and DSSTW due to reasons discussed in Section 4.

be more cost-effective than major irrigation, judged by their internal rates of return (based on both financial and economic prices).

6.5 Water Scarcity and Farmers' Cropping Decisions

Bangladesh is characterized by abundance of water during monsoon and acute shortage during the dry season leading to a growing concern that water scarcity constrains the farmers in their crop choice during the season. The consequences of scarcity of water for irrigation have been examined in the present study using survey data from a representative sample in three rice growing zones of Bangladesh. The survey was conducted on farm households in seven districts (Chuadanga, Jhenaidah, Mymensingh, Netrakona, Pabna, Rajshahi, and Thakurgaon) in seven upazilas and 56 villages. Relevant data were collected from 700 farm households in April 2014. Table 6.6 shows the distribution of farm households and their operational areas.

Table 6.6: Characteristics of Sample Farm Holdings

Land Ownership Group	Percent of farm households	Average size of own land (Decimal)	Percent of own land	Average size of cultivated land (Decimal)	Percent of cultivated land
Landless Farmers (< 0.5 Acres)	38.14	19.99	4.99	121.16	24.52
Marginal Farmers (0.5-1.0 Acres)	24.43	78.65	12.57	126.07	16.34
Small Farmers (1.0-2.5 Acres)	20.57	173.38	23.33	193.90	21.16
Medium Farmers (2.5-7.5 Acres)	13.00	383.65	32.63	360.93	24.90
Large Farmers (7.5 + Acres)	3.86	1049.30	26.48	639.07	13.08
All	100.00	152.85	100.00	188.47	100.00

Source: BIDS Survey 2014.

Compared to other South Asian countries, agricultural farm households in general are smaller in Bangladesh. For the sample farm households, the average size of operational holding has been found to be 189 decimals while the owned cropped area per household is just above 150 decimals. These estimates of average size appear to be higher than the national figure of 148 decimals and 132 decimals respectively (BBS 2008). When the distribution pattern of farm holding is analyzed, the proportion of small farmers (with operational holding from 0.50-2.49 acres) is found to be 83 percent, operating 62 percent of land. On the other hand, large farmers operating at least 7.5 acres account for 26 percent of farms and 13 percent of operational area. These figures are comparable to the average picture

one gets from the Agricultural Census 2008. In the Census, the proportion of small farm households was 84 percent in contrast to only 1.6 percent of large farmers. The corresponding areas operated were 51 percent and 12 percent respectively.

Given that the sample farm households are more or less similar to the characteristics of national farm households, one needs to ascertain how water scarcity would affect the farm households in terms of their income and employment. Table 6.7 shows the importance of agriculture in farm income and employment. For income, it ranges between 16 percent for landless farmers and 38 percent for large farm households. These ranges are higher than those observed in the national income estimates. Similarly, the share of agricultural employment in total employment for the farm households ranges between 54 percent for landless farmers and 64 percent for medium farmers. These estimates are also higher than national estimates of 48 percent. It is thus evident that contribution of crop agriculture in farm households' income and employment is non-trivial. Besides, more than 40 percent of marginal and small farm households borrow BDT 15,000 or more from the formal credit market for crop cultivation. Any shock such as water scarcity would thus severely jeopardize their livelihoods. It is in this context that the incidence, nature, causes and farmers' responses to water scarcity for crop production are analyzed.

Table 6.7: Contribution of Agriculture in Household Income and Employment

Land ownership group	Share of crop income in total household income (%)	Share of crop income in total household employment (%)
Landless Farmers (< 0.5 Acres)	16.25	54.50
Marginal Farmers (0.5-1.0 Acres)	19.28	53.59
Small Farmers (1.0-2.5 Acres)	22.66	56.24
Medium Farmers (2.5-7.5 Acres)	22.55	63.86
Large Farmers (7.5 + Acres)	38.62	60.79

Source: BIDS Survey 2014.

As expected, about 70 percent of the crops are cultivated in non-flooded and shallow flooded land, with the latter type marginally higher. Apart from paddy and pulses, the incidence of cultivation in medium flooded and deeply flooded land is marginal. This implies that irrigation water is an important factor in crop cultivation in these types of land, especially during the winter. While more than 40 percent of the plots are adjacent to the

source of irrigation, roughly the same are at an intermediate distance. This implies that distance from the source is not a critical issue in causing water scarcity. STWs/DSSTWs are the dominant modes of irrigation that account for more than 80 percent of irrigation water supply. DTWs account for about 15 percent. About 58 percent of these machines are run by diesel, the rest by grid electricity.[32] In more than 90 percent of the cases, the irrigators collect the payments of irrigation water in cash. About two-thirds of the payments are collected during crop cultivation, the rest after harvesting of the crops.

The dominant irrigated crop during the winter is *boro* paddy (Table 6.8). It accounts for about 70 percent of the cultivated area. The second most important crop is wheat, that accounts for only 14 percent. Spices and vegetables are other minor crops that jointly account for less than 10 percent of the cultivated area. These crops incidentally are more water-intensive. About one-third of the cultivated land suffers from water scarcity during the winter. Apart from *aman* paddy which sometimes needs supplementary irrigation, about one-third land under both *boro* paddy and vegetables faces water scarcity. However, water scarcity does not arise most of the time; rather it remains as an occasional phenomenon for most of the crops (Table 6.9). Thus, about 60 percent of land under different crops suffers from water scarcity occasionally while about one-third suffers rarely. Fortunately, the scarcity is not yet severe; for one-third of the land it is moderately inadequate while for more than 60 percent, it is mildly inadequate (Table 6.10).

Table 6.8: Land Allocation under Irrigated Crops and Incidence of Water Scarcity by Crops

Crop	Percent of land under irrigated crops	Incidence of water scarcity faced for the crop (%)
Aman	1.82	80.22
Boro	69.53	34.76
Wheat	14.18	24.69
Pulses	2.99	14.47
Oil seeds	1.44	23.82
Spices	5.29	19.39
Vegetables	3.28	36.57
Cash crops	1.46	14.55
All	100.00	32.35

Source: BIDS Survey 2014.

[32] Only one case of solar electricity operated STW was observed in the sample.

Table 6.9: Nature of Scarcity of Irrigation Water by Crops

(in percent)

Crop	Most of the time	Occasionally	Rarely
Aman	5.27	53.18	41.55
Boro	6.54	55.83	37.63
Wheat	13.76	61.89	24.35
Pulses	-	64.92	35.08
Oil Seeds	35.53	63.16	1.32
Spices	-	79.96	20.04
Vegetables	20.15	67.23	12.62
Cash crops	-	100.00	-
All	7.74	58.05	34.21

Source: BIDS Survey 2014.

Table 6.10: Severity of Scarcity of Irrigation Water by Crops

(in percent)

Crop	Severely inadequate	Moderately inadequate	Mildly inadequate
Aman	-	27.64	72.36
Boro	4.81	31.94	63.25
Wheat	10.85	37.73	51.42
Pulses	-	47.40	52.60
Oil seeds	26.49	45.70	27.81
Spices	-	14.54	85.46
Vegetables	-	71.00	29.00
Cash crops	-	100.00	-
All	5.05	34.07	60.88

Source: BIDS Survey 2014.

Farm households cited different reasons for irrigation water scarcity (Table 6.11). However, one-third of them opined that it is mainly caused by shortages of diesel/electricity. In about 20 percent of the cases, the crisis occurred due to over-extraction of groundwater which caused drawdown of the aquifers in the neighborhood. Some farm households experienced water scarcity due to lack of proper maintenance of the irrigation machines or faulty design of the distribution channels.

Table 6.11: Causes of Scarcity of Irrigation Water

Cause	Response (percent)
Shortage of fuel/power	34.91
Water layer is very deep	22.36
Irrigation machine/drains not maintained in time	14.05
Irrigation drains are not properly designed	13.60
Water distribution not appropriate	11.37
Rich/influential farmers get disproportionately higher share of water	3.46
Conflict between farmers' and water owners	0.25

Source: BIDS Survey 2014.

Table 6.12: Cultivation Plan for Future

(in percent)

Crop	Plan to produce		
	Same crop	Less water intensive crop	More water intensive crop
Aman	88.81	1.93	9.27
Boro	86.80	4.33	8.87
Wheat	97.11	2.89	…
Pulse	95.83	4.17	…
Oil Seeds	86.76	4.71	8.53
Spices	94.15	5.85	…
Vegetables	89.80	8.34	1.86
Cash crops	100.00	-	…
All	89.27	4.23	6.51

Source: BIDS Survey 2014.

Apparently, the scarcity of irrigation water does not seem to have any tangible impact on farmers' response in terms of crop choice or alternative use of land; farm households plan to devote about 90 percent of the land irrigated to the same crops (Table 6.12). These findings are at odds with Kabir and Hossain (2012), where about 40 percent of the farm households in the Ganges-Kobadak (GK) command area prefer to change the crops they grow, cultivating those crops which require less water. While less than five percent of farmers plan to grow less water intensive crops, this share is more than offset by the cultivation plan of more water intensive crops by more than six percent of the farmers. If relative profitability of crops the farmers grow currently, even with

occasional but moderate and/or mild water scarcity, is higher than the next best alternatives, it is only rational for farm households to stick to the same crops at least in the short to medium term despite water scarcity.

6.6 Concluding Remarks

The existing laws and regulations in Bangladesh do not cover all areas of water codes; many laws are outdated and/or are overlapping. The system lacks cohesiveness, which exacerbates the conflicts inherent in the water sector. Hence, more than regulations are needed; laws must be implemented effectively. To avoid rent seeking, regulations have to be drawn up cautiously, and they must be bolstered with provisions to ensure accountability and transparency.

To realize the development potentials of northwest region, it is necessary to go for an action plan that considers groundwater recharge using various structural and non-structural measures, strengthening the monitoring organizations, determination of water charge by the Water User Associations (WUAs), use of drought-tolerant crop variety, crop rotation or cropping pattern change, preparation of water budget that would include recharge, extraction and change in storage in the aquifers, improvement of technical performance of existing technologies, introduction of modern water management technology and/or water saving technologies, use of pre-paid meters in DTW pumps, exploration of alternative power sources (such as solar energy) for STW and DTW irrigation, social interventions such as awareness development.

For the development of the water resources in the southwest region, it is imperative to ensure optimal and expeditious use of surface water under the Indo-Bangladesh 1996 Treaty on the basis of the studies of the Gorai River Restoration Project and of the Ganges Barrage. Appropriate measures should be taken to address the problems of arsenic contamination of groundwater, drainage congestion in the coastal polder zone, management of the coastal embankment system and maintenance and/or improvement of the productivity and biodiversity of the Sundarbans. A major acceleration of the cyclone-proofing program is also required. Zoning of *bagda* shrimp production should be introduced to remove the problems of land-use conflict and soil salinization.

Due to the effects of climate change, there will be increased competition for water amongst the co-riparians in the future. Hence, the co-riparian states should have a shared long-term view of how these changes will be managed. Apart from these policies, some institutional and financial reforms are crucial to adopt in order to remove the barriers towards development of water resources in Bangladesh, especially in the southwest region.

Southwest region is most vulnerable to water related issues and is most at risk from sea level rise. The key impediments to irrigation have been identified as depletion of surface water including river water level and discharge, reduction of upstream flow, reduction of wetland areas, erratic rainfalls, decline of groundwater level, soil degradation and water contamination. It is therefore imperative to follow the best irrigation management practices and climate change adaptation techniques for sustainable use of groundwater, prioritizing conservation and community participation. It is also important to monitor groundwater recharge, surface and groundwater use and improvement in surface and groundwater quality and soil quality.

To maintain the polders in good conditions and to avoid further degradation, efforts for redesigning, proper coordination and regular maintenance have become imperative. Land use planning should be implemented particularly in respect to unplanned shrimp farming and enforcement mechanism of relevant acts and laws should be strengthened.

All modes of irrigation appear to be viable investments using national average benefits and generalized estimates of costs. However, benefits and costs may vary because of locational differences as reflected in different cropping patterns and differences in design and project size. Since the BCRs are higher for STW and DSSTW, the marked increase in the rate of installation of these modes will continue unabated as long as the current profitability of crop cultivation remains. But to ensure sustainable crop production in the long run, the irrigation modes need to be chosen carefully. Moreover, other factors such as the non-use values of irrigation and social as well as environmental costs should be taken into consideration, before making final judgments about the choice of irrigation modes and appropriate policy measures.

In so far as water scarcity for farmers cropping decisions are concerned, whatever marginal changes the farm households are currently making may be mitigated with assured supply of electricity. Since grid electricity is already over-burdened, the untapped solar energy may be explored as an alternative source.

References

Alam, M. S., and M. A. Islam. 2009. "Economics of alternate Wetting and Drying Method for Irrigation: Evidence from Farm Level Study." *The Agriculturists* 7, no. 1 & 2: 82-89. https://doi.org/10.3329/agric.v7i1.5258.

Bari, M. F., and A. H. M. F. Anwar. 2000. "Effects of Irrigated Agriculture on Groundwater Quality in Northwestern Bangladesh." In *Proceedings of Integrated Water Resources Management for Sustainable Development,* Vol. I., 19-21. New Delhi.

BRAC. 2013. *Study on Sustainability of Groundwater Use for Irrigation in Northwest Bangladesh*. Dhaka: BRAC.

Chowdhury, G. 2012. Interview with G. Chowdhury, Director of the Centre for Environmental and Geographic Information Services (CEGIS) and former Director General, Bangladesh Water Development Board, on 27th February by C. Dewan, Dhaka.

CSIRO-IWM (Commonwealth Scientific and Industrial Research Organisation-Institute of Water Modelling). 2014. *Bangladesh Integrated Water Resources Assessment Project Final Report.* Dhaka: AusAid-CSIRO Research for Development Alliance.

Dewan, C., and A. Mukherji. 2013. "Evolution of Participatory Water Management in Coastal Bangladesh: A Review of Projects and Policies." *Water International* 40, no. 3: 401-416.

Dey, Nepal C., and A. R. M. Mehrab Ali. 2010. *Changes in the Use of Safe Water and Water Safety Measures in WASH Intervention Areas of Bangladesh: A Midline Assessment.* Research Reports (2010): Health Studies, Vol no. XLII, 11-34. Dhaka: BRAC Research and Evaluation Division (RED). http://hdl.handle.net/10361/13156.

Dey, Nepal C., Sujit K. Bala, and Seiji Hayakawa. 2006. "Assessing the Economic Benefits of Improved Irrigation Management: A Case Study of Bangladesh." *Water Policy* 8, no. 6: 573-584. https://doi.org/10.2166/wp.2006.058.

Faruquee, R., and Y. Chowdhury. 1998. "Improving Water Resources Management in Bangladesh.' In *Bangladesh Agriculture in the 21st Century*, edited by R. Faruquee. Dhaka: The University Press Limited (UPL).

Finger, Matthias, and Jeremy Allouche. 2002. *Water Privatisation: Trans-national Corporations and the Re-regulation of the Water Industry*. London and New York: Spon Press.

FPCO (Flood Plan Co-ordination Organisation). 1995. *Bangladesh Water and Flood Management Strategy*. Dhaka: FPCO.

Government of Bangladesh. 1999. *National Water Policy*. Dhaka: Government of Bangladesh.

___. 2001. *Land Use Policy*. Dhaka: Government of Bangladesh.

___. 2004. *National Water Management Plan.* Dhaka: Government of Bangladesh.

Hossain, Mahabub. 1996. "Agricultural Policies in Bangladesh: Evolution and Impact on Crop Production." In *State, Market and Development: Essays in Honour of Rehman Sobhan*, edited by Abu Abdullah and Azizur Rahman Khan. Dhaka: The University Press Limited (UPL).

Hossain, Mahabub, and A. Bayes. 2009. "Rural Markets and Livelihoods." In *Rural Economy & Livelihoods: Insights from Bangladesh*. Dhaka: A. H. Development Publishing House.

Hossain, Mahabub, David Lewis, Manik L. Bose, and Alamgir Chowdhury. 2003. *Rice Research, Technological Progress, and Impacts on the Poor: The Bangladesh Case (Summary Report)*. EPTD Discussion Paper No. 110. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Hossain, Mahabub, M. A. Quasem, M. A. Jabbar, and M. M. Akash. 1994. "Production Environments, Modern Variety Adoption and Income Distribution in Bangladesh." In *Modern Rice Technology and Income Distribution in Asia*, edited by C. C. David and K. Otsuka, 221-279. Manila: Lynne Reinnar Publishers.

Hussain, Intizar, and Madhusudan Bhattarai. 2004. *Comprehensive Assessment of Socio-economic Impacts of Agricultural Water Uses: Concepts, Approaches and Analytical Tools*. Colombo: International Water Management Institute (IWMI).

Islam, K. M. Nabiul. 2014. *Performance of Small-Scale Water Projects: An Evaluation of LGED's Participatory Interventions*. Research Report No. 186. Dhaka: Bangladesh Institute of Development Studies (BIDS).

IWMI (International Water Management Institute). 2010. *Banking of Groundwater in Times of Change*. IWMI Water Policy Brief No. 32. Colombo: IWMI. https://doi.org/10.5337/2010.240.

Kabir, M. Humayun, and Md. Faruk Hossain. 2012. "Farmers' Perception on Water Related Issues: A Study of Bheramara Upazila, Kushtia." *Journal of the Asiatic Society Bangladesh, Science* 38, no. 1: 41-52. https://doi.org/10.3329/jasbs.v38i1.15319.

Kabir, M. Jahangir, Peter S. Carberry, Rohan Nelson, Iqbal Alam Khan, Neal P. Dalgliesh, and Perry L. Poulton. 2011. "Economic Viability of Rabi-season Crops." In *Sustainable Intensification of Rabi Cropping in Southern Bangladesh using Wheat and Mungbean*, edited by H. M. Rawson, 184-194. ACIAR Technical Reports No. 78. Canberra: Australian Centre for International Agricultural Research (ACIAR).

Karim, Z. 2013. *Master Plan for Agriculture Development in the Southern Region of Bangladesh*. Dhaka: Ministry of Agriculture, Government of the People's Republic of Bangladesh, and Rome: Food and Agriculture Organisation of the United Nations.

Khan, I. A., and S. Afroz. 2011. *Farmers' Livelihoods: Reality and Options*. ACIAR Technical Reports. Canberra: Australian Centre for International Agricultural Research (ACIAR).

Kumar, Manish, ed. 2012. *Problems, Perspectives and Challenges of Agricultural Water Management*. Rijeka, Croatia: InTech.

Mainuddin, Mohammad, Howard M. Rawson, Perry L. Poulton, Raisat Ali, Christian Roth, K. M. Nabiul Islam, Mohammad Saifuzzaman, M. M. Rahman, Mohammad Enamul Quader, Sardar M. Shah-Newaz, Motaleb Hossain Sarker, and M. Shahidul Islam. 2013. *Scoping Study to Assess Constraints and Opportunities for Future Research into Intensification of Cropping Systems in Southern Bangladesh*. Final Report. Canberra: Australian Centre for International Agricultural Research (ACIAR).

Miah, Md. Muslem Uddin. 2010, November. *Assessing Long-term Impacts of Vulnerabilities on Crop Production Due to Climate Change in the Coastal Areas of Bangladesh*. Dhaka: Bangladesh Center for Advanced Studies (BCAS).

Ministry of Agriculture. 1997. *National Minor Irrigation Development Plan*. Dhaka: Ministry of Agriculture, Government of Bangladesh.

Ministry of Water Resources. 2001. *National Water Management Plan*. Dhaka: Ministry of Water Resources, Government of Bangladesh.

MPO (Master Plan Organisation). 1985. *Economic Analysis of Agricultural Modes of Development*. Technical Report 22 (mimeo). Dhaka: Master Plan Organisation, Ministry of Irrigation, Water Development, and Flood Control, Government of Bangladesh.

___. 1991. *National Water Plan*. Dhaka: Master Plan Organisation, Ministry of Irrigation, Water Development and Flood Control, Government of Bangladesh.

Osmani, S. R., and M. A. Quasem. 1990. *Pricing and Subsidy Policies for Bangladesh Agriculture*. BIDS Research Monograph No. 11. Dhaka: Bangladesh Institute of Development Studies (BIDS).

Paul, Bimal Kanti. 1998. "Coping Mechanisms Practiced by Drought Victims (1994/5) in North Bengal, Bangladesh." *Applied Geography* 18, no. 4: 355-373. https://doi.org/10.1016/S0143-6228(98)00026-5.

Shahid, Shamsuddin. 2008, June. "Spatial and Temporal Characteristics of Droughts in the Western Part of Bangladesh." *Hydrological Process* 22, no. 13: 2235-2247. https://doi.org/10.1002/hyp.6820.

___. 2011. "Impact of Climate Change on Irrigation Water Demand of Dry Season Boro Rice in Northwest Bangladesh." *Climatic Change* 105, no. 3: 433-453. https://doi.org/10.1007/s10584-010-9895-5.

Shahid, Shamsuddin, and Houshang Behrawan. 2008. "Drought Risk Assessment in the Western Part of Bangladesh." *Natural Hazards* 46: 391-413. https://doi.org/10.1007/s11069-007-9191-5.

Simonovic, Slobodan P. 1997. "Risk in Sustainable Water Resources Management." In *Sustainability of Water Resources under Increasing Uncertainties*. IAHS Pub. No. 240. http://hydrologie.org/redbooks/a240/iahs_240_0003.pdf.

SRDI (Soil Resource Development Institute). 2012. *Saline Soils of Bangladesh*. Dhaka: Ministry of Agriculture, Government of Bangladesh.

WARPO (Water Resources Planning Organisation). 2001a. *National Water Management Plan: Executive Summary, Vol. 1*. Dhaka: Water Resources Planning Organisation, Ministry of Water Resources, Government of Bangladesh.

___. 2001b. *National Water Management Plan: Main Report, Vol. 2*. Dhaka: Water Resources Planning Organisation, Ministry of Water Resources, Government of Bangladesh.

___. 2001c. *National Water Management Plan: Regional Plans, Vol. 4*. Dhaka: Water Resources Planning Organisation, Ministry of Water Resources, Government of Bangladesh.

___. 2001d. *National Water Management Plan: Development Strategy*. Dhaka: Water Resources Planning Organisation, Ministry of Water Resources, Government of Bangladesh.

World Bank. 1972. *Land and Water Sector Study*. Dhaka: The World Bank.

___. 1993. *Water Resources Management*. A World Bank Policy Paper. Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/94026 1468325788815/Water-resources-management.

___. 1998. *Water Resources Management in Bangladesh: Steps Towards A New National Water Plan*. Dhaka: The World Bank.

Young, R. 1996. *Measuring Economic Benefits for Valuing Water Investments and Policies*. Technical Paper No. 338. Washington, D.C.: World Bank.

Zahid, A., M. A. Haque, M. S. Islam, and M. A. F. M. R. Hasan. 2009. "The Impact of Shallow Tube Wells on Irrigation Water Availability, Access, Crop Productivity and Farmers' Income in the Lower Gangetic Plain of Bangladesh." In *Groundwater Governance in the Indo-Gangetic and Yellow River Basins: Realities and Challenges*. International Association of Hydrogeologists Selected Papers 15, edited by Aditi Mukherji, Karen G. Villholths, Bharat R. Sharma, and Jinxia Wang. London: CRC Press, Taylor and Francis Group.

Chapter 7

Seeding the Future: Accelerating Seed System Development in Bangladesh

Firdousi Naher and David J. Spielman

7.1 Introduction

Evidence accumulated from many developing countries during the past 50 years has demonstrated that yield-enhancing cultivars are vital inputs to sustained agricultural productivity growth, particularly in land-scarce countries where yield growth can only be achieved through intensification (Evenson and Gollin 2003). But sustained productivity growth requires more than just strong scientific expertise and good plant breeding programs. It also requires a modern seed system that has the capacity and infrastructure to multiply, popularize, and distribute these cultivars. And while there are many different designs for a modern seed system, they all share one commonality—they shift seed use practices away from traditional approaches in which farmers select, save, and exchange seeds, to a system that integrates traditional approaches with modern science, public investment, and market signals to provide farmers with more systematic access to improved cultivars and quality seed. Necessarily, this shift also means that seed becomes an economic commodity: it becomes the embodiment of innovative effort undertaken by plant breeders, entrepreneurs, sales representatives, and farmers, across whom the gains from innovation must be distributed in a manner that encourages continuous production and further innovation. It is the role of the policymaker to develop policies that encourage both production and innovation to benefit society.

Seed plays a central role in Bangladesh's development strategy discourse. Since independence in 1971, policymakers have allocated substantial levels of public resources toward plant breeding programs, seed production facilities, and the popularization and distribution of improved cultivars for

rice, wheat, and many other crops that are fundamental to the country's food security and economy. Over time, policymakers have also introduced new rules and regulations to shift the seed system from a purely public sector domain to a more complex landscape of public, private, and civil society organizations, and from a purely technology-driven supply system to a more competitive market-based system (Harun-Ar-Rashid, Ali, and Gisselquist 2012; Waddington, Lantican, and Tripp 2012). This combination of public and private investment has contributed significantly to increasing agricultural productivity, particularly with respect to rice (Ahmed 2000; Dorosh 2006; Rashid, Gulati, and Cummings 2008; Hossain 2010). Yet despite Bangladesh's impressive progress, several issues continue to challenge conventional thinking among policymakers, investors, donors, and development practitioners. First, is this new and evolving landscape improving access to improved cultivars for small and marginal farmers? Second, given the continued role of the state in many aspects of the seed system, are there further policy reforms that can encourage sustainable private investment in the development, production, and marketing of improved cultivars without comprising access?

This paper examines the seed system in Bangladesh and the policies that influence its reach and growth. Section 7.2 provides a conceptual discussion to frame the decisions facing farmers, governments, and firms in the seed sector, and to highlight the roles of both crop reproductive biology and public policy. Section 7.3 describes the data and information sources used to analyze the performance of Bangladesh's seed system. Section 7.4 begins with an exploration of the policies, rules, and regulations that have influenced its development, and the impact of these policies on increasing smallholder access to improved cultivars. It then examines the opportunities and tradeoffs between policies designed to simultaneously increase smallholder access to improved cultivars and encourage greater investment in the seed system. Section 7.5 concludes with a discussion of policy options that better delineate appropriate roles for the private and public sectors in Bangladesh's seed system.

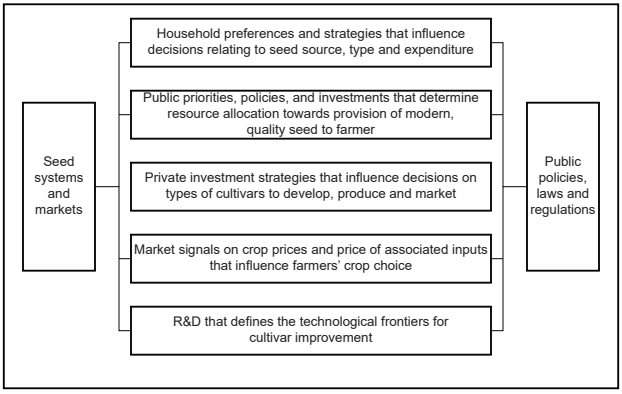
7.2 A Conceptual Framework: Towards Better Analysis of Seed Systems

A well-functioning seed system is a balancing act between formal and informal provisioning strategies, market and non-market delivery channels, and public and private sector investment, with the overarching goal of matching the supply of high-quality seed with farmers' demand. To

illustrate this balancing act, we present here a conceptual framework that highlights the inherent tradeoffs in a seed system and the policy options for addressing these tradeoffs. We begin with a schematic that lists out the basic elements of a seed system: household decisions, national development priorities, public policies and investment strategies, and private investment incentives, and technological opportunities. We explore each one in detail below (Figure 7.1).

Let us first consider the seed system from the perspective of the ultimate consumer or user—the farmer or farm household. While the rhetoric around seed systems tends to focus on farmers' "inalienable rights to seed" and "seed sovereignty" or on the state's responsibility to supply seed to farmers regardless of cost, we choose to view seed from the farmers' perspective, i.e., as an input to agricultural production. Although farmers face a complex set of decisions when managing a farm, we can narrow their decisions around seed purchasing to just four reasons: (1) to obtain a better cultivar with superior genetic traits; (2) to obtain better quality seed, assuming farmers cannot save seed without incurring significant costs and losses in saved seed viability or quality; (3) to renew the availability of the genetic traits embodied in the cultivar, for example, in the case of hybrids that lose their vigor when second-generation seed are saved and planted; or (4) to obtain seed when their own seed supplies and the supplies from their common sources have been destroyed from some type of disaster.

Figure 7.1: Elements of a Seed System



Source: Authors' perception.

This finite set of reasons helps narrow our understanding of the farmers' decision problem. For example, the farmer might consider a tradeoff between purchasing seed of a newer, improved variety that increases yield or embodies some other desirable trait, versus using tried and tested varieties that she is more familiar with. Or the farmer might consider a tradeoff between whether to use seed she has selected and saved from grain harvested on her farm during the prior season, versus purchasing seeds that is more costly but possibly of a better quality. Or, she might choose to diversify her on-farm varietal portfolio to minimize risks associated with cultivating just one variety, but give up uniformly higher yields in doing so. The choices a farmer makes are often correlated with such individual characteristics as the farmers' experience, education, and access to extension and advisory services; household characteristics such as wealth, landholdings, access to credit for input purchases, and (implicitly) the ability to tolerate risk; and geographic, market, and agro-ecological factors such as land suitability, distance to seed suppliers, and access to irrigation.

Next, let us consider the decision problem facing government—a somewhat different problem than the farmers', but one that is similarly fraught with tradeoffs. The government is responsible for setting national development priorities and, in doing so, building a system that can reliably supply high-quality seed of improved cultivars to farmers so that national goals for agricultural production, food security, and poverty reduction can be simultaneously achieved. The government's approach to building this seed system may take into account competing interests among stakeholders, whether represented directly though democratic institutions or expressed through the voice of civil society, or negotiated across coalitions of interest groups. The contested nature of modern seed systems relates not only to the distribution of the gains to technological innovation, but also to farmers' rights over extant genetic resources, farmers' ownership of the seed as a means of production, intellectual property rights ownership, and concerns related to market efficiency and transparency (see, e.g., Scoones and Thompson 2011; Kloppenburg 1988). Resultant public development strategies, policies, investments, and regulations are all derived from the path chosen by government to negotiate these contested interests and claims.

The more immediate decision problem facing the government is how to optimally invest scarce public resources in a system that must integrate research, production, and distribution of high-quality seed for improved cultivars. The decision cannot be taken on a broad, sector-wide basis because the returns to public investment will vary by crop, agroecology, and market. We illustrate this with several examples, advancing from the

simple principles of crop reproductive biology to markets and institutions designed that use biology to incentivize investment in better cultivars.

Consider, for example, rice and wheat. Both are self-pollinating crops, which (in simple terms), means that a farmer can purchase an improved cultivar, plant it, save a portion of the grain from harvest, and replant the grain as seed in the subsequent year *without experiencing significant loss* of the variety's desirable genetic characteristics such as yield, resistance to pests and diseases, or tolerance to abiotic stresses. During the past five decades, this mechanism—the combination of farmers' traditional seed-saving practices and public investment in breeding, production and distribution—has been the primary channel for supplying smallholders with new seed-based technologies for rice and wheat. And through this mechanism, the largest portion of the gains from innovation is appropriated by the farmer, and only nominal remuneration is provided to the innovators who developed and distributed the cultivar. But if the innovator is a public sector organization fulfilling its mandate to increase agricultural productivity, then the distribution of these gains is immaterial, and the costs of research, development, and delivery can be recouped from public funding. In effect, society places a value on public investment in this mechanism and is willing to finance it because the social gains are desirable.

The downside, however, is that the combination of farmer seed-saving practices and public investment provides minimal incentive to private sector agents to invest in breeding, production, and distribution. This is a classic market failure: the social benefits of making improved cultivars available to farmers exceed the private benefits of doing so. This market failure is the basic rationale for public investment in cultivar improvement and seed provision, and it extends from rice and wheat to other self-pollinating and asexually propagated crops such as legumes, pulses, potato, sweet potato, and cassava.

That said, market failures in seed systems can be overcome through two channels: biology and policy. First, consider we consider the reproductive biology of maize, specifically hybrid maize which represents the lion's share of all maize cultivated globally and which differs significantly from the rice, wheat and the other crops described earlier. Hybrid crops exhibit the unique characteristic of heterosis, or an increase in yield or vigor that results from genetic contributions derived by crossing distinct parental lines. However, since yield gains from heterosis decline dramatically after the first generation of seed is cultivated, farmers are compelled to purchase new seed each season, thus creating economic value. Innovators can appropriate the gains from innovation and recoup their investments

in research. Thus, the research, development, production, and marketing of hybrid maize is largely a private sector venture throughout the world. The economic incentive attributable to crop reproductive biology extends to other crops that have been hybridized, including sorghum, pearl millet, pigeon pea, and rice.

Second, market failures can be overcome through policies, specifically, legal mechanisms that allow private innovators to appropriate the gains from innovation. Institutions such as intellectual property rights (IPRs) allow companies to charge remunerative prices for seed, reward innovators for their successful investments in cultivar improvements, and reduce the transaction costs associated with contested claims over the rights to innovation rents. However, IPRs can also be costly to enforce and may constrain market reach to only those who are economically, geographically, or otherwise inclined to purchase seed at market prices.

Despite this seemingly neat division between the spheres of (publicly resourced) self-pollinating/asexually propagated crops and (privately resourced) hybrid crops, and despite the convenient biological and policy solutions available to overcome market failures, the reality of a modern seed system is much more complicated. For example, many governments in industrialized and developing countries invest in breeding programs for a wide range of crops—self-pollinating, asexually propagating, and hybrids—as part of their commitment to basic, upstream research where only the government can absorb the costs and risks associated long time horizons and uncertain outcomes. These investments are often essential to creating the basis for subsequent commercialization of viable technologies by the private sector. In other cases, governments invest in breeding programs and seed production activities because farmers may be constrained in their ability to purchase improved cultivars at a remunerative market price due to limits on farmers' purchasing power, geographic constraints to market access, or simply because the crop is question is used solely for own-consumption and does not generate sufficient income for farmers to purchase seed.

Yet, despite solid reasons for government involvement in the seed market, there are also tradeoffs to such involvement, especially in the medium- to long-term. Public breeding programs can crowd out private investment in cultivar improvement, while seed regulations meant to protect farmers from predatory marketing practices can also inhibit private investment and innovation. Seed production by parastatal can weigh heavily on government budgets and allocate scarce government funds away from other important public investments such as agricultural research, rural infrastructure, or social welfare improvement. For governments, this is the fundamental tradeoff

between direct state intervention in seed production and distribution, and indirect intervention through policies and regulations designed to encourage private investment (see, Naseem, Spielman, and Omamo 2010).

Next, we turn to the firm's decision problem, which should be fairly obvious by now. The firm must decide how to invest in remunerative activities in the seed system, specifically, how to appropriate the gains from innovation. The firm may choose an appropriation mechanism, for example, developing and marketing hybrids or seeking IPR protection for its non-hybrid products. The firm may also choose to specialize in a specific part of the seed system, for example, in developing and licensing out high-quality breeding materials, or by purchasing breeding material from public and private sources and multiplying large seed quantities for sale to farmers. Still other firms may choose to integrate their activities in end-to-end business models that cover advanced breeding and retailing. Whatever the choice of activities, the decision problem facing the firm is how to maximize the firms' profits given the costs of inputs required to develop, produce and market seed.

Ultimately, seed provisioning strategies rely on close integration between the public and private sectors. The question is whether the institutional architecture in a given country is efficient, effective, and open enough to encourage diverse provisioning strategies that are responsive to the heterogeneity across crops, geographies, and households. This is important given the expectations placed on the agricultural sector to improve food security, reduce poverty, and conserve the environment under ever-greater economic, demographic and climatic stresses. Towards that end, an analysis of a country's seed system requires in-depth understanding about the country's public research system, its regulatory system and the costs of regulation, its seed supply system, and the adequacy of information available to a heterogeneous farming population. We examine these aspects in the context of Bangladesh in the next section.

7.3 Data and Data Sources

Our analysis of the performance of Bangladesh's seed system draws on data and information from several sources. First, we draw on information extracted from two studies on the country's seed system that were commissioned by the International Food Policy Research Institute (IFPRI) in 2013. These studies were done by the Bangladesh Institute of Development Studies (BIDS) (Ali and Basher 2013), an autonomous public multi-disciplinary organization, and the Center for Agri-research and Sustainable Environment and Entrepreneurship (CASEED 2013), a private research and consulting firm. They reviewed the existing policies, regulations and acts pertaining to seed

and also identified the gaps and constraints in the various policy provisions as well as their implementation. Information from these studies are augmented with several recent studies covering specific aspects of Bangladesh's seed system that will be referred to in subsequent sections.

Second, we draw on official figures on seed system performance generated by various government entities: (i) the Seed Certification Agency (SCA), which regularly provides data on varietal registration of different crops; (ii) the Seed Wing of the Ministry of Agriculture which regularly publishes data on seed demand and supply in Bangladesh; and iii) the Bangladesh Agricultural Development Corporation (BADC), the state-owned enterprise mandated to produce and distribute improved cultivars in Bangladesh.

Third, we examine data from two recent household studies. The first survey is the Bangladesh Integrated Household Survey (BIHS), a nationally representative survey, covering 5,500 rural households across Bangladesh that was designed by IFPRI in 2011-2012. See Ahmed (2013) for complete details of the survey aims, its sampling frame, and the questionnaire design. The second survey is a 2013 agricultural technology adoption survey also designed by IFPRI to collect information on the uptake of stress-tolerant varieties of rice by farmers in the southern region of Bangladesh.[1]

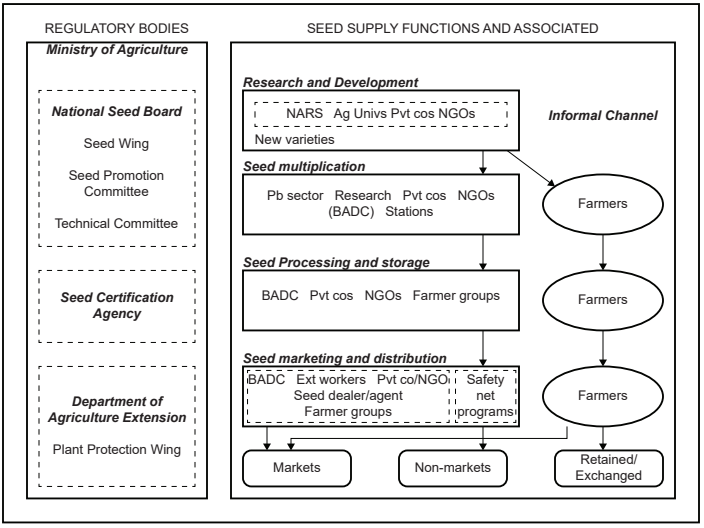
7.4 Seed System in Bangladesh

7.4.1 Policies, Regulations, and Processes

Bangladesh's farmers have long relied on their own efforts to select, save, and exchange seed with desirable genetic characteristics. Even today, these informal seed systems are an important source of seed for rice and many other crops. These informal systems are also closely intertwined with the country's formal seed system that was established in the 1950s. In its initial phases of development, this formal system combined public investments in plant breeding through the national agricultural research system (NARS) and public universities, with seed production, promotion and distribution through the Bangladesh Agricultural Development Corporation (BADC), and the Department of Agriculture Extension (DAE) (Figure 7.2). The hallmark of this system was the introduction of high-yielding, short-stature *boro* rice cultivars that put Bangladesh on the path to surplus rice production in the 1980s (Hossain 2010).

[1] The survey collected information from 3,400 randomly sampled rice farmers. It is representative of the Feed the Future (FtF) zone which covers most of southern Bangladesh and parts of Dhaka division. FtF is the US government's global hunger and food security initiative to support country-driven approaches to tackling hunger and poverty.

Figure 7.2: Seed System in Bangladesh: Functions, Actors and Regulatory Bodies



BADC Bangladesh Agricultural Development Council
cos. Companies
NARS National Agricultural Research System
NGO Non-governmental organization
Pvt. Private

Source: Authors' perception.

In the late 1980s, the Government of Bangladesh introduced several policy reforms designed to liberalize the agricultural sector in line with recommendations of the structural adjustment programs of the World Bank and IMF. For the seed system, the highlight of these reforms was the 1993 National Seed Policy, which called for balanced development of the seed sector by providing equitable opportunities to the public and private sector at all stages of the seed industry from breeding to marketing of seeds. The policy aims to change the BADC's role in Bangladesh's seed market by (i) limiting BADC seed production to notified[2] crops only, (ii) calling for the gradual withdraw of BADC from seed production of seeds of all

[2] Five crops *viz.* rice, wheat, potato, sugarcane and jute have been deemed as "notified" crops, requiring that the government test the cultivars for value in cultivation and use (VCU) and distinctiveness, uniformity and stability (DUS) prior to their approval for commercial introduction. For the non-notified crops, registration involves only an application and testing requirements are mandatory only for breeder and foundation seed.

other crops, (iii) requiring BADC seed prices to better reflect its costs, and (iv) phasing out subsidies to BADC. This policy was followed by the Seed Rules, 1998, wherein the mandatory requirements for seed certification was relaxed, thereby allowing seed producers to market truthfully labeled seeds.

Despite these policy reforms, the tangle of rules and regulations is still cited as one of the most significant barriers to growth and investment in Bangladesh's seed system (Hossain et al. 2001; Harun-Ar-Rashid, Ali, and Gisselquist 2012; Waddington, Lantican, and Tripp 2012). The time, effort, complexity, and costs required to register and release a new variety are considered onerous by both public and private innovators. Furthermore, new restrictions set forth under the 2005 amendment to the Seeds Act saw a reversal of several provisions in the 1993 policy, and prohibited private firms from conducting breeding activities for any notified crops, with the exception of breeding related to hybrid rice. To better understand the complexity and restrictions in this system—as well as some of the opportunities that have emerged from the original reform efforts of the 1990s—we examine the current process required to release new varieties and hybrids in Bangladesh.

For inbred varieties of notified crops, it is the responsibility of breeders from public research organizations to submit an application for new variety registration to the National Seed Board (NSB). The NSB lies under the control of the Ministry of Agriculture and is responsible for advising government and implementing seed policies and regulations covering varietal registration, seed quality, and other related aspects. For variety approval and release, new varieties have to undergo two types of variety tests (i) test for value, cultivation and use (VCU) and (ii) test for distinctness, uniformity and stability (DUS). Although the SCA is responsible for carrying out both VCU test and the DUS test, in reality only the DUS test is done by the SCA. The VCU test is done by the breeder himself through multi-locational trials that are conducted over two years and in six locations under the direction of field teams headed by the Department of Agriculture Extension (CASEED 2013).

Once it is confirmed that the variety being tested is not a duplication of some other existing variety, field reports are tabulated by the SCA and sent to the Technical Committee (TC) of the NSB. The TC which is headed by the Executive Chairman of the Bangladesh Agricultural Research Council (BARC) submits a recommendation to the NSB for release of the variety.

For non-notified crops, the process is slightly simpler. Commercialization and release only involve a straightforward application to the Seed Wing of the NSB with select details on the distinguishing characteristics of the

variety, ecological and cultural requirements, and susceptibility to diseases and pests. The absence of cumbersome procedures for varietal registration of these crops seems to generally reflect a belief in the regulatory system that non-notified crops are not important enough to register. This means that the regulatory costs associated with breeding, producing, and marketing non-notified crops are relatively lower than the costs for notified crops, thus opening the door to private investment (Table 7.1). Only in instances where seed for non-notified crops is imported, is there an additional layer of regulatory scrutiny. Specifically, phyto-sanitary safety of imported seed (typically, vegetable and hybrid rice seed) are examined by the Plant Protection Wing of the Department of Agriculture Extension which acts as the National Plant Quarantine Authority that was sanctioned under the Plant Quarantine Act of 2011.

Table 7.1: Registered Cultivars introduced by Public and Private Agencies, 1971-present

Crop	Public Agencies		Private Agencies	
	Pre-liberalization (1971-93)	Post-liberalization (1994-2012)*	Pre-liberalization (1971-93)	Post-liberalization (1994-2012)*
Notified crops				
Rice:				
Modern variety	29	40	-	3
Hybrid	0	3	-	89
Wheat	18	9	-	0
Potato	12	27	-	0
Sugarcane	10	14	-	0
Jute	8	8	-	0
Non-notified crops				
Maize	5	19	-	98
Vegetables	116	116	-	1064
Pulses	9	50	-	4

*For maize, vegetables and pulses, figures are till 2011.

Source: Authors' compilation based on SCA's list of approved varieties available at http://www.sca.gov.bd/.

It is worth pointing out while the regulatory bodies responsible for varietal evaluation and registration are mandated to involve representatives of the public, private, and civil society sectors in their composition and

decision-making, the current membership is drawn primarily from the public sector (Table 7.2).

Table 7.2: Representation of the Private Sector in Regulatory Bodies

Regulatory authority	Total members	Number of members		
		Public sector	Private sector	Farmers' groups
National Seed Board (NSB)	20	17	2	1
Technical Committee of the NSB	16	14	1	1
Seed Promotion Committee of the NSB	18	17	1	0

Source: Adapted from CASEED (2013).

Once a variety is released in Bangladesh, the next regulatory hurdle is seed quality assurance. Two separate systems operate at present—seed certification and truthful labeling—and are applied for different crops at different points in the production system. For notified crops produced by public agencies, seed certification is compulsory for breeder seed (BS) and foundation seed (FS), as per the 1998 Seed Rules. For seed of both notified and non-notified crops that is sold to farmers directly, seed must only be truthfully labeled. Since the policy was relaxed to allow for truthfully labeled seed (TLS), approximately 80 percent of seed supplied to the farmers is truthfully labeled, including seed that originates from BADC, the private sector, and NGOs (CASSED 2013). For imported seed, the Plant Protection Wing (under the Department of Agriculture Extension) serves as the national plant quarantine authority and issues a phyto-sanitary certificate for imported seed. The law requires importers to bring in only certified seeds, and once the certificate has been issued, then the seed can be sold to farmers.

Several seed producers also maintain their own, in-house quality assurance systems. For example, BADC has its own quality control department, while some private firms and NGOs manage their own quality assurance systems to ensure that their seed meets farmers' expectations for purity, germination, and expression of the genetic traits embodied in the variety or hybrid (Bødker, Wulff, and Torp 2006; Waddington, Lantican, and Tripp 2012). While TLS and self-regulation reduce the regulatory costs of releasing improved cultivars and hybrids into the market, they do pose their own set of problems. Specifically, firms (whether public or private) may not have the incentive to ensure seed quality if farmers do not seek recourse

through the judicial system or if the judicial system has insufficient capacity to adjudicate on fraudulent seed sales. An alternative approach to quality assurance, such as monitoring the open market for fraudulent or poor-quality seed through the SCA, is limited by insufficient field staff—only 30 seed inspectors for the entire country—and by insufficient seed testing facilities and related resources (Hossain et al., 2001).

Ultimately, seed is distributed in Bangladesh through three main channels. First, BADC sells the seed through its own network comprising of with 22 regional offices, 42 district sales centers, and 36 *thana* sales outlets (BADC 2013). Second, BADC distributes seed through a separate network of more than 300 companies, merchants and traders, 16,000 registered seed dealers, and as many as 120,000 seed retailers all over the country (CASEED 2013). BADC seed is sold at cost, and the parastatal's financial viability is implicitly aided by a subsidy that comes from public funding of its recurrent costs. Third, the private sector—a mix of small farmer seed entrepreneurs, one-man owned wholesalers/importers, international seed companies and joint venture companies—sells seed through private seed dealers and middlemen (Bødker, Wulff, and Torp 2006). Fourth, NGOs distribute seed through community groups and other civil society channels. It is worth noting that NGO participation in the seed system is non-trivial: BRAC, Bangladesh's largest NGO, has a seed distribution channel that includes around 550 dealers and distributors, and over 4,000 retailers (BRAC 2013). Seed distribution efforts receive support from the national Agriculture Extension Policy which was subsequently revised under the New Agricultural Extension Policy (NAEP) in 1996. The NAEP introduced a major shift in the provision of public extension by requiring the DAE to evolve from a centralized extension service provider to a more decentralized and pluralistic system (World Bank 2005). The provision of information on new varieties is part and parcel of this system's mandate.

7.4.2 Seed System Performance

One way of assessing seed system performance is to simply categorize Bangladesh in terms of its stage of seed system development. Pray and Ramaswami (1991) describe four stages. In the first stage, farmers rely on traditional practices of seed saving, selection, and exchange. In the second stage, farmers begin cultivating improved (modern) varieties that are bred by NARS or imported from foreign sources, and produced by parastatal or commercial seed companies. In the third stage, farmers cultivate modern varieties widely and the private sector becomes a significant source of

innovation in breeding, production, and marketing, eventually becoming the primary source of improved varieties and hybrids in the fourth stage.

At present, Bangladesh may be categorized as being in the late phase of the second stage, but is rapidly evolving toward the third stage. Most seed is still produced by farmers themselves and breeding, production, and distribution are still the primary domain of the public sector. However, the growth of private and NGO investment in breeding (e.g., BRAC's investments in hybrid rice) and marketing suggest signs for a significant transition (Harun-ar-Rashid, Ali, and Gisselquist 2012; Spielman et al. 2012).

To provide a better sense of seed system performance in Bangladesh, we look at several indicators. We examine below the national trends in seed multiplication and seed distribution. From the farmers' point of view, we explore their seed purchasing decisions and adoption rates across a range of crops, varieties, and divisions. We then calculate the average varietal age of specific popular rice varieties is also calculated.

7.4.3 Seed Multiplication and Distribution

Bangladesh's modern seed system has been fairly productive with respect to releasing new varieties of key food staple crops, particularly from the public sector side. Since 1970, the Bangladesh Rice Research Institute (BRRI) has released 65 modern rice varieties (61 inbreds and 4 hybrids), with an additional 10 varieties released by the Bangladesh Institute for Nuclear Agriculture (BINA) (as per the BRRI and SCA websites). Releases of improved wheat and potato have also come from the Bangladesh Agricultural Research Institute (BARI) while the Bangladesh Jute Research Institute (BJRI) and Bangladesh Sugarcrop Research Institute (BSRI) have released improved cultivars for their mandated crops (see Table 7.1). In most cases, these public sector efforts have been aided by collaborations with the Consultative Group for International Agricultural Research (CGIAR) centers, and with support from multilateral and bilateral donor funding.

The public sector has also been fairly effective at supplying seed—foundation seed for use in seed production and certified or truthfully labeled seed for sale to farmers—through the BADC (Table 7.3). Between 2003/04 and 2013/14, foundation seed production for vegetables and pulses—both non-notified crops—grew at an annual rate of 15 and 21 percent, respectively (Table 7.5). The BADC's distribution infrastructure is aided by both DAE and the private sector (Table 7.4).

Table 7.3: Quantity of Foundation, Certified and TFL Seed of Select Non-Notified Crops produced by BADC since 2003-2004

Year	Foundation Seed				Certified and TFL seed			
	Maize	Pulses	Oilseeds	Vegetables	Maize	Pulses	Oilseeds	Vegetables
	(metric tons)							
2003-04	4.0	35.7	36.4	10.9	-	261.9	408.0	13.0
2005-06	12.5	89.2	101.7	11.0	-	314.0	416.0	42.9
2009-10	15.1	129.9	140.3	23.0	115.8	1078.1	871.7	67.6
2012-13	32.9	299.8	149.8	30.7	223.1	1736.2	1429.0	90.5

Source: Authors' calculations based on BADC annual report (various years).

Table 7.4: Proportion of Commercial Seed distributed by BADC, DAE and Private Sector

	2008-09			2009-10			2010-11			2011-12		
	BADC	DAE	Private	BADC	DAE	Private	BADC	DAE	Private	BADC	DAE	Private
	(percentage)											
Aus	45	55	0	35	65	0	22	78	0	31	69	0
Aman	43	57	0	36	54	10	39	51	10	45	46	9
Boro	40	37	24	49	34	17	53	30	16	52	27	21
Wheat	64	36	0	69	31	0	69	31	0	69	31	0
Maize	2	0	98	1	0	99	2	0	98	6	0	94
Pulses	96	4	0	34	66	0	48	52	0	39	61	0
Potato	28	0	72	27	0	73	31	0	69	41	0	59
Vegetables	7	0	93	10	0	90	12	0	88	11	0	89

Source: Authors' compilation based on database of the Seed Wing, Ministry of Agriculture.

Although the Ministry of Agriculture reports a gap between seed demand and supply (Table 7.5), it should be recognized that "seed requirement" figures are heuristic at best and take insufficient account of price determinants of demand—of the seed itself, of the crop for which demand is derived, and of the price of complements (e.g., synthetic fertilizer) and substitutes (e.g., saved seed)—as well as non-price determinants such as genetic traits, seed quality, timeliness of delivery, and accessibility.

Table 7.5: Seed Requirement and Commercial Seed Distribution for Select Crops, 2008-09 to 2011-12

Crop	2008-09		2009-10		2010-11		2011-12	
	Seed req	Seed dist	Seed req	Seed dist	Seed req	Seed dist	Seed req	Seed dist
	('000' m tons)							
Boro	100.55	91.89	99.50	90.41	113.92	108.84	130.75	124.24
Aman	168.00	39.48	167.88	48.81	156.59	51.73	154.25	58.00
Aus	37.00	1.91	36.50	2.21	31.38	4.31	34.50	5.58
Wheat	70.20	31.17	69.60	34.16	45.00	39.34	55.70	39.84
Maize	5.78	4.58	6.80	4.04	4.56	4.59	5.00	4.80
Pulses	20.97	0.88	20.97	1.95	22.21	2.51	23.20	2.74
Potato	410	48.20	410	52.30	477	59.45	600	47.82
Vegetables	2.62	1.09	2.62	0.84	4.10	0.85	4.50	0.89

Note: The term "seed" here denotes both regular seed and non-seed planting material such as cuttings, buddings, saplings, and other planting materials. "Seed req" denotes seed requirement, and "seed dist" denotes "seed distributed."

Source: Seed Wing, Bangladesh Ministry of Agriculture, various years.

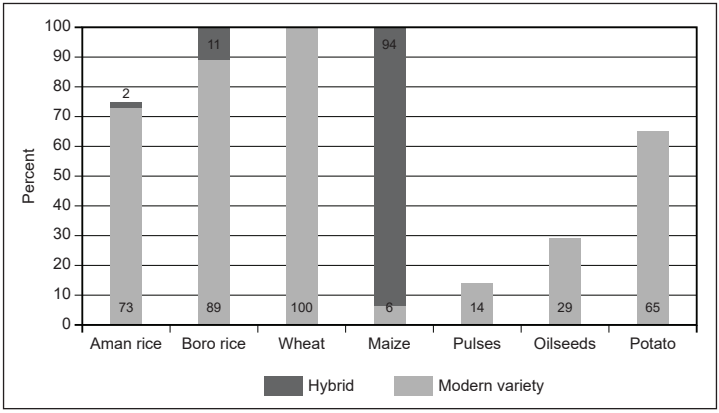
Despite the limitations of official demand assessment calculations, the figures in Table 7.4 do provide a snapshot of the private sector's role in seed provisioning. The private sector dominates the market for maize and vegetable seed and, to a lesser extent, potato. The private sector also plays an increasing role in the market for hybrid rice, where a total of 76 rice hybrids have been introduced by private companies since 2000 as compared to five hybrids originating from BRRI (Harun-Ar-Rashid, Ali, and Gisselquist 2012; Spielman et al. 2012). It is worth noting here that the term "private companies" used above also includes NGOs—specifically BRAC, the current market leader in hybrid rice.[3] It is also worth noting that while private (for-profit) companies and (non-profit) NGOs such as BRAC have forayed into the seed market following policy reforms in the 1990s, their investments have often also been supported by donor projects designed to encourage private investment in agricultural input markets (see Harun-Ar-Rashid, Ali, and Gisselquist 2012).

[3] In the latter half of 2000s, BRAC began investing in agricultural research and has since released 9 vegetable varieties, three maize hybrids, and three rice hybrids from its own research facilities (BRAC 2012). In 2009 the agency invested 141.6 million taka accounting for 5 percent of the country's total agricultural R&D spending (IFPRI 2011). As of 2011, BRAC accounted for an estimated 32 percent of the hybrid rice seed market and 50 percent of the maize seed market in Bangladesh (BRAC 2013).

7.4.4 Farmers' Technology Uptake for Rice and Average Varietal Age

Another useful performance indicator is the extent of adoption of improved cultivars by farmers (Figure 7.3). Data from BIHS indicate that the share of farmers growing modern rice varieties during the *aman* (monsoon) season totals 73 percent, with an additional two percent of farmers cultivating hybrids during the season and the remainder cultivating traditional varieties. The irrigated *boro* rice season—a rotation only feasible with the combination of tube well irrigation and short-stature, short-duration modern varieties—the share of farmers cultivating modern varieties unsurprisingly increases to 89 percent, with the remaining 11 percent cultivating hybrids. For other crops, comparable shares of farmers cultivate modern varieties or hybrids: 100 percent in the case of wheat and 94 percent in the case of hybrid maize.

Figure 7.3: Share of Farmers Cultivating Modern Varieties, 2011-12



Source: Authors, based on data from Ahmed (2013).

Improved cultivar adoption is much lower for non-cereal crops such as pulses, oilseeds and potatoes. In fact, pulses and, to a lesser extent, oilseeds are predominantly local varieties. This is not surprising given the NARS relatively limited performance around non-cereal crop improvement. BARI released its first improved lentil variety in 1991 and its first varietal release of grass pea in 1995. Altogether, the NARS has only released seven varieties of lentils (*masur*) and three varieties of grasspea (*khesari*) to date. Improved cultivar adoption for potatoes has been somewhat better with 65 percent of the farmers growing modern varieties, a likely reflection of the fact that BARI has released nearly 50 varieties since independence.

But crop-level aggregations of national data reveal only a limited amount of information. More disaggregated, variety-specific data provide insight into the prevalence of modern varieties, and the extent to which older modern varieties have been replaced by newer modern varieties with higher yields, more effective biotic and abiotic stress tolerance, or other desirable traits. For instance, wheat cultivation in Bangladesh is concentrated around two relatively older wheat varieties—*Sonalika* and *Kachan*—released in 1974 and 1983 respectively (Waddington, Lantican, and Tripp 2012). Few farmers have adopted more recent wheat variety releases such as *Shatabdi* (2000) and *Prodip* (2005) that were bred to address stress susceptibilities identified in the older wheat varieties. While the persistent use of older modern varieties by farmers may be partly attributable to farmer and consumer preferences for certain characteristics associated with these varieties, it may also be an issue of insufficient production, marketing and distribution.

The reliance on older modern varieties is also found in rice, particularly in *boro* rice. Just two varieties—BR 28 and BR 29, both released in 1994—account for cultivation by more than 50 percent of the rice farmers and occupy close to 70 percent of the country's acreage under boro rice. Across all rice growing seasons in Bangladesh, just five varieties account for 53 percent of rice cultivated area (Table 7.6). The average age of these varieties (weighted by cultivated area) is 20 years, suggesting a strong reliance on older modern varieties and relatively slow varietal turnover.[4] These observations are constant across all farm sizes.

Table 7.6: Rice Cultivated Area by Variety and Average Variety Age in Bangladesh

Farm size	Share of all rice cultivated area planted to top 5 varieties					Average age of top 5 varieties (Years)
	BR 29[a] (1994)	BR 28[a] (1994)	BR 11[c] (1980)	Hira[b] (2008)	BR 22[c] (1988)	
Marginal farmer (<.5 acre) (n=993)	17.88	21.57	10.46	1.23	3.55	20.75
Small farmer (.5-1.49 acres) (n=1,269)	18.88	20.70	10.35	2.76	3.18	20.24
Medium farmer (1.5-2.49 acres) (n=347)	18.86	17.33	11.00	3.30	2.06	20.29
Large farmer (2.5 acres and above) (n=2,830)	19.88	15.44	8.55	4.81	1.26	19.20
Overall	19.08	18.43	9.97	3.36	2.38	20.01

[a] denotes *boro* variety; [b] denotes *boro* hybrid; [c] denotes *aman* variety.

Note: Year of release for a specific variety is denoted above as "(yyyy)." The "average age of top 5 varieties" is calculated here as the average age of the top 5 varieties weighted by the share of area planted to each top-5 variety from the total area planted to all top-5 varieties.

Source: Authors, based on data from Ahmed (2013) and BRRI (http://tinyurl.com/oywzg3u).

[4] The average variety age for rice weighted by area under cultivation has been calculated along the lines of Brennan and Byerlee, 1991 and Heisey and Brennen, 1991.

A division-wise disaggregation of the three most popular rice varieties among farmers also indicates that BR 28 and BR 29 are the most popular *boro* rice varieties in all but one division, while the 32-year-old BR 11 was the most popular *aman* rice variety in five divisions (Table 7.7).

Table 7.7: Most Popular *Aman* and *Boro* Rice Varieties by Division

District	Season	
	Aman	Boro
Barisal	1. BR 11 (Mukta)	1. BR 8 (Asha)
	2. BR 23 (Dishari)	2. BR 28
	3. BR 22 (Kiron)	3. BR 49
Chittagong	1. BR 22 (Kiron)	1. BR 28
	2. BR 11 (Mukta)	2. BR 29
	3. BR 23 (Dishari)	3. BR 16 (Shahi balam)
Dhaka	1. BR 11 (Mukta)	1. BR 29
	2. BR 25 (Noya pajam)	2. BR 28
	3. BR 22 (Kiron)	3. Hira
Khulna	1. BR 23 (Dishari)	1. BR 28
	2. BR 22 (Kiron)	2. Hira
	3. BR 33	3. BRI hybrid-1
Rajshahi	1. BR 11 (Mukta)	1. BR 28
	2. BR 22 (Kiron)	2. BR 29
	3. BR 49	3. Hira
Rangpur	1. BR 11 (Mukta)	1. BR 28
	2. BR 25 (Noya pajam)	2. BR 29
	3. BR 10 (Progoti)	3. Hira
Sylhet	1. BR 11 (Mukta)	1. BR 29
	2. BR 22 (Kiron)	2. BR 28
	3. BR 25 (Noya pajam)	3. Hira

Source: Authors, based on data from Ahmed (2013).

However, these figures should not be viewed as firm evidence that farmers are slow to adopt new cultivars in Bangladesh. Many of these other popular varieties have staying power precisely because of their superior traits, for example, yields and duration in the case of BR 28 and BR 29 (Hossain et al. 2013). Moreover, there is evidence from IFPRI's recent survey of the southern region of Bangladesh (IFPRI 2013) suggesting that farmers are experimenting with—and adopting—modern varieties that have been specifically promoted for their stress-tolerance traits. Since 2010, approximately 9 percent of farmers

accounting for 3 percent of rice cultivated area have adopted at least one stress-tolerant cultivar (Tables 7.8 and 7.9). These varieties were developed by BRRI and BINA and promoted through several donor-funded research-for-development projects that specifically target southern Bangladesh.[5]

Table 7.8: Farmers cultivating Stress-tolerant Rice Varieties in Southern Bangladesh,[a] 2013

Variety	Percent of all farmers					Percent of rice cultivated area
	Marginal	Small	Medium	Large	All	
BRRI dhan BR-41 *(aman)*	0.00	15.63	13.21	13.16	12.74	0.29
BRRI dhan BR-43 *(aus)*	0.00	1.04	0.00	0.00	0.47	0.01
BRRI dhan BR-44 *(aman)*	4.00	2.08	0.00	7.89	2.83	0.05
BRRI dhan BR-46 *(aman)*	0.00	1.04	0.00	5.26	1.42	0.06
BRRI dhan BR-47 *(boro)*	28.00	10.42	15.09	21.05	15.57	0.47
BRRI dhan BR-48 *(aus)*	0.00	1.04	1.89	0.00	0.94	0.02
BRRI dhan BR-49 *(aman)*	20.00	16.67	16.98	18.42	17.45	0.41
BRRI dhan BR-50 *(boro)*	4.00	7.29	3.77	2.63	5.19	0.08
BRRI dhan BR-51 *(aman)*	0.00	6.25	3.77	10.53	5.66	0.18
BRRI dhan BR-52 *(aman)*	4.00	0.00	1.89	2.63	1.42	0.05
BRRI dhan BR-53 *(aman)*	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan BR-54 *(aman)*	4.00	0.00	0.00	0.00	0.47	0.00
BRRI dhan BR-55 *(boro/aus)*	4.00	0.00	1.89	0.00	0.94	0.01
BRRI dhan BR-56 *(aman)*	0.00	0.00	1.89	0.00	0.47	0.02
BRRI dhan BR-58 *(aman)*	0.00	1.04	1.89	0.00	0.94	0.01
Bina-7 *(aman)*	36.00	38.54	35.85	18.42	33.96	0.96
Bina-8 *(boro/aus)*	0.00	1.04	1.89	7.89	2.36	0.08
Bina -10 *(aman)*	0.00	0.00	3.77	5.26	1.89	0.07
Bina -11 *(aus/aman)*	0.00	2.08	0.00	0.00	0.94	0.01
Bina -12 *(aman)*	0.00	1.04	0.00	2.63	0.94	0.02
All	4.64	9.26	12.05	9.90	8.83	2.79

[a] Southern Bangladesh denotes the "Feed the Future" zone of influence designated by the United States Agency for International Development (USAID). See http://www.feedthefuture.gov/country/bangladesh.

Note: Farm sizes are as follows: marginal farmers: less than 0.5 acres; small farmers: between 0.5 and 1.49 acres; medium farmers: between 1.50 and 2.49 acres; and large farmers: 2.5 acres or more.

Source: Authors, based on data from IFPRI (2013).

[5] These projects include the Cereal Systems Initiative in South Asia (CSISA) led by CIMMYT, and the Stress-Tolerant Rice for Africa and South Asia (STRASA). Donors include the Bill and Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID).

Table 7.9: Share of Farmers Cultivating Selected Varieties for the First Time since 2000

Top 10 rice varieties	2009-2013		2004-2008		2000-2003	
	N	Percent	N	Percent	N	Percent
BR-28	148	7.55	200	13.52	168	13.47
BR-29	40	2.04	92	6.22	89	7.14
Guti Shorna	7.14	64	4.33	34	2.73	
BR-11 (Mukta)	56	2.86	57	3.85	54	4.33
BR-23 (Dishari)	56	2.86	56	3.79	47	3.72
BR-33	69	3.52	41	2.77	23	1.84
BR-39	89	4.54	32	2.16	10	0.80
Hira	38	1.94	65	4.39	24	1.92
Lal Shorna	32	1.63	18	1.22	32	2.57
BR-8 (Asha)	11	0.56	20	1.35	22	1.76

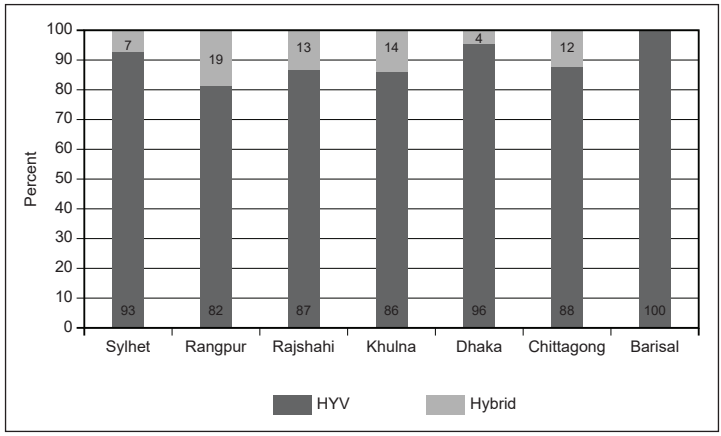
Source: Authors, based on data from IFPRI (2013).

Other indicators shed further light on the depth and breadth of the seed system's reach and performance in Bangladesh. Consider, for example, the small but significant share of *boro* rice cultivation that is attributable to hybrid rice. If hybrid rice is to play a role in increasing rice yields in Bangladesh, it is worth asking who is cultivating it at this early stage, and whether they are systematically different than other farmers who are yet to adopt. BIHS data indicate that hybrid rice is more prevalent among wealthier farmers, although variation across divisions seems relatively insignificant (Figure 7.4) (see also Spielman et al. 2012; Ward and Pede 2014).

Further evidence suggests that commercial input markets in Bangladesh are the primary source of seed for farmers. As shown in Figure 7.5, farmers rely on private dealers and retailers as their primary source for wheat and maize seed. However, a greater proportion of farmers cultivating rice and potato still rely on informal seed systems—own saved seed and exchanged seed. In the case of potato, seeds constitute more than 30 percent of the total cost of production prompting most farmers to use their saved seeds.

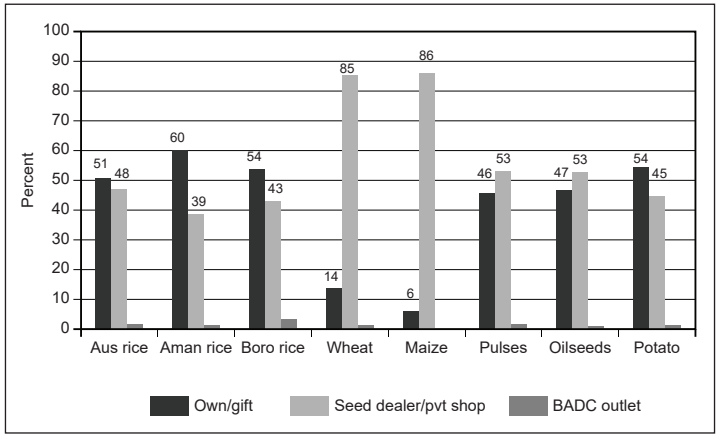
Figure 7.6 shows that seed purchases occur across all types of households, with purchased seed being as important for the poorest income quintiles as for the richest. However, as shown in Figure 7.7, a higher proportion of marginal farmers purchase seed compared to large farmers, where marginal farmers are characterized by an average farm size (based on operated land) of less 0.5 acres and large farmers by an average of 2.5 acres or greater.

Figure 7.4: Share of Farmers adopting of HYV versus Hybrid for Boro Rice



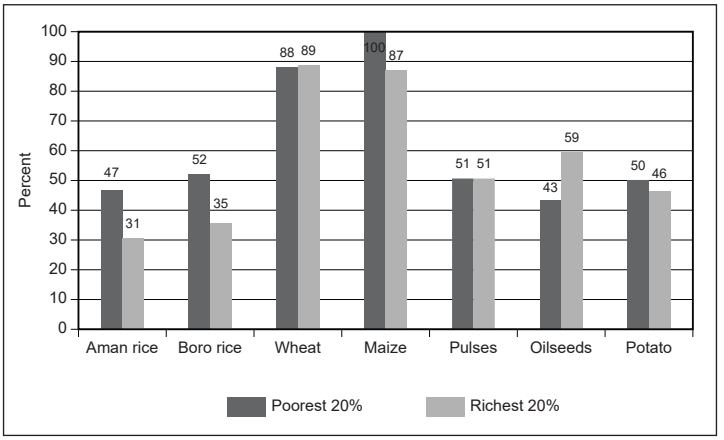
Source: Authors, based on data from Ahmed (2013).

Figure 7.5: Farmers' Sources of Seeds



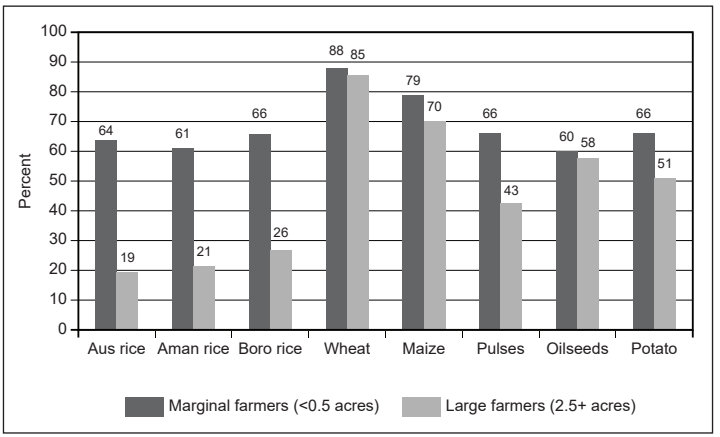
Source: Authors, based on data from Ahmed (2013).

Figure 7.6: Proportion of Farmers from Poorest and Richest Quintile who Purchased



Source: Authors, based on data from Ahmed (2013).

Figure 7.7: Demand for Commercial Seed by Marginal versus Large Farmers



Note: Differences in demand between marginal and large farmers are significant at 1% level for *aman* rice and *boro* rice; significant at 5% level for wheat, pulses and potato.

Source: Authors, based on data from Ahmed (2013).

7.5 Role of the Public Sector: BADC, NARS and DAE

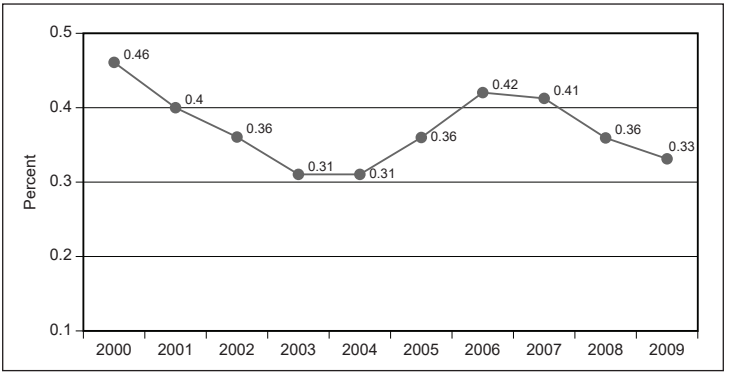
The public sector's role in Bangladesh's seed system revolves around three pillars: the BADC in seed production, the NARS for cultivar improvement, and the DAE for extension and advisory services. The most pressing issue regarding Bangladesh's seed system may be the role of BADC. In theory, the 1993 National Seed Policy aims to relegate BADC to the role of foundation seed producer for non-notified crops, thereby creating a financially viable public supplier of high-quality material to small- and medium-sized seed enterprises who can produce and market improved cultivars directly to farmers. This particular arrangement has been applied in India and other developing countries, and has contributed to the growth of private seed industries.

As noted earlier, there is evidence that BADC is increasing its production of foundation seed in compliance with the spirit of the policy. Yet there is also little evidence that BADC is withdrawing from the production of certified and truthfully labeled seed. BADC remains active in the production of certified and truthfully labeled seed for a wide range of crops, including hybrid maize where the private sector has a well-established comparative advantage. Meanwhile, BADC continues to price seed well below its costs of production, suggesting continued reliance on public funds to make ends meet.

For the research system, a key constraint is one of resources. Although investment in agricultural R&D (specifically cultivar improvement) has been repeatedly demonstrated to increase productivity and reduce poverty in developing countries, funding for the public research system in Bangladesh has been insufficient relative to the needs and expectations of the country. Agricultural R&D spending as a share of GDP from agriculture has hovered between 0.31 percent and 0.46 percent during the decade 2000-2009 (Figure 7.8). Though agricultural R&D intensity in Bangladesh compares favorably with India and Pakistan, it falls well below countries such as Malaysia, which spends more than 1 percent of its GDP from agriculture on R&D (ASTI 2014). This could serve as a useful benchmark for the level Bangladesh might reasonably expect its national research system to perform at in the future.

Agricultural research capacity has also deteriorated with the brain drain of qualified and experienced researchers. Moreover, the current generation of senior researchers is heading into retirement without adequate succession plans. Financing has been erratic and bureaucratic structures are inefficient and posts remain empty. Even though the allocation of resources for agricultural R&D has been inadequate, the actual expenditure since the past decade has been even less than the allocation.

Figure 7.8: Proportion of GDP from Agriculture Spent on R&D



Source: Authors based on ASTI (2014).

There is a second constraint that is more directly relevant to the seed system. Although the seed system is an important supplier of improved germplasm for state-owned seed companies and farms, many private sector firms and farmer organizations argue that they do not have equitable access to that same germplasm (Hossain et al. 2001). This limits the innovation pipeline from the research system to seed producers and, ultimately, to farmers in many countries. There is a need for both greater investment and deep structural reforms in the research system. This implies (i) strengthening public agricultural research focus on delivery of its improved varieties, i.e., widening the R&D pipeline with more and more frequent releases, and with increased access to breeder/foundation seed for all seed system actors, (ii) Increased, sustained investment in national research system, and (iii) reforms to research structures, management, funding systems.

Despite policy reforms in 1993, the playing field for the private sector remains uneven. BADC continues to rely on scarce public resources to produce, although there may be evidence that its reliance on private dealers and retailers for seed distribution might be one of the more impressive elements of its infrastructure. Still, BADC seems not to be backing into the foundation seed end of the business and using this position to stimulate the growth of small/medium-sized enterprises in the production and marketing of publicly bred self-pollinating cultivars. BADC may also be crowding out private investment in breeding, production, and marketing of certain crops, and it may be wasting scarce public resources by competing with the private sector in the maize seed market.

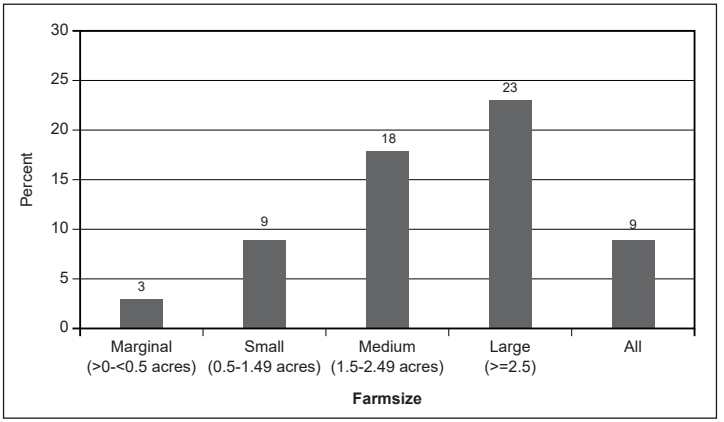
Another indicator of seed system performance is the extent to which information on new varieties is transmitted to farmers and through which channels. The transmission of information on new cultivars to farmers generally revolves around formal channels—primarily agriculture extension agents, nongovernmental organizations, and seed dealers—and more informal channels—social networks encompassing neighbors, friends, relatives, or other acquaintances. Despite the growth of more pluralistic extension system in line with the NAEP, the influence of the DAE has been minimal (Table 7.10). Farmer-to-farmer dissemination of information on issues such as crop variety, input dosages, and other advice seems to be the dominant channel, and just 7 percent of farm households surveyed by the BIHS were visited by an extension agent in the preceding 12 months. Barely 5 percent of farmers received advice on seeds, although almost all those who did receive advice found it useful. The provision of extension services agents appears to have a large-farmer bias (Figure 7.9).

Table 7.10: Availability of Agricultural Extension Services to Farmers

Extension activities	Farmers (%)
Visited by extension agent in past 1 year	6.9
- DAE worker	6.5
- Private/NGO worker	0.4
Received advice on seed	4.8
- Found advice extremely useful	32.5
- Found advice somewhat useful	66.0
- Did not find advice useful	1.5
Households from each farm size who received advice on seed:	
- Marginal farm households	1.4
- Small farm households	5.5
- Medium farm households	8.8
- Large farm households	11.2
Farmers visited by an extension worker	
- Single visit	31.0
- Repeat visits	69.0

Source: Ahmed (2013).

Figure 7.9: Percentage of Farmers Consulting Agriculture Extension Agent in Last One Year



Note: All means are significant at 1% level except for medium versus large farmers.
Source: Source: Authors based on Ahmed (2013).

In sum, the public sector in Bangladesh has been effective in provisioning improved rice varieties and hybrids—particularly for *boro*—but has been slow to replace the older cultivars for rice and wheat. Similarly, the private sector has played a central role in the rapid and relatively widespread introduction of hybrid maize. However, in the case of other, non-cereal crops such as pulses, legumes, and oilseeds, neither the public nor private sectors have played a significant role to date in developing or delivering new varieties.

7.6 Recommendations for a Reform Agenda

7.6.1 Strategic oversight and policy implementation

Public policy on seed needs to be based on empirical analysis rather than on pronouncements about quantities of seed provided or seed turnover rates. Many experts working on seed system reforms have pointed to the absence of centrally-managed, high resolution data and information on key seed system metrics like production quantities, technical performance parameters, market prices, and demand. Although there is a lot of information available from the monitoring and evaluation activities of many agricultural development organizations working all over the country, there is little coordination among these agencies. The outcome is fragmented, incomplete

and difficult to access data with, sometimes, questionable reliability. Seed data from the government agencies is available but is, often, haphazard and user-unfriendly. For instance, to procure information on breeder seed production and supply disaggregated by variety, one has to approach the research institute itself. These are not available on the organizations' website. Even within the institutes, the data is scattered and one has to skim through reams of pages to access relevant data. There is no dependable information on the quantity of quality seed being marketed and the standard of the marketed seed. Again, there is no organized information on the farmers' actual uptake of different varieties and their experiences with the field performance. Such kind of information is critical for providing feedback to national breeding programs who can take these into cognizance for further breeding activities to develop farmer-friendly varieties.

In general, crop statistics in Bangladesh have often been criticized for being very limited and for their lack of reliability. Though the data on rice is comparatively much more detailed than that of other crops, questions have been raised from time to time about the credibility of the data. For instance, the official database, the Bangladesh Bureau of Statistics, shows the area under rice and wheat in 2007-08 was 26,130 and 958 thousand acres respectively. A census done by the same organization in that very year reports the corresponding statistics as 21,756 and 635 thousand acres—a difference of 20 percent and 51 percent, respectively. Such a wide difference in figures from the same source is bound to generate confusion among different stakeholders and, most importantly, lead to inappropriate policy actions. It is crucial to have an in-depth analysis of the current production trends, popular new varieties and amounts of seed to produce and deliver to farmers. The need is for better decision-making tools—better data, information, and analysis, and a more dedicated effort to lay the groundwork for development of a more commercial seed system. This entails a spatially-disaggregated, variety-specific data for major crops, information management systems and portals that make information available to all actors and clear policy messages in support of private sector development.

7.6.2 Creating a 'real' level playing ground—forging public-private partnerships

Many private firms argue that current trade and investment policies—including the crowding-out effects of BADC—inhibit their ability to operate in Bangladesh's seed markets. There is scope for a slow withdrawal of BADC from certified and truthfully labeled seed production and into foundation seed production for small- and medium-sized enterprises who,

with some basic expertise and a relatively small amount of startup capital, can make seed production into a viable business venture. This is a fiscally responsible solution to strengthening the seed market, but it assumes that private firms and cooperatives will step in to fill the gap. One must tread cautiously since the open-pollinated crop reproductive biology may not provide sufficient incentives for private sector investment. That said, a withdrawal of BADC may work if accompanied by regulatory easing and business reforms that encourage private firms and cooperatives to invest in the seed industry. These reforms include easier loans, tax incentives and tariff reductions for importation of production equipment and materials, as well as targeted financing from the public or private sector to encourage the industry. Less attention can probably be given to those markets where private firms are more likely to concentrate, i.e., the higher-value market for hybrids or horticulture crops where farmers prefer to purchase high-quality seed each year. In these markets, the key is to maintain strong investment incentives by rationalizing the imposition of taxes, tariffs on imported equipment and materials, and ad-hoc non-tariff barriers that seem to be discouraging investment. This membership may bias decisions in favor of applications from public breeders and against applications from private or NGO breeders (Tripp and Louwaars 1997; CASEED 2013).

7.6.3 Reforming the seed regulatory regime

Stringent regulations, strict test standards, cumbersome procedures and slow processing tend to limit the number of improved cultivars that can be registered and put into production. New waiting-to-be released varieties have already been through a rigorous trial regime under the plant breeder. Yet another round of performance trials prior to their registration results in excessive delays. The SCA has very limited manpower and laboratories for seed testing. To make things worse, the skills for seed testing are specialized and repeated transfer of trained staff to other locations in the county often creates a void in the SCA. The varietal registration process could be rationalized through coordination among R&D institutions and the BADC, DAE, NGOs and seed companies during the variety testing and release process. This would help curtail duplication of efforts and make the process more time-efficient. For varieties that are registered and in use in neighboring countries with similar production environments, the requirement to register those varieties again when introduced in Bangladesh may be relaxed. Moreover, a harmonization of research for varietal testing among the different R&D institutes, along the lines that is prevalent in India, would ensure participatory testing of advanced lines across agro-ecological zones and facilitate movement of breeding material among the

institutes. For performance testing, there is need for a greater participation by farmers' groups who are the ultimate decision makers of adoption of the variety best suited for specific environments. The All India Coordinated Crop Improvement Program, for example, is actively involved in Front-Line Demonstrations on improved technologies and is also organizing *Kisan Melas* for effective and speedy dissemination of newer technologies.

In the arena of seed quality control, the SCA is the principal regulatory body in Bangladesh, responsible for seed certification and market monitoring. The country saw a major policy change in 1998 when the mandatory provision for seed certification was relaxed to allow for truthful labeling and the private sector was allowed to market TFL seeds. Almost 80 percent of the seeds supplied to the farmers are TFL seeds and BADC markets the lion's share of these. BADC has its own internal quality control system but many private agencies are also selling TFL seeds with little capacity and capability for quality control. SCA has very limited capacity to monitor seed quality once it reaches the market and is purchased by farmers. With only 30 field officers and 6 regional seed testing laboratories, the organization is under-funded and under-equipped to perform the wide-ranging duties assigned to it. The SCA certifies not only foundation seed and certified seed but also breeder seed.

Studies have shown that breeder seed produced by plant breeders have adequate genetic purity that could be used for large scale multiplication of commercial seed (Parsons 1985; Tripp and van der Burg 1997). The SCA could save on its precious resources by focusing on the certification of foundation seeds. Reforming the SCA to make it a full-fledged independent department endowed with complete powers can make it functionally capable and technically sound. This can go a long way in seed system development in Bangladesh. Another option could be to have independent certification agencies that seed producers may contract voluntarily. This is the situation in the US where most seed certification is in the hands of agencies formed by farmer cooperatives or associations (Tripp and van der Burg 1997). The caveat here is that there must be sufficient demand to pay for the development of such a private service. Given the high probability that the benefits from certification will outweigh the losses of poor farmers from poor germination or other seed-related problem, such an initiative could be very successful in Bangladesh. An equally important element of seed quality control is to have strict penalties for fraudulent seed production and marketing and other activities that diminish the quality of the seed. This is an area often overlooked in Bangladesh.

To import any type of seed into Bangladesh, an import permit (issued by the Plant Protection Wing of the DAE) and a phytosanitary certificate from the exporting country are required. In addition, imported varieties of the five notified crops (rice, wheat, potatoes, jute and sugarcane) must be

listed on the official list of varieties and must comply with the crop specific standards. To top these, are a series of tax and non-tax barriers that add up to the cost of private investment in the seed industry. Needless to mention, the final tax burden is on the farmer. An advance income tax of three percent is levied on imported rice seed. The tax structure for wrapped and canned seed is higher than unwrapped and un-canned seed with the result that latter group is more preferred by importers. The point of having a phytosanitary certificate from the country of origin is to ensure that the seed is good quality. However, on reaching the port, plant quarantine offices often want to conduct further checks on the quality of the seed that add up on the costs and time. Reforming the seed tax structure by easing of taxation, tariffs, and non-tariff barriers is crucial for overall seed sector development. Tax imposition should be reviewed in the light of quality seed supply at a cheaper price to the farmers; if feasible seed import should be exempted from taxes.

7.6.4 Reviewing and prioritizing research and development

There is an urgent need to review the current mandate of the agricultural research organizations to meet emerging needs and to rectify overlaps. The usefulness of the network of stations and sub-stations needs to be assessed including the possibility of closing redundant establishments. The deterioration of expertise must be checked and an appropriate pool of skill mix should be created. With growing populations, the strong need for increasing cereal productivity is understandable. But the rice-centric research efforts in Bangladesh have relegated other high-value nutrient-dense food crops to the background. Agricultural research should maintain a fine balance between the objective of continued food security for the masses and research and investment made for diversification out of primary staples. Farmers' flexibility in making crop choices must be made a priority through research at both the crop level and system level.

7.6.5 Tightening the role of agriculture extension

The extension agents are supposed to be the link between the farmers and the agricultural research stations but the reality is very different. There is a dire need to reform the extension service structure and delivery to fully exploit the benefits of the large, country-wide set-up that DAE already has. The financial sustainability of the extension services is often questioned—more than 90 percent of the annual revenue budget is spent on staff salaries while the operational funds for extension activities are largely provided by externally funded projects which serve specific objectives of individual projects (World Bank 2005). The cost-structure should be rationalized providing for

relocating staff from places (where private extension services run parallel alongside public extension) to marginalised areas. The extension agents should give feedback on actual field experience to the research institutes and help provide the crucial link between the farmers and the R&D institutes. It is critically important to develop the capacity of the extension staff through appropriate trainings which enhance their understanding of the agro-ecologies and location-specificity of production conditions. The staff should also be incentivized through a system of performance-related rewards or bonuses. Finally, there is a need to have a greater involvement of the private sector in extension service provision that can complement the public service and, perhaps, aid in shifting some of the latter to more remote, marginalised areas.

7.7 Conclusions

The seed sector in Bangladesh has evolved significantly since the opening up of the seed industry in the early 1990s. From being predominantly dominated by the informal sector, the seed market has developed to a point where commercial seeds have assumed heightened importance. This has been the outcome of policy provisions that have shaped in response to changing needs. Though most seed is still produced by the farmers themselves, the new varieties are produced and distributed by government or commercial seed companies. With the advent of the Green Revolution, Bangladesh made a relatively early transition to using modern varieties of rice and wheat which ultimately was instrumental in improving food security in recent years. The country now requires facilitation to move on to stage 3 wherein the use of improved varieties spreads as the private sector begins to be a significant source of new technology. The policy framework is already in place in Bangladesh but the effective implementation of policy is still under development. Accelerating seed system development will require building strategic, implementable and effective public-private partnerships in all areas of action, starting from generation of data, research and development to the actual provisioning of seeds to farmers. Only then can we ensure a seed system that provides equitably and efficiently to all farmers.

References

Ahmed, A. 2013. *Bangladesh Integrated Household Survey (BIHS) 2011-2012*. Dataset. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Ahmed, R. 2000. "Liberalisation of Agricultural Input Markets." In *Out of the Shadow of Famine*, edited by R. Ahmed, S. Haggblade, and T. E. Chowdhury. Baltimore: Johns Hopkins University Press.

Ahmed, S. M., and C. A. Meisner. 1996. Wheat research and development in Bangladesh. Bangladesh Australia Wheat Improvement Project and CIMMYT-Bangladesh, Dhaka.

Ali, S. M. Z., and A. Basher. 2013. *Seed Sector Development in Bangladesh: Review of Policies, Rules and Regulations.* Mimeo. Dhaka: Bangladesh Institute of Development Studies (BIDS).

ASTI (Agricultural Science and Technology Indicators Initiative). 2014. ASTI Data Tool—Bangladesh. Accessed March, 2014. http://www.asti.cgiar.org/data/.

BADC (Bangladesh Agricultural Research Institute). *Annual Report* (various years). Dhaka: BADC Monitoring Division.

BBS (Bangladesh Bureau of Statistics). 2010. *Reports on the Cost of Production of Aus Crop, Aman Crop, Boro Crop, Wheat, Maize, Potato and Pulses 2008-09.* Dhaka: BBS.

Bødker, L., E. Wulff, and J. Torp. 2006. *Bangladesh Seed Sector Country Profile: Overview of Seed Supply Systems and Seed Health Issues.* Denmark: Danish Seed Health Centre for Developing Countries, Copenhagen University.

BRAC. 2012. *Agriculture and Food Security.* Dhaka: BRAC Communications.

___. 2013. *BRAC Seed Enterprise.* Accessed January, 2014. http://afsp.brac.net/enterprises.

Brennan, J. P., and D. Byerlee. 1991. "The Rate of Crop Varietal Replacement on Farms: Measures and Empirical Results for Wheat." *Plant Varieties and Seeds* 4: 99-106.

BRRI (Bangladesh Rice Research Institute). *BRRI released Rice Varieties from 1970-2013.* Accessed January, 2014. http://tinyurl.com/oywzg3u.

CASEED (Center for Agri-research and Sustainable Environment and Entrepreneurship Development). 2013. *Seed Sector Development in Bangladesh.* Mimeo. Dhaka: CASEED.

Dorosh, P. 2006. *Accelerating Income Growth in Rural Bangladesh*. Washington, D.C.: World Bank.

Evenson R. E., and D. Gollin. 2003. "Assessing the impact of the green revolution, 1960 to 2000." *Science* 300, no. 5620: 758-762.

Haggblade, S., and R. Ahmed. 2000. "Old Lessons and New Directions in Food Policy." In *Out of the Shadow of Famine*, edited by R. Ahmed, S. Haggblade, and T. E. Chowdhury. Baltimore: Johns Hopkins University Press.

Harun-Ar-Rashid, M. Ali, and D. Gisselquist. 2012. *Private-sector Agricultural Research and Innovation in Bangladesh: Overview, Impact and Policy Options*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Heisey, P. W., and J. P. Brennan. 1991. "An Analytical Model of Farmers' Demand for Replacement Seed." *American Journal of Agricultural Economics* 73: 1044-1052.

Hossain, M., W. M. H. Jaim, M. S. Alam, A. N. M. Mahfuzur Rahman. 2013. *Rice Biodiversity in Bangladesh: Adoption, Diffusion and Disappearance of Varieties*. Dhaka: Research and Evaluation Division, BRAC.

Hossain, M. 2010. "Shallow Tubewells, *Boro* Rice, and their Impact on Food Security in Bangladesh." In *Proven Successes in Agricultural Development*, edited by D. J. Spielman, and R. Pandya-Lorch. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Hossain, M., A. Janaiah, M. Husain, and F. Naher. 2001. "The Seed Delivery System in Bangladesh: Institutional and Policy Issues." *The Bangladesh Development Studies* XXVII, no. 4: 1-40.

IFPRI (International Food Policy Research Institute). 2011. *Bangladesh: Recent Developments in Public Agricultural Research.* http://www.asti.cgiar.org/data/.

___. 2013. *Agricultural Technology Adoption in the Feed the Future Zone: Farm Household Survey 201.* Dataset. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Jaim, W. M. H., and S. Akter. 2012. Seed, Fertiliser and Innovation in Bangladesh: Industry and Policy Issues for the Future. Project paper. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Kloppenburg, J. 1988. *First the Seed. The Political Economy of Plant Biotechnology*, 1492-2000. Cambridge: Cambridge University Press.

Naseem, Anwar, David J. Spielman, and Steven Were Omamo. 2010, January. "Private-sector Investment in R&D: A Review of Policy Options to Promote its Growth in Developing-country Agriculture." *Agribusiness* 26, no. 1: 143-173. https://doi.org/10.1002/agr.20221.

Parson, Frank G. 1985, January. "The Early History of Seed Certification: 1900-1970." In *The Role of Seed Certification in the Seed Industry*, edited by M. B. McDonald Jr. and W. D. Pardee. Madison: Crop Science Society of America, Inc.

Pray, C. E. 2002. "The Growing Role of the Private Sector in Agricultural Research.' In *Agricultural Research Policy in an Era of Privatisation*, edited by Derek Byerlee and Ruben G. Echeverria. New York, N.Y.: CABI.

Pray, C. E., and B. Ramaswami. 1991. *A Framework for Seed Policy Analysis in Developing Countries.* Washington, D.C.: International Food Policy Research Institute (IFPRI).

Rashid, S., A. Gulati, and R. Cummings Jr. 2008. "Grain Marketing Parastatals in Asia: Why Do They Have to Change Now?" In *From Parastatal to Private Trade: Lessons from Asian Agriculture,* edited by S. Rashid, A. Gulati and R. Cummings Jr.. Baltimore: Johns Hopkins University Press.

Scoones, Ian, and John Thompson. 2011. "The Politics of Seed in Africa's Green Revolution: Alternative Narratives and Competing Pathways." *IDS Bulletin* 42, no. 4 (July): 2-23. https://doi.org/10.1111/j.1759-5436.2011.00232.x.

SCA (Seed Certification Agency). *Approved Notified Crop Varieties.* Accessed January, 2014. http://www.sca.gov.bd/Downloadforms.aspx?MenuID=8.

Singh, Harbir, Prasoon Mathur, and Suresh Pal. 2008. "Indian Seed System Development: Policy and Institutional Issues." *Agricultural Economics Research Review* 21: 20-29.

Spielman, David J., Deepthi Elizabeth Kolady, Patrick Ward, Harun Ar-Rashid, and Kajal Gulati. 2012. *Public Expenditures, Private Incentives, and Technology Adoption: The Economics of Hybrid Rice in South Asia.* IFPRI Discussion paper no. 01233. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Tripp, R., and N. Louwaars. 1997. Seed Regulation: Choices on the Road to Reform. *Food Policy* 22, no. 5: 433-446. https://doi.org/10.1016/S0306-9192(97)00033-X.

Tripp, R., and W. van der Burg. 1997. "The Conduct and Reform of Seed Quality Control. In *New Seed and Old Laws: Regulatory Reform and the Diversification of National Seed Systems*, edited by R. Tripp. London: Intermediate Technology Center.

Waddington, S. R., M. A. Lantican, and R. Tripp. 2012. Varietal Replacement and Evolving Seed Systems for Wheat and Maize in South Asia—A Scoping Study. Report prepared for the CIMMYT Socio-Economics Program. Dhaka/Delhi/Mexico City: CIMMYT.

Ward, Patrick S., and Valerien O. Pede. 2014. Capturing Social Network Effects in Technology Adoption: The Spatial Diffusion of Hybrid Rice in Bangladesh. *Australian Journal of Agricultural and Resource Economics* 59, no. 2: 225-241. https://doi.org/10.1111/1467-8489.12058.

World Bank. 2005. *Revitalising the Agricultural Technology System in Bangladesh.* Bangladesh Development Series Paper no. 7. Dhaka: World Bank.

PART 3

FOOD SECURITY AND OUTPUT MARKET

Chapter 8

Promoting National and Household Food Security in Bangladesh: Evolving Roles of Public Stocks, Cereal Distribution and Private Trade

Paul Dorosh

8.1 Introduction

Large-scale government interventions in cereal markets supported by public stocks have been a central part of food policy in the Indian sub-content since the days of British colonial India. Following the Great Bengal Famine of 1943, during which an estimated three million people died of hunger-related causes, the colonial government instituted a system of government sales and distribution of cereals designed to help ensure minimum food consumption for poor households (Sen 1982). Public distribution systems continued in both India and Pakistan following independence in 1947. The famine conditions in 1972-74 that followed the liberation war and Bangladesh's independence in December 1971 strongly reinforced the perceived need for major public interventions to ensure food security (see Ahmed, Haggblade, and Chowdhury 2000).

Over the past five decades, this public food grain distribution system (PFDS) has played a major role in addressing chronic food insecurity in Bangladesh. The heart of PFDS, at least in terms of the volume of cereals, has been annual distribution programmes involving in-kind transfers to poor households to reduce chronic undernutrition (such as, food-for-works and food-for-education programmes). Open market sales from public cereal stocks have also been used, particularly in the 1970s and 1980s, to prevent or mitigate price surges. Large-scale emergency relief operations have addressed food security needs following natural disasters, including the extraordinary floods that caused major production shortfalls in 1987, 1988 and 1998. Domestic procurement of rice and wheat, generally at a fixed

procurement price, has been a part of the government strategy to increase incentives for production through stable, remunerative prices for farmers.

Nonetheless, there have been major changes in PFDS over time as donors have reduced food aid and the Bangladesh government has improved targeting of its distribution programmes. There has been an increased reliance on market mechanisms since major liberalization in the early 1990s as well; although the spike in prices of rice in international and domestic markets in 2007 and 2008 led to pressures to reverse this trend. Increasing demand for and volume of higher quality rice in the last decade has muted the impact of interventions in the coarse rice market. Technical change in drying of paddy and an ongoing major expansion of government storage facilities promise further changes in the role of public stocks and distribution in the Bangladesh food system.

This chapter is designed to provide a broad assessment of the impact of public cereal stocks and market interventions in Bangladesh over time, as well as highlight future policy options. Section 8.2 describes the structure and evolution of PFDS in Bangladesh over the three major periods: (i) an initial period of heavy government intervention in markets, substantial food aid and relatively high stocks in the 1970s and 1980s; (ii) transition to lower volumes of food aid and distribution, accompanied with a significant role for private imports, from the 1990s through 2006; and (iii) aftermath of the 2007-08 world price spike with increasing calls for larger public stocks and more intervention in domestic markets. Section 8.3 then discusses the current PFDS and factors influencing the levels, timing and composition (rice versus wheat) of stocks, procurement and distribution. Section 8.4 covers the response to major production shortfalls and price shocks, as well as estimates of the impacts of current PFDS interventions. Section 8.5 summarizes and suggests implications for the current debate in Bangladesh on the role of large stocks and government interventions.

8.2 Structure and Evolution of PFDS[1]

8.2.1 Chronic Cereal Deficits and Major Government Interventions: 1971-1972 to 1991-1992

In the first few years after its independence in 1971,[2] Bangladesh was faced with massive food security problems. Poor weather, combined with an

[1] For overviews of the history of Bangladesh PFDS programmes and market interventions, see Ahmed, Haggblade, and Chowdhury (2000) and Ali, Ali, Jahan, Ahmed, and Rashid (2008).

[2] Bangladesh declared independence on 26 March 1971, but the ensuing war with (West) Pakistan lasted until 16 December 1971.

infrastructure greatly damaged by the war with West Pakistan, contributed to a sharp decline in the main monsoon season (*aman*) rice crop. Rice production fell sharply in 1971-1972 and 1972-1973, averaging 16.5 percent less than in 1969-1970. Moreover, constrained by a severe shortage of foreign exchange and very high international prices, rice imports were severely limited. Availability of cereals fell to 155.2 kilograms/person (compared to 180.1 kilograms/person in 1969-1970), (del Ninno, Dorosh and Islam 2002), resulting in the death of at least 30 thousand people from famine-related causes, though unofficial reports put the figure as high as 100 thousand.[3]

The Bangladesh government, with support from international donors, responded with sharp increases in public investments in infrastructure, agricultural research and extension, as well as an expansion in public distribution supplied largely by food aid. Major gains were achieved in the 1980s and 1990s due largely to increased production of the winter season (*boro*) rice crop, made possible by an expansion of shallow tube well irrigation and increases in fertilizer use and planting of improved high yielding variety (HYV) seeds. Wheat production also increased from 102 thousand tons in 1971-1972 to 1,075 million tons in 1980-81 (and ultimately reached a peak of 1.9 million tons in 1999-2000).[4],[5] Total rice and wheat production rose from 9.89 million tons in 1971-1972 to 24.91 million tons in 1999-2000, enabling Bangladesh to eliminate its "food gap", defined as the difference between the amount of food grain required to meet the consumption target of 454 grams of food grain per person per day and net domestic production (Figure 8.1).

The distribution of food aid (almost exclusively in the form of wheat) through PFDS was also a key component of government food security strategy. Food aid flows jumped from 502 thousand tons in 1969-1970 (the year before independence) to 1.56 million tons in 1972-1973. From 1972-1973 to 1991-1992, food aid averaged 1.26 million tons per year, supplying the grain for 60 percent of PFDS distribution during this period (Figure 8.2).

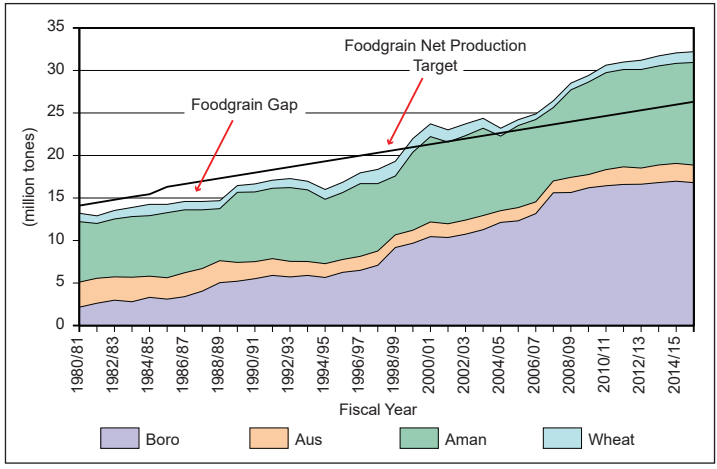
---

[3] See Alamgir (1980) and Sobhan (1979).

[4] Over the nearly 30 year period, wheat area harvested rose seven-fold and wheat yields doubled.

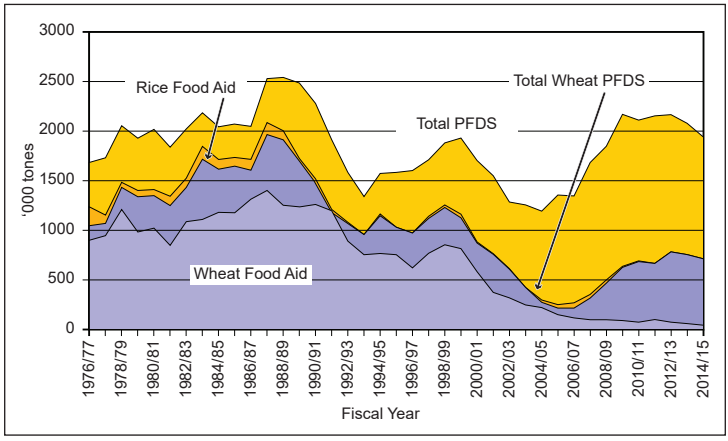
[5] Rice is the major food commodity in Bangladesh in terms of both production and consumption, accounting for 69.8 percent of the 2,450 calories/person/day consumed in Bangladesh in 2013. Wheat is a relatively minor food commodity, accounting for 6.1 percent of calories in the same year. Per capita rice and wheat consumption in Bangladesh were 171.7 and 17.5 kg/person/year, respectively (FAO Food Balance Sheet 2013).

Figure 8.1: Bangladesh: Net Production and Food Gap (1980-1981 to 2014-2015)



Source: Bangladesh Food Planning and Monitoring Unit (FPMU) data.

Figure 8.2: Food Aid and PFDS Distribution, 1976-1977 to 2014-2015 (3-year centred moving average)



Source: Calculated from Bangladesh Ministry of Food data.

The green revolution technology (fertilizer, improved seeds and irrigation) that spurred increased rice and wheat production directly benefits the farmers who adopted the technology. Increased production also benefited

consumers as real rice prices (i.e. rice prices adjusted for overall inflation) declined from the late 1970s to the early 1990s.

Public food grain stocks in the early 1970s were very low, reflecting low levels of distribution and very tight government budgets. Stocks averaged only 276 thousand tons (48 thousand tons of rice and 228 thousand tons of wheat) from 1972-1973 through 1974-1975 (Table 8.1). Thereafter, stocks were built up to an average of 865 thousand tons (374 thousand tons of rice and 491 thousand tons of wheat) from 1975-1976 through 1991-1992 as food aid and government domestic procurement increased (Figure 8.3). Given that total PFDS distribution changed little between these two periods, the ratio of stocks to distribution remained approximately constant at about 42 percent.

8.2.2 Market Liberalization, Reductions in Food Aid and Lower Public Stocks: 1992-1993 to 2006-2007

Several major changes in policy in the early 1990s had far-reaching effects on the Bangladesh food system: liberalization of private sector wheat and rice imports; elimination of major ration (sales) channels in the PFDS combined with a sharp reduction in domestic procurement; and donor decisions to reduce food aid, essentially linked to the success of Bangladesh in increasing cereal production.

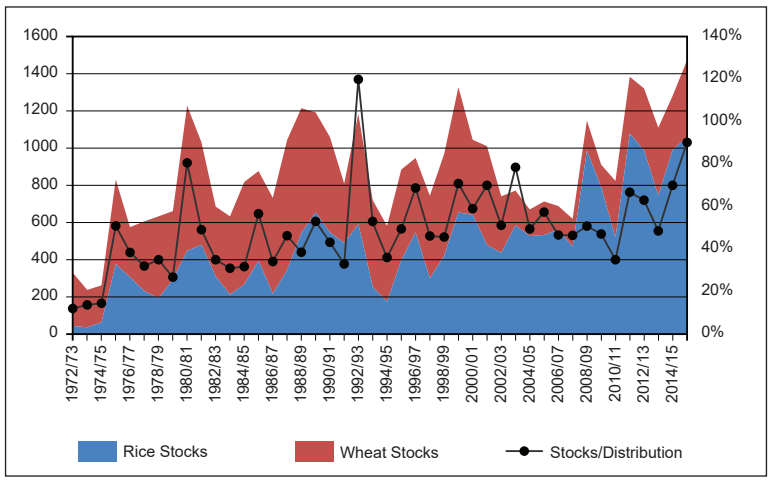
Liberalization of wheat and then rice imports in the early 1990s provided substantial stability to cereal prices. In spite of increased wheat production, domestic demand for wheat far outpaced the supply. From 1992-1993 through 1999-2000, commercial wheat imports averaged 402 thousand tons per year even with large-scale food aid; and wheat inflows averaged 780 thousand tons per year in this period. Commercial wheat imports subsequently increased to an average of 1,510 million tons per year from 2001-2002 through 2007-2008. In contrast, until 2003, when India began to subsidize exports, private sector rice imports were profitable only in years of relatively poor harvests, including both the 1997 and 1998 *aman* (monsoon season) harvests (discussed in detail below).

While private sector imports of wheat increased, food aid flows declined in the 1990s, in part because the steady increase in total domestic production of rice and wheat eliminated the food gap—a major rationale for food aid imports. After the European Union phased out its food program, food aid flows fell to only 242 thousand tons in 2002-2003. However, unlike the years just after independence, growth in foreign exchange resources (from textile exports and workers' remittances) and government revenues (linked to overall economic growth) reduced the importance of food aid resources

as a share of the value of imports and government expenditures to only 1.3 and 1.7 percent, respectively.[6]

The shift from rationed sales and open market operations to targeted cereal distribution brought about major gains in efficiency in terms of benefits and costs reaching poor households. Prior to these reforms, the rural rationing and urban statutory rationing channels accounted for about one-fourth of total food grain distribution (which averaged 2,294 million tons).[7] Total sales channels, including open market sales and other programmes, accounted for 63.5 percent of distribution, with relief and food-for-works channels accounting for the other 36.5 percent of distribution in these years (Dorosh 2001).

Figure 8.3: Bangladesh: Public Rice and Wheat Stocks, 1996-1997 to 2015-2016



Source: Calculated from Bangladesh FPMU data.

Reforms in 1991-1992 and 1992-1993 closed the rural rationing and statutory rationing channels, in an effort to improve the targeting of food grain distribution, as well as to reduce fiscal costs (Ahmed, Haggblade, and Chowdhury 2000).[8] As a result, both the percentage and total amount of

[6] By comparison, food aid averaged BDT 18.3 billion in real terms at 2000 prices from 1980 to 1984, equal to 22.1 percent of total aid, 11.6 percent of government expenditures, and 10.9 percent of total imports (del Ninno, Dorosh, and Islam 2002).

[7] Ration sales data are for 1988-1989 to 1990-1991.

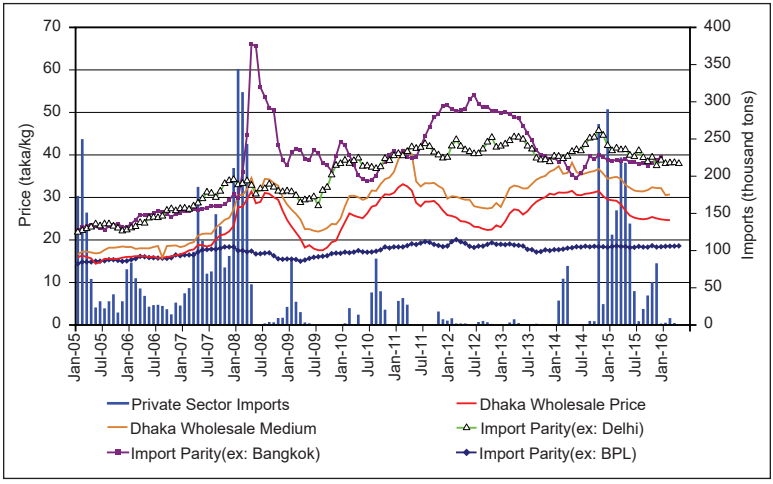
[8] For an analysis of political economy issues related to the food subsidy reforms, see Ahmed, Haggblade, and Chowdhury (2000).

food grain distributed through targeted and relief channels increased in the mid- to late-1990s, averaging 1,166 million tons per year from 1995-1996 to 1997-1998, amounting to 72.8 percent of the 1,603 million tons of total annual average distribution during these three years.

By the early 2000s, PFDS had shrunk to only 1.30 million tons per year (average from 2002-2003 to 2006-2007) and stocks fell accordingly to an average of 720 thousand tons per year (531 thousand tons of rice and 189 thousand tons of wheat). For the 1992-1993 to 2007-2008 period as a whole, however, average stocks were somewhat higher (856 thousand tons). The distribution for the period, however, was only about two-thirds that of the 1975-1976 to 1991-1992 period and stocks as a share of distribution rose to 59.6 percent (Table 8.1).

In spite of the reduced role of PFDS, market prices of rice were low and stable in the early 2000s because of private sector imports of relatively low-quality Indian rice supplied directly or indirectly from India's own Public Distribution System (Figures 8.4 and 8.5).[9]

Figure 8.4: Bangladesh: Import Parity and Wholesale Rice Prices and Private Sector Rice Imports, 2005-2016



Source: Calculated from Bangladesh Ministry of Food data.

[9] Econometric analysis by Dorosh and Rashid (2013) shows that Bangladesh wholesale rice prices were co-integrated with import parity prices of BPL (Below Poverty Line) rice from India from January 2002 through July 2007.

Table 8.1: Bangladesh Food Stocks and PFDS Distribution, 1972-1973 to 2015-2016

	Stocks ('000 tons)			Distribution ('000 tons)			Stocks/ Distribution (%)		
	Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total
1972-1973 to 1974-1975	48	228	276	n.a.	n.a.	2,067	n.a.	n.a.	41.1
1975-1976 to 1991-1992	374	491	865	624	1,479	2,103	63.5	34.9	42.2
1992-1993 to 2007-2008	475	380	856	740	749	1,489	69.4	56.0	59.4
2008-2009 to 2015-2016	900	289	1,189	1,399	665	2,065	65.7	45.4	59.0

Notes: Stocks as a share of distribution is calculated for each year as the average of monthly stocks divided by total annual distribution.

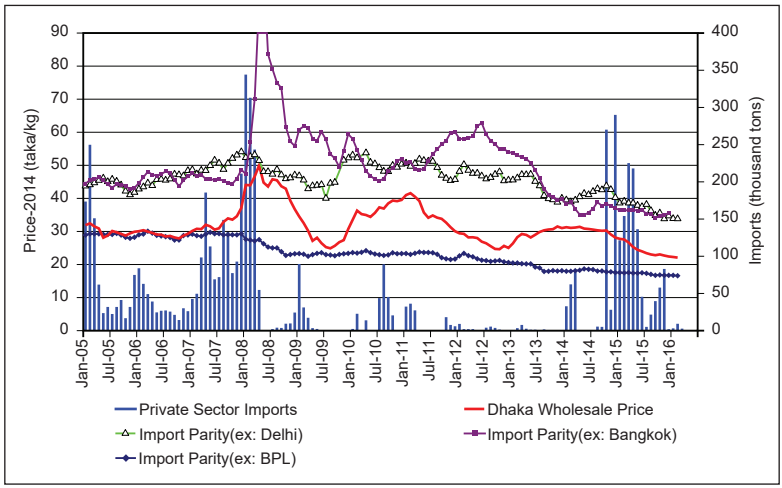
Source:
- 1972-1973 to 1988-89 Bangladesh Bureau of Statistics, Monthly Statistical Bulletin, various dates from Goletti, Ahmed, and Chowdhury (1991), Table 4, 8.
- 1988-1989 to 1995-1996 from Dorosh, Shahabuddin and Farid (2004), 74.
- Bangladesh Ministry of Food, Food Planning and Monitoring Unit (FPMU).

8.3 Renewed Emphasis on Public Stocks after World Price Shock: 2008-2009–Present

The period of relative stability of rice and wheat prices of the early 2000s ended with the 2007-2008 world price shock. For Bangladesh, the most serious aspect of the crisis was the decision by the Government of India to ban exports of ordinary (i.e., non-aromatic) rice in late 2007 because of their concerns about relatively poor wheat harvest (and relatively low domestic procurement) earlier in the year. Moreover, this export ban helped trigger a surge in prices and shortfalls in quantities in the international rice market. Ultimately, Bangladesh was able to negotiate a limited amount of imports from India, but not enough to prevent a surge in prices in Bangladesh, as well.

In the aftermath of the 2007-2008 price shock, the Government of Bangladesh again built-up rice (and subsequently wheat) stocks. Public rice stocks, which averaged 531 thousand tons over the 2002-2003 to 2006-2007 period, were increased rapidly to an average of 1,032 million tons in the July 2008 to December 2009 period, mainly through increased domestic procurement (Table 8.2). Public wheat stocks also rose from 145 thousand tons in 2007-2008 to 429 thousand tons in the July 2012 to February 2016 period, mainly sourced from public sector imports. Overall, public food grain stocks nearly tripled from 617 thousand tons in 2007-2008 to 1.69 million in the July 2012 to February 2016 period.

Figure 8.5: Bangladesh: Real (2014) Import Parity and Wholesale Rice Prices and Private Sector Rice Imports, 2005-2016



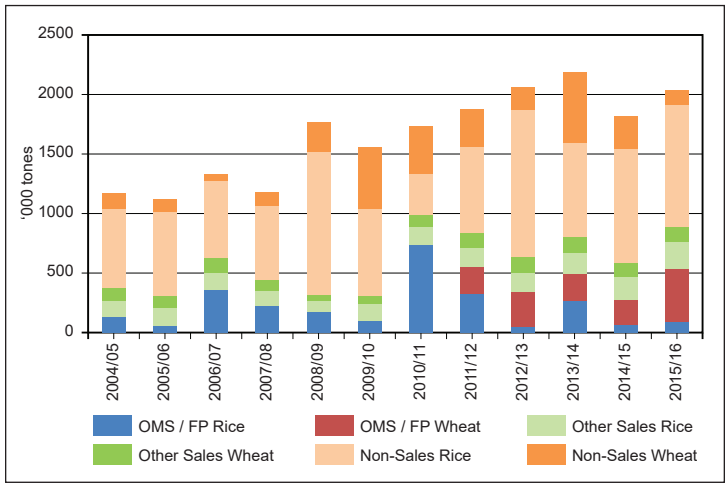
Source: Calculated from Bangladesh Ministry of Food data.

Public distribution was also scaled up after the 2007-2008 price surge. Total distribution averaged only 1.22 million tons per year (1.01 million tons of rice and 210 thousand tons of wheat) from 2004-2005 through 2007-2008; from 2009-2010 through 2015-2016 total public distribution averaged 2.065 million tons per year, steadily rising to a peak in 2013-2014 of 2.22 million tons (1.26 million tons of rice and 958 thousand tons of wheat). Much of this increased distribution was through sales channels, including 1.04 million tons through Open Market Sales (OMS) and Fair Price Cards in 2010-2011 (Figure 8.6). Given the increases in both stocks and distribution, the average stocks/distribution ratio remained unchanged at 59 percent.

The disruption of rice import supplies from India that occurred during the world price shock of 2007-2008 reinvigorated a longstanding debate on the optimal size of public cereal stocks in Bangladesh. In the late 1970s, donors urged the Government of Bangladesh to hold more stocks; by the early 1990s, the opposite recommendation was made, i.e., to substantially lower stocks, in part because of lower procurement and distribution levels (Goletti 2000). Another key factor, however, was the high rate of storage losses incurred. In the humid conditions of Bangladesh, rice stored in bags in warehouses absorbs moisture and deteriorates in quality from mold and

insect attack. Stock rotation through a first in-first out stock management plan mitigated losses to some extent, but in years when procurement was unusually high relative to distribution, rice stocks accumulated rapidly and much of this grain stayed in warehouses for nine months or more, even though there is generally significant quality deterioration after six months in storage. This implies that to avoid excessive storage losses, rice stocks need to be replaced at least twice per year. Thus, for a minimum rice stock of one million tons, distribution (including sales) must be at least two million tons to maintain stock quality (Dorosh, Shahabuddin, and Farid 2004).[10]

Figure 8.6: Bangladesh: Public Food grain Distribution Channels, 2004-2005 to 2015-2016



Source: Bangladesh Ministry of Food data.

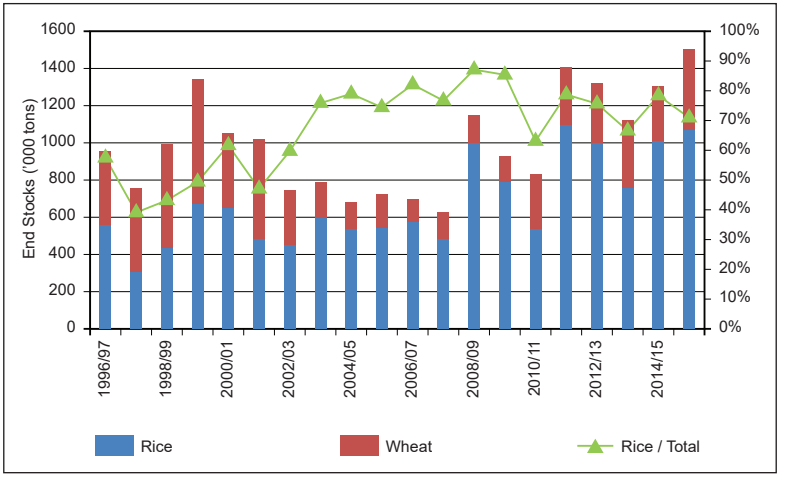
Losses in rice quality are not included in calculations of the official government calculations of the costs of PFDS in Bangladesh unless the rice is actually discarded (or sold as animal feed). Yet, these losses can be large in some years. Assuming a 15 percent deterioration in the market value of the 706 thousand tons of rice kept in storage for over seven months—essentially all of the rice distributed that year, estimated losses to recipients

[10] A new World Bank funded project begun in mid-2016 which is designed to ease the storage constraints in Bangladesh through construction of new warehouse facilities and silos for rice. By increasing the length of time rice can be safely stored, these investments could enable Bangladesh to increase rice stocks by a factor of two or three without increasing rice distribution. Nonetheless, long periods of storage still imply high interest costs.

of PFDS rice were BDT 1.02 billion (about 19 million US dollars) in 2000-2001, equivalent to 11 percent of the total net outlays (net costs) of PFDS rice distribution and 13 percent of the estimated market value of PFDS rice distribution (see Dorosh and Farid 2003; Dorosh, Shahabuddin, and Farid 2004).[11]

Note that not all of grains actually reach the intended beneficiaries. Estimates of leakages (diversions of grains) vary considerably across distribution channels and over time, ranging from more than 95 percent for the urban and rural rationing channels in the early 1990s (Ahmed 2000). Subsequent reforms reduced leakages substantially—to less than 20 percent for Food For Education in 2000 (Ahmed, del Ninno and Chowdhury 2004) and only 6 percent in the Vulnerable Group Development (VGD) program in 1998 (del Ninno 2001).

Figure 8.7: Bangladesh: Public Rice and Wheat Stocks, 1996-1997 to 2015-2016



Source: Bangladesh Ministry of Food data.

8.3 PFDS Response to Emergencies: The 1998 Flood

Since the late 1980s, Bangladesh has faced two major food crises. The first occurred in 1998 when a major flood hit the country, causing a production shortfall in excess of two million tons. The second, ten years later in 2008, resulted from an export ban on rice imposed by India that coincided

[11] In general, for the Bangladesh PFDS, storage losses for wheat, kept mainly in bulk in grain silos, are much lower due to better handling and storage conditions.

with a sharp rise in world cereal prices. In both cases, the shocks led to a significant drawdown of stocks, increased imports and ultimately increased food distribution.

8.3.1 Policy Response to the 1998 Flood

In mid-1998, domestic rice prices rose along with floodwaters that ultimately covered two-thirds of the country. As domestic prices reached import parity levels, private sector rice imports flowed across the border from India, quickly adding to total market supplies (at no cost to the government). Continuing its policy of encouraging private sector imports, the Bangladesh government enabled the private sector to import substantial quantities of rice and keep the domestic market price from rising above import parity levels.[12] According to official government estimates, more than two hundred thousand tons of rice per month were imported from August 1998 to March 1999, with private rice imports reaching 288 thousand tons in January and 345 thousand tons in February 1999.

Table 8.2: Bangladesh Cereal Rice Trade Regimes, Imports and Stocks, 1996-1997 to 2015-2016

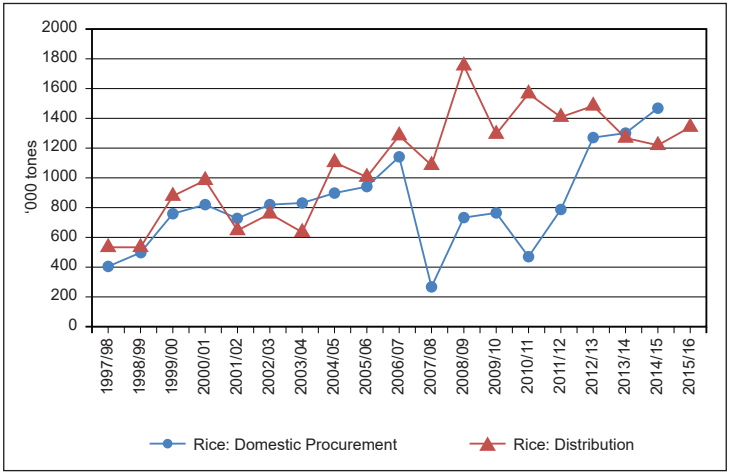
Period	Rice Import Trade Regime	Private Rice Imports	Public Wheat Imports	Public Rice Stocks	Public Wheat Stocks	Total Public Stocks
1996-1997	Autarky	30	711	551	398	949
1997-1998 to 1998-1999	Supply shocks; Private imports from India	1834	1154	360	509	869
1999-2000 to 2001-2002	Autarky/minimal private imports	358	602	593	541	1134
2002-2003 to 2006-2007	Private imports from India (BPL rice?)	948	256	531	189	720
2007-2008	Autarky (World Rice Price Shock)	1681	177	472	145	617
July 2008-Dec 2009	Autarky	125	403	1020	138	1159
Jan 2010-June 2012	Autarky	148	852	745	274	1019
July 2012-Feb 2016	Autarky	519	508	1258	429	1687

Source: Author and Bangladesh FPMU data.

[12] Earlier that year, following a production shortfall in late 1997, the Government of Bangladesh had removed a 2 percent import surcharge on rice (signaling support for private sector rice imports) and simplified customs procedures in order to encourage rice imports. See Dorosh (2001).

In comparison with private sector rice imports, government interventions in the domestic rice market, constrained by low levels of stock, were small, only 399 thousand tons from July 1998 through April 1999. Private sector rice imports, equal to 2.42 million tons in this period, were thus 6.1 times larger than government rice distribution.

Figure 8.8: Bangladesh: PFDS Distribution and Domestic Procurement of Rice, 1997-1998 to 2015-2016



Source: Bangladesh Ministry of Food, Food Planning and Monitoring Unit (FPMU) data.

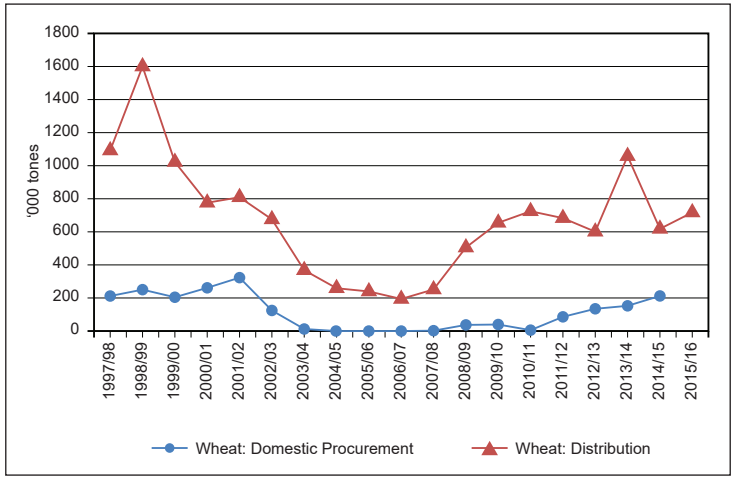
If private sector imports were unavailable (or banned) from any source then, with no change in government imports, total supply would have been 12.1 percent less (apart from private stock changes) and rice prices could have risen by 40 to 60 percent, to an average of between BDT 18.7/kg and BDT 21.3/kg.[13] Such an increase in the rice price level would likely have been unacceptable to the Government of Bangladesh and public sector imports would have been increased. But public sector imports of a magnitude equal to private sector flows would not have been feasible.

During the 1998 calendar year alone, private sector imports, mainly from India, reached 2.26 million tons. Had the Government of Bangladesh

[13] In the absence of private sector imports, domestic supply would have been 14.839 million tons, a 12.1 percent reduction in per capita supplies relative to the actual estimated levels. Assuming an elasticity of demand of -0.2 to -0.3, prices would need to rise by 12.1/0.3 (40 percent) to 12.1/0.2 (60 percent) to equilibrate market supply and demand. See del Ninno, Dorosh and Smith (2003).

imported this grain itself, the average cost of the imported rice delivered to local delivery points would have been approximately 14.9 to BDT 15.9/kg, BDT 1.0 to 2.0/kg above the private sector import costs, due to additional marketing costs totaling 50 to 100 million dollars. And, if the government received a net price of BDT 11.50/kg (equal to the Open Market Sales price of BDT 12/kg less BDT 0.50/kg OMS dealer's commission), the total unit subsidy would have been BDT 3.4 to 4.4/kg, and the total fiscal cost would have been 160 to 210 million dollars (del Ninno, Dorosh, and Smith 2003).

Figure 8.9: Bangladesh: PFDS Distribution and Domestic Procurement of Wheat, 1997-1998 to 2015-2016



Source: Bangladesh Ministry of Food, Food Planning and Monitoring Unit (FPMU) data.

Bangladesh had also experienced major production shortfalls at the time of the 1974 famine after the 1988 floods. In 1974, floods caused an 8.1 percent reduction in the *aman* rice harvest relative to trend (a 600-thousand-ton reduction in rice production for the calendar year, equal to 5 percent of production in the previous calendar year). Rice prices rose by 58.2 percent between May-July 1974 and August-November 1974 (Table 8.3). Low public stocks (208 thousand tons, only 2.7 kg/person) and the inability to rapidly acquire more grains in international market during the critical August-November period heavily constrained public distribution options and the government's ability to calm food markets.

Table 8.3: Bangladesh: Availability, Stocks and Market Prices in Major Flood Years

	1974-1975	1984-1985	1988-1999	1998-1999
Food grain production				
Aman (million tons)	6.29	7.93	6.86	7.74
Below trend (%)	-8.5	-0.1	-18.1	-18.0
Total rice shortfall (calendar year, million tons)	-0.61	-0.64	-0.24	-0.70
Per capita production (kg/person)				
Rice (calendar year)	149.1	144.9	136.6	138.8
Total food grain (calendar year)	150.3	157.4	146.6	153.1
Aus and *aman* share of production (%)	80.3%	73.3%	62.5%	47.0%
PFDS distribution (Aug-Nov)				
Total rice (thousand tons)	43	201	231	216
Total wheat thousand tons)	616	891	700	223
Food grain imports (July-June)				
Private rice imports (thousand tons)	0	0	0	2,663
Public rice imports (thousand tons)	267	695	61	393
Private wheat imports (thousand tons)	0	0	0	805
Public wheat imports (thousand tons)	2,030	1,898	2,075	1,603
Per capita availability (fiscal year)				
Rice (kg/person)	133.3	137.0	134.1	162.3
Wheat (kg/person)	21.8	33.3	29.2	30.5
Total (kg/person)	155.0	170.3	163.3	192.8
National wholesale prices				
Rice: percent change[a]	58.2%	3.7%	7.0%	12.4%
Wheat: percent change[a]	61.2%	12.8%	15.0%	10.7%
Public food grain stocks (Average Aug-Nov)				
Rice (thousand tons)	21	223	621	359
Wheat (thousand tons)	187	413	546	310
Total (thousand tons)	208	636	1167	669
Rice (kg/person)	0.3	2.3	5.8	2.8
Wheat (kg/person)	2.4	4.2	5.1	2.4
Total (kg/person)	2.7	6.5	10.9	5.3
Mid-year population (millions)	78.2	98.0	106.8	127.0

[a] Percentage change from May-July average to August-November average.

Source: Adapted from del Ninno, Dorosh, and Islam (2002).

The floods in 1988-1989 led to an 18.1 percent reduction in the *aman* harvest relative to trend. Public stocks (which averaged 1,167 million tons from August to November 1988) were nearly four times larger in per capita terms than in 1974 (2.7 and 10.9 kg/person in 1974 and 1988, respectively). Grain from these stocks combined with public sector imports enabled the government to use public distribution channels and stabilize markets and reach flood-affected households.

In 1998, average public stocks in August-November (669 thousand tons, 5.5 kg/person) were only half the per capita levels of ten years earlier (although double those of 1974). Nonetheless, the large inflow of private sector imports more than compensated for relatively small increase in public distribution. For the nine-month period from July 1998 through April 1999, public distribution of rice was only 399 thousand tons; private sector imports (banned in 1974 and 1988) were 6.1 times larger (2.42 million tons).

8.3.2 The 2007-2008 World Price Shocks

Although Bangladesh did not experience a major production shortfall in 2007 or 2008, the 2007-2008 world price shock had major adverse effects on Bangladeshi consumers. In October 2007, as world prices of rice and other cereals rose, India cut off rice exports due to relatively low public wheat stocks (Dorosh 2009; Headey and Fan 2008; Slayton 2009; Timmer 2010). Average wholesale rice prices in Bangladesh rose by 45 percent in real terms between November 2007 and April 2008, even though India agreed to allow fixed quantities of rice exports to Bangladesh at a price higher than BPL prices. Ultimately, total rice imports by Bangladesh reached 1.7 million tons in 2007-2008.

Model simulations of the changes in net rice supply (production, imports and net market injections by the government) and consumption demand (as determined by real per capita income and population growth) account for only 9 percent of the actual 45 percent increase in real rice prices actually observed (November 2007 to April 2008, as compared to one year earlier (Dorosh and Rashid 2013). However, simulations of an increase in private stockholding of about 900 thousand tons (equivalent to about two weeks of consumption) result in a simulated real price increase approximating the historically observed increase.

These simulations suggest that private stock changes could have been a major factor in explaining the price increases of 2007-2008. In the absence of an increase in private stockholding, a total of about one million tons of

net market injections (i.e., an extra 300 thousand tons of rice in addition to the approximately 700 thousand tons of net rice distribution that actually occurred in the period from November 2007 to April 2008) would have been sufficient to stabilize rice prices. These results suggest that ready availability of approximately one million tons of rice through drawdown of public stocks or imports would enable Bangladesh to handle similar disruptions in future, provided that private imports could supply an amount similar to that in 2008 (1.25 million tons).

8.4 Conclusions and Future Directions

Bangladesh has enjoyed considerable success in increasing food security both in terms of availability of food and access to food. Rice production more than doubled from independence in 1971 to 1999-2000 when Bangladesh achieved its target levels of domestic cereal production (454 grams per person per day). This increase in production has not only reduced the country's dependence on cereal imports, but has contributed to raising rural incomes and reducing the real price of rice from the early 1980s to the late 1990s that benefited all poor net consumers of rice. The trade liberalization in the early 1990s that permitted private rice and wheat imports has also enhanced national food security as private sector imports have added to total cereal supply, especially after major domestic production shortfalls.

The PFDS has also played an important role through targeted distribution that has increased access to food by poor households. Management of this system has involved complex policies related to the choice of commodities (rice versus wheat), domestic versus international procurement, maintaining incentives for private sector imports, and managing public stocks. In the 1970s and 1980s, food aid and government imports channeled through PFDS were major means of increasing the supply of food. During these years, much of this food was distributed through rationed sales at subsidized prices, although food for work programmes were also large. Large-scale domestic procurement at fixed prices during these periods was designed to spur production. Following liberalization of private imports of rice and wheat in the early 1990s that coincided with a shift from rationed sales to targeted distribution, PFDS functioned mainly as a safety net. Private trade in rice stabilized prices and supplies following the 1998 flood, as well as during the early 2000s.

Since the 2007-2008 world food price shock and temporary disruption of rice imports from India, the government policy has shifted towards lesser

reliance on international markets. Public cereal stocks have been increased, along with domestic procurement and public distribution (including a return to rationed sales). There are plans for investments in expanded grain storage and drying facilities that would enable storage of rice for longer periods without major quality deterioration, as well. Nonetheless, private sector imports of rice and wheat continue on a large scale, side by side with government purchases and sales in the domestic market, and large public stocks.

Food security in Bangladesh has been greatly enhanced over the past two decades by policies that have allowed a major public food grain distribution to co-exist with private sector trade. Increasing the efficiency of the public distribution system while maintaining incentives for private sector trade can help ensure that food security continues to improve in the coming decades as well.

References

Ahmed, A. 2000. "Trends in Consumption, Nutrition and Poverty." In *Out of the Shadow of Famine: Evolving Food Markets and Food Policy in Bangladesh*, edited by Raisuddin Ahmed, Steven Haggblade, and Tawfiq-e-Elahi Chowdhury, 101-120. Baltimore: Johns Hopkins University Press for the International Food Policy Research Institute (IFPRI).

Ahmed, A., Carlo del Ninno, and O. H. Chowdhury. 2004. "Investing in Children Through the Food for Education Program." In *The 1998 Floods and Beyond: Towards Comprehensive Food Security in Bangladesh*, edited by Quazi Shahabuddin, Paul Dorosh, and Carlo del Ninno, 271-312. Dhaka: IFPRI and the University Press Limited (UPL).

Ahmed, Raisuddin, Steven Haggblade, and Tawfiq-e-Elahi Chowdhury, eds. 2000. *Out of the Shadow of Famine: Evolving Food Markets and Food Policy in Bangladesh*. Baltimore: Johns Hopkins University Press for the International Food Policy Research Institute (IFPRI).

Alamgir, M. 1980. *Famine in South Asia: Political Economy of Mass Starvation*. Cambridge, Massachusetts: Oelgeschlager, Gunn and Hain Publishers, Inc.

Ali, A. M. M. Shawkat, Israt Jahan, Akhter Ahmed, and Shahidur Rashid. 2008. "Public Food Distribution System in Bangladesh: Successful Reforms and Remaining Challenges." In *From Parastatals to Private Trade: Lessons from Asian Agriculture*, edited by Shahidur Rashid, Ashok Gulati, and Ralph Cummings Jr., 103-134. Washington, D.C.: International Food Policy Research Institute (IFPRI).

BBS (Bangladesh Bureau of Statistics). (various years). *Statistical Yearbook of Bangladesh*. Dhaka: Ministry of Planning, Government of Bangladesh.

Bangladesh FPMU (Food Planning and Monitoring Unit). (various years). *Food Situation Reports*. Dhaka: Ministry of Food and Disaster Management.

del Ninno, Carlo. 2001. *Efficiency of Targeted Food Programs: A Preliminary Investigation of the VGD and RD Programs.* Food Management and Research Support Project Working Paper No. 3. Dhaka: International Food Policy Research Institute (IFPRI).

del Ninno, Carlo, and Paul Dorosh. 2003. "In Kind Transfers and Household Food Consumption: Implications for Targeted Food Programs in Bangladesh." *Journal of Development Studies* 40, no. 1: 48-78.

del Ninno, Carlo, Paul A. Dorosh, and N. Islam. 2002. Reducing Vulnerability to Natural Disasters: Lessons from the 1998 Floods in Bangladesh." *IDS Bulletin* 33, no. 4: 98-107.

del Ninno, Carlo, Paul A. Dorosh, and L. C. Smith. 2003. "Public Policy, Markets and Household Coping Strategies in Bangladesh: Avoiding a Food Security Crisis Following the 1998 Floods." *World Development* 31, no. 7: 1221-1238.

del Ninno, Carlo, Paul A. Dorosh, L. C. Smith, and D. K. Roy. 2001. *The 1998 Floods in Bangladesh: Disaster Impact, Household Coping Strategies and Response*. IFPRI Research Report No. 122. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Dorosh, Paul. 2001. Trade Liberalisation and National Food Security: Rice Trade between Bangladesh and India. *World Development* 29, no. 4: 673-689.

___. 2009. "Price Stabilization, International Trade and National Cereal Stocks: World Price Shocks and Policy Response in South Asia." *Food Security* 1, no. 2: 137-149.

Dorosh, Paul, and S. Rashid. 2013. "Trade Subsidies, Export Bans and Price Stabilisation: Lessons of Bangladesh-India Rice Trade in the 2000s." *Food Policy* 41: 103-111.

Dorosh, Paul A., and N. Farid. 2003. "Implications of Quality Deterioration for Public Food grain Stocks and Consumers in Bangladesh", Markets and Structural Studies Division Discussion Paper No. 56. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Dorosh, Paul A., Quazi Shahabuddin, and N. Farid. 2004. "Price Stabilisation and Food Stock Policy." In *The 1998 Floods and Beyond: Towards Comprehensive Food Security in Bangladesh*, edited by Quazi Shahabuddin, Paul Dorosh, and Carlo del Ninno, 271-312. Dhaka: International Food Policy Research Institute (IFPRI) and the University Press Limited (UPL).

FAO (Food and Agriculture Organisation). 2016. *Bangladesh Food Balance Sheet 2013.* http://faostat3.fao.org/download/FB/FBS/E.

Goletti, F, 2000. "Price Stabilisation and the Management of Public Foodgrain Stocks in Bangladesh." In *Out of the Shadow of Famine: Evolving Food Markets and Food Policy in Bangladesh*, edited by Raisuddin Ahmed, Steven Haggblade, and Tawfiq-e-Elahi Chowdhury, 189-212. Baltimore: Johns Hopkins University Press for the International Food Policy Research Institute (IFPRI).

Goletti, F, R. Ahmed, and N. Chowdhury. 1991. *Optimal Stock for the Public Foodgrain Distribution System.* Food Policy in Bangladesh Working Paper No. 4. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Headey, D., and S. Fan. 2008. "Anatomy of a Crisis: The Causes and Consequences of Surging Food Prices." *Agricultural Economics* 39 (supplement): 375-391.

Rashid, S., A. Gulati, and R. Cummings, Jr. 2008. *From Parastatals to Private Trade: Lessons from Asian Agriculture*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Sen, A. 1982. *Poverty and Famines: An Essay on Entitlement and Deprivation.* Oxford: Clarendon Press.

Slayton, T. 2009. *Rice Crisis Forensics: How Asian Governments Carelessly Set the World Rice Market on Fire*. Working Paper No. 163. New Delhi: Global Development Network.

Sobhan, R. 1979. "Politics of Food and Famine in Bangladesh." In *Bangladesh Politics*, edited by A. Emajuddin. Dhaka: Centre for Social Studies, Dhaka University.

Timmer, C. P. 2010. "Reflections on Food Crisis Past." *Food Policy* 35: 1-11.

Chapter 9

Food Security Implications of Rice Value Chain Management in Bangladesh

Mustafa K. Mujeri, Nazneen Ahmed, and M. I. Hossain

9.1 Introduction

Since Bangladesh's independence in 1971, the country's population has more than doubled to over 160 million in 2016. Despite a large population and severe resource constraints, the country has achieved significant development including steady growth in per capita income and impressive gains in human development. The incidence of poverty has also declined from nearly 60 percent in the early 1990s to less than a quarter in recent years. However, there are still millions of people who are food insecure, as commonly understood, in terms of complex multi-faceted issues concerning not just agriculture, technology and trade, but also involving multiple social and ecological considerations.

In Bangladesh, rice is the staple food with a per capita consumption of about 152 kilograms (kg) per year, which is one of the highest in the world (BBS 2012). On average, more than 75 percent of the calorie intake of the individuals comes from rice and around 15 million households or more than half of the country's population are engaged in rice production. In addition, millions more are involved in post-harvest, marketing, distribution and other activities related to the rice sector. It is therefore not surprising that rice plays a key role in food security in Bangladesh.

This chapter brings out two important concerns related to food security in Bangladesh: (i) the role of rice in food security in the midst of wide-ranging changes in marketing and distribution of agricultural products in the transitional economy; and (ii) potential of utilizing value chain management in improving the competitive advantage of rice sector, with a significant positive impact on food security.

The dynamics in the rice value chain naturally bear significant impact on the livelihood of those involved, including the rice farmers (Aji 2010;

Haq, Kabir, Eusuf, and Karim 2010; Chowdhury 1992). Both vertical and horizontal profit margins vary widely in the rice value chain due to market imperfections, unequal bargaining power among different players, informational asymmetries, and other factors influencing the functioning of the value chain (Pavithra, Singh, Ahmad, Sinha, and Mishra 2017). It is therefore important to understand the dynamics of the rice market value chain, and produce systemic and evidence-based knowledge that can support effective policymaking around food security.

9.1.1 Scope and Objectives

This study will look into the under-explored connection between the concepts of value chain management and food security, which has received little research attention in the context of Bangladesh. The broad objective is to analyze whether applying the concept of value (supply) chain management can improve the rice sector's competitive advantage, and if so, how this can be achieved in practice. These results will also contribute to food security policies because of the links between more competitive rice value chains and improved food security.

The study addresses two major issues in the rice sector: (i) importance of value chain management in the rice sector; and (ii) limitations of traditional food security policies, which are often considered to be costly and which mostly distort the rice market. The study argues that a competitive strategy is needed along with policies that rely more on the market, and encourage private sector trade and stock management in the rice sector.

9.2 The Rice Sector and Bangladesh Economy

Rice is the most important crop in Bangladesh. More than 77 percent of the country's cultivable land is used for rice production.[1] Rice accounts for around 70 percent of the crop value added in Bangladesh and 50 percent of agricultural GDP (Baffes and Madhur 2001). It constitutes 92 percent of the total food grains production in the country (Chowdhury 2009). Most rice is grown by small farmers who are engaged in subsistence farming, i.e., producing rice for family consumption and marketing the marginal surplus.

Because of its importance in terms of contribution to GDP, employment and calorie source, rice remains at the core of government policy towards food security and poverty reduction. Since 1971, various policies have been implemented to overcome food shortages (which is mostly interpreted in terms of deficit in the availability over consumption requirements of rice)

[1] Cited in http://irri.org/partnerships/country-profiles/asia-oceania/bangladesh/rice-in-bangladesh (accessed on 4 April 2012).

and to ensure food security. As stable supply of rice has great implications for food security, and achieving self-sufficiency in rice production is often viewed as synonymous to achieving food security (Hossain, Naher, and Shahabuddin 2005). For maintaining socioeconomic stability, an important concern of the government's policy is to maintain lower price of rice for the consumers while ensuring reasonable price for the growers.

9.2.1 Production System of Rice

Total production of rice in the country was only 10 million metric ton (MT) in 1971-72, which has risen to an annual average of 27 million MT during the decade of 2001-2010 (Table 9.1). The growth in rice production is due mainly to green revolution technology, based on high yielding varieties (HYVs) of rice, chemical fertilizers, and new irrigation technologies. In particular, due to the proliferation of shallow tube wells (STWs) for irrigation, production of rice during the dry season became possible. Moreover, liberalization of import of agricultural machineries and inputs since the early 1990s contributed to rapid growth of rice production.

Rice is produced in almost all areas of Bangladesh. The crop is produced in three seasons of the year. The cultivation of rice varies mainly with seasonal changes in water availability. Traditionally, the main rice variety has been rain-fed *aman*, which is produced in the monsoon season (August-December).[2] During the 1970s, *aman* constituted nearly 58 percent of total rice production (Table 9.1). Its dominance continued till the late 1980s. However, with the spread of HYVs technology, the production of irrigated dry season *boro* rice increased substantially (Figure 9.1). Whereas the winter season (January-May) *boro* rice crop constituted only 18 percent of total rice production during the 1970s, its annual average share rose to 53 percent during the last decade.

The liberalization of imports of diesel engines and pumps for tube well irrigation in the late 1980s, expansion in fertilizer use, and planting of HYVs contributed to the phenomenal increase in the production of *boro* rice. Moreover, the land area under *boro* cultivation increased over the years. During the 1981-90 period, *boro* area increased by an average of 9 percent per year, replacing mainly the lower yielding *aus* rice variety, which is produced during the rainy season (April-August). This shows that the expansion of *boro* production contributed to most of the increase in production and productivity of food grains over the years (Hossain 2010).

[2] The crop season may vary slightly in different areas. For example, *aman* production may also continue till January in some parts of the country.

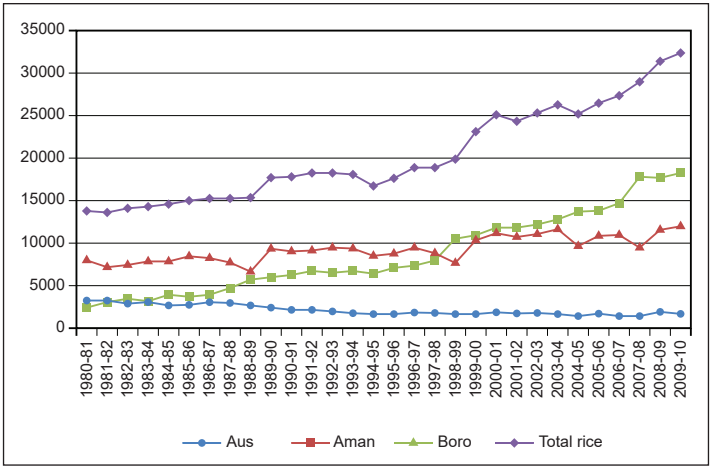
Table 9.1: Area, Production and Yield of Rice in Bangladesh

	Area under production (million hectares)	Share in total rice area (%)	Annual average growth (%)	Production (million MT)	Share in total production (%)	Annual average growth (%)	Yield (MT per hectare)	Annual average growth (%)
Aus								
1973-1980	3.47	31.69	0.44	3.05	24.74	2.88	0.88	2.42
1981-1990	2.90	27.83	-3.37	2.99	19.97	-2.82	1.03	0.55
1991-2000	1.65	16.21	-4.90	1.89	10.09	-3.22	1.15	1.75
2001-2010	1.18	11.05	-1.61	1.73	6.34	0.67	1.47	2.77
Aman								
1973-1980	6.31	57.65	0.68	7.11	57.71	2.99	1.13	2.30
1981-1990	5.82	55.94	-0.45	7.90	52.75	2.35	1.36	2.54
1991-2000	5.69	55.73	0.14	9.13	48.64	1.81	1.60	1.39
2001-2010	5.48	51.31	-0.35	10.96	40.24	2.18	2.00	2.34
Boro								
1973-1980	1.17	10.67	0.84	2.16	17.55	-0.02	1.85	-0.85
1981-1990	1.69	16.23	9.03	4.09	27.28	10.15	2.41	0.96
1991-2000	2.86	28.05	4.23	7.75	41.28	6.56	2.68	2.15
2001-2010	4.02	37.64	2.98	14.54	53.41	5.35	3.62	3.42
Total rice								
1973-1975	9.76	100	0.62	12.33	100	2.44	1.13	1.81
1981-1990	10.41	100	0.13	14.98	100	2.82	1.44	2.70
1991-2000	10.21	100	0.31	18.77	100	2.83	1.84	2.47
2001-2010	10.69	100	0.61	27.23	100	3.49	2.55	3.00

Note: The figures refer to yearly averages.

Source: BBS.

Figure 9.1: Production of Different Rice Varieties in Bangladesh



Source: BBS.

Table 9.2: Import of Rice in Bangladesh

Years	Domestic production of rice (million MT)	Import of rice (million MT)	Import as a percentage of domestic production (%)
2000-2001	25.09	0.15	0.61
2001-2002	24.30	0.94	3.88
2002-2003	25.19	1.25	4.96
2003-2004	26.19	0.99	3.79
2004-2005	25.16	0.71	2.82
2005-2006	26.53	0.94	3.54
2006-2007	27.32	0.61	2.25
2007-2008	28.93	0.70	2.42
2008-2009	31.32	0.62	1.97
2009-2010	32.26	0.10	0.31

Source: Authors' calculation using BBS data.

In addition to domestic production of rice, Bangladesh also imports small quantities of rice during normal years (Table 9.2). The import of rice has declined over time due to increases in domestic production, but imports do rise during years when normal rice production is hampered

by natural disasters like floods and cyclones. However, Bangladesh is still considered to be a net importer of rice as self-sufficiency in rice production is threatened by rising population and frequent natural disasters. The import of rice is often used as a tool to stabilize domestic price of rice, and thereby ensure food security of the poor. Prior to trade liberalization in the early 1990s, the government had a monopoly on food imports and rice was imported only through the government channel. Since allowing private sector import of rice after liberalization, it has gradually emerged as the main channel for import of rice. Bangladesh imports rice mainly from India, Vietnam, Myanmar and Thailand. During the last decade, import on average was less than 5 percent of domestic production.

9.2.2 Rice Trading and Marketing

Marketing plays a significant role in value addition of any product and in generating employment in the economy. The marketing of paddy and rice involves a large number of people in both rural and urban areas. The marketing of rice in Bangladesh takes place through two broad systems: (i) public food grain distribution system (PFDS); and (ii) private marketing of rice.

Under the PFDS, the government procures rice every year from the domestic market during the harvesting seasons as well as through imports. A small amount is also received under food aid from the donors. The government sells rice (mostly at a subsidized price) during seasons of peak prices and distributes to the poor and food insecure people through different safety net channels for free or at subsidized prices. Thus, the government attempts to stabilize rice price and provides access to food grain to the extreme poor and vulnerable groups through the system. Each year, the government sets the procurement price by considering production costs and a profit margin for the farmers. The government purchases rice from the millers and big traders, while rice millers/traders purchase paddy from the farmers/growers through their agents as well as from traders such as *farias* or *aratders*. The millers process the paddy into rice and sell to the government after completing some formalities. However, they are required to sell to the government at the previously declared price (Table 9.3).

Rice procured by the government through PFDS is distributed through three channels: open market sales (OMS) at subsidized price during periods of high price of rice; transferring rice to the poorest under the social safety net (SSN) programmes, and providing rice under the food for work (FFW) and similar programmes that employ the poor people in rural infrastructure development. In terms of the total volume of this operation, it is only around 4 percent of the total domestic consumption, and the recipients of food

vouchers are extremely poor people, so this government policy is unlikely to have distorting effects on the market (Haq, Kabir, Eusuf, and Karim 2010).

Table 9.3: Sources of Public Procurement of Rice

Year	Yearly procurement (thousand MT)			
	Domestic procurement	Food aid	Public sector import	Total rice under PFDS
2002-2003	816	4	0	820
2003-2004	828	4	0	832
2004-2005	897	27	72	996
2005-2006	944	34	0	978
2006-2007	1,101	27	0	1,128
2007-2008	602	82	296	979
2008-2009	1,449	35	396	1,880

Source: Bangladesh Food Planning and Monitoring Unit (FPMU).

Of the total rice sold or distributed domestically, 95 percent is channeled by the private sector. The private channel has a number of actors. These actors can be grouped under two major segments. One group is involved in the marketing of paddy while the other is involved in the marketing of rice. Several studies are available which identify different actors who operate in rice marketing (Haq, Kabir, Eusuf, and Karim 2010; Rahman et al. 2008; Murshid, Yunus, Ali, and Ahmed 2009). These include: growers, *farias*/paddy *beparis*, paddy *aratdars*, millers, rice *aratders*/commission agents, wholesalers, and retailers.

9.2.3 Existing Studies on Rice Value Chain

A number of macro- and micro level studies are available on the economics of rice production and marketing in Bangladesh, emphasizing mainly on management aspects at the farm level. However, there are only a few studies which focus on marketing aspect of rice, especially considering the whole value chain of rice marketing in Bangladesh.

Islam (1998), while identifying the marketing channels of aromatic paddy, estimates marketing cost and margins of different actors. According to the study, marketable surplus and net marketed surplus are nearly 81 percent and 37 percent respectively. The study notes that the margin is the highest for the millers followed by the retailers. Rahman et al. (1991) evaluates the role of intermediaries in paddy/rice marketing in Bangladesh, with particular attention to their services, marketing costs, margins and price spread. The study finds that the farmers' share in the consumer price is nearly 72 percent. The study

by Quasem (1987) focuses on the farmers' participation in paddy marketing, their marketed surplus and factors determining the surplus. The gross and net marketed surpluses are estimated to be 28 percent and 11 percent respectively.

Tasnoova and Iwamoto (2006), in a study on *Kataribhog* variety of rice marketing system in Dinajpur district, estimate the marketing costs and margins as well as identify marketing problems. The study indicates that the highest marketing margin is earned by the millers while they also incur the highest cost. However, retailers earn the highest net margin. The study of Murshid, Yunus, Ali, and Ahmed (2009) finds that the rice *aratdars* are the most influential in the rice value chain. Haq, Kabir, Eusuf, and Karim (2010) note that marketing margin increases as rice moves up in the marketing chain up to the millers and then the margin goes down. This higher marketing margin is determined by the capacity to store rice. The studies by Islam (1987) and Islam et al. (1985) also deal with different aspects of rice marketing.

9.3 Government Policy Regarding Rice

The policies of the government with regard to production and marketing of rice is linked with its objective of ensuring adequate availability and access to rice for all. The government intervenes in total availability of and access to rice through different channels including public procurement, public import, and by utilizing food aid for promoting food security.

In Bangladesh, improved agricultural productivity is critical to establishing basic food security for large numbers of people, and also provides initial stimuli to economic growth and development. Through productivity increases, food production expands and food prices fall relative to nominal wages. The poor can also procure more food thus improving household nutrition, while being able to direct some of their resources to other basic needs such as education. Incomes grow in rural areas stimulating investment in nonfarm activities and eventually leading to sustained growth.

The sustained improvement in rice productivity depends heavily on research investments. Efforts to expand production of staple food crop (rice) require improvements in agricultural policies and increase in yields on existing lands through more intensive and efficient use of inputs and through introduction of improved crop varieties. It also appears that the growth in productivity of the best agricultural lands in Bangladesh has flattened out in recent years. Such "plateauing" in yields is attributed, among others, to lack of sufficient investment in improved technologies. All these developments indicate that overall investment in agriculture must increase significantly in Bangladesh.

The government has taken comprehensive measures to improve productivity enhancing infrastructure which includes markets, roads, utilities (e.g.,

water, electricity) and communications. The expectation is that investments in these areas will improve efficiency by cutting intermediation and transaction costs, leading to lower input prices and cheaper technology. In particular, the government has taken several initiatives for the crop sector (which is dominated by rice) during the Sixth Five Year Plan (2010-2015) in the arena of food security (Box 9.1).

Box 9.1: Major Strategies for Crop Sector during the Medium Term

The medium-term development agenda for the crop sector, as articulated in the Sixth Five Year Plan (2010-2015), covers the following:

- Attain self-sufficiency in food grain production along with increased production of other nutritional crops
- Increase productivity and real income of the farming families in rural areas on a sustainable basis
- Ensure equal wage for equal work for women-men labor in agriculture
- Promote adoption of modern agricultural practices in drought, submergence and saline prone areas
- Encourage research on adaptation to climate change, proper use of genetically modified technology in agriculture
- Gradually shift the main HYV, irrigation-fed *boro* rice production to the southern areas and utilize new salinity, submergence, and other stress tolerant varieties and also utilize abundant surface water for irrigation
- Emphasize on yield gap reduction and also emphasize on maximization of yield in *aus* and *aman* crops with similar care in *boro* cultivation for ensuring self-sufficiency in food grains
- Strengthen farming system/cropping system/whole farm approach-based technology transfer
- Encourage comparatively large farm to graduate into commercial farming
- Promote the use of modern technologies with the help of ICT
- Form cooperatives and construct special growth centers only for the growers to ensure fair price

Source: The 6th Five Year Plan FY2011-FY2015, Accelerating Growth & Reducing Poverty, Planning Commission, Ministry of Planning, Government of the People's Republic of Bangladesh, 2011.

9.4 Food Security and Rice Value Chain Management in Bangladesh

With regard to food security, the usual practice of each country is to develop its own conceptions and orientations that guide its policy agenda. Bangladesh's food security agenda covers a wide range of initiatives to tackle

the problem of food insecurity. This includes diverse measures including support to agriculture, improving trade and infrastructure, developing markets, and addressing other issues in the area of food availability. There also exist programmes dealing with food access for vulnerable groups such as PFDS for subsidized food sales or free distribution, public works, or cash transfers. Similarly, attention is given to proper food utilization and its non-food determinants such as access to safe water and improved sanitation, nutrition education, and adequate health and nutrition services.

9.4.1 Food Security

Despite significant improvements, Bangladesh still presents a very uneven picture with respect to overall food security. The data on undernourishment indicate that about 20 percent of the population are estimated to be consuming less than 1,805 kilocalories (kcals) per day in 2005, which was 28 percent in 1990 (BBS 2005). The numbers around underweight children are even more concerning. In 2009, 45 percent of the children under-five years of age are underweight compared with nearly 66 percent in 1990. Underweight prevalence rate has fallen sharply between 1992 and 2000 but there has hardly been any improvement in the prevalence of underweight children during 2005-2009 (PC 2009).

Moreover, it is important to recognize that, just as poverty is multi-dimensional, food insecurity has many faces relating to inadequate energy intake, under-nutrition, increased vulnerability to diseases and disability, often leading to premature death. Poor households cannot ensure food security or fulfill all nutrition and health care needs. Furthermore, the quality of their diet is unlikely to meet dietary energy requirements and lack essential micronutrients. Poverty and hunger are closely interlinked, and undernourished people will be less productive, and have lower lifetime earnings, in turn causing greater vulnerability to illness and disability. Malnutrition can have severe and permanent consequences on the physical and intellectual development of children in poor households, leading to persistence of inter-generational transmission of poverty.[3]

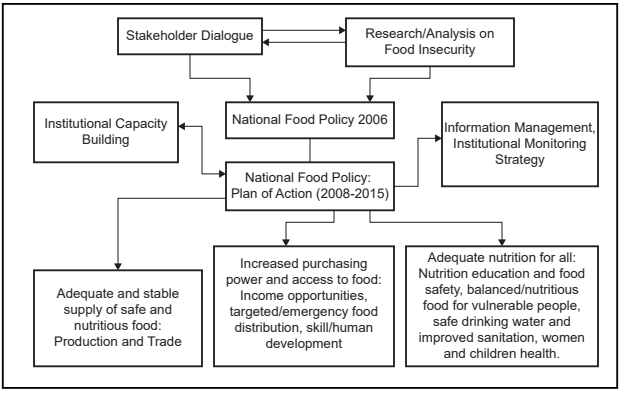
The concept of food security that Bangladesh uses is very similar to the widely used food security definition developed since the World Food Summit in 1996. Bangladesh's National Food Policy adopts a comprehensive and integrated approach to food security covering availability, access, and utilization dimensions of food security. The goal of the Policy is "to ensure a dependable food security system for all people of the country at all times" (MFDM 2006). Three major objectives have been stated which

[3] See "Financial Inclusion and Food Security in Bangladesh," InM, http://inm.org.bd/financial-inclusion-and-food-security-in-bangladesh/.

relate to ensuring adequate and stable supply of safe and nutritious food, enhancing purchasing power of the people for increased food accessibility, and ensuring adequate nutrition for all especially women and children.

For implementing the National Food Policy, Bangladesh has designed a Plan of Action including strategic areas of intervention and priority actions covering all dimensions of food security (FPMU 2008). The Action Plan aims at providing immediate access to food to the most vulnerable households through targeted food and cash transfers as well as developing production capacity, income generation, and nutrition through investments and accompanying policy measures (Figure 9.2).

Figure 9.2: Bangladesh National Food Security Policy Framework



Source: Authors' compilation.

9.4.2 Rice Value Chain Management

The concept of value chain refers to the network of organizations that participate, through their upstream (supply) and downstream (distribution) linkages, in various processes and activities to create value in the form of products and services for delivering to the consumers (Christopher 1992).[4] The complexity of the value chain depends on the number of involved organizations: the greater the number, the higher the complexity. Value chain management refers to the management of the entire flow of materials from the producers to the ultimate consumers covering the entire processes that provide products, services, and information that create value for consumers and other participants (Lambert and Cooper 2000).

[4] The term "value chain" is often used interchangeably with "supply chain" and "demand chain" in the literature. The term may also be conceived as an expansion of the concept of marketing channel.

The efficiency and effectiveness of management of the value chain depends on a host of factors which cover, on the one hand, issues affecting the relationships in marketing such as trust, commitment, and dependence and factors like organizational compatibility, commonality in vision and processes, and understanding of the working of the value chain, on the other (Mentzer et al. 2001). In Bangladesh, however, where the institutional factors are weak in the rice value chain, the important elements are the factors that determine "relationship marketing" such as dependence and relationships. It is argued that, in countries like Bangladesh, exchange relationships are significantly influenced by such factors as power and dependence, especially for agricultural products (Batt and Rexha 1999; Cox 2001a). It is important, therefore, to explore factors underlying trust, commitment, power, dependence, norms, and similar attributes that govern the working of the rice value chain in Bangladesh.

The benefit of value chain management largely stems from better collaboration and mutually supportive relationships among the chain participants. The benefits can be derived through several channels, such as reduced transaction costs, improved value creation, and increased competitive advantage.

Reduced Transaction Costs

A major outcome of a better value chain is improved interaction among the participants in the chain which increases efficiency and enhances competitiveness. While market information and transactions are assumed costless in standard neoclassical theory, in practice there are costs of using the market mechanism and carrying out market exchange. such as accessing market information and negotiating contracts which are termed as "transaction costs". In the literature, three major transaction costs are identified: information costs, bargaining costs, and enforcement costs (Williamson 1975; Cox 2001). Pro-active measures to improve the management of the value chain can reduce all three types of transaction costs, which are required to improve efficiency and increase competitive advantage. Transaction costs are reduced with improved coordination and integration among chain participants and improving transaction efficiency in the value chain (e.g., through better adjusting of frequency and reducing uncertainty).

Enhanced Value Creation

Value creation is the major reason for the participants to form the value chain. Moreover, the management style of the chain and the sharing value among the chain participants are crucial determinants of the stability of the relationships in the chain and its efficiency (Liu, Li, Tao, and Wang 2008). If, for example, the created value is not equitably shared, then the collaboration

among the participants across the entire chain will not be effective and they may work individually to maximize their own value rather than working together to enhance the value of the network's combined activities.

Another route to enhancing value addition is through encouraging product differentiation. Successful product differentiation requires closer relationships with network partners to ensure better communication and sharing of more accurate information across the chain, which can be ensured through effective value chain management. Product differentiation also creates opportunities to create greater value which can be shared among the participants by supplying products more tuned to individual tastes and preferences.

Increased Competitive Advantage

Effective management of the value chain improves consumer satisfaction (e.g., through product differentiation), which in turn increases competitive advantage of the value chain. Better integration as an outcome of value chain management gives the value chain competitive advantage over its competitors, which is likely to be sustainable. Gaining of competitive advantage, however, depends on adoption of more value adding activities by individual participants in their own business processes, as well as those across the chain participants for enhancing value creation in the chain, which in turn will increase the competitiveness of the chain itself.

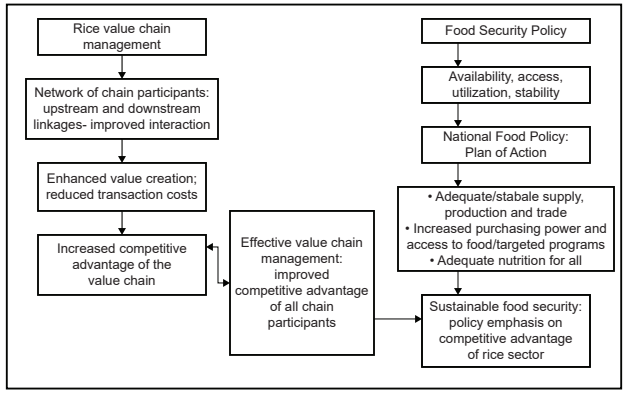
9.4.3 Linkages of Food Security and Rice Value Chain

In the case of agriculture, horizontal coordination has a long history in Bangladesh. Such coordination refers to forming alliances at a single level of the value chain such as farmers' cooperatives. On the other hand, value chain management is the vertical coordination among different levels of the value chain (e.g., farmers with small traders with large traders with millers with wholesalers with retailers). While the former has been promoted as a part of safeguarding the interests of the farmers often with government initiatives, the concept of vertical coordination is relatively new in Bangladesh. The issue, however, is becoming increasingly important as global trade barriers are declining, consumer preference is changing, information technology is becoming more widespread, and contract farming and marketing are emerging as new and more effective tools of market transactions. These are also becoming the driving forces of vertical integration and value chain management.

In view of the intricate relationships, the pursuit of sustainable food security in Bangladesh needs to focus on maintaining the competitive advantage of the rice sector through effective value chain management.

The potential links between rice value chain management and food security policy framework in Bangladesh is illustrated in Figure 9.3. Although the concept of value chain management is the concern of the private participants in the rice value chain, its major elements e.g., reduction in transaction costs, better risk sharing, promotion of more collaborative relationships, and enhanced value creation, are more likely to promote food security by enhancing competitive advantage of the sector and thereby contribute to achieving the desired outcomes of the food security policy such as availability, access, and stability.

Figure 9.3: Links between Rice Value Chain and Food Security Policy in Bangladesh



Source: Authors' compilation.

9.5 Study Approach

The present study uses a social constructionist paradigm with a focus on qualitative analysis. Both qualitative and quantitative data have been collected from primary and secondary sources for the analysis. The primary data uses separate semi-structured questionnaires for different participants in the rice supply chain. The data was collected during the months of March and April 2012 from seven purposively selected districts (Bogra, Brahmanbaria, Dhaka, Dinajpur, Kushtia, Naogaon, and Sherpur) out of 64 districts of the country (Figure 9.4). The study has also used case studies, inductive analysis, and marketing margin analysis. For capturing the impact of typical rice supply chains, three different chains have been studied. These are:

- *Traditional (bulk) rice supply chain:* The chain represents the private sector rice supply (coarse, medium and fine qualities) from growers

to final consumers through the traditional market network. The rice is generally packed in two different weights: 50 kg and 85 kg packages, although the first one is more prominent. The packaging material may or may not make explicit any brand name.

- *Modern (packed) rice supply chain:* The chain is a private rice supply chain usually supplying fine quality rice to final consumers through the supermarket stores and retail outlets. The rice is generally packed in different types of attractive small size packages (e.g., 1 kg, 5 kg, 10 kg and 20 kg), mentioning the brand name.
- *PFDS supply chain:* This chain represents the government rice supply chain involving the Ministry of Food and Disaster Management under which rice is distributed (especially to the poor and distressed population free or at subsidized prices) through the PFDS. Depending upon the domestic production situation, the rice is either procured from the domestic market through the public procurement system mainly from the millers/agents at pre-announced prices or imported directly by the government from abroad.

The marketing margin analysis examines differences between farm gate and consumer prices of rice. In the present study, marketing margin analysis has been used to track the distribution of value among different value chain actors including the farmers. The marketing margin is the difference between the price of rice the consumers pay at the retail level and the price the farmers receive at the farm gate level (Mendoza 1995). At a disaggregated level, the margins represent the price charged by different value chain participants in return for their services that add value to rice for the consumers including buying, packing, transporting, processing and storing (Davis 1985). Using the standard methodology, marketing margin is calculated using data from different actors at different stages of the rice value chain. Marketing margin is calculated at two stages: gross marketing margin (GMM) which is the difference between the selling and the purchasing price of rice at each stage of the chain; and net marketing margin (NMM) which excludes costs from the gross marketing margin at each stage:

$$GMM_{ir} = S_{ir} - P_{ir}$$
$$NMM_{ir} = GMM_{ir} - (C_{ir} - BPV_{ir})$$

where GMM_{ir} the gross marketing margin of rice at stage i of value chain, S_{ir} is selling price of rice at stage i, P_{ir} is purchase price of rice at stage i, NMM_{ir} is net marketing margin of rice at stage i, C_{ir} is the total cost for transforming initial product into the final selling product at stage i and BPV_{ir} is total value of by-products (in case of farmers and millers).

Figure 9.4: Map showing the Study Areas



Source: Field Survey.

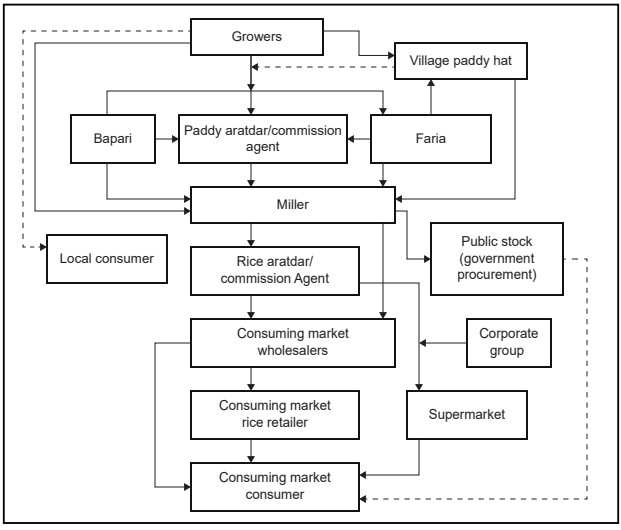
Since the marketing chain involves both paddy and rice, appropriate transformations have been used to make the results comparable across the entire chain. In the case of rice, FAO assumes 66 percent milling outturn while Zaman, Mishima, Hisano, and Gergely (2001) maintain that the milling outturn of husky millers is 63 percent, which indicates a conversion

ratio of 1.58. The present study uses conversion factors calculated from the primary data which are found to be 61.6 percent, 62.8 percent and 63.2 percent for coarse, medium and fine varieties of rice respectively.

9.5.1 Structural Aspects of Rice Value Chain

The general structural characteristics of rice value chains in Bangladesh are shown in Figure 9.5. The value or marketing chain of rice/paddy starts from the paddy growers. In the study areas, paddy growers usually sell their paddy to local rice traders who are known as *farias/beparis* at the farm gate or home and local market places; sometimes they also sell paddy to the rice millers at the mill gates, especially during the peak harvesting seasons. Most of the transactions between the growers and the traders during the harvesting periods reflect the urgent cash needs of the small growers and lack of their storage capacity. The small and medium farmers have less capital and storage capacity than the large farmers, so they are forced to sell the major share of their harvested paddy immediately after its harvest.

Figure 9.5: Rice Value Chain in Bangladesh



Source: Field Survey.

The *farias* are small rice traders in the villages who are involved in purchasing paddy from the local growers (often in small quantities) and selling the rice to the nearest village hats or markets. They collect paddy

from the growers' houses or farm gates and also local village *hats.* The purchased paddy is sold either to paddy *beparis* and agents of rice millers (commission agents) at nearest large markets or *hats* or directly to the millers at the mill gate. In the study areas, about 72 percent of the *farias* report that they sell their paddy to the commission agents of the rice millers. Over the years, the role of the *farias* (small traders) in the village paddy markets has been reduced due to improvements in rural infrastructure, especially the development of rural roads.

Available local transports e.g., rickshaws, vans, and other means are used by the *farias* for paddy marketing. Usually, they sell paddy at the spot price; so that their net margin is determined by several factors including the spot price prevailing on the day, quality of the purchased paddy, and transportation and packaging costs.

The *beparis* are relatively large traders handling larger volumes of paddy and generally are more regular paddy traders than the *farias*. In case of trading, their domain is not limited to their own villages only; they also tend to purchase paddy from different villages and distant markets. The *beparis* generally purchase paddy from the farmers as well as from the *farias*. The recent trend, however, is to collect increasingly more paddy directly from the farmers and from the local *hats.* The *beparis* sell their paddy to agents of the millers as well as directly to millers at mill gates. The study finds that around 52 percent of the total purchased paddy by the *beparis* have been collected from the farmers, while the rest come from paddy *hats,* and *farias*. On the other hand, two-thirds of the surveyed *beparis* report that they sell their paddy directly to millers using modes like trucks and vans. The *beparis* are observed to maintain a good relationship with the millers and the agents. This helps them to get access to supply situation in the rice market and sensitive price information to do profitable business.

The (paddy) *aratders* are wholesalers of paddy having access to storage facilities that enable them to sell paddy throughout the year. They purchase paddy from the farmers and markets/*hats* through the *farias, beparis* as well as employing their own staff. They mostly sell paddy to the millers. If necessary, they also provide credit to the *farias* and *beparis* for ensuring smooth supply of paddy. Thus, the operating capital requirements of the *aratders* are higher. The *aratders* and the agent of the millers have very similar market characteristics, but the margins received by them are determined differently. The margin of the *aratders* depends on the market price which is not pre-determined, while the commission agents receive a fixed margin for per unit of paddy. They sell paddy to the millers both in cash and credit.

The rice milling technology has undergone significant changes over the years, resulting in large growth in rice milling capacity (Haq, Kabir, Eusuf, and Karim 2010). The rice millers use different types of machine at different stages of their milling operation according to their milling capacity and other features. In terms of major characteristics, three types of rice mills (excluding the howlers) may be categorized:

- *Husking mills:* These mills use traditional technique in every stages of milling operation starting from drying, boiling, husking, and packaging. They use more physical labor than machines. The current average capital of the 29 husking mills surveyed under this study (locally known as *chatals*) is reported at BDT 6.4 million, while the initial average investment has been BDT 1 million. Of the total, 54 percent is loan-financed while the rest is equity capital.
- *Major or semi-automatic rice mills:* These mills use modern technology, but not at each stage of milling operation. These adopt what may be termed as "hybrid technology" combining some traditional techniques with modern ones. Under the study, four semi-automatic mills have been analyzed. The average capital is reported at BDT 3.35 million while the initial average investment is BDT 6.6 million. On average, 79 percent of the capital is credit-financed mostly from banks.
- *Automatic rice mills:* These mills use fully imported modern technology for rice milling. The average capital of these mills is nearly BDT 12 million while the initial average investment is BDT 3.46 million. Nearly 90 percent of the capital is credit-financed.

The millers collect paddy mostly from the *beparis,* agents and paddy *aratders*. Sometimes they also collect paddy from the farmers. They also employ their own employees to purchase paddy from different markets during the peak harvesting periods. The automatic rice millers dominate the entire milling activity with their huge milling capacity and increasing demand for auto-milled rice (which is finer than the milled rice by other techniques). The millers sell rice directly to the wholesalers as well as through the *aratders* or commission agents.

The (rice) *aratders* dominate the commission agents who maintain fixed establishments in the market places of upstream districts, which are operated between the millers and other traders of rice. They help the millers to sell their rice and for this they charge a fixed amount of money per unit of rice. They also do not bear the transport cost. Usually, the *aratders* show the sample of rice to the wholesalers and the deal is finalized in most cases over telephone. Once the deal is finalized, the wholesalers send money through the banking channels and the agents send rice using trucks.

The rice wholesalers are big rice traders with large storage capacity in the wholesale market for rice. They generally purchase rice from the millers through commission agents but the practice has undergone changes with rapid expansion of the automatic milling industry. The wholesalers, especially in the urban areas, purchase rice from the millers using modern communication technologies and banking services. Although the initial trading usually takes place after full payment for the shipment, but with building of trust and relationship between the two parties, the transactions involve both cash and credit. In the present study, nearly 92 percent of urban wholesalers are reported to have purchased rice from the millers directly. Out of the total, wholesalers have sold 82 percent of rice to urban retailers.

The retailers are the last actor at the downstream of the rice value chain. They have permanent outlets in market places. Some retailers concentrate only on rice while there are others who sell rice along with other commodities. They collect rice from the wholesalers and sell to the final consumers.

One recent development is the gradual expansion of the modern marketing chain to cater to the growing needs of the middle class and the urban consumers. There are dozens of departmental stores in and around the urban areas especially in Dhaka city, selling all types of consumer goods including packaged and quality-differentiated rice. The supermarkets purchase the required fine quality rice from the wholesalers, agents of millers, and packaged rice from the wholesale market. Some of these supermarkets also have their own branded rice of different qualities packed in attractive packages. Usually, the branded and quality rice fetches premium prices over similar quality unbranded rice.

9.5.2 Characteristics of Rice Value Chain

The educational qualification varies across the actors of the rice value chain (Table 9.4). Paddy *aratdars*, millers, rice *aratdars* and wholesalers have secondary school (SSC) or higher secondary (HSC) level of education while other actors mostly have primary level of education. Only a small proportion of the actors are graduates.

The actors in the rice value chain have significantly different requirements in terms of capital.[5] The *farias* are small actors in the chain whose average investment is Tk. 50 thousand, while the investment is much higher for millers and rice wholesalers (Table 9.5). In terms of investment, these two actors are the big players in the rice value chain. Among different types

[5] The growers' investment is not considered here as the investment varies widely depending on the amount of land owned or cultivated, land price, quality, location and a host of other factors.

of millers, primary investment by auto millers is almost 34 times that of husking mills and five times that of semi-auto mills.

Table 9.4: Educational Level of the Value Chain Actors

Educational Status	Grower	Faria/ bepari	Paddy aratdar/ agents	Millers	Rice aratdar/ agents	Whole-saler	Retailer
Illiterate	5.4	19.0	…	…	…	…	…
Only read and write	12.5	…	…	…	2.1	3.3	3.1
Primary incomplete (1-4)	3.6	19.0	16.7	6.3	4.3	…	…
Primary complete (5-9)	37.5	47.6	11.1	20.8	25.5	13.3	53.1
SSC	12.5	4.8	33.3	31.3	34.0	33.3	12.5
HSC	14.3	4.8	27.8	31.3	25.5	33.3	25.0
Graduate	14.3	4.8	11.1	10.4	8.5	16.7	6.3
Total	100	100	100	100	100	100	100

Source: Field Survey.

Table 9.5: Capital Investment of Rice Value Chain Actors

Actor	Primary capital (000 Tk.)	Own Fund (%)	Loan (%)	Loan from formal source (as % of total loan)
Faria/bepari	50.3	78.1	21.9	27.3
Paddy *aratdar*/agent	195	64.0	36.0	46.4
Miller	12,090	25.5	74.5	98.5
- Engle berg (Huller) or chatal	1,040	45.3	54.7	97.3
- Major or semi-auto	6,600	20.7	79.3	100
- Automatic	34,570	10.5	89.5	100
Agents/*aratdar* cum wholesaler	910	52.3	47.7	78.2
Wholesaler	1,240	34.0	66.0	20.0
Retailer	207	54.1	45.9	2.0

Source: Field Survey.

To ensure smooth supply of paddy, the millers keep stocks of paddy in their own warehouse, keep stocks with large growers and also maintain extended business communications with paddy wholesalers or commission agents in different parts of the country. The large stocks maintained by the millers can therefore influence the rice price, especially during the lean periods, and often high rice prices are attributed to the existence of

"syndicates" among the millers which enable them to manipulate prices. The piling up of stocks, even for short periods, gives the millers, especially the auto rice millers, leverage to influence price.

The study survey shows the existence of close relationship of the millers with the paddy *aratdars* and commission agents (Table 9.6). They collect nearly 76 percent of the paddy from these actors. Around 14 percent of the paddy collected by them are from growers, which is often settled with the condition that growers keep the stocks with them and the millers will collect later at convenient time. The miller collects paddy from different sources; only a small proportion of paddy is bought at the mill gate.

Table 9.6: Sources of Paddy for Different Millers

Actor	Husking Mill	Semi-auto or major	Automatic	All
Grower	13.8	9.4	14.9	14.0
Faria	1.9	…	1.7	1.7
Paddy *aratdar*/commission agents	71.0	90.6	80.4	75.6
Others	13.3	…	3.0	8.7
Total	100	100	100	100

Source: Field Survey.

The millers mostly sell their rice-to-rice *aradars* or commission agents (Table 9.7). More than 77 percent of the rice is sold through these actors. Thus, both in purchasing paddy or selling rice, the commission agents or *aratdars* play a big role in the rice value chain. Only a small proportion of rice is sold directly to the wholesalers or to the retailers.

Table 9.7: Major Buyers of Rice from Millers

Buyer	Husking mill	Major	Automatic	All
Rice *aratdar*/commission agents	76.0	75.5	80.1	77.5
Wholesaler	13.9	11.7	13.1	13.5
Retailer	5.7	1.1	4.7	5.1
Government	4.3	11.7	2.0	3.9
Total	100	100	100	100

Source: Field Survey.

9.5.3 Exchange Relationship and Dependence

Each value chain actor is usually involved in exchange relationship with actors working immediate at the upstream or downstream under substantially different environments. While there is diversity in the vertical relationship, differences are also observed horizontally. The rice growers, however, remain in a different segment of the market in their production stage where they are involved in the purchase of inputs like fertilizer, seed, pesticides and invest in irrigation.

Exchange Relationship of Growers

The major inputs used by the growers involving market transactions include seed, fertilizer, insecticides, irrigation and ploughing. A total of 53.6 percent of the surveyed growers report that the dealers determine the price of seed, while 37.5 percent hold that it is determined by the market (Table 9.8). In the case of fertilizer or insecticides, mainly the government determines the price (reported by 66.1 percent of the surveyed growers). Suppliers of irrigation facilities mainly determine the price of irrigation (reported by 66.1 percent of growers), while 30.4 percent hold that the government determines the price of irrigation.

Table 9.8: Determinants of Input Prices Perceived by Rice Growers

Input	Market	Dealer	Supplier	Government	Others
Seed	37.5	53.6	7.1	1.8	-
Fertilizer and insecticides	17.9	14.3	1.8	66.1	-
Irrigation	1.8	1.8	66.1	30.4	-
Ploughing	14.3	21.4	-	-	64.3

Source: Field Survey.

Exchange Relationship of Other Actors

Personal relationships and locality play important roles in the transaction of paddy from the growers to the millers directly or through *farias, beparis* or commission agents. More than 80 percent of the surveyed rice farmers sell paddy either to local people directly or in the local market (Table 9.9). This is true for all categories of rice farmers (e.g., small, medium and large). The *farias, beparis* or commission agents, paddy *aratdars* and millers (in general) also collect paddy from the locality. However, while the *farias* and

beparis prefer direct interaction with local farmers, other actors usually prefer exchange through the local market. In the upstream market (market for rice), rice *aratdars* and wholesalers prefer to purchase from exchange partners or persons having business relations, while the retailers mostly collect rice from the local market. This indicates that the wholesalers try to minimize their risks in business by having business relationship with their relatives and trusted persons in the business. At this tier of the value chain, since large volume of transactions are made without on-the-spot contacts, trust emerges as an important factor both for monetary reason and ensuring the quality of the product.

Table 9.9: Determinants of Source of Paddy/Rice Supply

Actor	Local individual	Local market	Quality	Price	Relatives
Paddy *farias*	72.7	9.1	18.2	…	…
Beparis	54.5	36.4	9.1	…	…
Commission agents	50.0	50.0	…	…	…
Aratdars	30.0	70.0	…	…	…
Millers	14.6	47.9	33.3	4.2	…
- Husking mill	10.3	51.7	31.0	6.9	…
- Major	…	25.0	75.0	…	…
- Automatic	26.7	46.7	26.7	…	…
Rice *aratdars*	21.3	4.3	…	…	74.5
Rice wholesalers	20.0	…	…	…	80.0
Rice retailers	81.3	3.1	…	…	15.6

Source: Field Survey.

In exchange transactions, the terms (e.g., prices at which exchange takes place) mostly depend on market conditions at the time of exchange. However, 45.5 percent of the *farias,* 18.2 percent of the *beparis*, 25 percent of the commission agents and 30 percent of paddy *aratdars* identify the millers as the major actor who sets the terms in the market (Table 9.10). Moreover, a significant share of the actors (including 40 percent of the *aratdars*) holds the view that *beparis* and millers together control the market.

Table 9.10: Major Actors Influencing Rice Market

Actor	Market conditions	Millers	*Baparis* and millars together	Government
Farias	36.4	45.5	18.2	…
Beparis	45.5	18.2	27.3	9.1
Commission agents	50.0	25.0	25.0	…
Aratdar	30.0	30.0	40.0	…
Millers	91.5	…	…	8.5
- Husking mill	89.7	…	…	10.3
- Major	75.0	…	…	25.0
- Automatic	100.0	…	…	…

Source: Field Survey.

9.5.4 Value Creation and Competitive Advantagew

The market conditions at a particular period are found to be the main determinant of the price of paddy. On the other hand, the strength of the negotiation power of the concerned agents ultimately determines the final price at which exchange takes place. Moreover, understanding with the millers plays a significant role in paddy transactions between millers and other agents in the downstream value chain. The quality of paddy or rice and the current market price are the two most important information for all actors in the chain. To understand the competitiveness of the rice value chain, it is important to know how the price is determined.

The survey shows that, in the case of paddy, only 3.5 percent of the respondents report the market conditions as the determinant of price; while most believe that price is set through understanding with millers, negotiations and through communications among relevant stakeholders (Table 9.11). Thus, there are indications of a lack of competitiveness in the paddy market. In the case of the rice market, most millers note negotiations, market price and the quality of rice to be the main influencing factors in price determination. In the upstream value chain, most commission agents, wholesalers and retailers mention the market condition as the main determinant of price of rice at the respective tiers of the value chain, indicating some degree of competitiveness at these stages.

Another way of looking into the competitiveness of the market is to find out the existence of leaders in the market (Table 9.12). Most of the actors consider themselves to be "ordinary" actors or price takers. However, most of the actors acknowledge the existence of leader in the value chain. According to most of the actors, millers are the leaders in the market. Even 19.2 percent

of the millers think that millers are the leaders. In this case, actually the traditional millers consider the large auto millers to be the leaders. Most of the actors also think that millers gain the most in the value chain. According to the respondents, the millers gain largely by keeping stocks when the price is low and with the financial leverage of selling rice on the basis of the market situation. Thus, it seems that there exists some form of coalition among powerful value chain actors who are able to influence the price. This increases the risks of other actors who are not the leaders, as market interventions by the millers may contribute to making the rice market more unstable.

Table 9.11: Factors affecting Price Determination of Paddy and Rice

	Percent of respondents
Farias, beparis, aratdars and agents: price settlement of paddy	
Price of paddy	5.3
Quality of paddy	8.8
Negotiations	22.8
Through communications	14.0
Understanding with millers	26.3
Market condition	3.5
Through other traders	19.3
Millers: price settlement of rice	
Market condition	23.7
Negotiations	34.2
Through agents	11.8
Keeping stock	2.6
Quality of rice	23.7
Through communication	3.9
Rice commission agents/rice *aratdars*: price settlement of rice	
Market condition	68.1
Settled by millers	27.7
Settled by the commission agents	2.1
Others	2.1
Wholesalers: price settlement of rice	
Market condition	53.3
Settled by millers	46.7
Retailers: price settlement of rice	
Market condition	96.9
Settled by millers/wholesalers	3.1

Source: Filed Survey.

Table 9.12: Leadership Perception of Supply Chain Actors

(percent of respondents)

	Growers	*Faria*	*Bepari*	Agents	*Aratdar*	Millers	Rice *aratdars*	Rice Wholesalers
Position/status in the rice supply chain								
Leader	1.8	…	…	…	…	4.2	2.6	6.7
Ordinary actor	78.2	90.9	63.6	75.0	100.0	95.8	92.1	66.7
Price taker	16.4	9.1	36.4	25	…	…	5.3	26.7
Others	3.6	…	…	…	…	…	…	…
Existence of leader								
Yes	70.6	54.5	70.0	85.7	60.0	55.3	63.2	100.0
No	25.5	45.5	30.0	14.3	20.0	47.7	36.8	…
Do not know	3.9	…	…	…	…	…	…	…
Who is leader								
Grower	…	…	…	…	…	3.8	…	3.3
Faria/bepari	20.0	…	…	…	…	7.7	…	3.3
Miller	71.4	83.3	100.0	100.0	100.0	19.2	95.8	93.3
Rice wholesaler	…	…	…	…	…	19.2	4.2	…
Supermarket	…	…	…	…	…	23.1	…	…
Retailer	…	…	…	…	…	3.8	…	…
Others	8.6	16.7	…	…	…	23.1	…	…

Continued

Continued from Table 9.12

	Growers	*Faria*	*Bepari*	Agents	*Aratdar*	Millers	Rice *aratdars*	Rice Wholesalers
Perception about who gets most benefits								
Grower	2.2	…	…	…	…	4.5	…	…
Faria/bepari	4.3	…	…	…	…	…	7.1	…
Miller	82.6	90.9	87.5	100.0	100.0	4.5	78.6	96.3
Wholesaler	6.5	…	…	…	…	4.5	…	…
Super market	4.3	9.1	12.5	…	…	54.5	10.7	3.7
Retailer	…	…	…	…	…	4.5	3.6	…

Note: Not all actors did respond to all queries.

Source: Field Survey.

9.6 Marketing Margin in the Rice Value Chain

In the vertically integrated value chain for rice, various segments of the market are managed by different actors facing divergent business environments. They perform different functions, face varying market opportunities, and thus earn different marketing margins. The analysis of marketing margin indicates the returns earned and costs incurred by various actors, thus revealing the quality of management of the value chain and indicating ways to improve the system.

9.6.1 Marketing Margin in Traditional Rice Value Chain

The main actors in the traditional rice value chain include growers, paddy *farias*, paddy *aratdars*, millers, rice *aratdars*, rice wholesalers and rice retailers. Table 9.13 summarizes the gross and net margins accrued to various actors in the traditional rice value chain. The margins have been grouped for three types of rice, namely coarse, medium and fine.

Table 9.13: Gross and Net Marketing Margins of Rice

(Taka per kg)

Actor	Gross margin			Net margin		
	Coarse	Medium	Fine	Coarse	Medium	Fine
Grower	0.91	2.43	6.41	0.60	2.07	6.00
Faria/bepari	2.02	1.90	2.53	1.26	1.12	1.68
Paddy *aratdar*/agent	1.30	1.81	3.97	0.53	1.01	3.13
Miller	5.28	5.48	7.73	1.63	1.76	3.98
- Husking	5.21	5.44	7.77	1.59	1.75	4.06
- Major or semi-auto	5.13	5.29	7.07	1.31	1.39	3.15
- Automatic	5.12	5.36	5.58	2.00	2.18	2.38
Agents/*aratdar* cum wholesaler	1.22	1.30	2.89	1.06	1.02	2.60
Wholesaler	2.36	2.13	2.18	1.63	1.38	1.43
Retailer	2.51	2.37	1.98	2.29	2.13	1.75

Note: In the case of transaction in paddy, rice equivalence is taken.

Source: Field Survey.

It is observed that except for rice wholesalers and retailers, all other agents in the value chain earn the highest gross and net margins in the case of fine rice, although the cost incurred by each agent for fine rice variety is also higher. As higher net margin is incurred at every stage, the ultimate price gets higher for fine rice. This is possible because the market for fine

rice is somewhat limited and this variety is mostly consumed by the richer segment of the consumers.

For the growers, both gross and net margins are significantly higher for the fine variety relative to coarse and medium varieties of rice.[6] One reason for this is the scarcity premium that the growers can earn due to relatively small supply of the fine variety of rice. The survey conducted under one study shows that, out of total production, the share of fine variety is less than 3 percent, while the shares of medium and coarse varieties are more than 80 percent and 17 percent respectively (BIDS 2012). There are significant variations in the proportion of production of different varieties during the three seasons. For example, during the *aus* season, the share of medium variety is reported to be 81 percent and that of coarse variety is 19 percent, while no fine variety is produced. In the *aman* season, the shares of fine, medium and coarse varieties are 2 percent, 69 percent and 29 percent respectively, while similar shares in the *boro* season are nearly 4 percent, 90 percent and 7 percent respectively. One of the major factors that contribute to low share of fine variety in total production is the existence of significant agronomic and technological constraints that limit wider cultivation of fine varieties of paddy.

For all types of rice, the millers earn the highest gross margin; however, when net margin is considered, margins earned by millers are much lower. This is because the processing cost incurred by the millers is proportionately higher than the cost of marketing by the growers or retailers. The more polished the rice, the more the cost incurred by the millers. Among different types of millers, the modern auto rice mills earn the highest net margins for coarse and medium rice, while traditional husking mills earn the highest net margin for fine rice. In case of fine rice, the cost incurred by auto rice millers gets higher as they incur extra cost for color sorting and polishing.

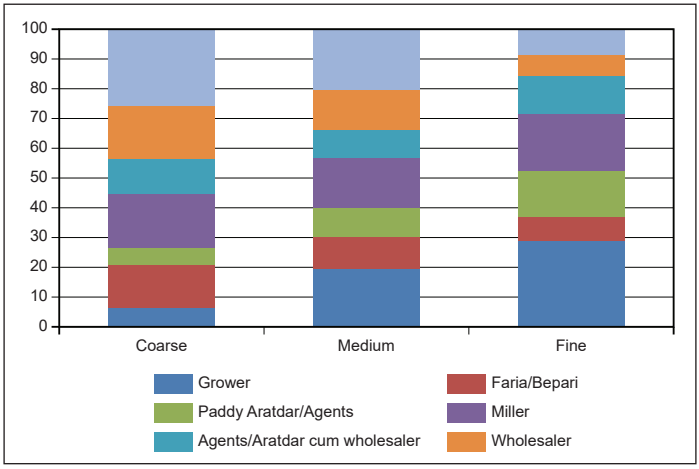
For coarse and medium rice, the retailers earn the highest net margin while the growers earn the highest net margin for fine rice. Whether for rice or paddy, the commission agents or *aratdars* earn a fair amount of net margin compared with other actors. While the social desirability of the existence of different tiers in the value chain may be debated, it is noticed that these tiers (and associated actors) play a crucial role in the marketing chain in terms of setting relationships between the buyers and the sellers and also in taking risks.

Figure 9.6 shows that the shares of big players in the rice value chain in terms of net marketing margin differ across different variety of rice. Around

[6] In the present study, production data are collected by broad categories of paddy (*aus, aman* and *boro)* in terms of name/type of paddy. The growers also classified their cultivated paddy in terms of three categories—coarse, medium and fine quality.

25 percent of the net margin of coarse rice goes to the retailers, while their share is 20 percent for medium rice. The growers earn 29 percent of the net margin for fine rice. Thus, the conventional belief that the net margin earned by the growers is very low is not supported by the findings of the present study for fine quality rice but the margins earned by farmers for medium and coarse varieties of rice are relatively low. More interestingly, though the growers are supposed to receive price support from the government for coarse rice (through the public procurement under public food distribution system), they earn very low net margin for this variety of rice.

Figure 9.6: Share of Different Actors in Net Marketing Margin



Source: Field Survey.

The percentage of profits earned by different actors in the rice value chain is given in Table 9.14. The profit is calculated as the percentage of difference between the breakeven price and the sale price. It is interesting to note that the growers earn the highest profit in case of medium and fine rice, while retailers earn the highest profit for coarse rice. The rate of profit varies from around 2 percent to 26 percent. The millers earn profit of 6 to 11 percent depending on the variety of rice. Thus, the millers earn lower rate of profit compared with that of the growers in case of medium and fine rice. However, the number of millers is much lower than the number of growers; therefore, the average profit of each miller would be much higher than the average profit of each grower.

Table 9.14: Profit Earned by Different Actors

(Tk. per kg. of rice)

Actor	Breakeven price			Sale price			% of profit		
	Coarse	Medium	Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
Grower	19.62	22.59	22.92	20.2	24.7	28.9	3.05	9.16	26.16
Faria/bepari	20.83	25.50	32.15	22.1	26.6	33.8	6.05	4.37	5.21
Paddy *aratdar*/agents	21.05	25.50	33.40	21.6	26.5	36.5	2.52	3.96	9.36
Miller	23.07	28.24	35.32	24.7	30.0	39.3	7.07	6.23	11.28
- Husking	23.11	28.25	35.24	24.7	30.0	39.3	6.88	6.21	11.52
- Major or semi auto	23.39	28.61	36.15	24.7	30.0	39.3	5.59	4.85	8.70
- Automatic	22.70	27.82	36.92	24.7	30.0	39.3	8.83	7.84	6.46
Agents/*aratdar* cum wholesaler	24.58	30.91	40.39	25.6	31.9	43.0	4.31	3.29	6.44
Wholesaler	27.28	32.24	41.48	28.9	33.6	42.9	5.98	4.30	3.46
Retailer	28.18	33.24	42.31	30.5	35.4	44.1	8.12	6.39	4.14

Note: Breakeven price = (purchase price of rice – by-product value) + cost.

Source: Field Survey.

9.6.2 Marketing Margin of Modern Value Chain

The modern value chain (supermarket) differs from the traditional chain after the miller/wholesale level. At this stage, while the traditional chain involves flow of rice to large number of wholesalers (when miller is the departure point) or retailers (where wholesaler is the departure point), the modern chain involves purchase of rice by limited number of supermarkets or by private rice trading firms selling packaged rice either from the millers or the wholesalers through their agents. The supermarkets sell both packaged and unpackaged rice. In case of packaged rice, the supermarkets may do the packaging on their own or purchase packaged rice from private companies who wholesale packaged rice.

The supermarkets usually sell rice (of similar quality) at 8 to 10 percent higher than the price in traditional retail shops. Moreover, these supermarkets sell mostly fine quality rice and some medium rice, but usually not the coarse variety of rice. This is because the supermarkets mainly cater to the rich and upper- middle-class consumers. Although many middle-class consumers roam the supermarkets for processed food or other packaged items, but for rice they mostly depend on traditional retail shops. Assuming that the gross margin estimation for all actors except the retailers to be the same as the traditional chain and adding gross margin earned for rice by the supermarkets, the distribution of the margin among different actors in the modern value chain is given in Table 9.15.

Table 9.15: Share of Gross Margin among Modern Rice Value Chain Actors

Actor	Coarse	Medium	Fine
Grower	8.5	23.0	31.0
Faria/bepari	15.6	11.5	8.5
Paddy *aratdar*/agents	6.5	10.4	16.0
Miller	24.0	21.6	21.6
Agents/*aratdar* cum wholesaler	8.2	6.4	11.2
Wholesaler	13.7	8.9	4.7
Supermarkets	23.6	18.1	7.0
Total	100	100	100

Source: Field Survey.

The supermarkets earn nearly 24 percent of the gross margin for coarse rice, 18 percent for medium rice and 7 percent for fine rice. The share is small for fine rice because the traditional retail shops also sell fine rice with

high margin, and therefore the difference of margins between traditional and modern retailers is not very evident.

9.7 Food Security and Improved Rice Value Chain

For agricultural commodities like rice, the spread between the prices at the farm level and the retail level (which is commonly known as the gross marketing margin) is taken as a measure of operational efficiency (Crawford 1997). The lower the gross marketing margin, the better is the marketing channel as the product is delivered to the consumers at lower cost.[7] There are, however, limitations of the concept as a measure of marketing efficiency since, with higher demand for more processed food and adoption of modern marketing techniques, the marketing margin may increase which is not necessarily related to marketing efficiency.

9.7.1 Implications of Marketing Margin Analysis

The results of the above marketing margin analysis show that the farmers receive from nearly 66 percent to 70 percent of the prices paid by the consumers for different varieties of rice. The share of all other participants is between 30 percent to 34 percent of the gross marketing margin. It should, however, be noted that the above share of the farmers includes the production cost of paddy. If the production cost is excluded, then the share would be much lower (between 7 percent to 29 percent). One should also note the low turnover rates for the farmers, since rice production takes more than three months whereas the other chain participants have much lower turnover rates, especially during the harvesting period. As is well known, the small rice farmers usually face significant disadvantages in terms of access to credit from the institutional sources, tied credit from informal sources at highly unfavorable terms, risks of crop loss due to natural disasters, high volatility of farm gate price, and many other adverse circumstances.

The village traders *(farias/beparis*), on the other hand, are seen to earn the lowest margin (around 10 percent) among different chain participants. The turnover rate of the village traders is, however, higher. Moreover, the village traders normally bear limited risk in business, and hence their returns may be considered relatively satisfactory relative to other chain participants especially the farmers.

---

[7] However, when the process involves processing of the product (e.g., transforming paddy into rice) such that the quality and attributes of the product change, then the gross marketing margin may not adequately reflect the efficiency of the marketing process since the transformation of the product has an impact on prices.

The study identifies the rice millers as the most powerful group in the chain. Through earning a large share in total value created from the rice trade, the rice millers have enough capacity and power to influence and control the value chain in a manner that can protect their interest.

The three rice value chains (studied in the present study) in operation in Bangladesh show that the farmers get similar prices under alternative chains. This indicates that the alternative value chains do not have much impact on farm gate prices. One implication of the above is that, although the millers produce differentiated rice using specific and finer quality characteristics under the supermarket value chain, such price differentiation does not get reflected at the farm gate level except for price variation across broader category (e.g., fine, medium, and coarse varieties as in traditional chain). This shows that, in the case of rice in Bangladesh, the end product quality variation does not bring much benefit to the farmers. The major beneficiaries of such differentiation are the millers and other participants in the downstream chain e.g., wholesalers, retailers, and the supermarkets.

It is, however, safe to assume that the role of the supermarket chain will continue to grow as the modern retail chain becomes more popular with the consumers. The rise in the number of modern retailers will also increase the production of packaged rice in the country. One likely development of such trends is that the market will become more differentiated, in which only the efficient suppliers will be able to survive in the longer term. The rice market will increasingly be dominated by branded and packaged rice of highly differentiated quality. The successful brands will be able to earn premiums facilitated by popularity and higher competitiveness. The traditional value chain, on the other hand, will cater to the needs of the rural and bulk consumers, with local producers competing to capture higher shares in the rice market.

From the above, it is clear that the supermarket value chain is potentially more profitable compared with alternative chains as it can generate higher profit margin per unit of the differentiated product (rice). However, the entry to this modern value chain is somewhat restricted to millers and other participants having quality output and adopting better business techniques. On the other hand, the entry to the traditional value chain is more open to chain participants having different attributes and operating with wide range of technical attributes and scale of operation.

The marketing margin analysis further shows the disadvantaged situation of the farmers who receive the least returns along with a higher share of risks. Their participation in post-harvest operations and downstream marketing of rice is minimal as most of the rice growers sell their paddy at the farm gate

or to the local traders. The rice millers are the most powerful actor in the rice value chain appropriating the highest share of the net margin. They also have high turnovers, especially the large ones. The large rice millers, by virtue of their big volume of business, can exert significant influence on the value chain, especially at the downstream level, and create pressure on the chain participants to act in favor of the interest of the large millers (CPD 2015).

In addition, only the big rice millers (and relatively big suppliers) enjoying large economies of scale and other advantages can take the advantage of entering into contracts with the government for supplying rice to the public procurement system. The large capacity of their machines and the use of modern technology give them the advantages of harnessing better paddy to rice conversion ratio and become more efficient. The present rice procurement system appears to exclude small and traditional rice millers, as well as farmers, and shows indications of increasing dominance by large rice millers (e.g., automatic and/or semi-automatic rice mills) who will exert significant control over rice processing and marketing in Bangladesh (CPD 2015).

9.7.3 Drivers of Competition in the Rice Market

For improving the efficiency of the rice value chain and ensuring a more equitable sharing of the marketing margins, it is important to identify the drivers of the competitive advantage of the chain and understand how dependency relationships and power structure among the chain participants affect the value creation process. The analysis of the value chains in the present study depicts a picture of traditional supplier-buyer relationships among the closest exchange partners, with very little orientation toward joint value creation. Since rice farming is dominated by small farmers having little land and a large number of village traders are involved as primary collectors from the farmers, it seems rather difficult to develop effective interdependencies at the upstream level of the chain.

On the other hand, the interrelationship among the chain participants at the downstream level depends on interactions of a complex set of factors including power, value creation, management capacity, and competitive position of the specific actor vis-à-vis his/her closest exchange partners. There exist several defining features of such relationships such as physical characteristics of rice (e.g., quality and product differentiation), mutual dependence in terms of power, influence, and other relational attributes, value sharing capacity, and the competitive power of the participant within the chain. These elements also are integral to forming and determining the overall strength of the chain itself. The rice value chains analyzed in

this study reveal that, despite the emergence of some collaboration-based relationships among some partners (e.g., millers, wholesalers, and retailers), these are very contextual and do not really contribute much to creating a competitive and efficient rice marketing in the country. As a result, the value chains remain weak with little coordination across different stages (both upstream and downstream) of the chain.

The rice value chains are characterized by the production and supply of rice in which the total margins remain relatively unchanged over the entire chain. This is also true for most of the food crops (O'Keefe 1997). In such circumstances, the appropriation of a larger margin by one participant necessarily means lower shares for others. This is particularly true for the traditional rice value chain where rice is traded in bulk and transactional relationships are the dominant features among the participants. The supermarket value chain, on the other hand, has more differentiation and greater scope of increasing the total margin of the chain by developing mutually interdependent relationships among exchange partners. However, since there exist asymmetric power relationships among the participants, moves toward forming closer relations often turn into unequal partnerships in which the focus becomes serving the interest of the powerful partner rather than collaborative achievement of common goal. Thus, asymmetric dependence and unequal power relationship inherent in the value chain are factors that constrain the realization of the benefits of quality differentiation.

Nevertheless, the study brings out the importance of power relationship and quality differentiation as the two important drivers of the quality of mutual relationships among the chain participants. The extent of value creation and its sharing by the participants which ultimately determine the competitive strength of the chain are influenced by several factors including various imbalances (e.g., power, size, and dependence) and nature of relationship management. Appropriate reorganization of these determinants is necessary to create an environment in which greater efforts would be forthcoming toward joint value creation across the chain and its more equitable sharing among the exchange partners.

9.7.4 Implications for the Rice Sector

The present study suggests that the existing rice value chains in the country are characterized by business behavior of the participants which follows a more individualistic rather than a system-based approach. Such a narrow pursuit of interests by the chain members does not promote efficiency across the chain, resulting in low value creation and unjust appropriation of value by the powerful partners. This also does not create competitive behavior

among the chain members which is vital for innovation and change. The situation is further complicated by the dominance of the small rice growers whose outputs are too little to supply directly to the rice millers. The existence of heterogeneous groups of middlemen among the major players (e.g., farmers and the rice millers) in the upstream of the chain makes it difficult to create beneficial interdependence relationships between these players. It is important therefore to adopt policies which would facilitate the emergence of a whole chain-based approach to develop the rice sector through public, private, or public-private partnership approach.

One important implication of adopting the value chain approach would be the reduced need to hold large inventories of rice/paddy by the major chain participants in order to ensure smooth supply management across different seasons. The traditional system creates a situation in which stock holding tends to remain concentrated with the powerful partners (e.g., millers and wholesalers). This acts against the interests of other partners, including the farmers, since such stock holding gives them undue power to control the rice market and the capacity to influence the whole chain to work to their own advantage. Furthermore, with the expected rapid expansion of the modern value chain, the rice millers would probably have to provide more financial support (e.g., tied credit) to the upstream suppliers of paddy to ensure regular supply of the desired quality and quantity of paddy by the upstream suppliers. As rice becomes more differentiated under the modern chain, the millers and downstream suppliers will also have incentives to work more closely with the farmers and upstream suppliers to produce and supply specialized rice that can fetch higher value in the market, such as specific variety fine quality rice, aromatic rice, and organic rice.

The expansion of the supermarket value chain is more likely therefore to lead to the creation of conditions in which more collaborative and dependent relationships may flourish in the rice market. As the trend towards seeking such relationships across different exchange partners gets stronger, this will create an opportunity for implementing the concept of value chain management to improve the competitiveness and efficiency of the entire chain. The key concern is to implement measures that will encourage the development of collaboration relationships based on established management principles which will be beneficial not only to the individual chain members, but will also improve the competitive advantage of the entire chain. However, if the power relationships among the chain participants continue to remain asymmetric, then the weak exchange partners would remain deprived and the entire value chain will be less competitive leading to low value creation and its inequitable sharing among the participants.

For improving the rice value chain, it is important to adopt measures based on the principles of value chain management which will contribute to improving the performance of the rice market. Equitable value sharing among the chain members will be key to improving the competitive advantage of the rice sector, which can in turn contribute to improving the overall food security in the country through a more productive and efficient rice sector (CPD 2015).

9.7.5 Policy Framework for Improving Rice Value Chain

The key concern in rice value chain management is to establish collaborative relationships on equitable terms among all exchange partners in the chain. Although such management brings benefit to all participants, it is difficult to develop comprehensive practices mainly due to the fact that this requires re-organizing power relationships which the strong chain partners are mostly unwilling to concede. The experience with respect to agribusiness sector in general even in developed countries is not very encouraging in this respect (see O'Keefe 1998; Cox and Chicksand 2007). In Bangladesh, even the recent trend towards closer relationships especially at the downstream level under the supermarket chain is largely guided by group interest rather than working collaboratively with all exchange partners. This happens mainly due to a lack of value chain orientation in the strategic management behavior.

For promoting food security, the major concerns with respect to rice in Bangladesh are to: (i) increase rice availability which needs higher productivity, efficient post-harvest practices, and an efficient rice value chain to serve the consumers more effectively; (ii) enhance access to rice through ensuring reasonably stable rice prices, improving farmer/rural incomes, and creating better participation and sharing of rice value additions; and (iii) increase stability of the rice sector which requires improved and sustainable competitive advantage of the rice sector.

In Bangladesh, the food security policy agenda puts emphasis on achieving self-sufficiency in rice production, for which one of the important strategic concerns is to ensure fair prices to the farmers for maintaining the profitability of growing rice. The value chain management therefore needs to contribute to enhanced and more stable rice income, which can be achieved by bringing the farmers closer into the rice value chain. Within the existing market structure, any trend of declining rice price in the retail market is rapidly transmitted to the farm gate level (e.g., during peak harvest periods) but similar price transmission seldom occurs in the case of price rise. Even if this occurs under the current production conditions, the

farmers are unlikely to benefit much as most of the poor farmers sell their produce immediately after harvest. It is important therefore to enhance the ability of the farmers to effectively participate in the value chain by giving them financial and other necessary support.

A critical element in developing collaborative working relationships among the chain partners is to create the realization that interdependent (but not dependency-based) relationships can promote collective welfare of all chain participants along with a competitive rice market. While the existence of asymmetric power relations is a major barrier, the rice millers and other key chain members can be persuaded to become the initial drivers for developing more collaborative relationships with favorable support from relevant public/private agencies.

The small farmers, who by far are the overwhelming majority of the rice growers, are constrained by several factors (e.g., small amount of rice which can only be sold to local traders, limited capacity of storage, inadequate access to finance) to enter into collaborative relationships with the value chain partners. One policy option to overcome the constraint is to form alliance of the small rice farmers (e.g., cooperatives, rice farmers' organization/association) which would give them collective capacity to effectively deal with vertical partners in the rice value chain. The creation of the economies of scale will increase their capacity and bargaining power, reduce transaction costs, and promote more balanced interactions with other exchange partners. Although the history of primary producer organizations in Bangladesh is an account of failures, proper recognition of the nature of rice value chain structure and relationships would be necessary in creating sustainable organizations of small rice farmers.

The strategic thrust of the present food security policy agenda focuses on increasing rice production and productivity using better technologies, ensuring more effective water and soil management, applying balanced doses of fertilizer and other inputs, and adopting improved management practices. The policies, however, do not explicitly recognize the importance of value chain management as an effective tool for developing the rice sector. In view of the potential benefits of adopting a holistic value chain approach, the rice sector development strategy needs to encourage the promotion of more collaborative rice value chains.

Since collaborative partnership in the rice value chain is fostered by quality difference and the recent trend in the rice market is towards more differentiation, the government's action should focus on creating awareness and facilitating a better understanding of the benefits of developing holistic value chain relationships covering all exchange partners. In this context,

the government's facilitating measures to promote both horizontal (e.g., among the rice farmers) and vertical (e.g. better inclusion of rice farmers) coordination will encourage the farmers and other chain members to participate in collaborative value chain relationships.

Along with supportive measures, the government needs to enact and enforce effective competition policy and regulations so that the strong partners cannot dominate the chain and the chain members get equitable share of the value addition. An important outcome of the value chain management approach is the improved position of the farmers who at present are marginalised in the value chain. This will not only increase farmers' income but also provide incentives to the farmers to increase rice production and productivity and thereby enhance food security in the country.

With gradual movement toward more differentiation in terms of quality and other attributes in the rice market, the pursuit of food security through increased rice production requires the adoption of a value chain approach rather than the current narrow focus covering the production of rice alone. Since the value chain focus provides the entire spectrum of the value creation process for different qualities of rice, this provides a better understanding of the entire rice market and its underlying dynamics. Moreover, the understanding of the specific features of each rice value chain individually has the advantage of identifying their separate characteristics and adoption of chain-specific approaches to policies and strategies for improving the competitive advantage of the rice market.

9.8 Summary and Conclusions

Rice plays the key role in the food security agenda of Bangladesh. As the main crop in the agricultural production system and the staple food for the population, improving the rice value chain can bring significant advantages for the chain participants, especially the small rice farmers, through enhanced competitiveness and more equitable distribution of value addition across the entire chain. This is also necessary for sustaining high growth in the rice sector necessary for food security in the country.

In the rice market, exchange relationships among the participants are mostly based on interactions confined to one stage of the chain rather than across the entire chain, and focused on transactional exchange rather than value creation. Such relationships do not create value jointly by the participants and hence are unlikely to enhance the competitive advantage of the chain (Mujeri 2019).

The findings of the present study suggest that the reliance on the market alone is not likely to lead to more efficiency in the rice value chain and

enhance the competitiveness of the rice farmers. The government needs to adopt effective policies for ensuring fair prices to the growers through procurement and other means, and support farmers by creating storage facilities for paddy by the farmers (e.g., through cooperative, private-public partnership and other mechanisms), and encouraging farmers to enter into more collaborative vertical and horizontal partnerships to enhance capability and bargaining power (CPD 2015).

Moreover, with collaborative arrangements, the scope of additional value creation increases as each member is involved in the management of the value chain collectively which can be shared by the members with each one gaining from the process. This can contribute positively to food security as it enhances the incomes of the farmers creating positive incentives for them to increase rice production and productivity. With higher incomes, the farmers can also have access to more diversified food and better nutrition.

Better value chain also has the potential to reduce wastages at different tiers of the chain. The issue of wastage is important in Bangladesh since even if it is assumed that, out of 10 percent of total seed, feed and wastage (SFW) that is now being used, 4 percent accounts for seed and feed and the rest is wastage, the absolute amount of wastage would be around 1.92 million metric tons. With an average per capita consumption of around 166 kg of food grains per year, these losses would be enough to feed about 12 million people, i.e., about a quarter of the country's poor for about a year. Thus, the wastage has significant impact both at the micro and macro levels of the economy, especially with respect to issues related to food security. Improved value creation could also play a catalytic role in promoting supportive non-farm economic activities that will contribute to greater food security.

The existing characteristics of the rice value chain in Bangladesh indicate that the value chains are not competitive and the values are distributed among the participants in an inequitable manner. With proper policies, the chain can be made more competitive with creation of higher value along with more equitable sharing of the value among the participants. It is observed that the rice millers appropriate the lion's share of the value along with wholesalers and larger buyers in the downstream of the chain. In the upstream, the farmers remain the most disadvantaged. Under the existing power structure, the trend towards greater differentiation in rice varieties leads to closer interactions across the chain participants, but such relationships become biased in favor of the strong partners with consequent adverse impact on the weak members especially the farmers. This also leads to adverse consequences for food security of the farmers and the weak participants in the chain. Obviously, any asymmetric dependence-based

relationship within the rice value chain is not congenial to promoting welfare of the farmers and overall food security in the country.

From the food security point of view, consideration of a value chain approach instead of the current "narrow production focus" dominating the government's policy towards the rice sector would be a positive development contributing to sustainability of the rice production system in Bangladesh. The government can facilitate the value chain transformation process while allowing private sector participants who dominate the rice sector to play the main role. The government will have to adopt measures to encourage the participants to develop both horizontal and vertical collaborations covering the entire chain. The adoption of effective competition policy and guidelines can contribute to more equal sharing of value across the chain.

To sustain the benefits of an improved supply chain, rice productivity needs to increase continuously through adoption of improved technology and other measures. The failure to provide fair prices to the farmers, low innovations and productivity, and market imperfections are the outcomes of unfair dependency relationships and lack of collaboration across the chain. The implementation of a value chain focus for the rice sector will improve the conditions of the chain participants as well as deliver rice of better quality and higher value to consumers.

References

Aji, J. M. M. 2010. "Improving Food Security Through Supply Chain Management: A Study of Rice Supply Chains in Indonesia." PhD diss., University of Queensland, Brisbane.

Baffes, John, and Madhur Gautam. 2001. "Assessing the sustainability of rice production growth in Bangladesh." *Food Policy* 26, no. 5 (October): 515-542. https://doi.org/10.1016/S0306-9192(01)00019-7.

Batt, Peter J., and Nexhmi Rexha. 1999. "Building Trust in Agribusiness Supply Chains: A Conceptual Model of Buyer-Seller Relationships in the Seed Potato Industry in Asia." *Journal of International Food and Agribusiness Marketing* 11, no. 1: 1-17. https://doi.org/10.1300/J047v11n01_01.

BBS (Bangladesh Bureau of Statistics). 2005. *Household Income and Expenditure Survey 2005*. Dhaka: BBS, Ministry of Planning, Government of the People's Republic of Bangladesh.

___. 2010. *Statistical Year Book of Bangladesh*. Dhaka: BBS, Ministry of Planning, Government of the People's Republic of Bangladesh.

___. 2012. *Statistical Yearbook of Bangladesh*. Dhaka: BBS, Ministry of Planning, Government of the People's Republic of Bangladesh.

Bhuiyan, N. I., D. N. R. Paul, and M. A. Jabber. 2002. "Feeding the Extra Millions by 2025: Challenges for Rice Research and Extension in Bangladesh." In *Proceedings of the Workshop on Modern Rice Cultivation in Bangladesh,* 29-31 January, 4-23.

BIDS (Bangladesh Institute of Development Studies). 2012. *Estimation of Parameters Needed for Integrated and Effective PFDS Planning in Bangladesh*. Dhaka: Ministry of Food, Government of the People's Republic of Bangladesh.

Chowdhury, M. A. T. 2009. "Sustainability of Accelerated Rice Production in Bangladesh: Technological Issues and the Environment." *Bangladesh Journal Agricultural Research* 34, no. 3: 523-529. https://doi.org/10.3329/bjar.v34i3.3979.

Chowdhury, N. 1992, January. *Rice Markets in Bangladesh: A Study in Structure, Conduct and Performance.* Bangladesh Food Policy Project Manuscript 40. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Christopher, M. 1992. *Logistics and Supply Chain Management*. London and New York: Pitman Publishing.

CPD (Centre for Policy Dialogue). 2015. *State of the Bangladesh Economy in FY2015 and the Closure of Sixth Five Year Plan*. Dhaka: CPD.

Cox, Andrew, and D. Chicksand. 2007. "Are Win-Wins Feasible? Power Relationships in Agri-Food Supply Chains." In *Supermarkets and Agri-Food Supply Chains: Transformations in the Production and Consumption of Foods*, edited by D. Burch and G. Lawrence. Cheltenham, UK and Northampton, M.A.: Edward Elgar.

Cox, Andrew. 2001a. "Managing with Power: Strategies for Improving Value Appropriation from Supply Relationships." *The Journal of Supply Chain Management* 37, no. 1 (March): 42-47. https://doi.org/10.1111/j.1745-493X. 2001.tb00099.x.

___. 2001b. "Understanding Buyer and Supplier Power: A Framework for Procurement and Supply Competence." *The Journal of Supply Chain Management* 37, no. 1: 8-15. https://doi.org/10.1111/j.1745-493X.2001.tb00094.x.

Crawford, I. M. 1997. *Agricultural and Food Marketing Management*. Rome: Food and Agriculture Organization of the United Nations.

David, C. C. 1998. *Towards an Efficient Path to Food Security: The Philippine Case*. Makati City: The Philippine Institute for Development Studies.

Davis, John. 1985. "Structure-Performance Relationships in the Broiler Market." *European Journal of Marketing* 19, no. 7: 11-25. https://doi.org/10.1108/EUM0000000004726.

del Ninno, Carlo, Paul A. Dorosh, and K. Subbarao. 2005. *Food Aid and Food Security in the Short and Long Run: Country Experience from Asia and Sub-Saharan Africa* (mimeo). Washington, D.C.: World Bank.

del Ninno, C., Paul A. Dorosh, and Lisa C. Smith. 2003. *Public Policy, Food Markets, and Household Coping Strategies in Bangladesh: Lessons from the 1998 Floods*. FCND Discussion Paper. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Dorosh, Paul A., and Quazi Shahabuddin. 2002. *Rice Price Stabilization in Bangladesh: An Analysis of Policy Options*. MTID Discussion Papers 46. Washington D.C.: International Food Policy Research Institute (IFPRI).

FAO (Food and Agriculture Organization). 2008. *Climate Change and Food Security: A Framework Document.* Rome: Food and Agriculture Organization of the United Nations.

FPMU (Bangladesh Food Planning and Monitoring Unit). 2008. *The National Food Policy Plan of Action 2008-2015.* Dhaka: Food Planning and Monitoring Unit, Ministry of Food and Disaster Management.

___. 2012. *Data Base on Food Situation*. Dhaka: Food Planning and Monitoring Unit, Ministry of Food, Government of the People's Republic of Bangladesh.

Haq, A. K. E., M. Kabir, M. A. Eusuf, and S. Karim. 2010. *Assessing Competition of Rice Sector in Bangladesh*. Dhaka: International Finance Corporation (IFC).

Hossain, M. M. 2010. "Changing Consumption Patterns in Rural Bangladesh." *International Journal of Consumer Studies* 34, no. 3: 349-356.

Hossain, Mahabub, Firdousi Naher, and Quazi Shahabuddin. 2005. "Food Security and Nutrition in Bangladesh: Progress and Determinants." *Electronic Journal of Agricultural and Development Economics* 2, no. 2: 103-132.

Islam, N. 1998. "Flood '98 and the Future of Urban Settlements in Bangladesh." Presented at the National Seminar on Flood '98 and Management of Floods in Future, 8 December 1998, Dhaka.

Islam, R., and A. Rahman. 1985. *Agrarian Change, Labour Contracts and Interlinked Transactions in Labour, Land and Credit in Rural Bangladesh—A Study with Micro level Data*. ARTEP Working Paper. Bangkok: International Labour Organisation and Asian Employment Programme.

___. 1987. *Rural Industrialisation and Employment in Asia: Issues and Evidence*. New Delhi: International Labour Organisation and Asian Employment Programme.

Lambert, Douglas M., and Martha C. Cooper 2000. "Issues in Supply Chain Management." *Industrial Marketing Management* 29, no. 1: 65-83. https://doi.org/10.1016/S0019-8501(99)00113-3.

Liu, Yi, Yuan Li, Lei Tao, and Ying Wang. 2008. "Relationship Stability, Trust and Relational Risk in Marketing Channels: Evidence from China." *Industrial Marketing Management* 37, no. 4: 432-446. https://doi.org/10.1016/j.indmarman. 2007.04.001.

Mendoza, G. 1995. "A Primer on Marketing Channels and Margins." In *Prices, Products, and People: Analyzing Agricultural Markets in Developing Countries*, edited by Gregory J. Scott. Boulder, C.O.: Lynne Rienner Publishers.

Mentzer, John T., ed. 2001. *Supply Chain Management*. Thousand Oaks, London and New Delhi: Sage Publications.

Mentzer, John T., William DeWitt, James S. Keebler, Soonhong Min, Nancy W. Nix, Carlo D. Smith, and Zach G. Zacharia. 2001. "Defining Supply Chain Management." *Journal of Business Logistics* 22, no. 2: 1-25. https://doi.org/ 10.1002/j.2158-1592.2001.tb00001.x.

MFDM (Ministry of Food and Disaster Management). 2006. *National Food Policy 2006*. Dhaka: Food Planning and Monitoring Unit, Ministry of Food, Government of the People's Republic of Bangladesh.

Ministry of Finance. 2012. *Bangladesh Economic Review 2011*. Dhaka: Ministry of Finance, Government of the People's Republic of Bangladesh.

Murshid, K. A. S., Nazneen Ahmed, Md. Yunus, and S. M. Zulfiqur Ali. 2009, December. *Re-emergence of Food Insecurity in Bangladesh? Instability in Food Production and Prices, Nature of Food Markets, Impact and Policy*. Dhaka: Food and Agriculture Organization (FAO) and the Food Planning and Monitoring Unit (FPMU).

Mujeri, Mustafa, K. 2019. "Fair Prices for Rice Farmers: Simple Idea but Complex Reality." *Financial Express*, updated on July 11, 2019. https://thefinancialexpress.com.bd/views/fair-prices-for-rice-farmers-simple-idea-but-complex-reality-1559575964.

O'Keefe, M. 1997. "Supply Chain Management." *Agricultural Science* 10, no. 3: 29-32.

___. 1998. "Establishing Supply Chain Partnerships: Lessons from Australian Agribusiness." *Supply Chain Management* 3, no. 1: 5-9.

Pavithra, A. S., K. M. Singh, N. Ahmad, D. K. Sinha, and R. R. Mishra, 2018. "Economic Analysis of Rice Value Chain in Bihar and Karnataka States of India." *International Journal of Current Microbiology and Applied Sciences* 7, no. 3: 2738-2747.

PC (Planning Commission). 2009. *The Millennium Development Goals: Bangladesh Progress Report 2009*. Dhaka: General Economics Division, Planning Commission, Government of the People's Republic of Bangladesh.

___. 2011. *The 6th Five Year Plan FY2011-FY2015*. Dhaka: General Economics Division, Planning Commission, Government of the People's Republic of Bangladesh.

Quasem, M. A. 1987. "Farmers' Participation in the Paddy Markets, Their Marketed Surplus and Factors Affecting it in Bangladesh." *Bangladesh Development Studies* 15, no. 1: 83-104.

Rahman, S. 1998. *An Analysis of Market Structure, Conduct and Performance of Paddy Processing Industry in Some Selected Areas of Naaogaon District*. Unpublished master's thesis, Department of Cooperation and Marketing, Bangladesh Agricultural University, Mymensingh.

Rahman, Mustafizur et al. 2008. *State of the Bangladesh Economy in FY2007-08*. Macroeconomics Working Papers No. 22300. Dhaka: East Asian Bureau of Economic Research.

Rahman, M. A., M. M. T. Islam, A. Ali, A. K. Das. 1991. "Effect of Partial Replacement of Wheat by Rice Polish and Molasses on the Performance of Laying Pullets." *Bangladesh Journal of Anim. Science* 20, no. 1-2: 113-117.

Sen, A. 1999. *Development as Freedom*. New York: Alfred A. Knopf.

___. 1982. *Poverty and Famine: An Essay on Entitlement and Deprivation*. Oxford: Clarendon Press.

Tasnoova, Shuraya, and Izumi Iwamoto. 2006. *Kataribhog Rice Marketing System in Dinajpur District, Bangladesh*. Memoirs of the Faculty of Agriculture, Kagoshima University, 41: 19-50. http://hdl.handle.net/10232/2841.

Timmer, C. P. 2004. *Food Security in Indonesia: Current Challenges and the Long-Run Outlook*. Working Paper No. 48. Washington D. C.: Center for Global Development.

Williamson, Oliver E. 1975. *Markets and Hierarchies, Analysis and Antitrust Implications: A Study in the Economics of Internal Organization*. New York: Free Press.

Zaman, Zaki Uz, Tokuzo Mishima, Shuji Hisano, and Moha'csi Gergely. 2001. "The Role of Rice Processing Industries in Bangladesh: A Case Study of the Sherpur District." *Review of Agricultural Economics* 57: 121-133. http://hdl.handle.net/2115/11214.

Chapter 10

Escalation of Real Wages in Bangladesh: Is it the Beginning of Structural Transformation?[1]

Xiaobo Zhang, Shahidur Rashid, Ahmad Kaikaus, and Akhter Ahmed

10.1 Introduction

With about 1,200 people per square kilometer, Bangladesh is one the most densely populated countries on the planet. The reality of intense population pressure is reflected in commonly portrayed images in the popular media, such as crowded buses and trains with passengers on top, endless lines of human-powered rickshaws, and deaths in the thousands from both natural and man-made disasters. With increasing landlessness, and a heavy reliance on labor markets, understanding the dynamics of wage formation in this setting is critically important for identifying the process of economic transformation and poverty reduction. However, both theories and empirics of wage determination in Bangladesh, and elsewhere in developing countries, have intrigued economists for decades.[2] The neoclassical theories, where labor demand and wages are determined by the marginal physical product, cannot explain stable wages amid seemingly unlimited supply of workers and massive involuntary unemployment in developing countries like Bangladesh. The reason is simple: if market clearing conditions hold, unemployed workers should bid down wages until full employment has reached. One set of theories that provide a more coherent explanation of stable wages amid abundant labor supply has been the nutrition-based efficiency wage theory, originally proposed

[1] An earlier version of the chapter was published in *World Development* 64: 273-285, December, 2014. This is reproduced with permission of the publisher.

[2] Ranis (2012) revisits the debates in contemporary contexts and Bardhan (1979) presents both theoretical and empirical analysis of the competing theories.

by Leibenstein (1957) and Mazumdar (1959). The premise of this theory is that since productivity depends on consumption, it is in the interest of the employers to pay a wage that ensures minimum calorie requirement of the workers so that they can work effectively.

However, neither neoclassical nor efficiency wage theories seem to be consistent with an emerging trend in Bangladesh—a sharp increase in real wage rate in recent years. This trend is quite contrary to the findings of earlier empirical studies on agricultural wage formation in the country. Using historical data from the 1950s and 1960s, Bose (1968) demonstrated that real agricultural wages in Bangladesh (then East Pakistan) had been declining since the end of colonial rule in the late 1940s. Subsequent studies—notably Khan (1977 and 1984), Boyce (1989), Ravallion (1990), and Boyce and Ravallion (1991)—echoed similar concerns about the downward trend in real agricultural wages. Extending Boyce and Ravallion's (1991) data set (1949-81) to 1999-2000, Rashid (2002) argued that the trend in the relative price of labor and food documented in the earlier studies had changed in the 1990s. In particular, rice was no longer the key determinant of agricultural wages, as predicted by the subsistence wage hypothesis.[3] However, none of the earlier studies reported a sharply rising trend with analysis of the underlying factors within a coherent theoretical framework. This chapter attempts to bridge this knowledge gap. Unlike previous studies, it (a) uses data from multiple sources, (b) analyzes the sources of income growth and their relationship with rising wages, (c) triangulates the results in light of the theories of economic transformation, and (d) highlights implications for poverty reduction.

The results suggest that real wage rates, especially in rural areas, have accelerated since the early 2000s. Triangulating these results with other evidence, we demonstrate that rising wages in Bangladesh is consistent with Arthur Lewis's (1954) dual economy model with unlimited labor supply. The evidence suggests that Bangladesh is at the stage of development commonly termed as the *Lewis Turning Point,* where workers begin to gain greater bargaining power in negotiating wages. Key drivers behind this trend have been increased nonfarm job opportunities, especially for women in the growing manufacturing sector. As labor costs have risen in other developing countries, such as China and India, Bangladesh has emerged as a new destination for labor-intensive industries (Zhang, Yang, and Wang 2011; IHS Global Insight 2010; Sincavage, Haub, and Sharma

[3] For detailed discussion on the subsistence wage theory in the context of Bangladesh, see Ahmed (1981).

2010). In the mid-1980s, the garment sector employed only 120 thousand people and exported about US$31 million worth of merchandise. By the mid-1990s, the sector employed 1.3 million people, mostly women, and exports reached US$2.2 billion. It grew further in the 2000s and exports soared to more than US$19 billion, equivalent to nearly 80 percent of the country's exports, and provided direct employment to about 4.0 million people in 2012 (Rashid, Tefera, Lemma, and Yunus 2014). The booming manufacturing sector has attracted millions of surplus workers, in particular women, from rural areas (Kabeer and Mahmud 2004). Initially, as laborers moved out of the agriculture sector, the impact on rural wages was minimal due to the presence of surplus labor. However, over time, as the supply of seemingly unlimited labor was exhausted, the terms of trade in the labor market started to shift in favor of workers, leading to a tightening labor market and an increase in agricultural wages.

Since physical labor is the primary asset for the poor, a change in the labor market can translate into improvement in the poor's livelihood and lead to a reduction in poverty. This appears to be the case in Bangladesh over the past decade when the country has made remarkable progress in reducing poverty. The poverty rate dropped from 49 percent in 2000 to 32 percent in 2010, falling by 1.7 percentage points per year (World Bank 2013). To put these numbers in perspective, about 1.6 million people have escaped poverty every year since 2000. In comparison, the rate of decline in poverty was much more modest between 1995 and 2000, from 51 percent to 49 percent, equivalent to only 0.4 percentage points per year.

The rest of the chapter is organized as follows. Section 10.2 presents a conceptual framework explaining the rise in wages as predicted by the Lewis's (1954) model. This is followed by a discussion on the analysis of two data sources to show that rural real wages accelerated in the second half of the decade spanning 2000 to 2010 in Section 10.3. Section 10.4 presents analysis of both household surveys and other official statistics to identify the factors behind an observed rise in real wages. The paper concludes with a summary of findings and their implications.

10.2 Conceptual Framework

Economic development is a process of transferring workers from low-productivity sectors, such as agricultural production to more productive sectors, such as manufacturing. In the early stage of structural transformation, the outmigration of rural workers from the agriculture sector to the manufacturing or nonfarm sector has little effect on wages of both sectors due

to excess unemployment and underemployment in rural areas. A defining feature of this early stage of development is that urban wages far exceed rural wages. Additionally, at this stage, wages remain low and stable in both sectors. Over time, as the economy grows there comes a point at which the excess labor in rural areas becomes fully absorbed by the emerging nonfarm sector, initiating a rise in wages. This was the key insight advanced by Lewis (1954), and such a point was coined as the "Lewis turning point".[4]

However, the empirical evidence on the existence of a Lewis turning point in South Asia is mixed. It has been widely shown that the East Asian economies experienced a noticeable Lewis turning point (Fei and Ranis 1975; Fields 2004; Zhang, Yang, and Wang 2011). However, studies on South Asia have failed to uncover such a trend as of 1970s (Rosenzweig 1980). In case of Bangladesh, the earlier studies presented results—that is, a declining trend in real wages at least up to early 1980s—that were quite contrary to the prediction of Lewis model. This is either because the Lewis model of economic development with unlimited labor did not hold in these countries; or because these countries did not reach the turning point at the time when the studies were conducted. As economic transformation occurs over a long horizon of time, studies are unlikely to discern the turning point if the sample period is not long enough to encompass the transformation.

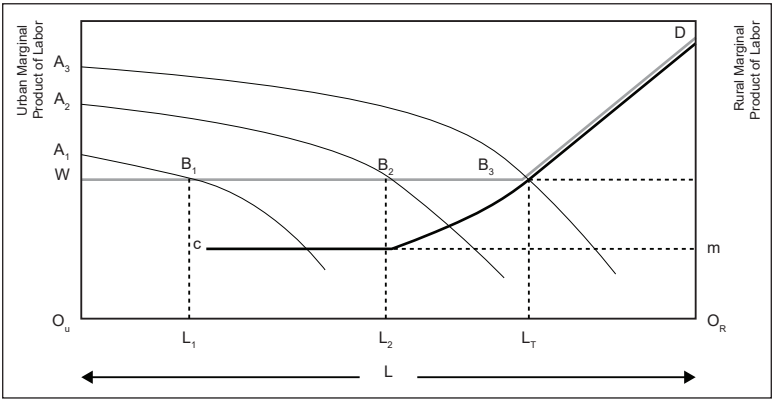
Figure 10.1 provides an illustration of the Lewis turning point in a dual economy set up where L is the total size of the labor force in the economy and O_R and O_U are origins of the rural and urban sectors, respectively.[5] The marginal product of labor in the urban sector is AB (A_1B_1, A_2B_2, and so on), whereas the marginal product of labor in the rural sector is CD. One key feature of the rural marginal product of labor, CD, is that there is a long flat line when the amount of rural labor is greater than O_RL_2. Initially, let us assume that the marginal productivity of labor in the urban sector is A_1B_1. At this point, the urban wage is w and the rural wage is m, with corresponding labor allocation of O_UL_1 in the urban sector and O_RL_1 in the rural sector. With capital accumulation and technological development, the

[4] For a good review of the literature, see Fields (2004).

[5] The model also applies to the farm and nonfarm sector within the rural areas. Growing non-agricultural employment with rural areas draws workers out of agricultural labor and into the nonfarm sector in the same way that growing employment opportunities in cities attract labors from rural areas to cities. As a matter of fact, many nonfarm employment opportunities, such as garment jobs, are in the rural areas. As more labor moves to the rural nonfarm sector, agricultural labor market becomes tight, eventually leading to rising agricultural wages.

marginal product of labor curve *AB* shifts rightward and the share of the labor force in urban sector increases. For example, when the curve shifts to A_2B_2, employment in the urban sector increases from O_UL_1 to O_UL_2; and the rural share declines by a similar magnitude. The rural wage at this point (the first Lewis turning point) starts to increase because the rural marginal product of labor curve, *CD*, has passed the horizontal stage. From then on, the rural wage continues to increase; urban wages remain constant until *AB* reaches the point L_T or the second Lewis turning point, where rural and urban wages converge and both begin to rise simultaneously.

Figure 10.1: Conceptual Model of Lewis Turning Point



Note: The thick gray line represents the urban wage curve; the thick black line indicates the rural wage curve.

Source: Adapted from Basu (1997).

This model predicts that the escalation of rural wages precedes the increase in urban wages which takes place after the economy reaches the Lewis turning point, L_T. The analysis in this chapter attempts to determine whether such a point can be detected in recent data from Bangladesh, where scholars have expressed concern that the economy is not growing fast enough to absorb the surplus labor (Islam 2007).

10.3 Evidence on Rising Real Wages

This section presents an analysis of data from two sources to document the pattern of rising real wages in Bangladesh.

10.3.1 Evidence Based on Monthly Wage Data

The first data source is monthly wage data from *Monthly Statistical Bulletins,* published by the Bangladesh Bureau of Statistics (BBS), which reports both rural and urban wages. The BBS collects information on daily wages for unskilled workers (e.g., helpers in construction, carpentry, and other semi-skilled works) in seven major cities (Dhaka, Chittagong, Rajshahi, Khulna, Narayanganj, Sylhet, and Barisal) and wages of agricultural workers in 25 districts.

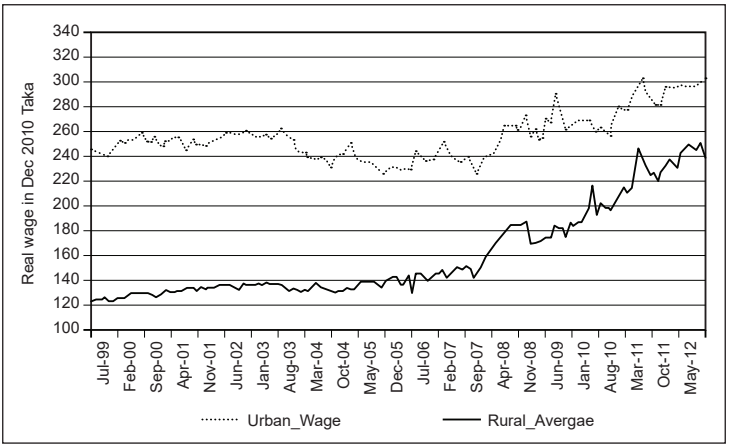
Figure 10.2 plots average urban and rural monthly real wages from July 1999 through October 2012. The nominal wages are converted to December 2010 prices using three different deflators, namely General Consumer Price Index (GCPI), Food CPI (FCPI), and the Coarse Rice Price (CRP). Panel A of the figure, where wages are deflated by the GCPI, clearly shows that the gap between the real rural and urban wages has narrowed, especially since 2008. Also, the growth rate of rural real wages has outstripped that of urban real wages. While rural real wages witnessed a rapid increase, urban real wages remained rather stagnant and did not exhibit an upward trend until early 2008. This finding is consistent with the prediction of the Lewis model that the escalation of rural real wages precedes that of urban wages.

The next two plots in Figure 10.2, referred to as 10.2b and 10.2c, show the trends in urban and rural wages deflated by FCPI and coarse rice price, respectively. Food accounts for the largest share of expenditures and wages are the main source of income for most rural poor in Bangladesh. Therefore, the dynamics of wages and food prices can serve as a good proxy for changes in the poverty dynamics (Boyce and Ravallion 1991). We also use wholesale price of coarse rice to deflate the wages. This is motivated by the fact that rice is the main staple in the country accounting for more than 70 percent of total calorie consumption for an average person in Bangladesh.[6] Moreover, most of the earlier studies on wage determination in Bangladesh had used rice as one of the key explanatory variables, and in some cases, results are used to draw welfare implications (e.g., Ravallion 1990). These two figures also serve as the robustness check of the figure in panel A. Notice that Figures 10.2a and 10.2b exhibit almost identical trends: rural real wages were roughly stable prior to the mid-2000s. However, since 2005, the growth of real rural wages has accelerated. The urban real wages slightly declined until 2007 and then rebounded.

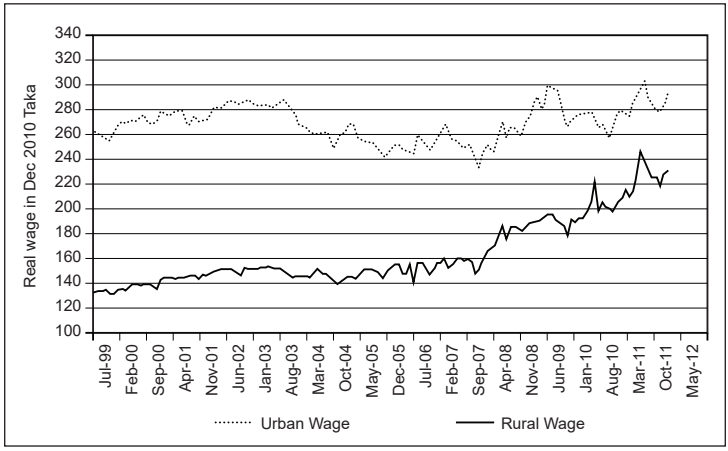
[6] Available statistics suggest that rice contributes more than 70 percent of total calorie consumption for an average person (IRRI 2012; Hossain, Naher, and Shahabuddin 2005).

Data on local rice prices are readily available. Official statistical publications report the prices of three types of rice produced and consumed in Bangladesh—coarse, medium, and fine. We use the price of coarse rice, as it is the cheapest and is commonly consumed by the poor. Figure 10.2c demonstrates the extent to which the rise in food prices negatively affected purchasing power in rural and urban areas. In 2001, workers in cities and rural areas could afford to buy 12 kilograms and 6 kilograms of rice, respectively, with their daily wage. However, at the height of the global food crisis in 2008, daily wages in urban and rural areas were worth only about 6 kilograms and 4 kilograms of rice, respectively. Facing the rising food prices, as Dorosh and Rashid (2013) report, the government implemented a number of policies to stabilize rice prices including open market sales and scaling up safety nets programs for the poor. Therefore, the welfare loss of the daily workers may not be as dramatic as the dip in wages to the rice price ratio in 2007-2008 indicates. By 2012, the purchasing power of rural daily wages had bounced back to the equivalent of about 11 kilograms of rice. If we compare only the initial and final data points within the sample period, we see that both rural and urban real wages have surged.

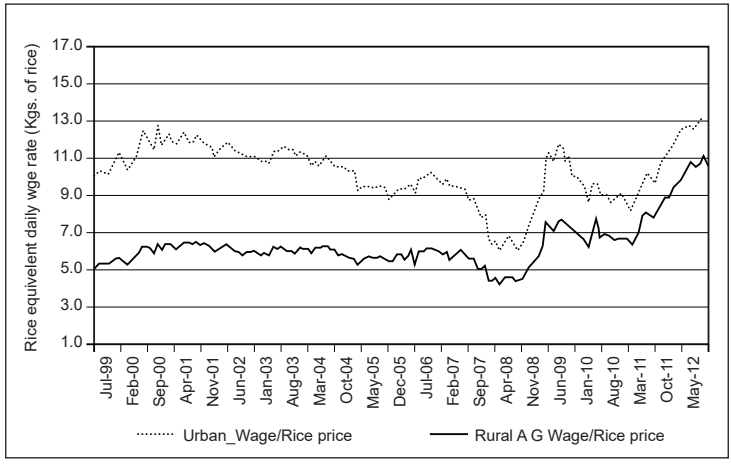
Figure 10.2: Monthly Real Wages of Rural and Urban Workers in Bangladesh, June 2001-2012. (a) Urban and Rural Real Wage at December 2010 Prices (Deflated by General CPI), (b) Urban and Real Wage at December 2010 Prices (Deflated by Food CPI), and (c) Nominal Daily Wages/Coarse Rice Price



a



b



c

Note: The rural sample excludes the rural wage from the mega-cities. Urban wages are for the unskilled workers (such as, helpers in construction sites, carpenters, and other sectors). The base year is set to 2009-2010.

Source: The monthly wage data are obtained from Monthly Statistical Bulletin (2001-2011), Department of Agricultural Marketing (DAM), Bangladesh. The real wages are deflated by general consumer price index.

10.3.2 Evidence Based on Household Income and Expenditure Survey (HIES) Data

While the monthly wage data have the advantage of higher frequency and longer time coverage, they have an important drawback: the sample covers only a small group of unskilled workers from selected locations. Therefore, to check the robustness of the aforementioned results further, we use the Bangladesh Household Income and Expenditure Survey (HIES), which is nationally representative and conducted every five years. A key advantage of using these data is that they are more representative of the population. However, we compromise on the frequency of observations, as the HIES is conducted every five years rather than monthly or annually. Based on the recent four waves of HIES—1995, 2000, 2005, and 2010—we tabulate the wage trend in agricultural peak and lean seasons.

Table 10.1 presents average rural wages, calculated from the HIES community surveys, by gender and by peak and lean agricultural seasons. Panel A of the table lists nominal daily wages, which are not comparable across the survey rounds due to inflation. As before, we use three different deflators to compute real wages: General Consumer Price Index (GCPI) with 2010 as a base (Panel B), Basic Needs Price Index (BNPI) (Panel C), and coarse rice prices (Panel D). While the magnitudes vary, two broad points are clear from these numbers: (a) irrespective of the deflators, wage rates of the female workers have increased faster than male workers; and (b) relative to earlier years, wage rates have accelerated since 2005 for both male and female workers.

Table 10.1: Rural Nominal and Real Wages by Gender and Season (at December 2010 Prices)

Year	Peak Season			Lean Season		
	Male	Female	Male/ Female	Male	Female	Male/ Female
Panel A: Nominal Daily Wage						
2010	194.33	141.62	1.37	154.92	113.08	1.37
2005	89.09	56.57	1.57	70.39	47.43	1.48
2000	70.29	48.2	1.46	55.95	39.96	1.40
1995	53.38	35.15	1.52	42.09	29.54	1.42
Growth rate 1995-2000 (%)	31.68	37.13	-3.97	32.93	35.27	-1.73
Growth rate 2000-2005 (%)	26.75	17.37	7.99	25.81	18.69	5.99
Growth rate 2005-2010 (%)	118.13	150.34	-12.87	120.09	138.41	-7.69
Growth rate 2000-2010 (%)	176.47	193.82	-5.90	176.89	182.98	-2.15

Continued

Continued from Table 10.1

Year	Peak Season			Lean Season		
	Male	Female	Male/ Female	Male	Female	Male/ Female
Panel B: Real Wages (GCPI)						
2010	193.55	141.03	1.37	154.16	112.57	1.37
2005	133.66	84.87	1.57	105.52	71.13	1.48
2000	134.01	92.25	1.45	106.6	76.31	1.40
1995	128.57	84.72	1.52	101.49	71.2	1.43
Growth rate 1995-2000 (%)	4.23	8.89	-4.28	5.03	7.18	-2.00
Growth rate 2000-2005 (%)	-0.26	-8.00	8.41	-1.01	-6.79	6.20
Growth rate 2005-2010 (%)	44.81	66.17	-12.86	46.10	58.26	-7.69
Growth rate 2000-2010 (%)	44.43	52.88	-5.53	44.62	47.52	-1.97
Panel C: Real Wages (BNPI)						
2010	193.55	141.03	1.37	154.16	112.57	1.37
2005	169.2	107.43	1.57	133.58	90.04	1.48
2000	164.66	113.35	1.45	130.98	93.77	1.40
Growth rate 2000-2005 (%)	2.76	-5.22	8.42	1.99	-3.98	6.21
Growth rate 2005-2010 (%)	14.39	31.28	-12.86	15.41	25.02	-7.69
Growth rate 2000-2010 (%)	17.55	24.42	-5.53	17.70	20.05	-1.96
Panel D: Real Wages (Rice Price)						
2010	202.79	147.89	1.37	161.74	118.17	1.37
2005	170.83	108.5	1.57	134.87	90.91	1.48
2000	182.29	125.01	1.46	145.13	103.6	1.40
1995	137.95	91.11	1.51	108.72	76.41	1.42
Growth rate 1995-2000 (%)	32.14	37.21	-3.69	33.49	35.58	-1.54
Growth rate 2000-2005 (%)	-6.29	-13.21	7.97	-7.07	-12.25	5.90
Growth rate 2005-2010 (%)	18.71	36.30	-12.91	19.92	29.99	-7.74
Growth rate 2000-2010 (%)	11.25	18.30	-5.96	11.44	14.06	-2.30

Notes: GCPI = general consumer price index; BNPI = Basic Needs Price Index. The real wages are in 2010 prices weighted and deflated spatially. The nominal wages are from HIES community surveys. Since BNPI does not exist for 1995, the real wages do not include that year. We normalized rice price in 2010 as one.

Source: Authors' calculation based on four rounds of HIES by the BBS: 1995, 2000, 2005, and 2010.

The General Consumer Price Index may underestimate the inflation level, especially for the poor (Deaton 2003; World Bank 2008). Furthermore, using a national GCPI to adjust wages across regions masks the spatial

difference in price levels. To remedy these potential problems, we use two alternative deflators. In Panel C, we replace the GCPI with the Basic Needs Price Index (BNPI) as a deflator. The BNPI is based on a national upper poverty line, which is computed using both the price index and the Cost of Basic Needs (CBN) method weighted by population (Lanjouw and Lanjouw 2001). Specifically, the food poverty lines for 2010-11 were updated from the 2005 food poverty lines using stratum-specific Törnqvist indices, whereas the upper and lower nonfood poverty lines were re-estimated using the Cost of Basic Needs method, as had been done for 2005 (World Bank 2010). Note that BNPI was designed to deflate only across the latest three rounds, which is why values for 1995 are omitted from Panel C. Additional details pertaining to the construction of the BNPI and the benefit of its use can be referred to the World Bank (2008).

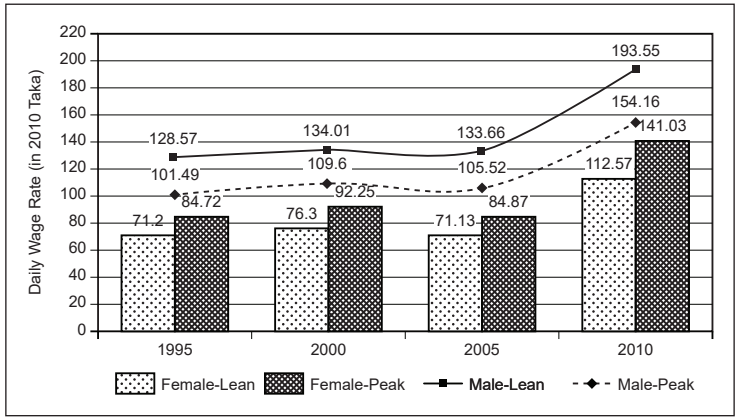
Using the regional-specific BNPI, we first compute real wages at the rural division level and then derive the national rural real wages based on the division of real wages. The magnitude of real wage growth rates shown in Panel C dropped significantly compared with Panel B after adjusting for spatial price differences. We observe that, in both peak and lean seasons, male wages grew 18 percent from 2000 to 2010, whereas female wages rose 24 percent during the peak season, and 20 percent during the lean season. Interestingly, over the past decade, the male-to-female wage gap has been declining from 1.45 and 1.40 during the peak and lean seasons, respectively, to 1.37 in both seasons, which suggests gender-differentiated wage growth patterns that are in line with the growth of the manufacturing industry (in particular, garments and textiles) in Bangladesh.

Panel D presents national real wages adjusted by rice price. We first use the coarse rice price index at the local level to deflate nominal wages. We then compute the national average of real wages based on local real wages. Once again, we find that real wages grew much faster in 2005-2010 than in the earlier period of 2000-2005. In fact, when using this deflator, real wages dropped between 2000 and 2005, while the growth rate for 2005-2010 is slower than that reported in Panel A. This finding is perhaps because rice prices escalated more rapidly than the prices of other items in the consumption basket during the peak of the food price crisis in 2007 and 2008.

Figure 10.3 shows the trends of real rural wages from 1995 to 2010. Nominal wages are deflated by rural CPI; and the bars and lines in the figure represent female and male wages, respectively. It is apparent from this figure that from 1995 to 2000, real wages only inched up, ranging from 4.2 percent growth for male workers in peak seasons to 7.2 percent growth for female

workers in lean seasons. From 2000 to 2005, however, real wages declined for both male and female workers, regardless of seasons. By contrast, with an annual growth rate of about 10 percent, real wages have improved dramatically since 2005. In particular, the rate of growth of female real wages has overtaken real wage growth rates for males, resulting in the reduction of male-to-female wage ratio from 1.57 in 1995 to 1.37 in 2010.

Figure 10.3: Seasonality of Real Wages by Gender



Note: Nominal wages are deflated by the rural consumer price index (CPI) is used to adjust real wages.

Source: Authors' calculation based on four rounds of HIES by the BBS: 1995, 2000, 2005, and 2010.

Having observed real wage escalations in rural areas, one may wonder whether urban wages have exhibited a similar pattern. Table 10.2 presents nominal and real daily wages in cities. Unlike the rural surveys, HIES did not have a community module for urban regions. As a result, we had to extract the wage data from household surveys. Even in cities, a significant portion of people work in the informal sector earning daily wages. For those earning monthly salaries in the formal sector, we converted salaries into daily wages using the average number of working days per month. A small number of people reported incomes from both salaries and daily wages. In this case, we computed the average daily wage based on monthly salaries derived from formal jobs and daily wages earned in informal jobs weighted by the respective number of working days. Similar to Table 10.1, we also use CPI and BNPI as deflators to derive real wages.

Table 10.2: Urban Nominal and Real Daily Wages by Gender (HIES)

	Male	Female	Male/ Female	National
Panel A: Nominal Wages				
2010	270.11	232.32	1.16	260.26
2005	161.65	149.75	1.08	157.57
2000	112.85	71.51	1.58	107.27
Growth rate 2000-2005 (%)	43.24	109.41	-31.60	46.89
Growth rate 2005-2010 (%)	67.10	55.14	7.71	65.17
Growth rate 2000-2010 (%)	139.35	224.88	-26.33	142.62
Panel B: Real Wages (GCPI)				
2010	253.43	223.21	1.14	245.11
2005	230.33	216.51	1.06	225.24
2000	203.23	129.26	1.57	194.07
Growth rate 2000-2005 (%)	13.33	67.50	-32.34	16.06
Growth rate 2005-2010 (%)	10.03	3.09	6.73	8.82
Growth rate 2000-2010 (%)	24.70	72.68	-27.79	26.30
Panel C: Real Wages (BNPI)				
2010	253.43	223.21	1.14	245.11
2005	291.57	274.08	1.06	285.12
2000	249.72	158.84	1.57	238.46
Growth rate 2000-2005 (%)	16.76	72.55	-32.33	19.57
Growth rate 2005-2010 (%)	-13.08	-18.56	6.73	-14.03
Growth rate 2000-2010 (%)	1.49	40.53	-27.78	2.79

Note: The real wages are in 2010 prices, weighted and deflated spatially. The nominal wages are obtained from HIES household surveys. Urban daily wage is calculated as follows: (annualized daily wage + annual salary)/number of days worked in the year. Wages are from wage earners 15 years and older.

Source: Household, Income, and Expenditure Survey by BBS. Using three rounds: 2000, 2005, and 2010.

Panel A of the table presents the estimates of urban nominal wages in 2000, 2005, and 2010. Female wages more than doubled from 2000 to 2005, whereas male wages increased by only 43 percent during the same period. In the later period of 2005-2010, both male and female wages surged by more than 55 percent. However, the pattern of nominal wages does not necessarily reflect the trend of real wages due to inflation. In Panel B, we deflate the nominal wages by GCPI. After the price adjustment, the

previously torrid growth in wages becomes less impressive. Female real wages rose by 68 percent from 2000 to 2005 but only 3 percent from 2005 to 2010. The growth rate of male real wages was only 13 percent and 10 percent, respectively, in the two periods. Panel C presents real wages adjusted by BNPI. Since BNPI reports a higher inflation rate than GCPI during 2005-2010, it is natural to observe a drop in real wages during this period. Interestingly, the finding that female real wages quickly caught up to their male counterparts in 2000-2005 continues to hold. Interestingly, the sudden surge in female real wages between 2000 and 2005 resembles the pattern seen using the GCPI. Over the whole period of 2000-2010, female real wages witnessed a 41 percent increase.

Because women account for a small share of the labor force, the national wage patterns more closely resemble male wage patterns. Unlike the rapid growth in real wages in rural areas, the growth of urban real wages was lackluster. On the whole, the real wage patterns derived from HIES are largely in sync with those observed from the monthly wage data. Results from both methods indicate that the escalation of real wages did not happen until the second half of the 2000s. Also, the increase in real wages was more pronounced in rural areas than in cities. Once again, these findings are consistent with the model prediction (shown in Figure 10.1) that the increase in real wages tends to first manifest in the low-productivity sector.

To summarize, the evidence from two different data sources suggests that real wages in Bangladesh, which were either stable or declining in the past, have accelerated significantly in recent years. A particularly striking feature of the trend is that real wages of female workers have grown faster than the real wage of male workers. What explains such a trend in a country with an abundant supply of labor? We try to answer this question next by analyzing likely factors behind this observed wage growth.

10.4 Plausible Factors behind Rising Real Wages

10.4.1 Nonfarm-Sector Expansion

According to the Lewis hypothesis, the key to reaching the turning point is to increase the marginal product of labor in the nonfarm sector. This prediction has two important components: (a) a change in the allocation of labor forces across sectors; and (b) capital accumulation and reinvestments to increase productivity. There are several evidences to suggest that there has indeed been a change in the allocation of labor force in urban and rural areas. According to the Bangladesh Labor Force Survey (LFS) data, the size of active labor force in urban areas increased from 9.2 million in 1999-2000

to 13.3 million in 2010. In other words, active urban force grew by almost 45 percent, which was about 7 percent higher than the growth in rural labor force. On the aggregate, labor force in agriculture has declined from about 52 percent in 2002-2003 to 47 percent in 2010.[7] However, it should be noted that LFS survey misses out a significant change in rural Bangladesh. Rural areas in Bangladesh today are much different from what they were 20 years ago. Many small towns have become very vibrant, equipped with modern amenities like electricity, banking with ATM, and running water with low lift pump. Yet, they are not considered as urban centers by the Bangladesh Bureau of Statistics. As a result, estimates of urban labor force are actually underestimated. The panel evidence, presented in Rashid, Tefera, Lemma, and Yunus (2014), reinforces this fact. This study uses four rounds of panel survey of rural households, conducted between 1988 and 2008, by the Bangladesh Institute of Development Studies (BIDS) and the International Rice Research Institute (IRRI). The results show that the share of income from agriculture in rural Bangladesh has declined from 58 percent in 1988 to 42 percent in 2008, representing a total reversal in the farm-nonfarm compositions.

We present three sets of evidence on the second implications. First, reinvestment is possible when an economy generates surpluses. According to available macroeconomic time series data, domestic saving had experienced a prolonged spell of negative growth (-1.4 percent per year) during 1960-1979. This began to change in the 1980s. Annual growth in domestic savings averaged nearly 12 percent during 1980-2000 and 8.23 percent growth since 2001.[8] Second, since the early-1980s, the Bangladesh Government has made greater efforts to attract FDI, particularly in the garments sector. As shown in Figure 10.4, FDI in the garments sector has grown from less than US$2 million in 1995 to US$113.8 billion in 2012. The FDI flow appears to correspond well with the increase in the number of workers in the sector, which has grown from about 120 thousand in the mid-1980s to about 4 million in 2012.[9]

[7] See the Report on Labor Force Survey 2010 http://203.112.218.66/WebTestApplication/userfiles/Image/Latest%20Statistics%20Release/LFS%20Report%202010.pdf.

[8] Authors' calculations based on WDI data.

[9] There is a debate in the literature on the relationship between FDI, labor productivity and wages. The impact of FDI depends upon the type and locations of FDI. If FDI mainly targets natural resources in a developing country, it may create a resource curse and hinder industrial development. If FDI is aligned with a host country's comparative advantage, such as cheap labor, it often increases local productivity and labor income (Lin 2012). As a matter of fact, there is a large body of literature documenting the positive role of FDI on productivity and wages in East Asian economies, such as China (Zhang and Zhang 2003; Wooster and Diebel 2010).

Finally, remittances primarily from the migrant workers have been significant in the past decade or so. According to the available official statistics, total remittance to the country in 1980 was about US$300 million, which grew by more than 10 percent per year to reach US$780 million by 1990. Since then, it grew at 13.5 percent per year and reached about US$12.0 billion in 2012, accounting for 44 percent of the total remittances to the LDCs (UNCTAD 2012). At the national level, the share of remittances in GDP increased from 0.20 percent in 1976 to about 11 percent in 2012. Put it differently, as a share of GDP, remittance now accounts for more than half of total agricultural value added (18 percent) in the country. Our analysis of the HIES data confirms these aggregate numbers. As shown in Table 11.3, the share of remittances in total household income rose from 7 percent in 2000 to 9.4 percent in 2010, and this change is more pronounced in rural areas. In 2000, the share of remittance income in rural areas was 7.5 percent, whereas, in 2010, this figure jumped to 10.5 percent.

Table 10.3: Share of Income from Different Sources (%)

Year	Farm	Nonfarm	Social Safety Net	Remittances	Miscellaneous
Panel A: National					
2010	27.87	47.84	0.33	9.40	14.56
2005	30.29	42.86	0.45	7.19	19.19
2000	32.64	40.65	0.42	7.04	19.17
Panel B: Urban					
2010	7.30	71.16	0.08	6.42	15.04
2005	8.33	69.20	0.14	4.82	17.50
2000	6.10	68.10	0.06	5.35	20.47
Panel C: Rural					
2010	35.41	39.29	0.42	10.49	14.38
2005	37.74	33.93	0.56	7.99	19.77
2000	39.39	33.67	0.52	7.47	18.84

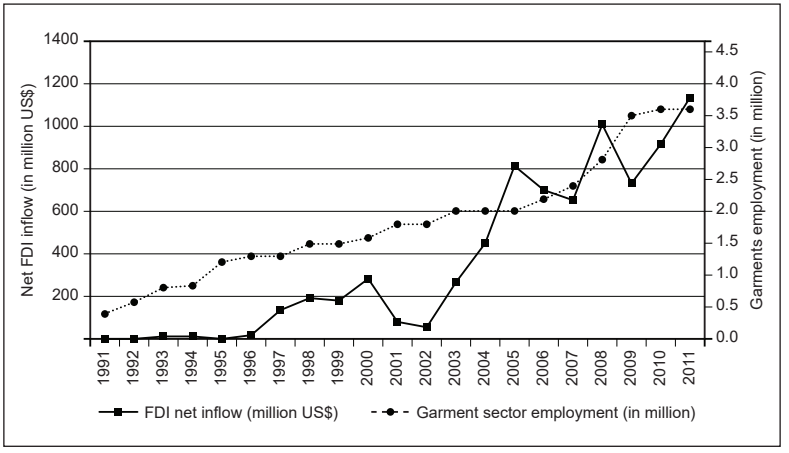
Note: Farm income refers to net income derived from farm, forestry, and fishing. Nonfarm income includes nonfarm self-employment income and nonfarm wage income. Nonfarm self-employment income refers to net income derived from nonfarm enterprises plus daily wages. Nonagricultural wage income is net income of (nonfarm wages/salary + program transfers + stipends + housing rental). In 2010, the major social safety programs include Vulnerable Group Feeding (VGF), Cash for Work, Old

Age Allowance, Vulnerable Group Development (VGD), Primary Education Stipend Project, Food for Work, Test Relief, Allowance for Widow and Distressed Women, Agricultural Subsidy and Fuel Price Support for Marginal Farmers, Gratuitous Relief (GR), and Food for Education (FFE). In 2000, the social safety nets captured in HIES were VGF, VGD, FFE, and GR.

Source: Authors' calculations based on HIES in 2000, 2005, and 2010.

Some of these growing remittances have possibly trickled down to business investments, such as building commercial fish ponds, which in turn would generate nonfarm jobs. Of course, a significant portion of remittances are likely to have been spent on consumption as observed in the literature in other countries (Nguyen and Mont 2012). If so, remittance would have a direct impact on poverty reduction. It has been documented that massive inflow of remittances may depress the labor supply in developing countries. In the case of Bangladesh, the labor force participation rate has remained stable (Inchauste, Olivieri, Jamie, and Winkler 2012), suggesting that the effect on labor supply, if any, seems to be rather limited.

Figure 10.4: Foreign Direct Investment (FDI) and Employment in the Garments Sector



Source: Bangladesh Garments Manufacturers and Exporters Association (BGMEA) worker database (http://garmentworkers.com.bd/); and the FDI data are from the World Bank (2012).

To examine components within the nonfarm sector that have been significant, we further disaggregate nonfarm income into three categories by gender in rural and urban areas in Table 10.4: daily wages, self-employment, and salaried employment. The left panel lists the major income sources in 2000, 2010, and 2015, while the right panel presents the t-test p-values between the sample periods, 2000-2005, 2005-2010, and 2000-2010. Two of these three categories are clearly defined, but the self-employment may vary from little street vendors to small enterprises. Therefore, we do not call income from self-employment as micro-enterprise income as Khandker, Samad, and Ali (2013) do. The test results are in total conformity with the other results and in line with Lewis's (1954) predictions. Per capita income from daily wage income has increased several folds in rural and urban areas and the change is statistically significant. For instance, rural real female monthly wage was only BDT 321 in 2000 and jumped to BDT 913 in 2010, while rural male wage increased from BDT 476 to BDT 902 in the same period. Clearly, female wages have grown faster than male wages. In comparison, the salaried income has improved much slowly. The change in urban female salaried income from 2000 to 2010 is not statistically significant. Accordingly, the gap between daily wage income and salaried income has narrowed.

The informal sector accounts for a large share of total employment in Bangladesh. As shown in Table 10.5, more than 70 percent of employment was concentrated in the informal sector in 2010. However, the share of employment in the formal sector steadily increased from 2000 to 2010 in both rural and urban areas for both males and females.[10] In 2010, more than half of the workers (54.4 percent) in urban areas were employed in the formal sector, compared with only 17.2 percent in rural areas. By comparison, even though declining since 2000, the share of informal-sector employment in rural areas has been persistently high. For the nation as a whole, only 19.4 percent of the employed workforce worked in the formal sector in 2000, but jumped to 27.9 percent in 2010. More interestingly, the share of women working in the formal sector surpassed the share of males, and the gap widened from 10 percentage points (28.15 percent for females and 18.15 percent for males) in 2000 to nearly 13 percentage points (39.16 percent for females and 26.21 percent for males) in 2010, perhaps due to the disproportionately increasing demand for female workers in the manufacturing sector, especially the garments industry.

[10] The formal sector includes government organization, autonomous body, private office, public mill/factory, private mill/factory, and local government or non-governmental organization; it excludes household and other salaried wages. The informal sector includes all informal-sector workers.

Table 10.4: Changes in Nonfarm Income by Sources in Bangladesh, 2000-2010

Location/ Gender		Per capita income	2000	2005	2010	t-tests for difference between the means (p-values)		
						2000-2005	2000-2010	2005-2010
Rural	Female	Rural female	742	767	1,297	0.753	0.006	0.003
		Daily wage	321	246	913	0.269	0.000	0.000
		Self-employed	376	537	1,289	0.081	0.000	0.000
		Salaried income	470	512	1,255	0.681	0.014	0.015
	Male	Rural male	1,241	856	1,323	0.277	0.010	0.000
		Daily wage	274	326	902	0.043	0.000	0.000
		Self-employed income	476	503	1,286	0.537	0.000	0.000
		Salaried income	1,139	533	1,271	0.250	0.556	0.000
Urban	Female	Urban female	1,946	2,415	2,388	0.601	0.020	0.040
		Daily wage	513	224	1,121	0.000	0.000	0.000
		Self-employed	884	835	2,312	0.794	0.000	0.000
		Salaried income	1,808	1,913	2,236	0.936	0.471	0.622
	Male	Urban male	2,299	1,843	2,387	0.006	0.013	0.000
		Daily wage	563	319	1,148	0.000	0.000	0.000
		Self-employed income	1,217	866	2,236	0.000	0.000	0.000
		Salaried income	1,623	1,183	2,191	0.037	0.003	0.000

Continued

Continued from Table 10.4

Location/ Gender		Per capita income	2000	2005	2010	t-tests for difference between the means (p-values)		
						2000-2005	2000-2010	2005-2010
National	Female	National female	1,301	1,246	1,792	0.873	0.016	0.009
		Daily wage	405	237	994	0.001	0.000	0.000
		Self-employed	636	642	1,855	0.952	0.000	0.000
		Salaried income	1,032	1,011	1,699	0.967	0.037	0.033
	Male	National male urban	1,676	1,185	1,809	0.034	0.010	0.000
		Daily wage	385	323	1,002	0.005	0.000	0.000
		Self-employed income	810	645	1,802	0.000	0.000	0.000
		Salaried income	1,336	777	1,696	0.092	0.018	0.000

Notes: All income figures are deflated by CGPI (2010 = 100). Non-earned income (such as, remittance, transfers from safety nets or public works programs, pension, etc.) are excluded in calculating the nonfarm income.

Source: Authors' calculation based on the HIES survey rounds (2000, 2005, and 2010).

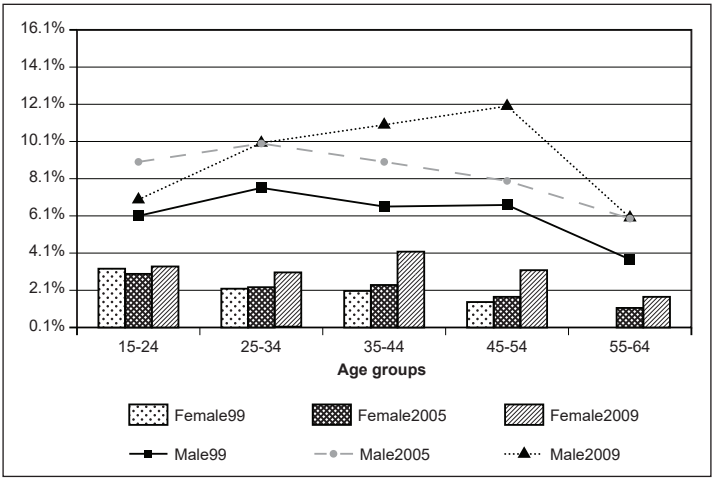
Table 10.5: Share of Employment in Formal and Informal Activities by Sector and Gender (%)

Year	National	Urban	Rural	Female	Male
Panel A: Formal Sector					
2010	27.89	54.40	17.24	39.06	26.21
2005	23.49	44.71	15.59	34.40	22.04
2000	19.41	43.12	12.93	28.15	18.19
Panel B: Informal Sector					
2010	71.20	43.83	82.20	57.31	73.16
2005	75.16	51.54	83.66	60.67	76.92
2000	79.56	53.74	86.45	68.53	81.00

Note: The numbers in the formal and informal sectors may not add up to 100 as some people report activities in both sectors.

Source: Authors' calculations based on HIES in 2000, 2005, and 2010.

Figure 10.5: Share of Working-Age Population in Manufacturing Sector by Gender



Source: Labor Force Surveys, different years.

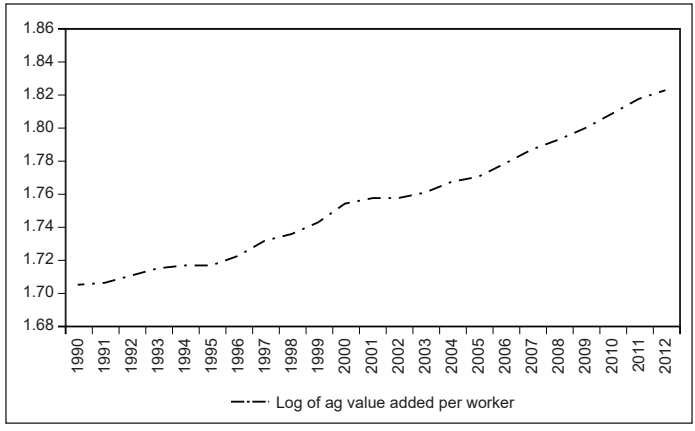
Figure 10.5 plots the share of working-age population employed in the manufacturing sector by gender and age cohorts for 1999-2000, 2005-06, and 2009-2010. The estimates are generated from three rounds of the National Labor Force Survey (BBS 1999-2000, 2005-2006, 2009-2010). The share of women working in the manufacturing sector, represented by the bars in Figure 10.5, has significantly increased from 2005 to 2010 across all age groups with

most noticeable change occurring among the 35-44 age-cohort. Over time, men have also become more likely to work in the manufacturing sector for most age groups, as shown by the lines in the figure. However, the demand for female workers in the manufacturing sector has increased disproportionately as compared with men, which is perhaps why female wages have increased more rapidly than that of their male counterparts in the past several years.

10.4.2 Alternative Interpretations of Rising Wages

The wage formation under Lewis theory does not conform to the neoclassical theory in that wage rate does not equate with the marginal product of labor. In other words, if neoclassical theory were true in Bangladesh, the observed trend in real wages should match the trend in labor productivity. To examine this hypothesis, we compare the agricultural value-added per worker over time (Figure 10.6). The growth in labor productivity follows a rather linear trend, without any major kinks. In other words, agricultural labor productivity does not display a trend similar to the trend in rural real wages, shown earlier. Thus, we conclude that labor productivity alone cannot explain the acceleration of wage growth in 2005-2010. However, there can be other factors that have triggered the recent wage escalation. One such factor is the massive increase in the public spending on social safety net programs. Here is how the explanation goes. As the poor receive transfers from large scale social safety net programs, their reservation wage may go up and hence a sudden increase in public transfers can cause wages to go up; and since most of the transfers are in the rural areas, the escalation in wages should be more pronounced in rural wages.

Figure 10.6: Agricultural Labor Productivity



Source: The data are from World Bank Development Indicator, 2012.

For a better understanding of the source of such perception, consider the well-known 100-Day Employment Generation Programme (100-DEGP) as an example. This program, introduced in 2008-2009, had a budget of BDT 12.0 billion, equivalent to US$150 million, covering nearly two million beneficiaries. On average, each beneficiary received BDT 6,000 (US$75). However, this program was replaced by a scaled-down version of the program called the Employment Generation for Hardcore Poor (EGHP). The first phase of EGHP was implemented during September to November 2009, with a budget of BDT 1.76 billion targeting 0.44 million poor. The award size for each beneficiary averaged BDT 4,000 (about US$50). The second phase of EGHP, which lasted from March to April 2010, targeted 1.2 million poor people with a budget of BDT 6,000 million (about US$60 per person). Although the second phase of EGHP was significantly larger than the first, it was still far below 100-DEGP in scale. A common perception in the country is that this massive government transfer might have contributed to an increase in real wages. However, when we mapped the timing of these transfers programs with the trends in real wages presented earlier, we see that rural real wages had taken off before these new programs were launched. During the same period, the garment sector alone generated 0.5 million new jobs. Assuming each garment worker earned US$720 per year (US$60 per month multiplied by 12 months), the increase in earnings derived from the new jobs created in the garments sector dwarfed the corresponding rise in earnings due to 100-DEGP and EGHP.

Since HIES includes detailed questions on incomes received from different government programs, we can use these data to further investigate whether government transfers have played a greater role in household income over time. Table 10.6 presents the share of income derived from various social safety nets and public transfer programs.[11] For the country as a whole, individuals received only 0.34 percent of their income from social programs in 2010.[12] Compared to 2000, when the figure was 0.42 percent, the share has actually declined. Because most of the poor live in rural areas, naturally rural people receive a larger share of their income from social safety nets than their city counterparts. However, even among the rural

[11] For 2005, it was impossible to calculate the price of the in-kind social safety nets, as the questionnaire did not specify what was received, only the amount (kg). For 2010, values for in-kind payments, such as rice and wheat, were taken from the community survey. In 2000, social safety nets were defined as wheat or rice received from four programs.

[12] Certainly, we shall cast a cautious note here because most of the government programs are geographically and self-targeted programs and given the sampling framework, safety nets program beneficiaries are under-represented in the HIES data. Therefore, the overall share of transfer income may mask the true picture of the positive changes to income that the poor received.

population, the share of transfer income in the total household income was as low as 0.44 percent in 2010 and 0.52 percent in 2000. It is improbable that transfers constituting such small shares of household incomes could shape the general wage picture. Moreover, the trend in transfer income shares does not resemble the pattern of real wages. In comparison, the share of income derived from nonfarm activities and remittances increased from 48 percent in 2000 to 57 percent in 2010.

Table 10.6: Share of Household Income from Social Safety Nets (%)

HIES Survey Years	Safety-net transfers as % total HH income		
	National	Rural	Urban
2000	0.42	0.52	0.06
2005	0.47	0.58	0.14
2010	0.34	0.44	0.09

Source: Authors' calculations based on HIES 2000, 2005, and 2010.

Based on these analyses, we conclude that while the government programs might explain a blip in the real wage patterns during 2008-2009, the infusion of government transfers does not seem to fit into the long-term trend in real wages. Overall, the evidence suggests that the hypothesis that government transfers played a major role in boosting real wages is a weak one.

The expansion of microfinance institutions (MFIs) is thought to be another contributing factor to rising real wages. The MFI membership has increased from about 8 million in 1996 to over 34 million in 2010 although, in the past several years, the growth has leveled off (World Bank 2013). The loan disbursements grew from over BDT 15 billion (USD$ 0.34 billion, or $43 per member, $3 per person) in 1997 to about BDT 370 billion (USD$ 5.3 billion, or $155 per member, $36 per person) in 2010 (World Bank 2013). The share of the loan from microcredit in total starting capital increased from 3.4 percent in 2000 to 8.2 percent in 2010. Yet, compared with the FDI in the garments sector (USD$114 billion) in 2012, the size of MFIs is much smaller, accounting for only 4.6 percent. One major role of MFIs is to help microenterprises ease their credit constraints. Most likely due to the rapid spread of MFIs, the percentage of microenterprises reporting credit constraints declined from 27.1 percent in 2000 to 22.1 percent in 2010. Nonetheless, despite the penetration of MFIs, the share of income from microenterprises in total nonfarm income has dropped from 41.8 percent in 2000 to 36.1 percent in 2010, while nonfarm wage and salaried income have increased from 58.3 percent to 64 percent in the same period

(Khandker, Samad, and Ali 2013). The same study further reports that between 2000 and 2010, (a) the share of households with microenterprises has declined from 28.4 percent in 2000 to 24.3 percent, and (b) the number of workers per microenterprise has declined from 1.6 to 1.4. Overall, microenterprises generated less employment in 2010 than in 2000.

While the impacts of microfinance cannot be denied, it is hard to establish that access to microfinance significantly contributed to the general wage pattern, especially sudden rise since 2005. One can do some simple calculations using the numbers reported in Khandker, Samad, and Ali (2013). Suppose that the MFI loans generated a net rate of return (i.e., after paying about an interest rate of about 15 percent to MFIs) of 10 percent on micro-enterprise investment. Now, given per capita income is about US$750 and per capita MFI loan is US$36, the contribution of the loan to per capita income would be about 0.48 percent {($36 × 0.10) ÷ 750}. This implies that, at the national level, the impact of MFIs on per capita income generation is likely to be small at any reasonable assumption about the rate of return.[13] As a matter of fact, regression results in Khandker, Samad, and Ali (2013) show that presence of commercial banks or microcredit program in the village has no significant effects on household participation in microenterprise activities.

10.5 Income Sources and Change in Poverty

This section presents the results of our analyses of the contributions of each of the key income sources in poverty reduction. The analytical approach is simple. We first calculate the actual change in the head-count poverty rates between HIES rounds; and then we hold one of the income components constant at the previous round and simulate the changes in the incidence of poverty. The results are presented in Table 10.7, which strongly reinforce the earlier points in the paper: the labor markets and remittances have played the most significant roles in reducing poverty in Bangladesh over the past decade.

For illustration, consider the changes in poverty between 2000 and 2005. It is seen that rural poverty rates declined by 16 percent over the period. But if the 2005 wage rates of the agricultural workers had remained at the 2000 level, all other things being equal, rural poverty would have declined by only 7.3 percent instead of 16 percent. Similarly, if nonfarm wages are held constant at the 2000 level, the rural poverty incidence would have dropped by 7.7 percent, less than half of the actual decline. If manufacturing wages and remittances were held constant at the 2000 level, the poverty rate would have decreased by 2.4 and 10.1 percent, respectively.

[13] Note that our emphasis here is on the impacts of MFI loan at the national level, not at the household level.

Table 10.7: Simulated Effects of Changes in Income Sources on Poverty Reduction in Bangladesh, 2000-2010

Income components*	From 2000 to 2005			From 2000 to 2010			From 2005 to 2010		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Actual % change in poverty (Head count)	-16.0	-11.8	-18.0	-29.7	-38.8	-33.5	-16.4	-30.6	-18.9
Simulated % changes in poverty holding each variables constant at 2000 or 2005									
Agricultural daily wages	-7.3	-3.4	-8.7	-8.6	-7.6	-12.2	2.2	-6.7	0.1
Nonfarm daily wages	-7.7	2.5	-9.1	-5.1	-1.7	-8.3	7.0	1.9	5.3
Manufacturing wage income	-2.4	11.8	-3.5	-0.4	5.9	-3.5	9.0	4.8	7.6
Remittances	-10.1	-1.7	-11.8	-11.4	-12.7	-14.9	0.7	-8.6	-1.5
Safety net transfers	-16.0	-11.8	-18.0	-29.7	-38.8	-33.5	-16.4	-30.6	-18.9

* Agricultural and nonfarm wages include both daily wage of casual workers and daily wage equivalent of the salaried workers.

Source: Authors' calculations based on the HIES Rounds: 2000, 2005, and 2010.

Three broad observations from Table 10.7 are worth highlighting. First, in terms of magnitudes, wage incomes have been more important in reducing poverty between 2005 and 2010 than between 2000 and 2005. In particular, while holding wages constant at 2000 level resulted in lower reduction of poverty, holding them constant at 2005 would have resulted in an increase in poverty in 2010 relative to 2005. This finding reinforces the relevance of Lewis's (1954) theory in explaining real wage escalation in Bangladesh. Second, the incomes from the manufacturing wages appear to have made the largest contribution to the poverty reductions in Bangladesh since 2000. If the manufacturing wages did not change, incidence of urban poverty would have increased; and rural poverty would have declined moderately between 2000 and 2005 and increased between 2005 and 2010. Finally, the actual and simulated poverty reduction effects remain the same for safety net transfers in all three time periods. This implies that the public transfers, as captured by the HIES survey rounds, had no effects on poverty reduction in Bangladesh since 2000.[14]

10.6 Conclusions

Real wages in Bangladesh, especially in rural areas, have escalated in recent years. This is quite contrary to previous studies, which reported declining real wages, even during the height of green revolution. Using data from several sources, this chapter has (a) documented this unusual, but so far persistent, trend in real wages, (b) triangulated the evidence in light of the alternative theories of wage determination and economic development, and (c) presented evidence on the effects of wage escalation on poverty reduction in the country.

The study finds a consistent pattern in all data sets: after a long period of stagnation, real wages, especially in rural areas, began to grow at a faster pace in the past few years. This is likely an outcome of the government's strategies that capitalizes on the country's comparative advantage in labor intensive technology. A prominent outcome of such a development strategy is the rapid expansion of ready-made garment industries, as well as associated linkages, during the past three decades. Since the manufacturing sector offers better-paid jobs than the informal and agricultural sectors, expansion of garment sector has helped more workers, including the ones migrated from the rural area, improve their incomes and livelihoods.

[14] The safety nets programs in Bangladesh are geographically targeted and hence may not be adequately represented in the HIES survey, which is nationally representative and based on a PPS sample.

Whether this rising trend in real wage will continue in the foreseeable future was beyond the scope of this study. However, given rising labor costs in China and India, Bangladesh is expected to enjoy comparative advantage in labor-intensive industries in the years to come.

A central premise of this chapter has been to find a theoretical explanation for this unusual yet persistent rising trend in real wages. The convergence of rural and urban wages in recent years, as well as a linear trend in labor productivity, clearly suggest that this trend cannot be explained by neoclassical theory of wage formation unless there have been other policy-induced factors. There are two such commonly perceived factors: a massive increase in public transfers and accelerated efforts by the highly acclaimed microfinance programs in the country. However, the evidence does not support either of these two alternative explanations. Both the MFI loans and public transfers are just too small to drive a sharp escalation of real wage rates. In particular, our analysis suggests that, at the national level, a 10 percent rate of return on MFI loan can lead to less than half a percentage point increase in per capita income; and other things remaining the same, holding public transfer constant at 2000 level does not make any difference in the incidence of poverty in the subsequent HIES survey rounds.

The other two theories—namely subsistence and nutrition-based efficiency wage theories—cannot explain the rising trend either. These theories are rooted in the idea that in countries with abundant supply of workers, it is optimal for the employers to pay a wage rate that is enough to meet the subsistence or nutritional needs of a worker. We have not tested these alternative theories in the chapter, but if one agrees with the trends and other analysis in the chapter, the conclusion should be obvious: a sudden and persistent increase in real wage rates is contradictory to these theories. Thus, we conclude that recent trend in real wages in Bangladesh can only be explained by the Lewis (1954) theory of economic development with unlimited supply of labor.

Rising real wages have profound policy implications. Our results clearly suggest that the combination of increased job opportunities, higher wages, and more remittances have been the main forces behind Bangladesh's remarkable record of poverty reduction over the past decade. Overall, these factors have made greater contributions to poverty reduction than government transfers and the expansion of microfinance institutions. However, if the workers' productivity does not keep up, Bangladesh can lose the labor costs advantage that it has enjoyed for decades. Furthermore, to ensure continued inflow of remittances, the other key driver of poverty

reduction, the Bangladeshi workers will have to remain globally competitive. Therefore, well-designed public investments in education and other human capital development will be critical to sustaining the rising real wage trend long enough for the country to move to the subsequent stages of economic transformation.

Increasing demand for labor due to growing manufacturing sector also has implications for long term food security. Rural workers will no longer be in abundant supply. This calls for a reorientation in agricultural policies with due attention to improving overall agricultural productivity in light of rising labor costs. Agricultural mechanization, which has historically been taken with caution due to the fear of labor displacement, should now be gradually promoted through policy actions. Finally, as more people find better-paying jobs, the number of poor will decline. A logical response to this trend is redesigning the country's safety net programs so as to target a smaller group of vulnerable populations that is unable to participate in the labor market.

References

Ahmed, Iqbal. 1981. "Wage Determination in Bangladesh Agriculture." *Oxford Economic Papers* 33, no. 2 (July): 298-322. https://www.jstor.org/stable/2662904.

Bardhan, Pranab K. 1979. "Wages and Unemployment in a Poor Agrarian Economy: A Theoretical and Empirical Analysis." *Journal of Political Economy* 87, no. 3 (June): 479-500. https://www.jstor.org/stable/1832019.

Bose, Swadesh R. 1968. "Trend of Real Income of the Rural Poor in East Pakistan, 1949-66." *The Pakistan Development Review* 8, no. 3 (Autumn): 452-488. https://www.jstor.org/stable/41981663.

Boyce, James K. 1989. "Population Growth and Real Wages of Agricultural Laborers in Bangladesh." *Journal of Development Studies* 25, no. 4: 467-489. https://doi.org/10.1080/00220388908422124.

Boyce, James K., and M. Ravallion. 1991. "A Dynamic Econometric Model of Agricultural Wage Determination in Bangladesh." *Oxford Bulletin of Economics and Statistics* 53, no. 4: 361-376. https://doi.org/10.1111/j.1468-0084.1991.mp53004002.x.

BBS (Bangladesh Bureau of Statistics). 1999-2000. *Labor Force Survey.* Dhaka: BBS.

___. 2001-2011. *Monthly Statistical Bulletin of Bangladesh.* Dhaka: Ministry of Planning, Government of Bangladesh.

___. 2005-2006. *Labor Force Survey.* Dhaka: BBS.

___. 2009-2010. *Labor Force Survey.* Dhaka: BBS.

___. 2010. *Household, Income, and Expenditure Survey*. Dhaka: BBS.

Bangladesh Garments Manufacturers and Exporters Association (BGMEA). 2012. "BGMEA Worker Database." http://garmentworkers.com.bd/.

Basu, Kaushik. 1997. *Analytical Development Economics: The Less Developed Economy Revisited*. Cambridge, M.A., and London: MIT Press.

Deaton, A. 2003. "Prices and Poverty in India, 1987-2000." *Economic and Political Weekly* 38, no. 4: 362-368.

Dorosh, Paul, and Shahidur Rashid. 2013. "Trade Subsidies, Export Bans and Price Stabilization: Lessons of Bangladesh-India Rice Trade in the 2000s." *Food Policy* 41: 103-111.

Fei, J. C. H., and G. Ranis. 1975. "A Model of Growth and Employment in the Open Dualistic Economy: The Cases of Korea and Taiwan." *Journal of Development Studies* 11, no. 2: 32-63.

Fields, Gary S. 2004. "Dualism in the Labor Market: A Perspective on the Lewis Model after Half a Century." *The Manchester School* 72, no. 6: 724-735. https://doi.org/10.1111/j.1467-9957.2004.00432.x.

Hossain, Mahabub, Firdousi Naher, and Quazi Shahabuddin. 2005. "Food Security and Nutrition in Bangladesh: Progress and Determinants." *Journal of Agricultural and Development Economics* 2, no. 2: 103-132. ftp://ftp.fao.org/es/ESa/ejade/hossain.pdf.

Inchauste, Gabriela, Sergio Olivieri, Jaime Saavedra, and Hernan Winkler. 2002, September. *What is behind the Decline in Poverty Since 2000? Evidence from Bangladesh, Peru, and Thailand.* Policy Research Working Paper No. 6199. Washington, D.C.: World Bank. https://doi.org/10.1596/1813-9450-6199.

IHS (Information Handling Services) Global Insight. 2010. "Indian Wage Inflation to Eclipse China in 2010 as GM India Ends Strike on Pay Issues." Country & Industry Forecasting. http://www.ihs.com/products/global-insight/industry-economic-report.aspx?id=106593653.

International Rice Research Institute (IRRI). 2012. *Rice in Bangladesh*. Manila, The Philippines: IRRI. http://irri.org/index.php?option=com_k2&view=item&id= 10824:rice-in-bangladesh.

Islam, R. 2007. "What Kind of Economic Growth Is Bangladesh Attaining?" *Development Prospects of Bangladesh: Emerging Challenges.* Paper presented at an international seminar Development Prospects of Bangladesh: Emerging Challenges, Bangladesh Institute of Development Studies, Dhaka.

Kabeer, Naila, and Simeen Mahmud. 2004. "Rags, Riches and Women Workers: Export-oriented Garment Manufacturing in Bangladesh." In *Chains of Fortune: Linking* Women Producers and Workers with Global Markets, edited by Marilyn Carr, 133-162. London: Commonwealth Secretariat.

Khan, A. R. 1977. *Poverty and inequality in rural Bangladesh*. Geneva: International Labor Organization (ILO).

Khan, A. R. 1984. "Real Wages of Agricultural Workers in Rural Bangladesh." In *Poverty in Rural Asia*, edited by A. R. Khan and E. Lee. Bangkok: International Labor Organisation (ILO)-ARTEP.

Khandker, Shahidur R., Hussain A. Samad, and Rubaba Ali. 2013. *Does Access to Finance Matter in Microenterprise Growth? Evidence from Bangladesh*. Policy Research Working Paper No. 6333. Washington, D.C.: World Bank. http://hdl.handle.net/10986/12156.

Khundker, N. 2002. "Globalisation, Competitiveness, and Job Quality in the Garment Industry in Bangladesh." In *Bangladesh: Economic and Social Challenges of Globalisation*, edited by M. Muqtada, A. Singh, and M. A. Rashid, 61-82. Dhaka: The University Press Limited (UPL).

Lanjouw, Jean, and Peter Lanjouw. 2001. "How to Compare Apples and Oranges: Poverty Measurement Based on Different Definitions of Consumption." *Review of Income and Wealth* 47, no. 1: 25-42. https://doi.org/10.1111/1475-4991.00002.

Leibenstein, H. 1957. *Economic backwardness and economic growth: Studies in the theory of economic development.* New York: Wiley and Sons.

Lewis, W. A. 1954. "Economic Development with Unlimited Supplies of Labor." *The Manchester School* 22, no. 2: 139-191.

Lin, Justin Yifu. 2012. *New Structural Economics: A Framework for Rethinking Development and Policy*. Washington, D.C.: World Bank.

Mazumdar, D. 1959. "The marginal productivity theory of wages and disguised unemployment." *Review of Economic Studies*, 26, 190-197.

Nguyen, Cuong Viet, and Daniel Mont. 2012. "Economic Impacts of International Migration and Remittances on Household Welfare in Vietnam." *International Journal of Development Issues* 11, no. 2: 144-163.

Ranis, G. 2012. *Labor Surplus Revisited*. Economic Growth Center Working Paper No. 1016. New Haven, C.T.: Yale University. Available at: http://www.econ.yale.edu/growth_pdf/cdp1016.pdf.

Rashid, Shahidur. 2002, March. *Dynamics of Agricultural Wage and Rice Price in Bangladesh: A Re-Examination*. MSSD Discussion Paper No. 44. Markets and Structural Studies Division Washington, D.C.: International Food Policy Research Institute (IFPRI).

Rashid, Shahidur, Nigussie Tefera, Solomon Lemma, and Mohammad Yunus. 2014, February. *Population Pressure and Livelihood Dynamics: Panel Evidence from Bangladesh*. IFPRI Discussion Paper No. 01326. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Ravallion, Martin. 1990. "Rural Welfare Effects of Food Price Changes under Induced Wage Responses: Theory and Evidence for Bangladesh." *Oxford Economic Papers* 42, no. 3 (July): 574-585. https://www.jstor.org/stable/2663062.

Rosenzweig, Mark. 1980. "Neoclassical Theory and the Optimising Peasant: An Econometric Analysis of Market Family Labor Supply in a Developing Country." *The Quarterly Journal of Economics* 94, no. 1: 31-35. http://hdl.handle.net/10.2307/1884603.

Sincavage, J. R., C. Haub, and O. Sharma. 2010. "Labor Costs in India's Organized Manufacturing Sector." *Monthly Labor Review* 133, no. 5: 3-22.

UNCTAD (United Nations Conference on Trade and Development). 2012. *Least Developed Countries Report 2012: Harnessing Remittances and Diaspora Knowledge to Build Productive Capacities.* Geneva: United Nations. http://unctad.org/en/PublicationsLibrary/ldc2012_en.pdf.

Wooster, Rossitza B., and David S. Diebel. 2010. "Productivity Spillovers from Foreign Direct Investment in Developing Countries: A Meta-Regression Analysis." *Review of Development Economics* 14, no. 3: 640-655. https://doi.org/10.1111/j.1467-9361.2010.00579.x.

World Bank. 2008. *Poverty Assessment for Bangladesh: Creating Opportunities and Bridging the East-West Divide*. Dhaka: World Bank.

___. 2010. *Bangladesh—Technical Note*. Unpublished.

___. 2012. *World Bank Development Indicators*. Washington, D.C.: World Bank.

___. 2013. *Bangladesh Poverty Assessment: Assessing a Decade of Progress in Reducing Poverty, 2000-2010.* Washington, D.C.: World Bank.

Zhang, Xiaobo, Jin Yang, and Shenglin Wang. 2011. "China Has Reached the Lewis Turning Point." *China Economic Review* 22, no. 4: 542-554. https://doi.org/10.1016/j.chieco.2011.07.002.

Zhang, Xiaobo, and Kevin H. Zhang. 2003. How Does FDI Affect Regional Inequality within a Developing Country? Evidence from China. *Journal of Development Studies* 39, no. 4: 47-67. https://doi.org/10.1080/713869425.

Chapter 11

Sudden Onion Price Surge in Bangladesh: A Situation Analysis for Policy

Akhter U. Ahmed and Ahmad Kaikaus

11.1 Background

Onion is a key ingredient in most Bangladeshi meals, so its sudden price spurt in the domestic market in early-July 2013 raised deep concerns among the people and the government. While such a price surge hits low-income consumers the hardest, it can also become an important political issue. For example, in India, onion prices were regarded as the decisive factor in the 1998 state elections in Delhi and Rajasthan and were responsible for bringing down the central government in 1980. Following the 2013 price hike, a situation analysis of the onion price surge was conducted with a view to derive policy recommendations for onion price stabilization in the country. The analysis of onion price situation was based on information collected from a number of sources.

A rapid surveillance of onion wholesale markets in Dhaka city to collect information from wholesalers on daily stocks and selling prices of both local onions and those imported from India:

- Interviews with onion importers and traders on suspected causes of onion price hike;
- Estimates of production costs and marketed surplus of onion based on data from the IFPRI-PRSSP 2011-2012 Bangladesh Integrated Household Survey (BIHS) results;
- Telephone interviews with selected onion farmers from the 2011-2012 BIHS sample;
- Consultations with relevant officials in the Ministry of Agriculture, Ministry of Commerce, and the Tariff Commission;
- Analysis of (i) secondary time series data on daily and monthly onion wholesale and retail prices from the Department of Agricultural

Marketing; (ii) yearly onion production trends from the Bangladesh Bureau of Statistics (BBS) and the Department of Agricultural Extension (DAE); and (iii) weekly and monthly onion import data from the Bangladesh Bank (central bank); and

- Reviews of online and print media about the onion price issue in Bangladesh and India.

11.2 Onion Price Analysis

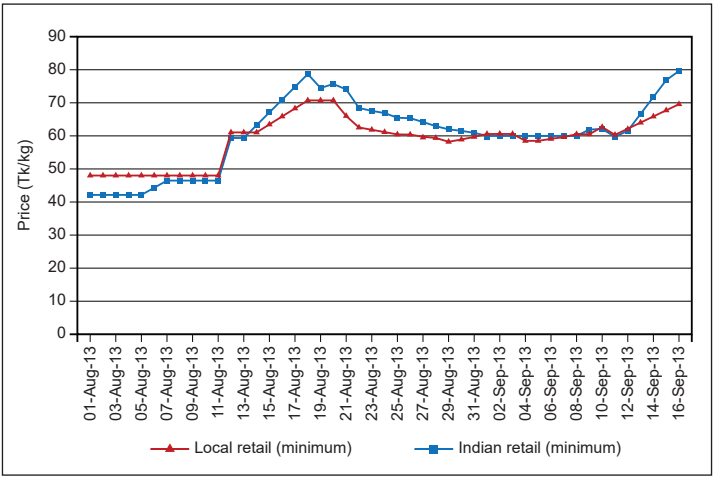
Two types of onion are available in the domestic market: local (Bangladeshi) and imported (from India). From early July to 18 August 2013, the market prices of both types of onion rose sharply. The price of Indian onions jumped from BDT 25 per kilogram (BDT/kg) on June 2 to BDT 78/kg on August 18, giving a 212 percent price increase in only two and a half months. The average retail price of local onion registered a 133 percent increase during the same timeframe, starting at BDT 30/kg on June 2 and reaching BDT 70/kg on August 18 (Figure 11.1 and Table A11.1). In the span of one year—from 18 August 2012 to 18 August 2013—the retail price of Indian onion rose by 290 percent and that of local onion by 133 percent (Figure 11.2).

Indian onion's retail price began falling on 19 August 2013 while local onion's on 21 August 2013. By 4 September 2013, the retail prices were BDT 60/kg for Indian onion (down 23 percent from the August peak price) and BDT 58/kg for local onion (down 17 percent from the August peak price). However, the prices started rising again from 8 September 2013. On 16 September 2013, the retail price of Indian onion reached BDT 80/kg, and the price of local onion reached BDT 70/kg (Figure 11.1 and Table A11.1).

Although the average wholesale prices of local and Indian onions came down in the last week of August and early September of 2013, the reductions were not fully translated into the retail prices (Figures 11.3 and 11.4). This is probably because the retailers who purchased onions at higher wholesale prices would not reduce retail prices until they exhausted their stock purchased at higher prices. But this pattern did not hold for the opposite price trend: when the wholesale price started rising again in the second week of September, retail prices of local and Indian onions adjusted promptly to the rising wholesale prices.

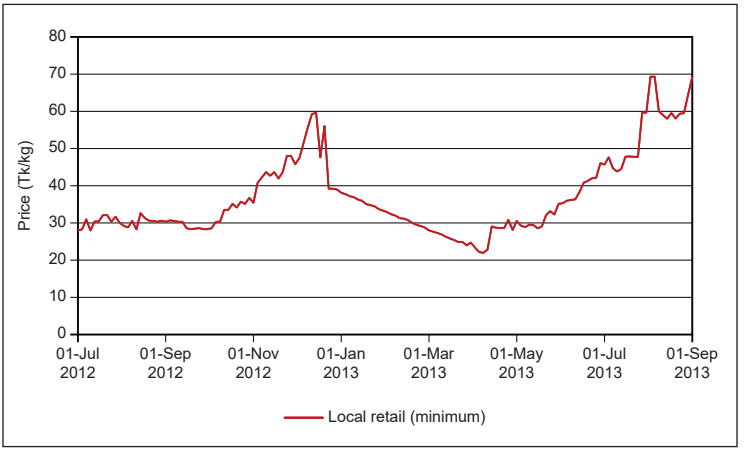
Local onion prices have typically been higher than Indian onion prices, but that pattern reversed during the price surge, as seen in Figures 11.1 and 11.5.

Figure 11.1: Daily Retail Prices of Bangladeshi and Indian Onions in Dhaka City, 1 August to 16 September 2013



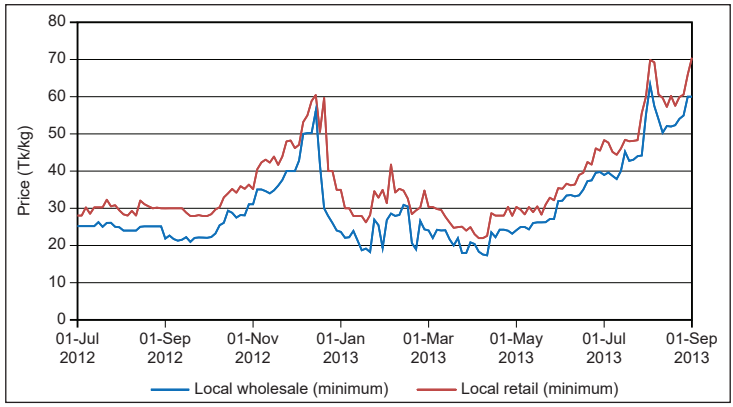
Source: Department of Agricultural Marketing, Ministry of Agriculture. See Table A1.

Figure 11.2: Daily Retail Prices of Bangladeshi and Indian Onions in Dhaka City, 1 July 2012 to 16 September 2013



Source: Department of Agricultural Marketing, Ministry of Agriculture. See Table A12.1.

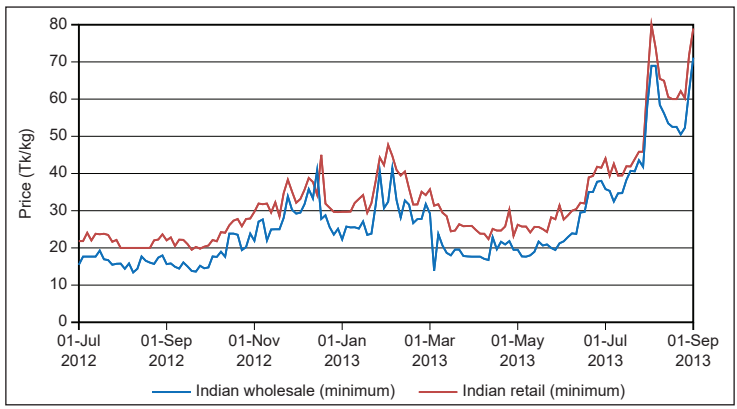
Figure 11.3: Daily Wholesale and Retail Prices of Bangladeshi Onion in Dhaka City, 1 July 2012 to 16 September 2013



Source: Department of Agricultural Marketing, Ministry of Agriculture. See Table A1.

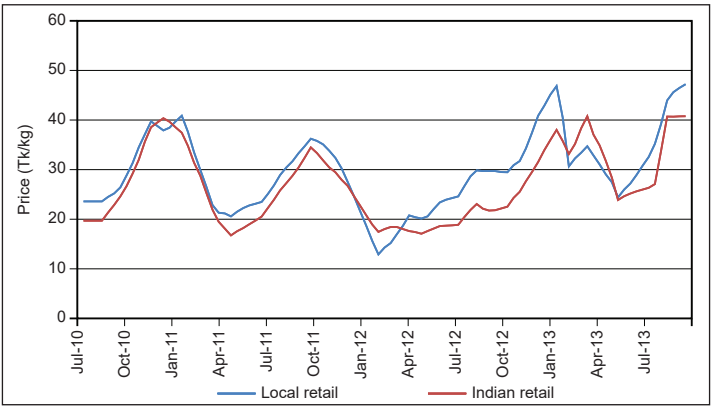
Onions in Bangladesh are produced in two ways: from roots (around 15 percent of total production) and from seed (around 85 percent of total production). Onions from roots are harvested in December while those from seed are harvested between early April and early May. The monthly price trends shown in Figure 11.5 suggest that onion prices are relatively low during the harvest time, particularly during April of 2011, 2012 and 2013, when prices were indeed at their lowest.

Figure 11.4: Daily Wholesale and Retail Prices of Indian Onion in Dhaka City, 1 July 2012 to 16 September 2013



Source: Department of Agricultural Marketing, Ministry of Agriculture. See Table A1.

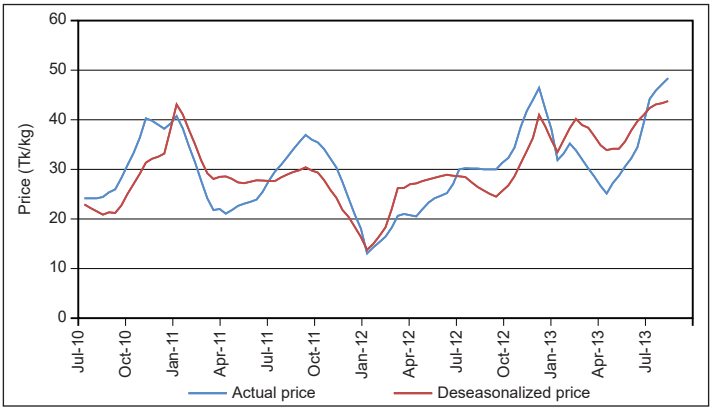
Figure 11.5: Monthly Average Retail Prices of Bangladeshi and Indian Onions, July 2010-August 2013



Source: Department of Agricultural Marketing, Ministry of Agriculture. See Table A2.

To examine the extent of irregularities in onion prices, we separated the seasonal price effects resulting from onion harvests from the price trends.[1] Figure 11.6 shows that the seasonal effects of onion harvests on prices have largely been removed from the deseasonalized price series.

Figure 11.6: Monthly Prices of Bangladeshi Onions, July 2010-August 2013 (actual versus deseasonalized prices)

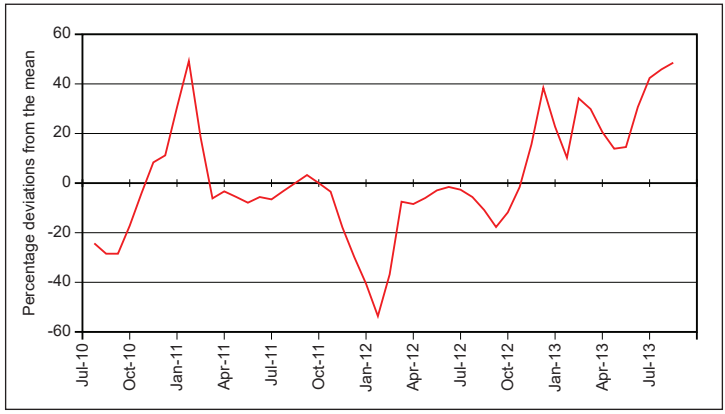


Source: Department of Agricultural Marketing, Ministry of Agriculture. See Table A2.

[1] First, we computed a seasonal index for monthly average prices of local onion by using the 'ratio to moving average' method, which involves the estimation of a 12-month centred moving average of the price series. Then, we 'deseasonalized' the price series by dividing every entry in the original price data by the seasonal index.

Figure 11.7 shows the irregular movements of onion prices.[2] The maximum positive deviation from the mean was 73 percent in August 2013, followed by 46 percent in January 2011, 45 percent in July 2013, and 38 percent in December 2012. The maximum negative deviation was 54 percent in January 2012. These variations were mostly caused by irregular or random factors rather than by changes in domestic onion production. The irregular factors probably include fluctuations in onion imports and import prices, hoarding by onion traders, or transportation problems.

Figure 11.7: Irregular Variations in Prices of Bangladeshi Onions, July 2010-August 2013



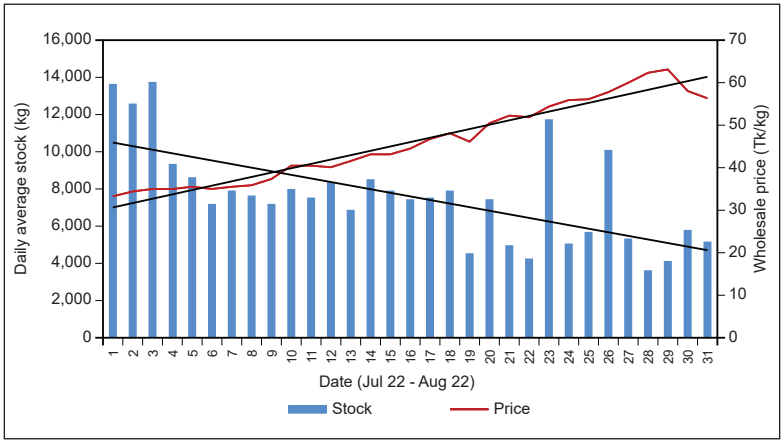
Source: Department of Agricultural Marketing, Ministry of Agriculture. See Table A2.

The Data Analysis and Technical Assistance (DATA), a Bangladeshi survey firm, collected information from onion wholesalers on daily stocks and selling prices of imported and local onions from 22 July 2013 to 22 August 2013 and interviewed traders for their views on what caused the onion price hike. The DATA team collected information from four wholesale markets in Dhaka city: Kawran Bazar, Mohammadpur Krishi Market, Moulavi Bazar, and Shyambazar.

The daily average stocks and selling prices of Indian onions can be seen in Figure 11.8 and for local onions in Figure 11.9 at Shyambazar, the largest wholesale market for onions in Dhaka city, from 22 July to 22 August 2013.

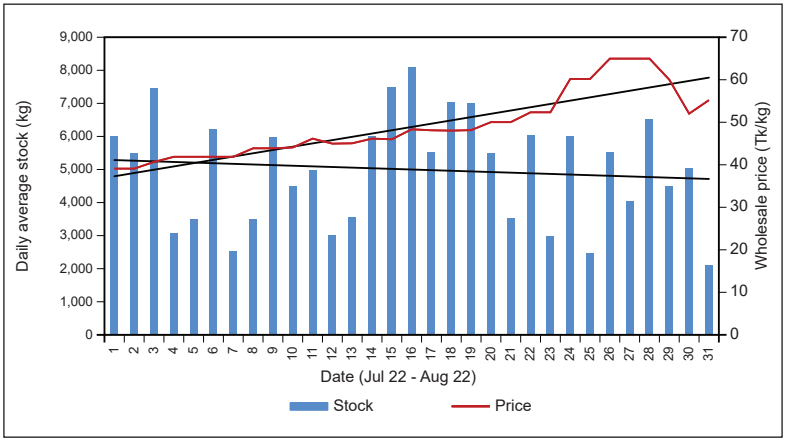
[2] We transformed the deseasonalized prices into percentages of the overall deseasonalized-price-series average and presented the results in Figure 11.7 as percentage deviations from the average.

Figure 11.8: Daily Stocks and Selling Prices of Indian Onion at Shyambazar Wholesale Market in Dhaka City, 22 July-22 August 2013



Source: Rapid surveillance data collected by Data Analysis and Technical Assistance (DATA).

Figure 11.9: Daily Stocks and Selling Prices of Bangladeshi Onion at Shyambazar Wholesale Market in Dhaka City, 22 July-22 August 2013



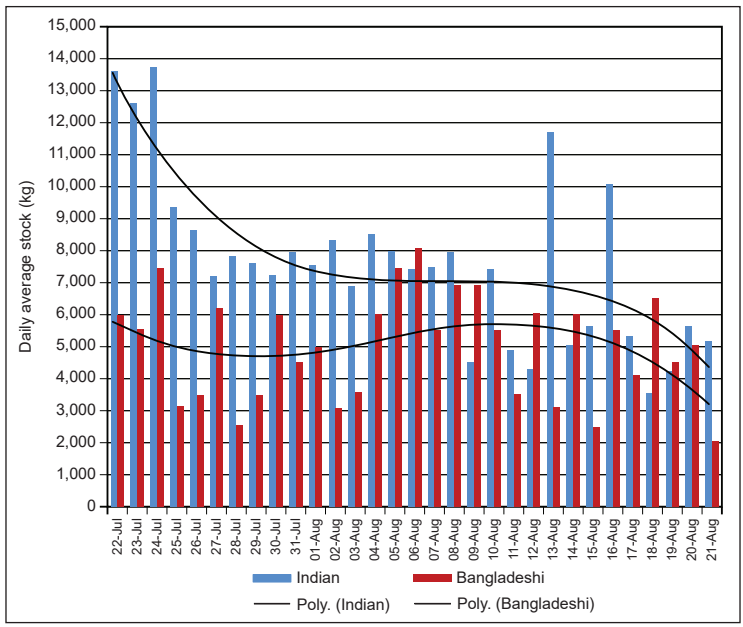
Source: Rapid surveillance data collected by Data Analysis and Technical Assistance (DATA).

Figure 11.8 shows that the fitted trend lines for onion selling prices and onion stocks are negatively associated; that is, as the stocks increase, the selling price decreases and vice versa. This relationship is much stronger

for imported Indian onions than for Bangladeshi onions (Figure 11.9). These patterns at the wholesale market indicate that Indian onion plays a key role in determining the market price of onions.

Figure 11.10 compares the patterns of daily average stocks of Bangladeshi and Indian onions at the Shyambazar wholesale market from 22 July to 22 August 2013. Imported onions constitute less than one-third of total onion availability (that is, the total of domestic production and imports) in the country. Even though the day-to-day variation in daily stocks of local and Indian onions have been quite large, imported onions accounted for 60 percent of the average total stocks (Indian plus local) during the period from 22 July to 22 August in the largest wholesale market in Dhaka city, the main consumption center of the country. These patterns again show the dominance of imported Indian onions in the domestic market.

Figure 11.10: Daily Average Stocks of Bangladeshi and Indian Onions at Shyambazar Wholesale Market in Dhaka City, 22 July-22 August 2013



Source: Rapid surveillance data collected by Data Analysis and Technical Assistance (DATA).

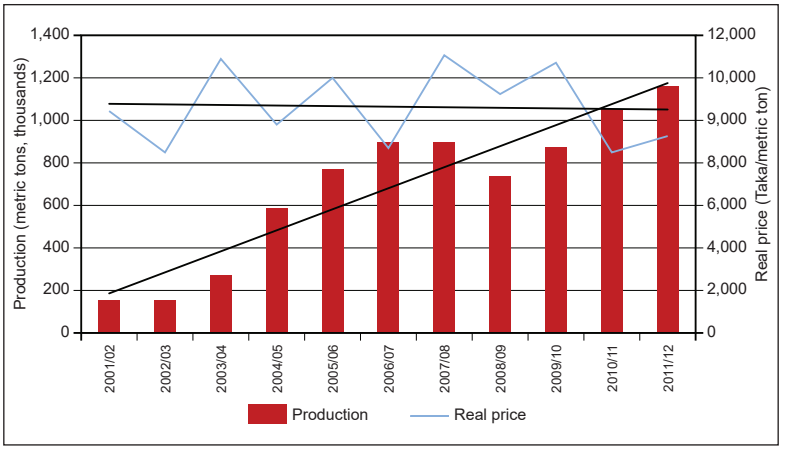
11.3 Supply of Onion

The supply of onion in Bangladesh consists of domestic production by farmers and imports (mainly by private importers but also by the government).

11.3.1 Domestic Production and Long-term Price Trends

Figure 11.11 shows the trends in domestic production and real prices, which are adjusted for inflation and expressed in constant 1995-1996 prices.[3] Onion production in Bangladesh has increased remarkably—by almost sevenfold—from only 150 thousand tons in 2001-2002 to 1.16 million tons in 2011-2012. The changes in real prices within the domestic market, however, do not reflect any noticeable association with the changes in national production levels. Actually, the pattern of onion prices more likely reflects the production situation in India.

Figure 11.11: Domestic Onion Production and Real Wholesale Onion Prices, 2001-2002 to 2011-2012



Note: Annual nominal prices of onion have been deflated by the general consumer price index, where 1995-1996=100.

Source: Bangladesh Bureau of Statistics; Department of Agricultural Marketing. See Table A3.

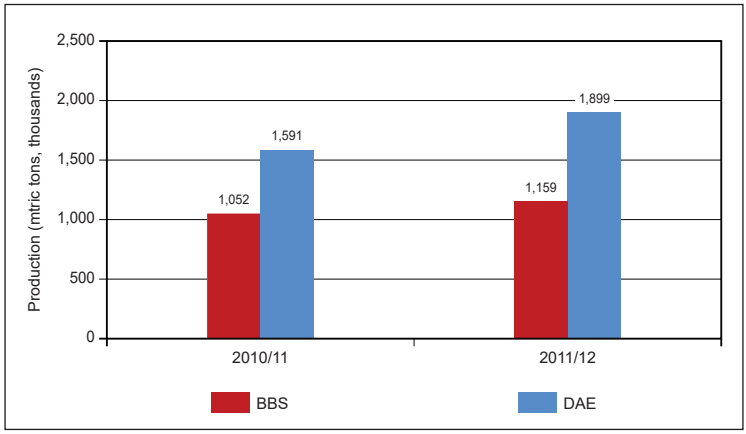
11.3.2 Discrepancies in Onion Production Statistics

The official source of agricultural statistics on cultivated area, production, and yields is the Agriculture Wing of the Bangladesh Bureau of Statistics (BBS), Statistics Division, Ministry of Planning. The Department of Agricultural Extension (DAE) of the Ministry of Agriculture also reports these statistics. However, there are often major differences in the statistics provided by

[3] The annual nominal prices of onion have been deflated by the general consumer price index (CPI base: 1995-96=100).

these two government agencies. For example, the most recent BBS onion production estimate for 2011-2012 is 1,159 thousand metric tons while the DAE estimate is 64 percent higher at 1,899 thousand metric tons (Figure 11.12).[4] During our consultations, DAE and Tariff Commission officials said the discrepancy comes from the fact that the DAE makes its production estimates immediately after harvest, when onions are wet and their leaves are still attached. The onions weigh 30-40 percent more at this time than at a later stage when they are dry and leafless.

Figure 11.12: Discrepancies in Estimates of Onion Production: BBS versus DAE



Source: Agricultural Statistics Wing, BBS and Department of Agricultural Extension (DAE).

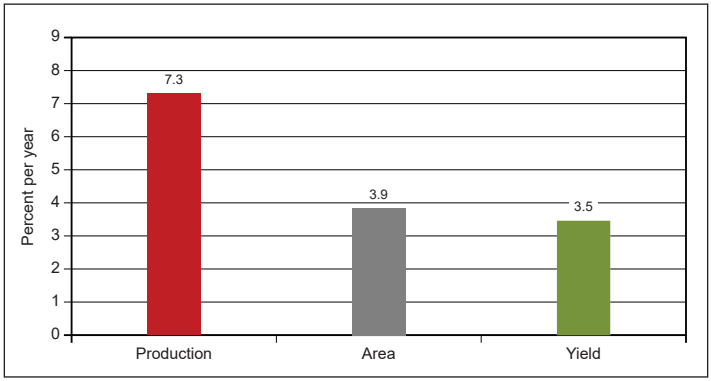
Growth rates of onion production, area and yields

Figure 11.13 shows the annual growth rates of production, area, and yields from 2004-2005 to 2011-2012.[5] Onion production grew at an annual rate of 7.3 percent, which is quite remarkable even though the base year production level in 2004-2005 was relatively low. The expansion of onion cultivation area contributed to 53 percent of the production increase; the remainder (47 percent) was due to increase in yields. This suggests that research can play an important role in increasing onion production through productivity improvements.

[4] For the year 2012-2013, DAE website reports that the total production was 1.914 million metric tons. The BBS estimate for 2012-2013 is not available.

[5] Least-square growth rates calculated by authors based on BBS data.

Figure 11.13: Annual Growth Rates of Onion Production, Area, and Yields, 2004-2005 to 2011-2012



Source: Bangladesh Bureau of Statistics. See Table A12.3.

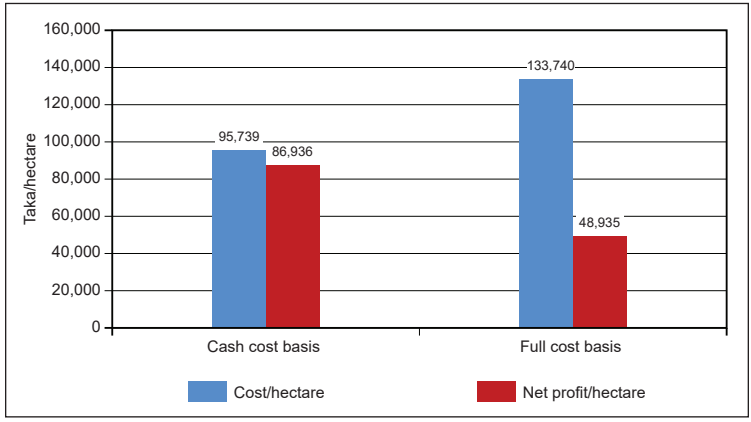
11.3.3 Costs and Profitability of Onion Production

We estimated costs and profitability of onion production based on data from the 2011-2012 Bangladesh Integrated Household Survey (BIHS), a nationally representative survey developed and conducted by IFPRI-PRSSP that collected detailed plot-level data on agricultural production practices and other aspects of livelihoods of rural households.[6]

Figure 11.14 provides the estimates of production costs and net profits from onion cultivation in 2012. The average cost of onion production on a cash-cost basis (that is, when imputed values of land rent and family labor are not taken into account) was BDT 95,739/hectare; on a full-cost basis (including the imputed values of land rent and family labor) the production cost is BDT 133,740/hectare. Net profit (gross revenue minus the cost of production) therefore was BDT 86,936/hectare on a cash-cost basis and BDT 48,935/hectare on a full-cost basis.

[6] Total cost per hectare is obtained by adding the costs of: inputs (seeds, fertilizers, manure, and pesticides), irrigation, seedling raising, equipment/bullock/mechanical power rentals, hired and family labor, and imputed land rent for both farmer-owned and rented-in land. Dividing the cost per hectare by onion yield gives cost per metric ton of onion. On the revenue side, average onion yield per hectare (9,689 kg) is multiplied by farmers' average selling price (BDT 18.85/kg) to calculate gross revenue or return per hectare in 2012. Dividing the gross revenue per hectare by onion yield gives gross revenue per metric ton of onion. Subtracting the cost of production from gross revenue gives the net profit of producing onion.

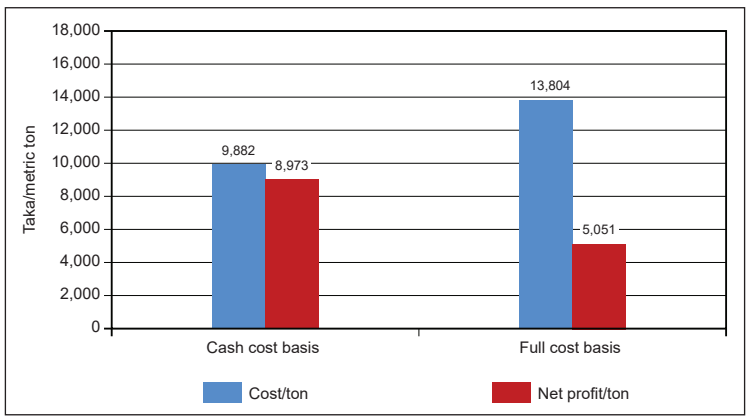
Figure 11.14: Cost of Production of Onion per Hectare, 2012



Source: Estimated from IFPRI-PRSSP 2011-2012 BIHS data.

The cost of producing one metric ton of onion can be viewed in terms of a break-even point, which indicates the price a farmer must receive for the crop in order to cover costs. On a cash-cost basis, the rate of profit per ton was quite high: 91 percent of average cost per ton of onion produced. Even when the imputed values of land rent and family labor were accounted for in the cost calculations, the profitability was 37 percent of full cost of production per ton of onion (Figure 11.15).

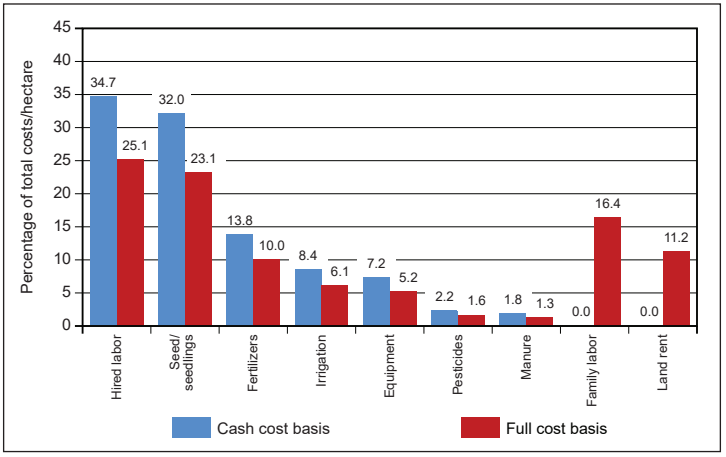
Figure 11.15: Cost of Production of Onion per Metric Ton, 2012



Source: Estimated from IFPRI-PRSSP 2011-2012 BIHS data.

Figure 11.16 presents input costs as percentages of both cash costs and full costs of onion production per hectare. Labor has the biggest share of costs followed by seeds and seedlings. Family labor and imputed land rent account for 16 percent and 11 percent of full costs, respectively.

Figure 11.16: Shares (percent) of Input Costs in cash and Full Costs of Production of Onion, 2012



Source: Estimated from IFPRI-PRSSP 2011-2012 BIHS data.

11.3.4 Price Sensitivity of Onion Farmers

According to recent estimates, the short-run price elasticity of onion supply is 0.23, meaning a 10 percent increase in price would induce farmers to produce 2.3 percent more onion (Yunus and Shahabuddin 2013). Farmers will probably make their production decisions based on market price before the planting season (around November).

DATA interviewed 25 selected farm households among those who participated in 2011-2012 BIHS. Twelve of the 25 households cultivated onions this year (harvested in April 2013), and farmers in those households said they would substantially increase the area under onion cultivation next year because of the expected high profits. Mofizul Islam, a farmer from Kumarkhali Upazila of Kushtia District, said:

> Of course, I will cultivate more onion next year. Compared to other crops, onion is more profitable. Market price remains between 800 and 1,000 taka per *maund* [37.32 kg]. For every *bigha* [one-third of an acre], the yield is 30 to 40 *maunds*, and expenses are between 12,000 to 15,000 taka per *bigha*.

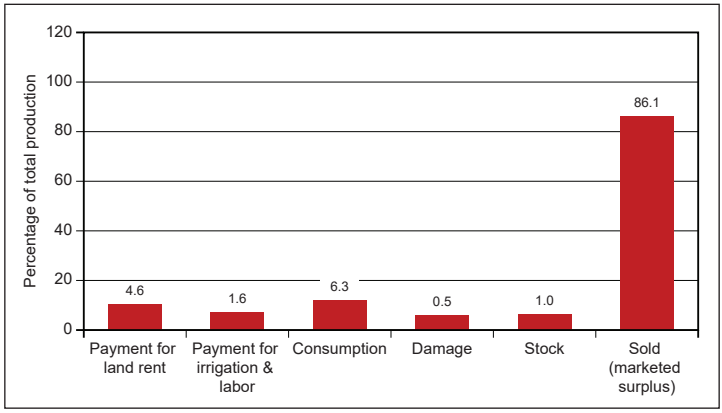
So, the profit is almost double the production cost. However, if farmers could get loans, then many more farmers could grow onion and much more area could be under onion cultivation.

Farmers who did not cultivate onion this year expressed a strong interest in producing it next year with the expectation of high profits. "I will cultivate onion next year because the price is so high. I regret that I did not grow [it] this year. I could earn a huge profit," said Alamgir Hossain, a farmer from Bhanga Upazila of Faridpur District.

11.3.5 Marketed Surplus Rate of Onion

The results of our analysis of the 2011-2012 BIHS data (presented in Figure 11.17) show that onion has a high marketed surplus rate and suggest that it is a highly commercial commodity.[7] In 2012, onion farmers in Bangladesh sold about 86 percent of their gross onion production.

Figure 11.17: Uses of Onion produced by Bangladeshi Farm Households



Source: IFPRI-PRSSP 2011-2012 Bangladesh Integrated Household Survey.

11.3.6 Onion Imports

Although the government imported onion from Myanmar in the last week of August 2013, historically, India has been the only source of onion imports

[7] We analyzed the use of onion produced by Bangladeshi farm households using data from 2011-2012 BIHS, which collected plot-level data on in-kind payments for land rent, irrigation, and labor use; crop production; input use; farmers' home consumption; loss/damage after harvest; farm-level stock; and the marketed quantity for one year (from 1 December 2010 to 30 November 2011).

to Bangladesh. Second only to China, India produces around one-quarter of the global onion supply and exports about 10 percent of its total onion output—much of it to Bangladesh, Malaysia, and Singapore. However, drought-induced losses in India's main producing regions, Maharashtra and Karnataka, led the price of onion to rise sharply in July and August 2013. The National Horticultural Research and Development Foundation of India predicted an estimated 10 percent decrease in production. To stabilize the price of onion, India's state-run trading agencies issued import tenders in the last week of August 2013. The main importing firm—New Delhi-based state-run National Agricultural Cooperative Marketing Federation of India—mentioned on its website that it was exploring import potentials from China, Egypt, Iran, and Pakistan. Another state-run international trading company based in New Delhi (PEC Ltd.) also saw interest from international suppliers to supply 300,000 tons of onions.

On 14 August 2013, amid concerns about the political repercussions of spiraling onion prices, India's Commerce Ministry set the minimum export price at US$650 per ton to discourage exports and control rising prices.[8] This measure contributed to the price hike for Bangladeshi onion importers.

To deal with the price surge, the Trading Corporation of Bangladesh decided to import 5,000 tons of onion from both India and Myanmar through private importers. A September 17 newspaper article reports that, between end-August and mid-September, 2013, Bangladesh imported 2,500 tons of onion from China, Myanmar, and Pakistan.[9] In August 2013, the government started selling onion directly to the consumers through its open market sale program at a fixed price of BDT 47/kg.

According to the Tariff Commission, alternative sources of onion import are China, Egypt, Malaysia, Myanmar, Pakistan, Turkey, and Vietnam, but the cost-effectiveness and technical feasibility of importing from these countries needs to be carefully examined. Although Myanmar is closest in proximity to Bangladesh and its current onion price is low compared to India, the process of opening a letter of credit and settlement with Myanmar would be quite cumbersome and time-consuming. This must be weighed against importing onion from countries that are farther away, which would result in higher transit losses of the semi-perishable crop.

Figure 11.18 shows the trends in monthly imports of onion from June 2011 to July 2013. The level of import has fluctuated considerably during

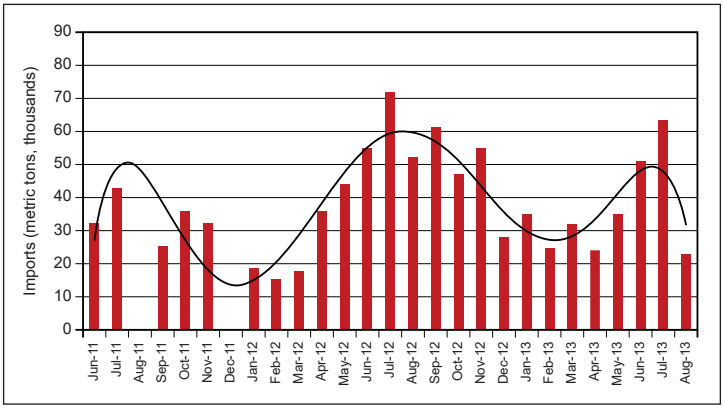
[8] The minimum export price was US$250/ton on 4 August 2013 and jumped to US$400/ton just after the Eid celebration on 10 August 2013.

[9] "Reliance is now on onion from Pakistan and Myanmar (translated)," *Prothom Alo*, 17 September 2013.

this period. It is quite puzzling that while onion imports increased by 163 percent—from 24 thousand tons in April 2013 to 63 thousand ton in July 2013—the price also sharply increased. From July to August 2013, however, onion imports dropped by 63 percent.

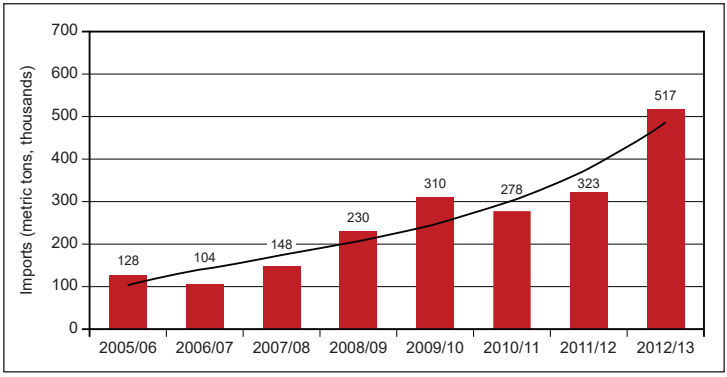
Figure 11.19 shows the trends in annual imports of onion from 2005-06 to 2012-13 and illustrates that imports have increased three folds during this period.

Figure 11.18: Trends in Monthly Onion Imports, June 2011-July 2013



Source: Import Monitoring Section, Bangladesh Bank. See Table A4.

Figure 11.19: Trends in Annual Onion Imports, 2005-2006 to 2012-2013

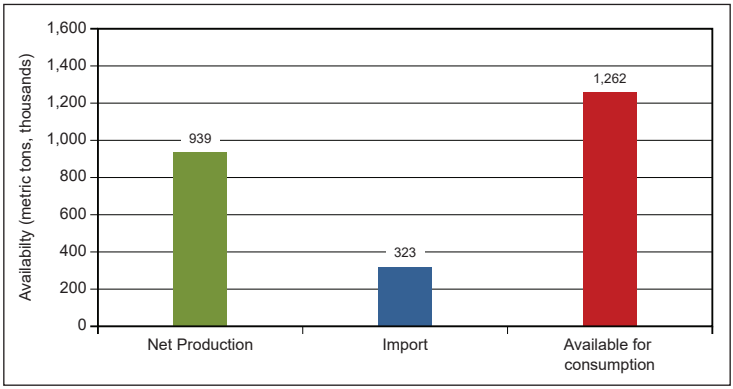


Source: Bangladesh Tariff Commission, Ministry of Commerce. See Table A5.

11.3.7 Onion Availability for Consumption

The annual onion availability for consumption in Bangladesh consists of net domestic production plus imports. Based on this, we estimated onion availability for consumption at 1.3 million metric tons in 2011-2012 (Figure 11.20).[10]

Figure 11.20: Onion Availability for Consumption, 2011-2012



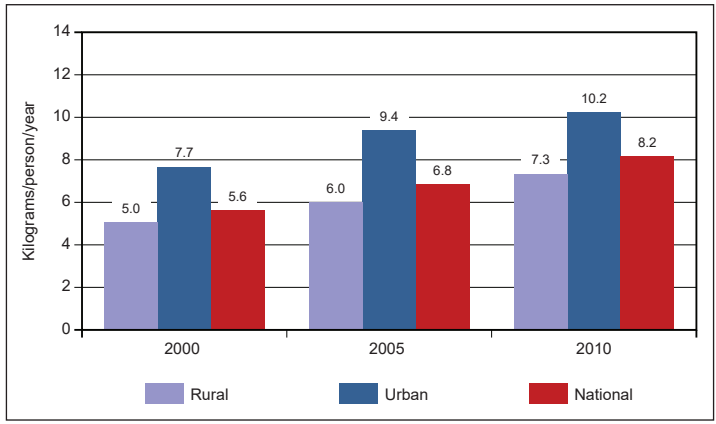
Source: Estimated from Bangladesh Bureau of Statistics data.

11.4 Onion Consumption

The Bangladesh Bureau of Statistics (BBS) conducts the nationally representative household income and expenditure survey (HIES) in both rural and urban areas every five years. This survey covers household expenditures for food and non-food as well as quantities of food consumed. Based on three rounds of HIES data, we estimated annual per capita onion consumption in 2000, 2005, and 2010. Figure 11.21 shows the trends at the country, rural, and urban levels for per capita onion consumption, which increased by 46 percent nationwide from 2000 to 2010. Urban residents eat more onions than rural households; in 2010, they consumed 40 percent more onions per person than rural residents did.

[10] Customarily in Bangladesh, the total of seed, feed, and wastage for foodgrains (such as rice and wheat) is considered to be 10 percent, which is deducted from gross production to calculate net production. However, unlike cereals, which are not perishable, onion is a semi-perishable commodity.There exists no standard for estimation of net domestic onion availability for consumption. Without an available standard, we calculated the net production quantity by deducting 20 percent from total onion production to account for seeds, excess moisture, and post-harvest losses and taking into consideration the perishability of onion.

Figure 11.21: Trends in Per Capita Onion Consumption, 2000, 2005, and 2010



Source: HIES 2000, 2005, 2010.

11.4.1 Demand for Onion

There are differing estimates for the demand for onion in 2013. The Department of Agricultural Extension provides two estimates—2.1 million metric tons and 2.7 million metric tons[11]—while Tariff Commission estimates the demand at 2.4 million metric tons.[12] In an August 19 newspaper article,[13] a Ministry of Commerce official remarked that the estimates for onion production differ drastically between the government agencies that provide them (that is, DAE and BBS). The concept of demand is different from that of requirement. In economics, demand is a consumer's desire, willingness, and ability to pay a price for a specific good or service.[14] In our analysis, we made onion-demand projections from 2010 to 2020. The estimate for change in demand is based on

[11] Department of Agricultural Extension, Ministry of Agriculture.

[12] Ministry of Commerce position paper prepared for 3 June 2013 meeting at the Prime Minister's Office.

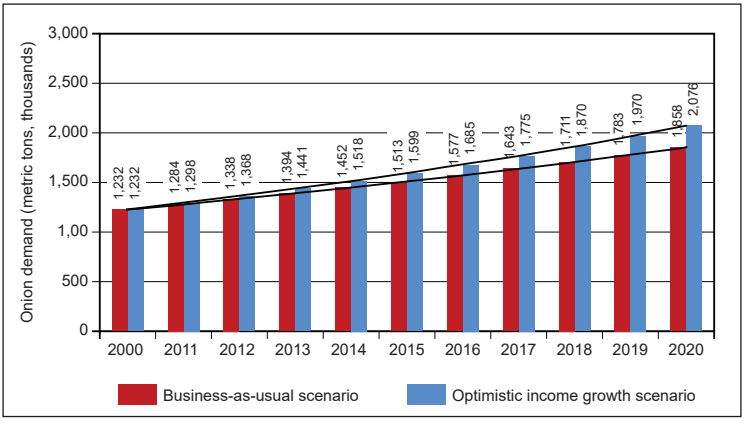
[13] "Ministry in Dark on Onion Production," *Dhaka Tribune*, 19 August 2013.

[14] The quantity demanded is the amount of a product people are willing to buy at a certain price; the relationship between price and quantity demanded is known as the "demand relationship." Movement along a demand curve due to a change in the good's price results in a change in the quantity demanded, not a change in overall demand. Rather, a change in overall demand refers to a shift in the quantity demanded based on changes in factors other than the price of the good. For example, if a person's income increases, his demand is likely to increase. If the population grows, demand will also increase. Demand can also change due to changes in taste and preference or changes in the prices of related commodities.

changes in income and population, holding prices and other factors constant at their 2010 levels.[15] We make per capita annual onion demand projections under two scenarios on the growth of real per capita income. First, we envisage a business-as-usual scenario, where the current trend in real (that is, inflation-adjusted) income growth of 3.6 percent per capita from 2000 to 2010 is expected to continue (Ganesh-Kumar, Prasad, and Pullabhotla 2012). Second, we use an optimistic scenario of 5 percent per capita real income growth.

Figure 11.22 presents the projected total demand for onion under the two income growth scenarios from 2010 to 2020.[16] From the base year demand of 1.23 million metric tons, the demand for onion is expected to increase to 1.86 million metric tons in 2020 (51 percent increase) under the business-as-usual scenario and to 2.08 million metric tons (69 percent increase) under the optimistic income growth scenario. The estimates show that the projected demand of 1.3 million metric tons in 2012 under the business-as-usual scenario reflects the availability of onion for consumption (net production plus import) of 1.3 million metric tons, as shown in Figure 11.20.

Figure 11.22: Projected Onion Demand, 2010-2020



Source: Authors' estimates using data from BBS and World Bank.

15 We have used 2010 HIES estimate of actual per capita consumption (8.16 kg/year/person) as the base year demand. For income, we use the gross national income per capita from the World Bank's *World Development Indicators* and 0.54 as the value of income elasticity of demand for onion.

16 To calculate the total demand for onion by population, we have multiplied the annual per capita consumption forecasts with the predicted annual population figures obtained from the World Bank.

11.4.2 Effects of Onion Imports on Market Prices

Amid the onion price surge, the Trading Corporation of Bangladesh (TCB) imported 5,000 metric tons of onion to dampen the domestic market price. But, specifically, what impact did it have? We use a mathematical demand-supply model to estimate it under different scenarios (see Appendix B for model description and parameters used for estimations).

The price of a commodity is determined by the interaction of its demand and supply in the market. We assume that the retail market price of onion before the import (the "base price") is BDT 62/kg. If the entire quantity of imported onion is distributed in the country within a span of one week, then the market supply of onion would increase by 5,000 metric tons, and the retail price would drop to BDT 51/kg. However, if the imported quantity is distributed within a span of two weeks, then the market price would only fall to BDT 56/kg. If no subsequent new supply comes to the market after the 5,000 metric tons is exhausted, then the price would return to the base level. These effects are calculated with the assumption that all other things (for example, private imports, stocks held by farmers and traders, the transportation situation, income, prices of other commodities, and additional factors) are held constant at the base level in order to isolate the effects of TCB's import from other factors.

11.4.3 Contributory Factors to Steep Onion Price Rise

From our situation analysis, we conclude that the main reason for the recent onion price surge was a decline in onion production in India due to unfavorable weather conditions in its major onion production zones. Based on the media reports from Bangladesh and India, it can be inferred that there is actually an onion-price crisis in India as well.

Although onion imports in Bangladesh increased substantially from April to July 2013, onion prices still rose sharply during this period. This was probably because Bangladeshi traders anticipated a significant decline in imports of onion from India (due to the weather-induced production shortfall there) so they began speculative stockpiling of the product in order to make extra profits. Once the Bangladesh Government announced its decision to import onion from sources other than India, traders began supplying the stored onions into the local market. As a consequence, the price of onion showed a downward trend, but it was short-lived: prices began to rise again as onion imports fell considerably once the Indian government raised their minimum export price from US$250 per ton to US$650 per ton to discourage exports and control rising onion prices in India.

11.5 Conclusions for Policy

The market supply of onion in Bangladesh declined not only because of the reduction in imports from India but also because local traders took advantage of the situation by curbing the release of their stored onions into the market in order to make extra profit. On 17 August 2013, the Bangladesh Government announced its decision to import onion from Myanmar. Following this announcement, the market price of onion began to drop, likely because the traders supplied their previously stored stock of onion into the local market. Despite this, onion prices started rising again, but, this time, as a consequence of the significant reduction in imports.

We have drawn the following conclusions and short-, medium-, and long-term policy recommendations regarding management of onion production and prices.

Short-term recommendations

- Bangladesh's dependency on India as virtually the only source of onion imports makes the country vulnerable. The government needs to carefully examine the feasibility of alternative sources such as China, Egypt, Malaysia, Myanmar, Pakistan, Turkey, and Vietnam.
- Although government imports have the potential to decrease market price, their expected impacts on prices need to be more carefully assessed. While relatively small imports distributed over a long period of time would not have much impact on the market price, too much price reduction could create disincentive for farmers to produce onion.
- Bangladesh is mostly dependent on onion imports between September and December. Therefore, the government has to be vigilant during this period to prevent traders from engaging in speculative storing during this period.
- Timely provision of high-quality inputs to farmers—particularly seeds, fertilizers, and pesticides—is important for increasing domestic production of onion and reducing the dependency on imports.

Medium-term policy recommendations

- The government should explore ways to promote more participation in the onion trade by creating an enabling environment. This would increase competition in the supply market and thereby erode the scope for seeking windfall profits through speculation.

- Timely, adequate, and accurate information is the basis for policy formulation and decision-making, but there are often major discrepancies in the information and data on agricultural production reported by the two government agencies responsible for collecting it—Bangladesh Bureau of Statistics (BBS) and the Department of Agricultural Extension (DAE). Measures should be taken to reconcile the data reported by these agencies, improve their quality, and minimize their delivery time.

Long-term policy recommendations

- The most efficient and sustainable way to tackle the onion crisis would be to mitigate dependency on imports by taking steps to increase domestic onion production. Research can play a pivotal role in this by finding ways to increase production by improving productivity. Since Bangladesh currently has very little fallow arable land available, future production increases will have to come from higher yields of onion. This will mean developing new technologies and innovations through research to address production problems. Agricultural technologies can offer significant promise for augmenting onion productivity, but only if they are disseminated to farmers through effective extension systems and supported by appropriate policies and institutions.

References

Ganesh-Kumar, A. S. K. Prasad, and H. Pullabhotla. 2012,Supply and Demand for Cereals in Bangladesh, 2010-2030. IFPRI Discussion Paper No. 1186. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Yunus, Mohammad, and Quazi Shahabuddin. 2013. *Farmers' Supply Response to Prices and Non-Price Factors in Bangladesh.* Policy Research and Strategy Support Programme Report. Dhaka: International Food Policy Research Institute (IFPRI) and Bangladesh Institute of Development Studies (BIDS).

Appendix A

Table A11.1: Daily wholesale and retail prices of local and Indian onions (BDT/kg), 1 July 2012-16 September 2013

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
1-Jul-12	25	28	16	22
2-Jul-12	25	28	16	22
3-Jul-12	25	28	18	22
4-Jul-12	25	28	18	22
5-Jul-12	25	30	18	24
8-Jul-12	25	28	18	24
9-Jul-12	25	28	18	24
10-Jul-12	25	30	18	22
11-Jul-12	25	30	18	22
12-Jul-12	25	30	18	24
15-Jul-12	26	30	19	24
16-Jul-12	26	30	19	24
17-Jul-12	26	30	17	24
18-Jul-12	25	30	17	24
19-Jul-12	25	32	17	24
22-Jul-12	26	32	17	24
23-Jul-12	26	30	17	22
24-Jul-12	26	32	17	24
25-Jul-12	26	30	16	22
26-Jul-12	25	32	16	22
29-Jul-12	25	30	16	22
30-Jul-12	25	30	16	20
31-Jul-12	24	30	15	20
1-Aug-12	24	28	15	20
2-Aug-12	24	30	15	20
5-Aug-12	24	28	16	20
6-Aug-12	24	28	16	20
7-Aug-12	24	30	16	20

Continued

Continued from Appendix A11.1

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
8-Aug-12	24	28	14	20
12-Aug-12	24	28	15	20
13-Aug-12	24	28	15	20
14-Aug-12	25	32	18	20
22-Aug-12	25	30	16	20
23-Aug-12	25	30	16	22
26-Aug-12	25	30	17	22
28-Aug-12	25	30	18	22
29-Aug-12	25	30	18	24
30-Aug-12	25	30	18	24
1-Sep-12	22	30	16	22
2-Sep-12	23	30	16	22
3-Sep-12	23	30	16	23
4-Sep-12	22	30	16	22
5-Sep-12	22	30	16	23
6-Sep-12	22	30	16	22
9-Sep-12	21	30	15	20
10-Sep-12	21	30	15	22
11-Sep-12	22	30	17	22
12-Sep-12	21	30	17	22
13-Sep-12	21	30	16	22
16-Sep-12	22	30	16	22
17-Sep-12	22	28	15	20
18-Sep-12	21	28	15	20
19-Sep-12	21	28	15	20
20-Sep-12	21	28	14	20
23-Sep-12	22	28	14	20
24-Sep-12	22	28	14	20
25-Sep-12	22	28	14	20
26-Sep-12	22	28	16	20
27-Sep-12	22	28	15	20
30-Sep-12	22	28	15	20
1-Oct-12	22	28	15	20
2-Oct-12	22	28	15	20
3-Oct-12	22	28	17	21
4-Oct-12	22	28	18	22
8-Oct-12	23	30	18	22
9-Oct-12	25	30	18	22

Continued

Continued from Appendix A11.1

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
10-Oct-12	25	30	19	24
11-Oct-12	25	30	18	24
14-Oct-12	26	34	18	24
15-Oct-12	28	32	20	24
16-Oct-12	29	34	23	24
17-Oct-12	29	34	24	27
18-Oct-12	29	35	24	27
21-Oct-12	28	35	24	28
22-Oct-12	28	34	24	28
23-Oct-12	27	34	24	28
25-Oct-12	28	36	20	26
29-Oct-12	28	35	20	28
30-Oct-12	30	38	24	28
31-Oct-12	31	36	24	28
1-Nov-12	30	36	24	28
4-Nov-12	31	35	26	30
5-Nov-12	31	35	24	30
6-Nov-12	35	40	27	30
7-Nov-12	35	40	27	32
8-Nov-12	35	42	27	32
11-Nov-12	35	42	28	32
12-Nov-12	35	42	28	32
13-Nov-12	35	44	28	30
14-Nov-12	33	42	24	30
15-Nov-12	34	42	25	30
18-Nov-12	35	44	25	32
19-Nov-12	35	42	25	28
20-Nov-12	35	42	25	30
21-Nov-12	36	42	25	30
22-Nov-12	36	42	25	30
26-Nov-12	38	44	30	34
27-Nov-12	40	45	34	36
28-Nov-12	40	48	34	38
29-Nov-12	40	48	34	38
2-Dec-12	40	48	30	35
3-Dec-12	40	46	30	33
4-Dec-12	40	46	30	35
5-Dec-12	40	46	30	32

Continued

Continued from Appendix A11.1

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
6-Dec-12	40	46	30	32
9-Dec-12	45	50	30	34
10-Dec-12	48	55	31	34
11-Dec-12	50	52	34	38
12-Dec-12	50	55	35	38
13-Dec-12	50	55	34	38
17-Dec-12	50	60	34	38
18-Dec-12	52	60	36	38
19-Dec-12	56	60	30	35
20-Dec-12	56	60	30	35
23-Dec-12	34	44	27	35
24-Dec-12	46	60	30	40
26-Dec-12	28	40	26	32
27-Dec-12	28	40	26	32
30-Dec-12	28	40	26	30
31-Dec-12	26	38	26	30
1-Jan-13	26	38	23	30
2-Jan-13	24	35	25	30
3-Jan-13	24	35	25	30
6-Jan-13	24	35	23	30
7-Jan-13	22	30	24	30
8-Jan-13	23	30	24	30
9-Jan-13	21	30	26	30
10-Jan-13	22	30	26	30
13-Jan-13	22	30	26	30
14-Jan-13	22	28	25	32
15-Jan-13	24	28	26	32
16-Jan-13	22	28	26	32
17-Jan-13	22	28	25	32
20-Jan-13	20	28	27	34
21-Jan-13	18	28	27	34
22-Jan-13	19	28	25	34
23-Jan-13	19	26	25	32
24-Jan-13	19	26	24	30
27-Jan-13	18	28	24	32
28-Jan-13	18	28	24	33
29-Jan-13	25	30	30	36
30-Jan-13	26	35	33	34

Continued

Continued from Appendix A11.1

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
31-Jan-13	27	33	34	36
3-Feb-13	25	33	40	45
4-Feb-13	24	35	38	45
5-Feb-13	24	35	35	45
6-Feb-13	20	32	30	43
7-Feb-13	24	30	30	43
10-Feb-13	30	43	40	48
11-Feb-13	28	38	38	46
12-Feb-13	27	36	38	45
13-Feb-13	28	35	37	45
14-Feb-13	28	34	35	42
17-Feb-13	28	35	32	40
18-Feb-13	28	35	30	40
19-Feb-13	30	35	33	40
20-Feb-13	31	35	33	38
24-Feb-13	30	32	32	36
25-Feb-13	28	32	30	36
26-Feb-13	25	30	27	35
27-Feb-13	20	28	28	32
28-Feb-13	18	28	28	32
3-Mar-13	20	30	28	32
4-Mar-13	22	30	30	32
5-Mar-13	28	33	32	35
6-Mar-13	24	35	32	35
7-Mar-13	24	33	30	35
10-Mar-13	24	30	30	34
11-Mar-13	24	30	29	35
12-Mar-13	22	30	26	34
13-Mar-13	22	30	18	32
14-Mar-13	24	30	24	32
18-Mar-13	24	30	24	32
19-Mar-13	24	30	24	32
20-Mar-13	24	28	20	30
21-Mar-13	24	28	20	30
24-Mar-13	24	28	18	28
25-Mar-13	23	28	18	25
27-Mar-13	20	25	20	25
28-Mar-13	20	25	20	25

Continued

Continued from Appendix A11.1

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
31-Mar-13	22	25	20	25
1-Apr-13	20	25	20	26
2-Apr-13	20	25	20	26
3-Apr-13	18	25	20	26
4-Apr-13	18	25	18	26
7-Apr-13	18	24	18	26
8-Apr-13	18	25	18	26
9-Apr-13	20	25	18	26
10-Apr-13	21	24	18	26
11-Apr-13	21	24	18	26
16-Apr-13	18	22	18	24
17-Apr-13	18	22	18	24
18-Apr-13	18	22	18	24
21-Apr-13	17	22	17	23
22-Apr-13	18	24	17	24
23-Apr-13	22	28	22	25
24-Apr-13	23	28	20	25
25-Apr-13	23	28	20	25
29-Apr-13	22	28	20	25
30-Apr-13	24	28	22	25
2-May-13	24	28	21	25
5-May-13	24	28	22	26
6-May-13	24	30	22	28
8-May-13	23	28	21	25
9-May-13	23	28	20	26
12-May-13	24	28	20	26
13-May-13	24	30	20	26
15-May-13	24.5	30	18	26
16-May-13	25	30	18	26
19-May-13	25	28	18	26
20-May-13	25	30	18	25
21-May-13	24	30	18	25
22-May-13	25	28	18	25
26-May-13	26	30	19	26
29-May-13	26	28	22	26
30-May-13	26	28	21	26
2-Jun-13	26	30	21	25
3-Jun-13	26	32	21	28

Continued

Continued from Appendix A11.1

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
4-Jun-13	27	33	21	28
9-Jun-13	27	32	20	28
10-Jun-13	27	33	20	30
11-Jun-13	27	34	21	28
12-Jun-13	32	35	22	28
16-Jun-13	32	35	22	28
17-Jun-13	32	36	22	28
20-Jun-13	34	36	24	30
23-Jun-13	33	36	24	30
24-Jun-13	33	36	24	30
26-Jun-13	34	38	30	32
27-Jun-13	33	38	30	32
30-Jun-13	35	40	30	32
1-Jul-13	35	40	30	34
2-Jul-13	38	42	35	36
3-Jul-13	37	40	35	38
4-Jul-13	37	42	35	40
8-Jul-13	38	42	35	40
9-Jul-13	40	45	37	42
10-Jul-13	41	46	38	42
11-Jul-13	40	46	38	42
14-Jul-13	40	45	38	42
15-Jul-13	39	48	36	44
16-Jul-13	40	48	36	44
17-Jul-13	40	46	36	42
18-Jul-13	40	48	36	44
21-Jul-13	39	45	34	42
22-Jul-13	39	45	32	42
23-Jul-13	38	44	32	40
24-Jul-13	40	44	35	40
25-Jul-13	40	44	35	40
28-Jul-13	39	45	35	40
29-Jul-13	40	46	38	42
30-Jul-13	42	48	38	42
31-Jul-13	44	48	41	42
1-Aug-13	43	48	41	42
4-Aug-13	43	48	41	42
5-Aug-13	43	48	41	42

Continued

Continued from Appendix A11.1

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
7-Aug-13	44	48	45	46
11-Aug-13	44	48	42	46
12-Aug-13	55	60	55	58
13-Aug-13	55	60	55	58
14-Aug-13	52	60	60	62
18-Aug-13	64	70	70	78
19-Aug-13	64	70	70	74
20-Aug-13	62	70	70	75
21-Aug-13	57	65	60	74
22-Aug-13	55	62	60	68
25-Aug-13	54	60	58	65
26-Aug-13	50	60	57	65
29-Aug-13	52	58	54	62
1-Sep-13	52	60	53	60
2-Sep-13	52	60	53	60
3-Sep-13	52	60	53	60
4-Sep-13	52	58	53	60
5-Sep-13	53	58	50	60
8-Sep-13	54	60	52	60
9-Sep-13	54	60	52	62
10-Sep-13	54	62	52	62
11-Sep-13	56	60	55	60
12-Sep-13	56	62	60	62
15-Sep-13	60	68	70	78
16-Sep-13	60	70	74	80

Source: Department of Agricultural Marketing, Ministry of Agriculture.

Table A11.2: Monthly wholesale and retail prices of local and Indian onion (BDT/kg), July 2010-August 2013

Date	Local		Indian	
	Wholesale	Retail	Wholesale	Retail
Jul-10	21	24	17	20
Aug-10	22	24	17	20
Sep-10	23	26	21	24
Oct-10	28	32	28	30
Nov-10	37	40	36	39
Dec-10	34	38	34	41
Jan-11	37	41	34	38
Feb-11	37	31	32	30
Mar-11	18	22	17	21
Apr-11	16	21	14	17
May-11	20	23	16	19
Jun-11	22	24	17	21
Jul-11	28	29	22	26
Aug-11	32	33	27	30
Sep-11	35	37	30	35
Oct-11	32	35	26	31
Nov-11	27	30	23	28
Dec-11	18	22	19	23
Jan-12	11	13	15	18
Feb-12	13	16	16	19
Mar-12	18	21	16	18
Apr-12	16	20	14	17
May-12	20	24	16	19
Jun-12	22	25	16	19
Jul-12	26	30	19	23
Aug-12	26	30	18	22
Sep-12	26	30	19	23
Oct-12	28	33	23	27
Nov-12	40	42	28	33
Dec-12	41	47	34	38
Jan-13	27	32	30	34
Feb-13	30	35	37	41
Mar-13	26	30	29	33
Apr-13	21	25	21	25
May-13	25	29	22	26
Jun-13	31	34	24	27
Jul-13	42	45	35	41
Aug-13	44	48	41	41

Source: Department of Agricultural Marketing, Ministry of Agriculture.

Table A11.3: Onion production, area, and yield in Bangladesh

Year	Production in metric tons (thousands)	Area in acres (thousands)	Yield (metric tons/acre)
2001-02	150	91	1.6
2002-03	153	93	1.6
2003-04	272	128	2.1
2004-05	589	213	2.8
2005-06	769	286	2.7
2006-07	894	318	2.8
2007-08	889	309	2.9
2008-09	735	266	2.8
2009-10	872	291	3.0
2010-11	1,052	312	3.4
2011-12	1,159	335	3.5

Source: Yearbook of Agricultural Statistics of Bangladesh, Bangladesh Bureau of Statistics.

Table A11.4: Monthly onion imports, June 2011-July 2013

Date	Onion import in metric tons (thousands)
Jun-11	32
Jul-11	43
Sep-11	25
Oct-11	36
Nov-11	32
Jan-12	19
Feb-12	15
Mar-12	18
Apr-12	36
May-12	44
Jun-12	55
Jul-12	72
Aug-12	52
Sep-12	61
Oct-12	47
Nov-12	55
Dec-12	28
Jan-13	35
Feb-13	25
Mar-13	32
Apr-13	24
May-13	35
Jun-13	51
Jul-13	63
Aug-13	23

Source: Import Monitoring Section, Bangladesh Bank.

Table A11.5: Annual onion imports, 2005-06 to 2012-13

Date	Onion import in metric tons (thousands)
2005-06	128
2006-07	104
2007-08	148
2008-09	230
2009-10	310
2010-11	278
2011-12	323
2012-13	517

Source: Bangladesh Tariff Commission, Ministry of Commerce.

Appendix B

An Analytical Model for Estimating the Effects of a Supply Shift on Onion Price

The model is within the Marshallian framework of partial equilibrium analysis and based on an analytical framework that takes into account the fact that a share of total food production in developing countries is consumed by producers themselves (Ahmed and Sampath 1992). The model is based on the assumption that the market for food crops produced by numerous small growers and sold to a mass of consumers is competitive. This implies that crop prices are set by demand and supply in the domestic market. The analytical model is graphically illustrated in Figure B1, and the mathematical formulation of the model is given below.

We undertake this analysis for the Bangladesh domestic onion market. In Figure B1, the vertical line D_hH represents the onion demand curve of producers for home consumption. This demand curve is drawn as insensitive to changes in onion price. The vertical demand curve for producers' home consumption represents the amount of onion consumed by the surplus farmers and the total quantity produced by the deficit farmers. The horizontal distance between the demand curve for farmers' home consumption (D_hH) and the market demand curve (D_mD_0) measures the quantity of onion bought by consumers. This quantity called the "gross marketed surplus" is supplied by the surplus onion producers.

The supply curve for onion OS_0 represents the aggregate supply of onion from domestic production. Imports of onion will induce a shift in the onion supply curve. While the market equilibrium before the supply shift of onion is at A, the market equilibrium is established at B after the rightward shift in the aggregate supply curve from OS_0 to OS_1.

To quantify the impact of the supply shift for onion, a mathematical treatment of the above relationship is developed. Assuming a constant price elasticity of demand, the market demand function can be represented as

$$q = ap^{-\varepsilon}, \tag{1}$$

where p and q are the price and quantity demanded of onion, respectively. The constant a includes demand shifters, and ε is the price elasticity of demand.

A constant elasticity supply function for onion without a shift in supply can be expressed as

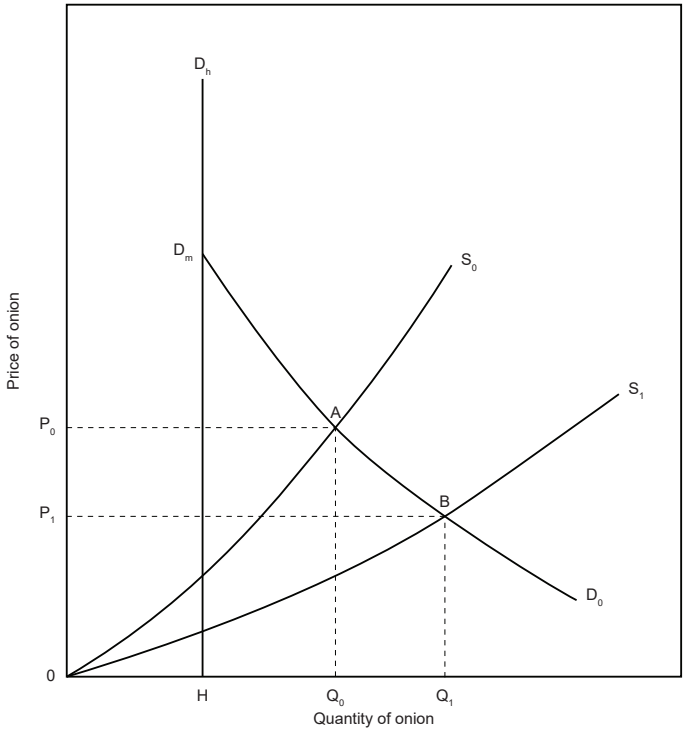
$$q = bp^{\beta}, \tag{2}$$

where p and q are the price and the quantity supplied, b includes supply shifters, and β is the price elasticity of supply.

Assuming an m shift in demand schedule, the new demand function can be expressed as

$$q = a(1+m)p^{-\varepsilon}. \tag{3}$$

Figure B1: Effects of a change in onion supply on market price of onion



If the import of onion results in a k shift in onion supply schedule, then the new supply function can be expressed as

$$q = b(1+k)p^{\beta} \tag{4}$$

The two equilibrium prices of onion (P_0 and P_1), without the supply shift and with the supply shift, respectively, can be derived by equating equations (1) and (2) and (3) and (4) and solving them for P_0 and P_1. Thus,

$$P_0 = \left(\frac{a}{b}\right)^{1/(\beta+\varepsilon)}, \text{ and} \tag{5}$$

$$P_1 = P_0\left(\frac{1+m}{1+k}\right)^{1/(\beta+\varepsilon)}. \quad (6)$$

Similarly, we can obtain the equilibrium quantities of onion (Q_0 and Q_1) with the supply shift as

$$Q_0 = a^{\beta/(\beta+\varepsilon)} b^{\varepsilon/(\beta+\varepsilon)}, \text{ and} \quad (7)$$

$$Q_1 = Q_0(1+m)^{\beta/(\beta+\varepsilon)}(1+k)^{\varepsilon/(\beta+\varepsilon)}. \quad (8)$$

with subscripts 0 and 1 indicating the situations without and with the supply shift, respectively.

Assumptions and parameters used for the present exercise

- For estimating the value of the supply shift parameter (k), we used the import of 5,000 metric tons of onion by the Trading Corporation of Bangladesh.
- For estimating the impact of imports on the market price of onion, we assume no shift in the demand for onion; therefore, the value for m is set at 0.
- We used the predicted 2013 consumption of 1.394 million metric tons of onion as the baseline quantity (Q_0).
- We used the retail price of BDT 62/kg prevailing on 29 August 2013 as the base price.
- We used 0.82 as the value of price elasticity of demand for onion.
- Since domestic production of onion will not change in response to the high price before next year, we used a low value of 0.1 for the price elasticity of supply. We did not set the value at zero because farmers and traders are likely to release their onion stock in response to the high price.

Appendix References

Ahmed, Akhter U., and R. K. Sampath. 1992. "Effects of Irrigation-Induced Technological Change in Bangladesh Rice Production." *American Journal of Agricultural Economics* 74, no. 1: 144-157.

Chapter 12

The "Quiet Revolution" in the Aquaculture Value Chain in Bangladesh[1]

Ricardo Hernandez, Ben Belton, Thomas Reardon, Chaoran Hu, Xiaobo Zhang, and Akhter Ahmed

12.1 Introduction

There are two strands in the socioeconomic literature on aquaculture. The first, which we call "micro socioeconomics," is work centered on the role of farm households as fish producers, and the impacts of aquaculture on rural communities where aquaculture takes place. This strand can be divided into three themes: (i) farm technology diffusion and efficiency (e.g., Dey et al. 2005; Rauniyar 1998); (ii) farm interactions with the environment (e.g., Islam 2014; Primavera 2006); (iii) livelihoods. The latter can be divided further into studies linking aquaculture to poverty reduction and studies of impacts of aquaculture on communities. The "poverty" literature has focused on the role of small-scale and subsistence forms of aquaculture for household food security and incomes (e.g., Bondad-Reantaso and Subasinghe 2013). The "community" literature adopts a more critical approach to the distribution of benefits and losses from aquaculture among farm and non-farm households (e.g., Paprocki and Cons 2014; Toufique and Gregory 2008).

In focusing on the farm and its immediate environs, studies in the first strand tend to take the aquaculture value chains as given, paying little attention to chain transformation (change in structure and conduct) over time. The first strand is often based on surveys with small or unrepresentative samples, or on community case studies, and is "micro" in scope, largely neglecting the "meso" structural context in which farms and farm households are embedded.

The second strand, which we call "value chains," has been dominated by work on international fish and seafood value chains, particularly those to export markets in developed countries (e.g., Goss, Burch and Rickson

[1] An earlier version of the chapter was published in *Aquaculture,* 493: 456-468. This is reproduced with permission of the publisher.

2000), rather than domestic market value chains linking rural to urban areas. A corollary of this focus is a near exclusive attention to value chains supplying the few species (principally shrimp and salmon) demanded by developed country markets (Belton and Bush 2014).

The second strand also tends to focus on value chain governance and institutions (e.g., contracts, standards, and certification schemes). For example, it includes studies on the role of third-party standards and certification in governing value chains serving developed country export markets (Hatanaka, Maki, Carmen Bain, and Lawrence Busch 2005). This has highlighted challenges of compliance with such standards for small farmers (e.g., Marschke and Wilkings 2014).

By contrast, the second strand pays little attention to technological change among actors within chain segments. Moreover, even though the strand takes in a view not just of the aquaculture farm but also of midstream and downstream segments of the value chains, it tends to do so with small, non-representative sample surveys or case studies or key informant work (e.g., Macfadyen et al. 2012; Veliu, Gessese, Ragasa, and Okali 2009). As a result, there has been little detailed quantitative work on the dynamics of transformation of the structure (such as concentration over or within segments) and conduct (such as technologies used by the actors) of value chains overall and per segment.

The above synopsis of the literature leads to our making two critiques which we focus on the Asian context. On the one hand, contrary to the export focus of the existing aquaculture value chain literature, the great majority of fish farmed in Asia is sold and consumed in Asian domestic markets. For example, in Bangladesh, 94 percent of aquaculture production is destined for domestic consumption (calculated from FAO 2016). Furthermore, 42 percent of this fish is consumed in urban areas,[2] with urban dwellers having an average consumption per capita of 21.8 kg per capita, 31 percent greater than that of rural consumers (Toufique and Belton 2014). Rapid increases in urban consumption of farmed fish are consistent with changes taking place in food systems throughout Asia, as consumption has diversified from basic staples into higher value non-staple foods with rising real incomes. These developments are particularly significant for Bangladesh, where fish is the most important food after rice in terms of share of the food budget in value terms (Reardon et al. 2014).

On the other hand, both the "micro socioeconomics" and "value chain" literatures tend to have a static perspective. This approach is at odds with

[2] Compare that with the proportion of Bangladeshi population living in urban areas, which was 34 percent in 2015 http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS

several trends. First, aquaculture is growing fast in Asia. Over 1984 to 2014, Bangladesh's farmed fish jumped from 124,000 tons to 1.96 million ton, increasing by 1,580 percent. As a result, aquaculture now accounts for 55 percent Bangladesh's fish supply, up from just 16 percent three decades ago (DOF 1994, 1997; 2006, 2015). Second, there has been a rapid shift from home-consumption (from one's own pond) to purchasing farmed fish from the market: consumers of farmed fish got 92 percent of it via purchase from the market in 2010, versus only 79 percent in 2000 (data extracted from BBS 2011).

Let us surmise that the share of purchases in farmed fish consumption grew by 10 percentage points in total consumption each decade, extrapolating from that change in the 2000s. That would mean that the purchase share was about 60 percent in the 1980s. Applying that assumption to the volume of farmed fish output in 1984 means there were roughly 75,000 tons in 1984. Applying the 92 percent to the output volume of 2 million tons in 2014 means there were roughly 1.84 million tons in 2010. That means the farmed fish market grew by a factor of 25 times in three decades. Note from above that in 2014 there were 1.96 million tons of farmed fish in 2014. Hence, 1.84/1.96 of the farmed fish output is marketed, or 94 percent is marketed, and only 6 percent is home-consumed.[3] This implies that "commercial aquaculture" (which we define simply as fish farming output that is sold, with no specification of the size of the farm) has moved to be far more important than subsistence fish farming. Yet subsistence aquaculture is the traditional focus of much of the literature on aquaculture in Asia.

Third, there has been rapid diversification of farmed fish composition. This involves a shift from traditional carps to introduced species (*tilapia* and *pangasius*) that lend themselves better than carp to intensification through higher stocking densities combined with use of manufactured feeds. This is an example of what economics terms the "product cycle", where in the evolution of a sector one observes a shift from traditional niche products to commoditized bulk products for a larger market, and finally to differentiated products either as varieties of the commoditized products or new niche products introduced. Typically, there is also technological change accompanying the increase in scale and, finally, in the creation or adaption for introduction of differentiated products. The product cycle in aquaculture has not been studied in Asia as an evolution in the market, although there has been extensive study of the technical issues in the farming of *tilapia* and *pangasius*.

[3] Note that the present fish farm survey results presented in this chapter show a sales share in total aquaculture output of 92 percent, so the macro and micro data track closely.

Fourth, far less studied is a rapid transformation of the structure of domestic aquaculture value chains in Asia, shown by the present survey results for Bangladesh. As the sector expanded, rapid commercialization and diversification of species occurred, and there was a proliferation of value chain actors, and in some cases concentration among them. This has been occurring both upstream from the farm, in feed milling and hatcheries, and downstream from the farm, in transport and wholesale.

The great majority of these changes have been driven by small and medium enterprises. These changes can be categorized as "immanent development" (Belton and Little 2011), that is, development unplanned and undirected by government or NGOs, arising mainly from private household, firm, and community choices, driven by changes in demand, technology, communications, and infrastructure, and abetted by propitious policies. This can be contrasted with "interventionist development" (NGO projects, centralized planning by governments). The "Quiet Revolution" in agro-food systems in Asia, observed by Reardon, Chen, Minten, and Adriano (2012) in rice and potatoes in Bangladesh, India, and China, is symptomatic of these broad processes of immanent development led by small farms and small off-farm enterprises. We argue that aquaculture in Bangladesh has experienced a similar quiet revolution.

Despite the rapid growth and restructuring of the upstream segments of inputs and services to aquaculture, and the downstream segments moving farmed fish to wholesale markets and retailers and consumers, these off-farm components have been little studied in Bangladesh—and certainly not yet using representative sample surveys of the actors in these chains. This omission is important because these structural changes in the supply chain have facilitated on-farm growth and technology change and commercialization.

In this chapter, we address the above four trends as a confluence, with an emphasis on the latter one, structure and conduct change in the aquaculture value chain in Bangladesh, with a focus on fish. We address two questions and thus important gaps in knowledge about value chain transformation. First, how is the domestic fish value chain restructuring? Second, how is the conduct of the segments changing in terms of product composition and technology? It is beyond the scope of this study to explore impacts on farmers or consumers of these value chain changes; that is an agenda for further research.

The chapter proceeds as follows. First, we describe the survey method. Second, we outline the characteristics of the main geographical "zones" or clusters included in the study, where high concentrations of farms and

other off-farm value chain actors occur. Third, we address the structure and conduct changes in the various segments of the aquaculture value chains in these zones serving rural and urban markets. Fourth, we conclude with policy implications.

12.2 Multi-layered Methodology in Comparative Perspective

We use a multi-layered methodology that is unique in several respects. First, we undertake a meso analysis (district by district, over a set of districts) focusing on growth and industrial organization, namely size distribution and thus concentration of actors per segment. This uses key informant focus groups at the district levels across four cluster areas (the main aquaculture areas in the country) to reconstruct inventories of numbers by size strata of actors in the main segments of the aquaculture value chain (hatcheries, feed mills, feed dealers, fish farms, and fish wholesalers).

Second, we undertake a micro analysis (in the same districts as the meso study) focusing on land and non-land productive assets and conduct (technology of production, procurement of inputs, and marketing of outputs) of a substantial sample of actors per segment of the value chain. These are formal structured surveys, not key informant studies. The questionnaires use the same logical structure but applied to their segment so they give comparable information over the segments about each segment and its relation to the other segments, such as traders' purchases from farmers and farmers' sales to traders, or whether farmers get value chain finance (advances) from traders. We call this micro survey approach "stacked value chain surveys" (after Reardon, Chen, Minten, and Adriano 2012) as full surveys are stacked one on top of the other from the upstream to the downstream segments. This differs sharply from the typical value chain study which uses very small samples and tends to rely on key informants, and does not use comparable questionnaires across segments or statistically robust samples. These kind of small sample studies thus cannot test hypotheses concerning determinants of behavior and variation over strata of actors in given segments, or determinants of linkages among the segments.

To the best of our knowledge, this multilayered approach has not been done in any other aquaculture value chain study. It is unique in several ways. First, no other study has done this meso analysis. Second, no other aquaculture study has done the stacked survey approach. Third, no other aquaculture value chain study has taken advantage of the cross perspective of meso and micro quantitative analysis.

We view our methodological approach as distinct from but complementary with two other multilayered approaches in recent research on value chains

and rural economic transformation in developing regions. First, Ponte and Sturgeon (2014) provide a conceptualization of value chain analysis that combines three levels (macro, or the whole value chain's governance, a micro level of determinants and dynamics of exchange at individual value chain nodes, and a meso level of the diffusion of the nodal level linkage mechanisms). Their approach emphasizes institutions and governance. Second, recent work in development geography on agrarian transitions in Asia (e.g., Rigg and Vandergeest 2012) combines two levels: community and household/individual livelihoods. Analysis of community takes place at a similar geographic scale to our meso level, but is more complex and focuses more on social outcomes of transformation. Similarly, analysis of livelihoods focuses on the micro level of determinants and consequences of a broader set of actions (e.g., migration and local nonfarm activity) than those pertaining to specific value chains, as well as on economic decisions that affect household interactions with the market. The work focuses on the rapid social and economic change occurring in rural Asia, including for example de-agrarianization.

Our study is complementary to Ponte and Sturgeon (2014) because our empirical approach allows cross-segment testing at the meso and micro level of the presence of "institutions" such as value chain finance. The study is also complementary to the approach of Rigg and Vandergeest (2012) to agrarian transitions. While our analysis does not offer (in the manifestation here) a fine-grained analysis of implications of change for individuals, households and communities, the "quiet revolution" provides an alternative framework for viewing processes of rural change related to agriculture. The study also provides an empirical example of rural transformation (with urban linkages) that does not necessarily entail de-agrarianization (delinking of livelihoods from agriculture)—quite the opposite, though our view of agriculture includes both farm and off-farm elements. Future research could combine a stacked survey approach with more fine-grained qualitative attention to the dynamics of livelihoods for those included or excluded from value chains and the communities of which they are part.

12.3 The Study Areas and Their Characteristics

To select our study zones, we undertook an extensive field-based "rapid reconnaissance" to identify the major clusters of (fish) aquaculture in the country. The importance of these areas was confirmed by crosschecks with official statistics and analysis of the 2008 Agricultural Census. On this basis, four production zones or clusters are identified in the Southwest, South-

center, North, and East. Each includes an array of most or all of the segments of the rural part of the farmed fish value chain.

The zones are listed in Table 12.1. The sample for the stacked survey has been drawn using purposive stratified random sampling because fish farming is concentrated in certain districts, and a nationally representative sample is neither necessary nor financially feasible. In each district, upazilas (sub-districts) with negligible fish production are eliminated from potential selection. This resulted in retention of 102 upazilas in 20 districts (Table 12.1). Within each zone, upazilas are randomly selected using proportional probability sampling (PPS), and 32 are selected out of the retained universe of 102. All *mouzas* (administrative sub-units) in each selected upazila are selected; those with fewer than 20 fish farmers are dropped. Once the list of *mouzas* was thus trimmed, two to three *mouzas* were randomly selected per selected upazila in each zone. These become the primary sampling units (PSU). Once PSUs are selected, a census of fish farmers is made in each, and 25 farmers are randomly selected per PSU (20 farmers, plus 5 replacements). The final farm household sample is distributed over 20 districts, 32 upazilas, and 77 *mouzas* (PSU).

Table 12.1: Zones and Sampled Districts

Zone	Districts
East	Chittagong, Noakhali, Comilla, Brahmanbaria, Sylhet, Cox's Bazar
North	Bogra, Dinajpur, Gazipur, Mymensigh, Natore, Narsingdi
Southwest	Khulna, Satkhira, Bagerhat
South-center	Barisal, Bhola, Chandpur, Jessore, Gopalgonj

Source: Study Survey 2014.

The selected *mouzas* are representative of 86 percent of the fish pond areas in the districts selected. In turn, the districts selected constitute 61 percent of all pond production in the country. (Bangladesh has 64 districts, and our 20 districts represent 61 percent of pond production of the country according to BBS numbers for 2014).

Survey questionnaires included four categories of questions: (a) demographic and business characteristics such as asset holdings; (b) intermediate input and factor procurement (land, labor, and capital, including variable and quasi-fixed inputs); (c) production technology and value addition; (d) marketing of outputs. In each upazila, a rapid enumeration of hatcheries, traders, and feed dealers was conducted. Hatcheries, traders, and feed dealers were randomly

selected for survey from these lists. The sample design for feed mills was based at the district level. Enumeration of feed mills was conducted in the sampled 20 districts, and mills were selected randomly.

Table 12.2: Definitions of Actor Size by Actor Type

Actor	Defining characteristic	Size category	Definition
Hatcheries	Total production area in decimals	Small	Less than 0.04 ha
		Medium	0.04-0.8 ha
		Large	>0.8 ha
Feed Mills	Total metric tons of feed produced per month	Small	Less than 50 MT
		Medium	50 to 300 MT
		Large	More than 300 MT
Input dealers	Total metric tons of feed sold per month	Small	Less than 10 MT
		Medium	10 to 100 MT
		Large	More than 100 MT
Farmers	Total pond area in decimals	Small	<0.2 ha
		Medium	0.2-0.8 ha
		Large	>0.8ha
Traders	Total metric tons of fish traded per week	Small	Less than 1 MT
		Medium	1 to 5 MT
		Large	More than 5 MT

Source: Study Survey 2014.

The sample design for the recent history, inventory of numbers and changes in value chain actors was based on *mouzas* selected for the household sample. In each *mouza*, two to five interviews were conducted with key stakeholders concerning the number and size distribution of value chain actors at the upazila and district level over 2004, 2009, and 2014. To obtain an indication of whether concentration of market share was taking place, information was collected for three "size of actor" categories (small, medium, and large). The definition of the size category varied by type of actor, but did not vary across zones.

Table 12.3 shows selected characteristics of the four zones or clusters. Several points stand out. First, there is a fairly homogenous picture across zones in terms of general characteristics. This may be because all the areas identified as containing high densities of ponds are located in major lowland rice growing areas with relatively easy access to the capital city, Dhaka. The study zones have broadly similar socio-economic conditions, as compared to more peripheral and remote areas with less conducive geographies and agro-ecologies for aquaculture.

Table 12.3: Zone Characteristics

Item	South-west	South-centre	North	East	All
Total area (km^2)	8,710	8,492	13,752	15,809	46,763
Population density (inhabitants/km^2)	757	1,354	1,388	1,445	1,302
Monthly per capita expenditure (BDT)	2,359	2,842	2,621	2,932	2,730
Road density (km of roads/km^2)					
2004	0.11	0.18	0.19	0.21	0.18
2009	0.12	0.19	0.21	0.20	0.19
2014	0.12	0.19	0.22	0.22	0.20
Share of paved roads in total roads					
2004	54%	60%	77%	55%	63%
2009	79%	84%	92%	78%	84%
2014	81%	82%	92%	82%	85%
Aquaculture area (ha)					
2004	168,493	38,614	39,795	113,994	360,896
2009	168,560	45,529	40,619	113,337	368,044
2014	220,223	116,809	126,667	111,794	575,493
Fish pond area (ha)					
2004	11,815	33,570	39,758	68,037	153,180
2009	16,630	46,368	60,071	48,901	171,970
2014	24,247	44,257	60,110	71,493	200,107
Change in pond area (%)	105.2	31.8	51.2	5.1	30.6
Aquaculture production (MT)					
2004	125,677	89,953	103,824	219,135	538,589
2009	140,289	114,416	121,491	231,098	607,294
2014	225,798	269,568	469,830	300,914	1,266,110
Fish production (MT)					
2004	37,264	87,852	101,110	177,415	403,641
2009	32,313	149,843	292,211	156,821	631,188
2014	56,107	182,123	398,979	240,468	877,677
Change in fish production (%)	50.6	107.3	294.6	35.5	117.4

[a] Aquaculture area is the total area of the two main culture systems: fish pond, shrimp/prawn farms, plus other minor production systems (pen and cage culture, and culture-based fisheries in oxbow lakes (*baor*), and seasonal floodplains).

Source: BBS Statistical Yearbook of Bangladesh, 2005, 2010, and 2015.

The study zones are of similar size. They have population densities of around 1,400 persons per square km, except for the Southwest (with 800 persons/km^2). The lower population density in the Southwest is a function of a large part of the land in its three districts being comprised of uninhabited mangrove forest. Income differences over zones are proxied by differences in total per capita expenditure per month. Again, the zones do not differ a great deal, with an expenditure of roughly $2,100 per year for a five-person household. Road density per square kilometer corresponds closely with differences in population density (lower in the Southwest, similar in other zones). The share of paved roads in total roads jumped dramatically over the 10 years from 2004 to 2014 in all zones, to more than 80 percent. The North, which had the highest share of paved roads in 2014, at 92 percent, also had the highest share in 2004, with 77 percent, indicating a historically well-developed transport infrastructure.

Second, as noted above, fish farming has developed rapidly in Bangladesh since the 1990s, accelerating during the 2000s. This is reflected in the table in the expansion of fish pond area which grew by 31 percent across the four zones (fastest in the Southwest and North, with increases of 105 percent and 51 percent respectively, and lowest in the East, which grew only 5 percent). Fish pond output increased more rapidly than pond area, indicating that intensification was taking place. Output rose 117 percent overall, with the greatest increase in the North (295 percent) and South-central region (107 percent), and lowest in the East (36 percent).

Third, yields (per hectare of pond surface) in the zones varied considerably, with 2.3 tons/hectare (ha) in the Southwest, to 3.4 in the East, 4 in the South-center, and 6.7 in the North. As a result of its high productivity, the North cluster (mainly Mymensingh) accounted for 45.5 percent of fish production in the four zones, from 30 percent of pond area. Large differences in land (pond) yields across zones reflect differences in the technologies deployed, with the North being the most "advanced" zone, and "cradle" of intensive aquaculture in Bangladesh. This status is partly path dependent, reflecting a number of initial conditions including: (i) superior road access to the capital city Dhaka (ADB 2005); (ii) a history of commercially oriented "green revolution" rice farming in districts such as Bogra (Crow 2001); (iii) the location of key institutions such as the Bangladesh Fisheries Research Institute (BFRI) in Mymensingh district which played an important role in the transfer of seed and production technologies for new species to well-connected farmers and hatcheries in the area (Belton and Little 2011).

12.4 Transformation of Structure and Conduct in the Value Chain

This section is organized into three sub-sections. The first focuses on "growth and concentration", essentially an industrial organization perspective, using the meso data. The second focuses on commercialization cum spatial elongation as they are closely linked. This draws especially on the micro data, and is a combination of structure and conduct analyses. The third subsection focuses on technological cum product composition/product cycle change and patterns, using primarily the micro data, but also linking back to the meso data to show that there is a mirror relation where input use changes on farms and input supply firms proliferate to meet that demand.

12.4.1 Growth and Concentration

There has been rapid development and proliferation of the off-farm components of the fish value chain in the study zones. The combination of this plus the rapid rise in aquaculture farms in these areas is creating dense clusters of value chain actors in these places. This has occurred "upstream" in the value chain, in hatcheries, feed milling, feed wholesale and retail, and farms, and "midstream and downstream" in transport, rural and urban wholesale markets (*arat*) and traders (*aratdar*), and retailing. In all segments, astounding development of these enterprises—and acceleration of that development in the past 5-10 years - has taken place. Tables 12.4 to 12.8 show structural change, proxied by numbers of different actors and shares of the size strata in the total number. We discuss this segment by segment, from upstream to midstream.

12.4.1.1 Hatchery Segment Restructuring

Over the four zones, the survey data show that there was a 207 percent increase in hatcheries over the ten years, with the rate of growth fastest in the Southwest (314 percent), and slowest in South-center (150 percent). This rate of expansion exceeded that of either fish farm numbers (up 63 percent), or farm output (up 117 percent), thus suggesting a shift to purchased seed. Big hatcheries (over 0.8 ha in size) accounted for 53 percent of hatchery area in 2014, a bit lower than 58 percent in 2004, showing slight de-concentration. The share of numbers of big hatcheries in all hatcheries over all zones together dropped a bit from 19 percent in 2004 to 15 percent in 2014. But still by 2014 the hatchery segment was concentrated: the big hatcheries had 19 percent of numbers but 53 percent of total hatchery area.

Table 12.4: Structural Change in Hatchery Clusters over 10 Years

Zone	Hatcheries											
	Total number			Share of small in total number			Share of medium in total number			Share of large in total number		
	2004	2009	2014	2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest	7	14	22	0%	0%	0%	88%	86%	91%	13%	14%	9%
South-center	80	102	120	7%	7%	5%	67%	65%	75%	25%	28%	20%
North	177	281	410	49%	50%	54%	33%	32%	31%	18%	18%	14%
East	104	142	209	37%	39%	39%	43%	43%	46%	20%	18%	15%
All	368	539	761	44%	46%	51%	37%	35%	35%	19%	18%	15%
				Share of small in total production area			Share of medium in total production area			Share of large in total production area		
				2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest				0%	0%	0%	71%	68%	79%	29%	32%	21%
South-center				0%	0%	0%	48%	45%	57%	52%	55%	43%
North				3%	3%	3%	38%	38%	42%	60%	59%	55%
East				2%	2%	2%	42%	45%	50%	57%	53%	48%
All				2%	2%	3%	40%	40%	44%	58%	58%	53%

Source: Fish Value Chain Meso Level Survey 2014.

The rapid increase in hatchery numbers, outstripping farm growth, and the tendency toward size de-concentration, may indicate the spread of new small and medium sized hatcheries beyond original "core" clusters. The preponderance of hatcheries in northern Bangladesh reflects the emergence of Bogra and Mymensingh as major producers of seed, for historical reasons described above. Bogra hatcheries export *pangasius* seed to India in addition to serving the domestic market (Ali, Haque, and Belton 2013).

Hatchery growth has been accompanied by rapid expansion of nurseries, particularly in nearby areas, which buy hatchlings or fry from hatcheries and raise them to fingerling size for sale to farms, directly, via small traders (*patil wallah*), or (over longer distances) by larger agents. Overall (from the survey but not shown in the tables), 53 percent of the seed produced by hatcheries is sold to fingerling traders, and 44 percent direct to farmers and nurseries.

12.4.1.2 Feed Mill Segment Restructuring

For feed mills (Table 12.5), as with hatcheries, there is a high degree of spatial concentration in the North, where 62 percent of the country's mills are located. These are located mostly in Gazipur, a highly industrialized peri-urban district bordering Dhaka to the South and Mymensingh to the North. Just under one-third of mills are located in the Southeast, around Chittagong, Bangladesh's second city and main seaport, and another major industrial center.

The number of feed mills jumped even faster than that of hatcheries, reflecting the later introduction and adoption of feeds as compared to hatchery seed. Interviews conducted during our rapid reconnaissance indicated that there were 7-8 feed mills (defined as formal firms, not backyard feed operations on farms) in Bangladesh in 2003. The number increased 15-fold to about 100 mills by 2014. Table 12.5 indicates the numbers of mills increasing by 268 percent over the period to 255, and rising fast in all zones. The difference between the 100 formal firms and the 255 total mills arises because the latter figure includes "semi-auto" feed mills—low-cost, locally manufactured machines used to produce small quantities of feed on-farm or by one local farm for several others around it.

The feed mill segment is even more concentrated than the hatchery segment for two reasons. First, many have developed from the addition of lines by existing large domestic poultry feed firms, with a "head start" in the industry, from major investments by foreign companies such as China's New Hope, Thailand's CP, and India's ACI Godrej. Second, there are economies of scale involved in sourcing raw materials, maintaining high utilization rates, and spreading fixed costs over a large volume. Big mills (with a capacity of 300 tons/month) accounted for 67 percent of total feed production volume in 2014, although the share of volume had barely changed from 2004 (66 percent).

Table 12.5: Structural Change in Feed Mill Clusters over 10 Years

Zone	Feed mills											
	Total number			Share of small in total number			Share of medium in total number			Share of large in total number		
	2004	2009	2014	2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest	4	5	7	68%	56%	49%	23%	37%	46%	9%	7%	5%
South-center	2	7	9	0%	29%	22%	50%	43%	56%	50%	29%	22%
North	62	100	154	30%	30%	27%	40%	37%	38%	30%	34%	35%
East	28	43	84	43%	30%	45%	26%	38%	27%	31%	32%	28%
All	95	155	255	35%	30%	33%	35%	37%	35%	30%	32%	32%
				Share of small in total volume			Share of medium in total volume			Share of large in total volume		
				2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest				17%	13%	11%	41%	59%	71%	42%	28%	18%
South-center				0%	3%	3%	28%	36%	48%	72%	61%	49%
North				4%	3%	3%	33%	29%	29%	64%	68%	69%
East				6%	3%	6%	23%	30%	26%	71%	66%	68%
All				4%	3%	4%	30%	30%	29%	66%	66%	67%

Source: Fish Value Chain Meso Level Survey 2014.

12.4.1.3 Feed Dealer Segment Restructuring

Input dealers (Table 12.6) are mainly feed dealers who distribute feed for mills. They are very numerous, totaling 15,000 over the four zones, up from 7,690 in 2004 (hence a two-fold growth, versus a 1.6-fold growth of farmers). Like hatcheries and mills, input dealers are concentrated in the North (which is home to 56 percent of dealers, but only 35 percent of farmers). But they are underrepresented relative to farmers in the Southwest and South-center, perhaps unsurprisingly given that fish yields (and thus by implication feed use), are lowest in these two zones. Some concentration in market share is present, with larger dealers (those selling more than 100 tons of feed per month) having 54 percent of the traded volume in 2004. Their share dropped to 48 percent in 2014 as many new small dealers entered the scene.

12.4.1.4 Fish Farm Segment Structure Restructuring

Fish farmers are more evenly distributed spatially than other value chain actors over the four clusters, with the North accounting for 36 percent and the Southwest and South-center 29 percent each, but the East only 9 percent. The total number of fish farmers across the four zones grew 63 percent, from 1.08 million in 2004 to 1.76 million in 2014, but the relative share of farm numbers across zones changed little over this period.

From the perspective of average household operated aquaculture land (pond surface), the average farm size in our study zones changed little over the decade, even as the total population of these nearly doubled. When the average area of aquaculture landholdings operated across zones between 2008 and 2013 is compared, the overall increase was moderate (7.2 percent). However, there is considerable variation between zones, with the North and South-center registering the largest increases, up 19 percent, up from (0.3 ha to 0.35 ha), and 17 percent from 0.24 ha to 0.28 ha, respectively, with other zones registering little change.

Fish farming households sampled in the stacked survey operated 0.29 ha of ponds in 2008 and 0.31 ha in 2013. Fish farmers in Bangladesh hold 0.86 ha of land (fish and non-fish land combined). Therefore, they are located in the second upper land quintile of farmers in the country, and they have approximately double the 0.45 ha average landholding of rice farmers (Ahmed et al. 2013). However, they are smaller than a typical fish farmer in other countries in the region, such as Myanmar and Thailand.

Table 12.6: Structural Change in Feed Dealer Clusters over 10 Years

Zone	Feed dealers											
	Total number			Share of small in total number			Share of medium in total number			Share of large in total number		
	2004	2009	2014	2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest	1,373	1,915	2,461	66%	69%	65%	31%	29%	31%	3%	3%	4%
South-center	1,428	2,109	3,111	50%	48%	43%	42%	45%	48%	8%	7%	9%
North	4,308	6,835	8,448	43%	41%	44%	32%	36%	36%	25%	23%	20%
East	581	907	1,464	69%	62%	60%	28%	32%	34%	3%	5%	7%
All	7,690	11,766	15,483	50%	49%	49%	34%	36%	37%	16%	15%	14%
				Share of small in total volume			Share of medium in total volume			Share of large in total volume		
				2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest				13%	15%	12%	68%	67%	64%	19%	19%	23%
South-center				7%	7%	5%	61%	67%	63%	32%	27%	31%
North				4%	4%	4%	31%	35%	38%	65%	61%	58%
East				15%	11%	9%	65%	61%	58%	20%	28%	32%
All				6%	5%	6%	41%	44%	46%	54%	51%	48%

Source: Fish Value Chain Meso Level Survey 2014.

Table 12.7: Structural Change in Fish Farmer Cluster over 10 Years

Zone	Fish farmers											
	Total number			Share of small in total number			Share of medium in total number			Share of large in total number		
	2004	2009	2014	2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest	335	417	494	15%	17%	17%	41%	41%	46%	44%	42%	37%
South-center	319	384	487	39%	35%	42%	39%	45%	34%	22%	20%	23%
North	343	474	634	43%	46%	45%	34%	33%	32%	23%	21%	23%
East	84	112	148	44%	43%	45%	34%	37%	32%	22%	20%	24%
All	1,081	1,388	1,763	33%	34%	36%	37%	39%	37%	29%	27%	27%
				Share of small in total pond area			Share of medium in total pond area			Share of large in total pond area		
				2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest				4%	4%	4%	30%	31%	36%	66%	65%	59%
South-center				14%	12%	15%	41%	47%	36%	46%	41%	49%
North				15%	17%	16%	36%	37%	34%	48%	46%	50%
East				16%	16%	16%	36%	41%	34%	48%	44%	50%
All				10%	11%	12%	35%	37%	35%	54%	52%	53%

Source: Fish Value Chain Meso Level Survey 2014.

Table 12.8: Landholdings and Tenancy by Year and Zone

Zone	Southwest		South-center		North		East		All	
	2008	2013	2008	2013	2008	2013	2008	2013	2008	2013
1. Total non-fish land overall (Ha/HH) (zeroes in average)	0.26	0.31	0.45	0.54	0.38	0.42	0.33	0.39	0.34	0.40
2. Total fish pond land, (Ha/HH) (zeroes in average)	0.59	0.64	0.24	0.28	0.30	0.35	0.49	0.48	0.43	0.46
2.1 Total operated land (used, including owned and rented-in lands)	0.51	0.52	0.18	0.21	0.17	0.22	0.20	0.20	0.29	0.31
2.1.1 Self-owned	0.36	0.33	0.12	0.12	0.10	0.11	0.05	0.05	0.18	0.17
2.1.2 Joint-owned with another HH	0.12	0.16	0.04	0.08	0.01	0.06	0.09	0.10	0.07	0.10
2.1.3 Rented in	0.04	0.03	0.02	0.01	0.06	0.05	0.06	0.05	0.04	0.04
2.2 Rented out	0.07	0.08	0.02	0.03	0.02	0.02	0.03	0.03	0.04	0.04
2.3 Jointly owned, used by other HH	0.01	0.03	0.04	0.04	0.10	0.11	0.25	0.24	0.10	0.10
3. TOTAL land	0.85	0.95	0.69	0.82	0.68	0.77	0.82	0.86	0.77	0.86

Note: HH = household

Source: Fish Value Chain Farm Household Survey 2014.

Further, the average 0.31 ha of pond area per fish farm in our sample is five times the average 0.06 ha area of "homestead ponds" reported by Belton and Azad (2012) in Bangladesh. This difference is explained above in the sample methods section where we note that districts with high concentrations of fish farming, which our household survey analysis shows, tends to be correlated with higher shares of commercial farms and lower shares of (subsistence) homestead fish ponds, were purposively selected.

Moreover, fish farming tends to be concentrated among the upper stratum of small farms. Figures extracted from Bangladesh Integrated Household Survey (BIHS) data—a nationally representative survey of rural households conducted by the International Food Policy Research Institute (IFPRI) in 2011-2012—show that 89 percent of the aquaculture households contributed just 25 percent of total production, while the top 2.4 percent of fish farming households accounted for 50 percent of total output.

Our meso survey data reflect this concentration. Larger farms (with 0.4 ha or more of pond area) constituted 27 percent of fish farms but had 53 percent of pond area in 2014, with little change in this share since 2004. The share of area among farmers of other size categories also remained stable over this period, at around 35 percent for medium and 11 percent for small farms (<0.2 ha), suggesting that while many new producers have entered farming, there has been little, if any, consolidation into larger farm units.

Table 12.9: Factor Productivity in 2013

Observations in 2013	South-west	South-center	North	East	All
	465	280	420	340	1505
1. Total fish output (kg) per:					
1.1 Labor day (own + hired)	9.0	7.2	32.7	20.8	18.9
1.2 Own labor day	10.3	10.5	42.5	23.8	23.9
1.3 Pond hectare	801	2,565	10,017	2,916	3,352
1.4 Capital (thousand BDT)[a]	5.3	9.8	25.2	10.2	13.0

[a] Capital is calculated as the total variable cost (labor, rent, purchased inputs, etc.), plus the annual amortization of quasi-fixed assets.

Source: IFPRI/MSU Fish Value Chain Farm Household Survey 2014.

Finally, Table 12.9 shows yields of 3.35 tons/ha on average in the sample in 2013. The North has far higher land-yields than the rest of the zones. This helps to explain why the concentration of farms in the North is low relative to the high concentration in the North of hatcheries, feed mills, and

input dealers. The North simply has a much more intensive production technology, heavy in external inputs supplied by these off-farm enterprises, and that intensification is reflected in its extraordinary yields relative to the rest of the fish farming clusters. Absolute yield growth was greatest in the North, up 96 percent, from 5 tons/ha to 9.8 tons/ha, while in relative terms the East grew faster from a lower base, up 113 percent from 1.3 to 2.7 tons/ha. South-center grew only 19 percent, from 2 to 2.4 tons/ha, while the Southwest remained stagnant at 0.7 tons/ha (see Table 12.13).

12.4.1.5 Fish Wholesale Segment Restructuring

The fish wholesale segment has been expanding rapidly. This occurred with a proliferation, especially during the 2000s, of rural fish wholesale markets, and an increase in fish wholesale markets in cities such as Dhaka. Fish trader numbers more than doubled across the four zones, from 14,800 in 2004 to 31,300 in 2014 (2.1 times, versus 1.6 times for farmers).

The largest share of traders was in the North (41 percent) in 2014, which had only 23 percent of the traders in 2004. Trader startups followed the concentration of fish production. Most village traders started about 10-15 years ago, over the same period as the beginning and development phase of the aquaculture boom.

12.4.2 Commercialization and Spatial Elongation

In Bangladesh mainly over the past 15 years, the value chain for farmed fish has commercialized, and it has "lengthened" geographically. This is a typical trend in transformation and modernization of food supply chains, with concomitant inter-district market integration and reduction of transaction costs. This happened for example in rice and potatoes in Asia over the past decade (Reardon, Chen, Minten, and Adriano 2012). The commercialization of fish farming is itself dependent on the proliferation of services we discussed above: the development of off-farm components of the value chain permits a division of labor wherein small farmers can specialize in pond operations, and enjoy cost saving via economies of scale, economies of scope, and economies of agglomeration by relying on the upstream feed and seed purveys and downstream wholesale and logistic services that themselves are specialized enterprises. Belton, Ahmed, and Jahan (2014) contend that the availability of these services facilitates the entry of smaller producers into commercial fish farming; Reardon, Chen, Minten, and Adriano (2012) contend similarly for rice and potato sectors. We discuss the trends of commercialization and chain lengthening below, from upstream to midstream.

Table 12.10: Structural Change by Rural Fish Traders Cluster over 10 Years

Zone	Rural fish traders											
	Total number (hundreds)			Share of small in total number			Share of medium in total number			Share of large in total number		
	2004	2009	2014	2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest	42	46	59	71%	74%	76%	26%	22%	20%	4%	4%	4%
South-center	24	33	38	61%	59%	45%	28%	26%	35%	11%	15%	20%
North	34	54	128	61%	58%	76%	22%	23%	14%	17%	19%	9%
East	48	74	88	68%	74%	71%	24%	21%	23%	8%	6%	6%
All	148	207	313	66%	67%	71%	24%	22%	20%	9%	10%	9%
				Share of small in total volume			Share of medium in total volume			Share of large in total volume		
				2004	2009	2014	2004	2009	2014	2004	2009	2014
Southwest				21%	23%	23%	45%	41%	37%	34%	36%	40%
South-center				11%	9%	5%	30%	24%	24%	59%	67%	71%
North				9%	7%	17%	19%	18%	19%	73%	75%	64%
East				15%	20%	18%	32%	33%	35%	53%	47%	48%
All				13%	13%	15%	30%	26%	26%	57%	61%	58%

Source: Fish Value Chain Meso Level Survey 2014.

12.4.2.1 Seed Commercialization

Farmers have shifted from trapping wild fish on their farms or buying locally available wild seed in the early 1990s (Ahmed, Rab, and Bimbao 1993) , to stocking hatchery-produced seed in the 2000s. By 2011, 98 percent of fish seed was produced by private hatcheries (Belton and Little 2011).

The shift to hatchery-produced seed resulted in a lengthening of the distances over which seed was traded. Private hatcheries developed first in Jessore where there were ideal iron-free water conditions and technical training was initially provided by a government hatchery in the 1970s. A vibrant long-distance trade in seed between Jessore and other areas, including the Northwest, developed rapidly. From the early 1990s, techniques first demonstrated in Jessore were established in other areas, such as Bogra in the North (also a location with iron-free groundwater), as a result of informal transfer of technical knowledge among seed producers (Lewis, Gregory, and Wood 1993). Many hatcheries were also established in Comilla (an area with a history of nursing wild seed captured, and the site of one of the earliest government hatcheries), and Mymensingh—a location with less ideal environmental conditions, but with technical support from government institutions, aquaculture development projects, and demand for seed from a rapidly growing farm sector. The geography of hatcheries reflects a mix of initial environmental and institutional conditions and the location sources of demand.

These trends have given rise to a situation in which there is a correlation of the level of activity of the broad cluster and the co-location of hatcheries. There is strong spatial concentration of hatcheries in the North, which has more than half of the hatcheries in the four zones. But our survey also finds that on average half of what hatcheries produce is sold to buyers outside of their own district (not shown in the tables). Hatcheries tend thus to be "shared" across districts and even zones.

12.4.2.2 Feed Commercialization

The commercialization of aquaculture feeds and the geographical lengthening of that segment have occurred in lockstep. There has been a long-term shift from little use of feed of any type (Ahmed, Rab, and Bimbao 1993), to use of feed available on-farm (e.g., cow manure, rice bran), to purchase of the latter, and increasingly, to purchase of formulated pelleted feeds. Ninety percent of the latter are made by medium and large-scale commercial mills in 2015 (Mamun-Ur-Rashid, , Belton, Phillips, and Rosentrater 2013).

Large feed mills in the peri-urban industrial zone north of Dhaka, where most feedlot poultry farming occurs, distribute feed throughout the country.

Mills are concentrated there for centralized acquisition of inputs, and because (similar to other countries) many fish feed manufacturers originally produced poultry feeds before diversifying into fish feed by adding additional lines. Eighteen of the 25 largest poultry feed mills in Bangladesh also produce fish feeds (Khaleduzzaman and Khandaker 2009).

The input acquisition supply chain for feed manufacture stretches over long distances. Most dried fish, one of the main ingredients in fish feed, is sourced from marine fisheries in coastal districts of Bangladesh but increasingly also imported from India and further afield, as is soy (another key ingredient). Meat and bone meals, important protein sources for feed, are sourced from the European Union (Mamun-Ur-Rashid, Belton, Phillips, and Rosentrater 2013). Much of the equipment utilized in the value chain (e.g., feed milling machines, vehicles, pumps, cold chain equipment) is imported, mainly from East and Southeast Asia, as are chemicals (Mamun-Ur-Rashid, Belton, Phillips, and Rosentrater 2013).

As elsewhere in Asia, foreign expertise has played an important role in the development of hatchery and feed operations (Belton 2012). For example, training received by Bangladeshi entrepreneurs (both at courses in Thailand and from foreign consultants working in Bangladesh) has been important in the establishment of monosex *tilapia* hatcheries. Over time, dependence on these sources of information has lessened as technical knowledge has become more widely available within Bangladesh.

12.4.2.3 Fish Farm Commercialization

The shift from subsistence to commercial production in the fish sector occurred as initially fish were only home-consumed from the household pond, then increasingly sold into nearby markets, and then marketed also to more distant urban markets. These sequential changes have occurred rapidly. As recently as the early 1990s, Ahmed, Rab, and Bimbao (1993) observed that only a small fraction of total harvested farmed fish entered the market outside the local village.

In contradiction to the traditional view of fish farming in Bangladesh as mainly subsistence-oriented, the value chain survey of the farm segment shows that 75 percent of households sell fish. Strikingly, the share of farms with a marketed surplus even in these dense aquaculture clusters was only 57 percent just five years prior to this, indicating that extremely rapid commercialization occurred. The Southwest has the highest share of fish farming households marketing fish (88 percent), in line with shrimp and prawn production in that zone (besides farmed fish); most of the shrimp are exported. Figures are around 70-75 percent for the South-center and North, and 60 percent for the less advanced (in terms of fish farming) East.

Table 12.11: Disposal of Fish Farm Harvest by Final User Type, 2013

Observations in 2013	South-west	South-center	North	East	All
	465	280	420	340	1505
1. Share of farmers selling fish	87.5	70.7	74.5	59.7	74.5
2. Farmer's own consumption	15.4	18.5	4.2	12.2	8.4
3. Sales through different value chains:					
a. Consumed by another farm household	0.3	0.0	0.0	0.0	0.0
b. Direct consumer	0.0	0.7	0.9	0.0	0.7
c. Retailer at traditional market	11.4	7.7	2.7	15.6	6.0
d. Assembler (collector)	5.6	2.8	8.1	14.7	8.4
e. Large wholesaler	49.2	54.5	68.1	56.4	62.8
f. Supplier (broker)	1.5	8.6	8.7	0.6	6.6
g. Supermarket	0.0	0.0	0.0	0.0	0.0
h. Auctioned	16.6	7.1	7.3	0.5	7.1
i. Others	0.1	0.0	0.0	0.0	0.0
j. Total	100.0	100.0	100.0	100.0	100.0

Source: IFPRI/MSU Fish Value Chain Farm Household Survey 2014.

Table 12.11 shows the disposal of fish output by aquaculture households in 2013 by final user type. Note that only 8 percent of the fish was home consumed; thus, the average household was highly commercialized. Interestingly, while yields differ a lot over zones, the marketed surplus rate does not: the home consumption share is 4 percent in the North zone and about 15 percent in the other zones.

Moreover, in contrast to the common image of the rural fish market being dominated by small rural brokers, the market has shifted to rural sourcing by large wholesalers based in towns and secondary cities. Tables 12.12 and 12.13 show that about two-thirds of the marketed volume goes to large wholesalers; again, that differs between the North with 68 percent and the average of the other zones at 54 percent. Three-quarters of the sales to large wholesalers are affected locally (in the village, union, or upazila). By contrast, local rural brokers have a mere 5 percent share of the market. Just over a decade earlier, fish farmers usually sold their fish to local traders or fish collectors (ADB 2005). Interestingly, this is the same market structure development that has occurred in rice and potatoes in Asia (Reardon et al. 2012).

Table 12.12: Disposal of Fish Farm Harvest by Final User Location, 2013

Observations in 2013	South-west	South-center	North	East	All
	465	280	420	340	1505
1. Farmer's own consumption	15.4	18.5	4.2	12.2	8.4
2. Sales through different value chains:					
2.1 Consumed by another farm household	0.3	0.0	0.0	0.0	0.0
2.2 Direct consumer	0.0	0.7	0.9	0.0	0.7
2.3 Retailer at local (village, union, upazila) traditional market	11.4	7.7	2.7	15.6	6.0
2.4 Assembler locally	5.6	2.6	5.5	14.7	6.7
2.5 Assembler in same district	0.0	0.2	2.5	0.0	1.7
2.6 Large wholesaler locally	46.3	46.7	64.4	31.8	55.5
2.7 Large wholesaler in same district	2.7	4.3	2.9	14.8	4.9
2.8 Large wholesaler in different district	0.1	3.5	0.8	9.7	2.3
2.9 Supplier (broker) locally	1.2	8.6	6.9	0.6	5.4
2.10 Supplier (broker) in same district	0.3	0.0	0.0	0.0	0.0
2.11 Supplier (broker) in different district	0.0	0.0	1.8	0.0	1.2
2.12 Supermarket	0.0	0.0	0.0	0.0	0.0
2.13 Auctioned locally	16.3	5.4	1.9	0.0	3.4
2.14 Auctioned in same district	0.1	1.1	5.3	0.0	3.6
2.15 Auctioned in different district	0.2	0.6	0.1	0.5	0.2
2.16 Others	0.1	0.0	0.0	0.0	0.0
2.17 Total	100	100	100	100	100

Source: IFPRI/MSU Fish Value Chain Farm Household Survey, 2014.

12.4.2.4 Rise of the Fish Trader Segment to Urban Areas

Growth in sales of farm output has been accompanied by a proliferation of traders in the midstream segment of the chain. As urban demand has grown and the road network has developed (Table 12.3), fish is increasingly sold by traders in the zones of production to Dhaka, and from one division to another. The national Household Income and Expenditure Survey, (BBS 2011) shows that from 2000 to 2005 the share of fish consumed in urban areas rose from 29 percent to 42 percent.

The conduct of the segment has also changed from the traditional image common in Asia that traders are advancing funds to farmers to "lock in" farmers in transactions. Our survey shows that none of the farmers received any cash advance from fish traders. That is confirmed by the present trader survey. But the trader survey shows that around 40 percent of traders, both

rural (operating from villages) and peri-urban (operating from secondary cities or towns), provide advances of working capital to other traders in order to secure supplies of fish, with an average loan duration of just under one month.

Among rural and peri-urban traders, our survey shows that the great majority have stalls in rural and peri-urban wholesale markets. Most rural fish traders (63 percent) and peri-urban traders (79 percent) take a commission on the transaction of fish (rather than through arbitrage where they buy and then sell). None of the rural traders and few of the peri-urban traders surveyed own trucks, and only 6 percent rent them, indicating their role as intermediaries who operate from a base and just link buyers and sellers, relying on hiring transporters (or having the farmer hire transporters to deliver). The average monthly working capital of rural traders is a little under half that of peri-urban traders as expected.

Few traders (<2 percent) own ice making plants, and almost none owns a cold storage. Only 31 percent of rural and 20 percent of peri-urban traders report icing the fish. This likely reflects their role as commission agents, who rapidly broker sales between buyers and sellers, without taking possession of the fish themselves, with buyers usually assuming responsibility for procuring ice from ice suppliers or manufacturers. The low ice use rate is not for lack of access to ice firms: 80-90 percent of the traders feel they have good access to ice firms. The domestic market demands whole fresh fish, with little, if any value addition occurring. It is thus not observed that wholesalers, feed companies, or hatcheries process their own fish.

12.4.3 Technological cum Product Composition/Product Cycle Change and Patterns

Important inter-linked changes have occurred in the technologies and the product composition of farm production concurrent with the above structural changes in the value chain. We discuss these below.

12.4.3.1 The Product Cycle

The "product cycle" is a widely observed feature of product development in many sectors of the economy, and can be observed for a range of agricultural sectors, including fish and fruit, in a number of other countries. Sequentially, the stages of the product cycle are: (i) local niche product stage; (ii) commodity stage, during which a local (or exotic) niche product is "commoditized" by production in large quantities, driving down costs, but with little product variety or quality differentiation; (iii) product differentiation stage: when

the commodity becomes differentiated along the lines of several possible tangible and intangible attributes (e.g. variety, quality, organic versus conventional, confined versus free range); (iv) commoditization stage, where the differentiated products are themselves produced on larger scale and commoditized, and; (v) introduction of new niche or differentiated products. The cycle can continue indefinitely depending on the capacity of innovation in the sector and the market.

We posit that the Bangladesh fish sector has followed a typical "product cycle" development path, facilitated by the linked technology changes along the value chain described above, although to date only the three stages can be discerned. The first (and ongoing) technology change linked to the first product cycle step (moving from niche to commodity) is the shift from capture of wild fish stocks from open waters, to their production in ponds under controlled conditions. This shift began in earnest during the 1980s, as ponds were increasingly utilized for aquaculture, primarily by stocking native carp species which were an important component of inland capture fisheries at that time (Ali 1997).

Carp cultivation expanded rapidly from the 1980s onwards, as hatcheries produced seed of both indigenous carps (e.g., *rohu*)—formerly a highly prized but infrequently accessible "local niche" product—and exotic carps (e.g., silver carp) became more widely available, leading to their commoditization.

In the mid-1990s, *pangasius*, an exotic (to Bangladesh) catfish, was introduced from southeast Asia (where it itself had originated as a local niche variety that had been commoditized). *Pangasius* was well suited to commoditization under intensive farming conditions due to its fast growth and hardy physiology (including the ability to breath atmospheric oxygen), which equate to good survival rates, and the ability to survive at high stocking densities. Production of *pangasius* grew rapidly in Bangladesh from the late 1990s onwards, with the product commoditizing as supply increased and real prices fell (Ali, Haque, and Belton 2013).

Widespread production of monosex Nile *tilapia* seed began in the early 2000s, facilitating its rapid uptake by farmers and commoditization.[4] *Tilapia*, which originates from Africa, has also shifted from being a local (African) niche product to a commodity with a pan-global distribution over the past 50 years. It was introduced into Bangladesh from its commoditized

[4] The introduction of hatchery technology needed to produce 'monosex' (all-male) tilapia seed was a necessary precursor to the commoditization of tilapia. All-male populations of tilapia do not breed, and grow quickly and to large sizes, whereas mixed-sex tilapia breed precociously, expending energy on reproduction rather than growth. This results in many stunted fish with low market value (Belton 2012).

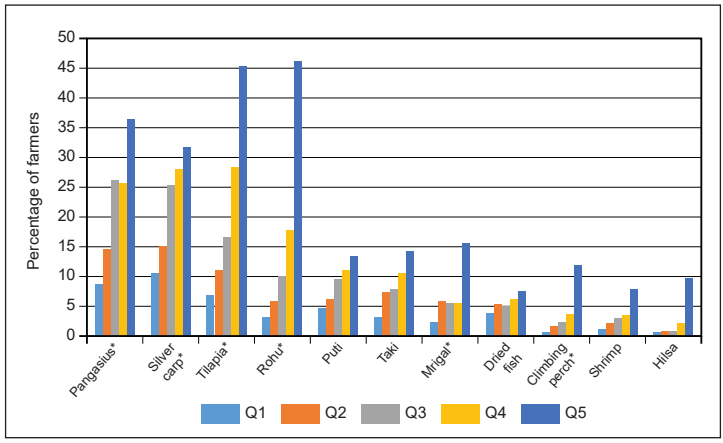
base in Southeast Asia (Belton and Little 2011). Although *tilapia* is not an air breather like *pangasius,* its fast growth, ability to tolerate high stocking densities and poor water quality, adaptability to a range of diets, and suitability for use in a wide range of food preparations, all make it an ideal candidate for intensification.

From the late 2000s there has been a further wave of farm production of native fish species such as climbing perch (*koi* in Bangla language), walking catfish (*magur*), stinging catfish (*shing*), feather back (*chitol*), and butterfish (*pabda*) which were formerly available only from domestic capture fisheries. Climbing perch farming in particular has already undergone rapid expansion of intensive production for the mass market, resulting in full commoditization. Climbing perch, a popular wild fish in Bangladesh, is, like *pangasius*, an air breather capable of surviving at high densities under conditions of poor water quality. The strains raised in Bangladesh at present were imported from Thailand and Vietnam and are faster growing and larger than the native wild strain. It is likely that one or two of the species in this niche group will also eventually become fully commoditized, and may subsequently spread to other countries as *pangasius*, *tilapia*, and improved climbing perch strains have to Bangladesh.

Data from BIHS depict on the consumption side the product cycle (Figure 12.1). After becoming commoditized during the 2000s, *pangasius* and *tilapia* are now the first and third most consumed fish in rural areas of Bangladesh. *Rohu*, an indigenous carp species that was among the first fish to be commoditized, and traditionally the most important farmed fish, is now ranked fourth in terms of consumption. The very recently commoditized climbing perch now ranks eighth. This change has occurred quickly. Comparison with similar household survey data collected in 2006-2007 shows *rohu* still the most consumed fish at that time, with *pangasius* third, *tilapia* ninth, and climbing perch not yet produced in sufficient quantities to feature (Belton, van Assledonk, and Thilsted 2014).

Our farm survey also shows evidence of product cycle changes in each zone in 2008 compared with 2013. There is a significant increase in production of *pangasius, tilapia*, and "niche" species in the North, and niche species in the East. Overall, carps are the dominant category of fish species produced in the study zones. However, the share of carps has decreased slightly (2 percent) while the share of *pangasius* has increased significantly (7 percent increase), as has *tilapia* to a lesser degree (3 percent increase). It is interesting that the production of niche species has increased slightly in the study zones, but in the North increased by 72 percent, and in the East increased 16 times, though from a low base.

Figure 12.1: Average Weekly Consumption Per Capita of Ten Most Consumed Fish Species in Rural Bangladesh



Note: Q1 = Expenditure quintile 1, etc.; Fish marked with an asterisk are produced predominantly from aquaculture. Source: Derived by authors from the BIHS data.

Table 12.13: Aquaculture Production by Fish Category, 2008 and 2013

Zone	Southwest		South-center		North		East		Total	
	2008	2013	2008	2013	2008	2013	2008	2013	2008	2013
Production (kg/year)										
Carps	173	175	235	325	521	928	233	369	291	445
Tilapia	58	71	60	99	182	503	169	309	116	244
Pangas	0	0	66	105	544	1,358	103	207	180	401
Shrimp	129	134	7	8	0	0	12	7	48	51
Niche	46	45	58	69	186	408	18	285	172	200
Others	42	46	60	70	92	216	94	137	70	117
Total	448	470	485	675	1,525	3,414	630	1,314	876	1,458
Share of production (%)										
Carps	39	37	49	48	34	27	37	28	33	31
Tilapia	13	15	12	15	12	15	27	24	13	17
Pangas	0	0	14	16	36	40	16	16	21	28
Shrimp	29	28	1	1	0	0	2	1	5	3
Niche	10	9	12	10	12	12	3	22	20	14
Others	9	10	12	10	6	6	15	10	8	8

Source: Fish Value Chain Farm Household Survey 2014.

12.4.3.2 Capital-led Intensification

The conventional image of the pond-fish sector was once millions of backyard "homestead ponds", utilized primarily for subsistence (home consumption). Dey, Bose, and Alam (2008, 13) refer to aquaculture in Bangladesh as a "low-input activity for household consumption".

However, the small and medium commercial farms that now dominate aquaculture output are making a transition from the traditional production technologies toward intensification—first by labor and then by productive capital (such as formulated feed and medicines and some equipment such as aeration). The main technology changes observed in the survey are as follows.

Rapid increase of purchased feed and seed. Use of wild fish seed has been replaced by use of hatchery produced fish seed. Jahan et al. (2015) report that less than 4 percent of farmers use fish seed from open-water sources. Seed stocking density has also increased. Our farm survey shows that nominal expenditure on fingerlings per hectare more than doubled between 2008 and 2013.

Moreover, there has been a transition in zones surveyed from no use of feed, to use of feed inputs available on farm, to use of hand-made feeds made with ingredients purchased off-farm, to use of purchased manufactured feeds, formulated to meet the complete nutritional requirements of the fish produced and, increasingly, from formulated sinking feed to floating formulated feed. The latter allows for greater production efficiencies via reduction of waste and higher digestibility.

Strikingly, our farm survey shows that 38 percent of farmers in 2013 used commercial pelleted feeds, up from 30 percent in 2008; both figures are surprisingly high, and run counter to the common image of fish farming in Bangladesh as mostly extensive or semi-intensive (ADB 2005). Use of commercially manufactured pelleted feeds is significant because their use can increase fish growth rates, facilitating higher yields, and is consistent with product cycle driven diversification into species of fish (e.g., *pangasius, tilapia*, and climbing perch) that require formulated diets to attain optimal growth.

Our survey results show that use of other supplementary feeds usually associated with semi-intensive farming (e.g., rice bran, mustard oilcake), was already widespread in 2008 (60 percent of farmers), but grew to 69 percent of farmers by 2013. This indicates a range of stages of intensification, with some farmers shifting from extensive to semi-intensive production and others "upgrading" to more intensive production with pelleted feeds.

Rapid increase in the use of chemicals. Use of medicines and other chemicals, including lime, antibiotics, salt, fungicides, insecticides, and feed additives such as vitamins have increased in line with higher stocking densities and feed use. This has occurred as the incidence of disease has increased and better management has been necessary to maintain water quality within the parameters required for fish survival and growth (Ali, Rico, Jahan, and Belton 2016).

Our farm survey shows that use of lime for pond preparation was already a widespread practice in 2008 (63 percent of farmers), and was adopted by 73 percent by 2013. Use of medicines and vitamins was less common (6 percent of farms each in 2013), increasingly slightly from 4 percent in 2008. Use of both these inputs was greatest in the North reflecting its intensified technology, and lowest in the least commercial zone, the East.

Increase of use of hired labor. Hired labor use has increased along with the overall need for labor. Whereas in the early 1990s aquaculture used little household labor as compared to crop or livestock cultivation (Ahmed, Rab, and Bimbao 1993), commercial forms of aquaculture in Bangladesh now generate higher average demand for hired labor per unit area of land than paddy cultivation, due in part to the long fish cropping cycles (Belton, Ahmed, and Jahan 2014) and more yield and input use to manage.

Our farm survey data show that both total labor inputs (measured in value terms, as the imputed value of the wage rate for family labor and the cost of outlays on hired labor), and inputs of hired labor have intensified per unit of (pond) land. The total outlay per hectare for labor (family plus hired) in 2013 was 1.6 times what it was in 2008. The share of hired (non-family) labor in total labor (hired plus own labor) doubled over the same period, from 11 percent to 21 percent.

Hiring labor was concentrated among a small subset of commercial farms. The share of farms hiring casual workers was 16 percent for pond preparation; 5 percent for stocking, 5 percent for the post-stocking/growing-out stage, and 6 percent for harvesting. The share of farms hiring salaried or permanent laborers is still much lower. Moreover, differences in total labor inputs and in hired labor vary markedly across zones, in line with patterns of intensification. Total labor use in 2008 was 50 percent higher in the South-center and North than in the Southwest and East. By 2013, these differences are even more extreme, with labor use per hectare in the South-center and North 100 percent higher than in the Southwest and East.

Rapid increase/investment in quasi-fixed capital (equipment). There has been substantial investment by fish farmers in productive capital. Investments

(at nominal terms) in assets used for fish farming[5] jumped by 235 percent over 2008-2013. The rate of investment is similar over all zones, with the exception of the South-center, which is somewhat slower. However, the rapid jump in productive fish-related capital holdings masks the fact that few fish farms had these. Pumps, owned by 14 percent of households, were by far the most frequently owned item. Investment growth is thus from a relatively concentrated base among the small/medium commercial farms. The money value of the stock of quasi-fixed capital inputs (rate of investment in capital) on fish farms rose faster than labor flow (total use of labor, measured in value terms) from 2008-2013.

Investment in agricultural equipment by fish farmers is reflected in productive capital stocks used for crop farming increasing by 185 percent. This too was similar across zones. Fish farmers also invested in livestock (increasing by 533 percent), while non-farm productive assets climbed 730 percent, and consumer durables by 240 percent. Even discounting these rates for inflation, these findings show that fish farmers are a vibrant capital accumulating segment.

Table 12.14: Fish Farm Capital to Labor Ratio by Zone, 2008 and 2013

Item	South-west	South-center	North	East	All
Capital/labor ratio, 2013	1.52	0.39	0.63	0.48	0.75
Capital/labor ratio, 2008	0.96	0.33	0.47	0.32	0.51
Change, 2008 to 2013 (%)	58	18	34	50	47

Source: Fish Value Chain Farm Household Survey 2014.

In sum, from 2008 to 2013 there has been a remarkable increase in use of external inputs by farms. Total outlay on external inputs (feed, fertilizer, chemicals and so on) tripled per hectare. The rate of external input use did not differ a great deal across three of the four zones. Average expenditure on inputs was much greater in the North however, reflecting the intensive technologies utilized there.

Despite the rapid increase in total outlay on external inputs, the composition of that outlay is very stable. Feed remains central, accounting for 78-79 percent of external input costs in both 2008 and 2013. Fertilizer[6]

[5] Assets used in fish farming are calculated by the summation of the value of the following assets: pumps, generators, aerators, nets, weighing scales, boats, bicycles, motorcycles, pickup trucks, trucks.

[6] Fertilizer is used to induce growth of phytoplankton in the pond, which provides a natural feed for fish.

stays at 5 percent; fuel 7-8 percent; and pesticide and lime 5-6 percent. Fifty percent of farmers (with a lower share in the East) use chemical fertilizer in the pre-stocking phase, up sharply from 39 percent in 2008. Use of other inputs also increased: 75 percent of farms use lime for pond preparation in 2013, up from 63 percent in 2008, and a third uses water pumps for filling the pond in 2013, up from one fifth in 2008, both indicating greater attention to maintenance of good water quality. In combination, these trends all point to a broad shift away from "traditional" low input forms of production, with capital intensification in the farm sector occurring in step with rapid growth, diversification and technological change in the feed and seed value chain segments.

12.4.4 Mirroring of Farm Capital-led Intensification: Growth and Technological Change in the Input Supply Segments

Capital intensification in the farm sector has occurred in steps with rapid growth and diversification in upstream value chain segments, most importantly feed and seed. As noted in Section 12.1, there has been a proliferation of feed mills, but overall a concentration of production in larger mills. Larger feed mills have multiple lines, and differentiate feed types for different fish species and age groups, by protein content, complementing the species differentiation taking place on farms and in hatcheries, in line with the product cycle. The most recent shift in feed mill technology has come about through the use of extrusion machinery to produce feeds that float instead of sink, providing further product differentiation, and offering efficiency gains to producers. Mamun-Ur-Rashid, Belton, Phillips, and Rosentrater (2013) find that from 2008 to 2012, production of formulated fish feeds almost trebled from 360,000 tons to an estimated one million tons. The share of floating feeds in total formulated feed production grew from less than 5 percent to close to 20 percent. The extrusion equipment used to manufacture floating feed represents a major investment. The size of mill and adoption of extrusion are closely correlated, and big mills dominate the floating feed supply. This factor may result in further concentration in the industry over time. The growing use of formulated feed has also seen rapid expansion in the number of fish feed dealers (both wholesalers and retailers) as noted in Section 12.4.1, and veterinary chemical/medicine input retailers.

Technological shifts have also occurred within the seed supply segment of the value chain. The product cycle is observed in hatcheries, mirroring farm production: The share of hatcheries reporting carps to be the most important species sold fell from 59 percent to 45 percent over 2008 to 2013, while the share of hatcheries reporting *pangasius* and *tilapia* (combined) as

their most important species rose from 15 percent to 20 percent, and the share of "niche" species jumped from 11 percent to 26 percent.

12.4.5 Reflections on the Policy Determinants of the Transformation

The government has played an important role in the early stages of some off-farm value chain segments. For instance, the first fish feed mill in Bangladesh was established in Mymensingh by SABINCO, a joint venture investment company owned by the Governments of Saudi Arabia and Bangladesh. This arguably provided proof of concept for private investors. The government has also played a role in the hatchery sector. For instance, Bangladesh Fisheries Research Institute (BFRI) in Mymensingh was central to the development of *pangasius* and *koi* farming by establishing and disseminating spawning protocols for both species, and importing *pangasius* brood from Thailand. Several universities and a large number of colleges offer fisheries and aquaculture degrees, providing graduates to the private and NGO sectors.

Other than these types of investments, sector specific policies and regulations have had little effect for the most part. There are laws intended to govern both the hatchery and animal feed sectors, but these are widely recognized to be poorly enforced. There has been, however, some continuity in the pro-business outlook of consecutive governments, despite frequent political instability. Policies friendly to foreign direct investment help to explain the high level of foreign ownership in the feed mill sector. However, the cost of doing business in Bangladesh is high, and this likely contributes to the high level of informality among small and medium-sized enterprises (SMEs). Similarly, legal recourse to contractual enforcement is poor, which again is likely to account for the predominance of informal trust-based coordination between value chain actors, in preference to formal contractual relations.

Despite Bangladesh's highly developed NGO sector, and large number of NGO-led aquaculture programs implemented over several decades, it is notable that NGOs have played a rather limited role in the development of the aquaculture value chain in Bangladesh, with the biggest impacts derived from the earliest projects, before "take-off" had occurred.

Nonetheless, successive governments have invested in infrastructure (rural roads, water management schemes, power generation). Telecommunications also grew following the sector's liberalization. These have likely been the most important non sector-specific policy changes. Agricultural land is privately owned and the government adopts a *laissez faire* approach to land use (e.g., there are no regulations in place on the type of crops that must be produced

on specific types of land). This in part accounts for the rapid growth of ponds, as fish farmers have been unencumbered by such restrictions. Microcredit provided mainly by the vibrant NGO sector is abundant, but is rarely invested in fish farming due to insufficient loan sizes and inconvenient loan repayment schedules. Growth of off-farm employment opportunities has likely fueled investments in fish farms through savings, but it is difficult to pinpoint a specific responsible policy, other than some of the general ones that similarly affect investments in fish farms.

12.5 Conclusions

The study has produced a single, powerful finding: the fish value chain in Bangladesh is growing and transforming very rapidly, in all segments. The quiet revolution in the fish value chain is a domestic market revolution. Dynamism of the aquaculture value chain in Bangladesh is shown in two inter-linked ways.

First, there has been a tripling of volumes and actors in all the segments of the value chain over the past decade. Second, there has been rapid capital deepening in the form of investments by hundreds of thousands of actors in the fish value chain; apparent in a great jump in feed use, investment in equipment and pond construction, and investments in mills, hatcheries and vehicles. These investments have been made by, and provided opportunities for, a multitude of smallholder farmers and small and medium enterprises throughout the chain.

Second, there has been diversification and specialization beyond carps into production of commercial species such as *tilapia* and *pangasius* catfish, which have raised yields and helped to move the fisheries sector along the "product cycle." One important positive externality of this process has been a reduction in the price of farmed fish over time, making an important contribution to food security.

This growth has been oriented towards the domestic market, as very little of Bangladesh's farmed fin-fish is exported. Unlike in the global value chain literature (which deals primarily with changes in value chain organization and conduct associated with adoption of standards and contracts driven by buyers and NGOs in developed country markets), we identify very little change having taken place as a result of the imposition of standards and contracts.

Policy has played some role in facilitating this growth, in particular through early investments in fish seed production, as well in electricity and road infrastructure in rural areas. A *laissez faire* policy in terms of crop choice has also been important. However, the direct influence of

government and NGOs in "causing" this quiet revolution has been relatively minor in comparison with the investments of millions of farm households and small and medium enterprises. Policies and investments that support a broad enabling environment for a wide variety of businesses (e.g., rural infrastructure development and minimization of regulatory constraints to enterprise start up and growth) will generally be of greater importance than those that aim to solve sector or segment specific problems. This can include things that government does not do, as much as those that it does (e.g., not restricting conversions of agricultural land to ponds).

References

ADB (Asian Development Bank). 2005. *An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction*. Operations Evaluation Department. Manila: ADB.

Ahmed, A. U., A. Kaikaus, V. Chou, R. Hernandez, P. Menon, F. Naeem, F. Naher, W. Quabili, E. Sraboni, B. Yu, and Z. Hassan. 2013. *The Status of Food Security in the Feed the Future Zone and Other Regions of Bangladesh: Results from the 2011-2012 Bangladesh Integrated Household Survey*. Technical Report. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Ahmed, Mahfuzuddin, M. Abdur Rab, and Mary Ann P. Bimbao. 1993. *Household Socioeconomics, Resource Use and Fish Marketing in Two Thanas of Bangladesh*. ICLARM Technical Report No. 40. Manila: International Center for Living Aquatic Resources Management (ICLARM).

Ali, M. Youssouf. 1997. *Fish, Water and People: Reflections on Inland Open Water Fisheries Resources of Bangladesh*. Dhaka: The University Press Limited (UPL).

Ali, M. Hazrat, Mohammad Mahfujul Haque, and Ben Belton. 2013. "Striped Catfish (Pangasianodon hypophthalmus, Sauvage, 1878) Aquaculture in Bangladesh: An Overview." *Aquaculture Research* 44, no. 6: 950-965. https://doi.org/10.1111/j.1365-2109.2012.03101.x.

Ali, Hazrat, Andreu Rico, Khondoker Murshed-e-Jahan, and Ben Belton, B. 2016. "An Assessment of Chemical and Biological Product Use in Aquaculture in Bangladesh." *Aquaculture* 454: 199-209. https://doi.org/10.1016/j.aquaculture. 2015.12.025.

BBS (Bangladesh Bureau of Statistics). 2011. *Household Income and Expenditure Survey 2010*. Dhaka: BBS, Ministry of Planning, Government of the People's Republic of Bangladesh.

Belton, B. 2012. "Culture, Social Relations and Private Sector Development in the Thai and Vietnamese Fish Hatchery Sectors." *Asia Pacific Viewpoint* 53, no. 2:133-146. https://doi.org/10.1111/j.1467-8373.2012.01487.x.

Belton, B., Nasib Ahmed, and Khondoker Murshed-e-Jahan. 2014. *Aquaculture, Employment, Poverty, Food Security and Wellbeing in Bangladesh: A Comparative Study*. Program Report No. AAS-2014-39. Penang: CGIAR Research Programme on Aquatic Agricultural Systems.

Belton, B., and Arif Azad. 2012. "The Characteristics and Status of Pond Aquaculture in Bangladesh." *Aquaculture* 358-359: 196-204. https://doi.org/10.1016/j.aquaculture.2012.07.002.

Belton, B., and Simon R. Bush. 2014. "Beyond Net Deficits: New Priorities for An Aquaculture Geography. *The Geographical Journal* 180, no.1: 3-14. https://doi.org/10.1111/geoj.12035.

Belton, B., and David C. Little. 2011. "Immanent and Interventionist Inland Asian Aquaculture Development and Its Outcomes." *Development Policy Review* 29, no. 4: 459-484. https://doi.org/10.1111/j.1467-7679.2011.00542.x.

Belton, B., Imke Joseph Mariana van Assledonk, and Shakuntala Haraksingh Thilsted. 2014. "Faltering Fisheries and Ascendant Aquaculture: Implications for food and nutrition security in Bangladesh." *Food Policy* 44: 77-87. https://doi.org/10.1016/j.foodpol.2013.11.003.

Bondad-Reantaso, M. G., and R. P. Subasinghe. 2013. *Enhancing the Contribution of Small-scale Aquaculture to Food Security, Poverty Alleviation and Socio-economic Development*. FAO Fisheries and Aquaculture Proceedings No. 31. Rome: FAO.

Crow, B. 2001. *Markets, Class and Social Change: Trading Networks and Poverty in Rural south Asia*. Basingstoke: Palgrave.

Dey, Madan Mohan, M. L. Bose, and M. F. Alam. 2008. *Recommendation Domains for Pond Aquaculture. Country Case Study: Development and Status of Freshwater Aquaculture in Bangladesh*. World Fish Center Studies and Reviews No. 1872. Penang: The World Fish Center.

Dey, Madan Mohan, Ferdinand Javien Paraguas, Nartaya Srichantuk, Yuan Xinhua, Ramchandra Bhatta, and Le Thi Chau Dung. 2005. "Technical Efficiency of Fish Farming under Polyculture System in Freshwater Pond in Asia: A Cross-country Comparison." *Aquaculture Economics and Management* 9, no. 1&2: 39-64. https://doi.org/10.1080/13657300590961528.

DOF (Department of Fisheries). 1994. *Fisheries Statistical Year Book of Bangladesh 1992-1993*. Dhaka: Fisheries Resource Survey System, Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh.

___. 1997. *Fisheries Statistical Year Book of Bangladesh 1995-1996*. Dhaka: Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh.

___. 2006. *Fisheries Statistical Year Book of Bangladesh 2004-2005*. Dhaka: Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh.

___. 2015. *Fisheries Statistical Year Book of Bangladesh 2013-2014*. Dhaka: Fisheries Resource Survey System, Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh.

Faruque, G.. 2007. "An Exploration of Impacts of Aquaculture Production and Marketing on Rural Livelihoods in Three Regions in Bangladesh." PhD diss., Institute of Aquaculture, University of Stirling, Scotland.

FAO (Food and Agriculture Organization). 2016. "FishStat J database." Food and Agriculture Organisation of the United Nations, Rome. Accessed 1 July 2016, http://www.fao.org/fishery/statistics/software/fishstatj/en.

Goss, Jasper, David Burch, and Roy E. Rickson. 2000. "Agri-Food Restructuring and Third World Transnationals: Thailand, the CP Group and the Global Shrimp Industry." *World Development* 28, no. 3: 513-530. https://doi.org/10.1016/S0305-750X(99)00140-0.

Hatanaka, Maki, Carmen Bain, and Lawrence Busch. 2005. Third-party Certification in the Global Agrifood System. *Food Policy* 30, no. 3: 354-369. https://doi.org/10.1016/j.foodpol.2005.05.006.

Islam, Md. Saidul. 2014. *Confronting the Blue Revolution: Industrial Aquaculture and Sustainability in the Global South*. Toronto: University of Toronto Press.

Jahan, K. M., Ben Belton, Hazrat Ali, Goutam Chandra Dhar, and Ismat Ara. 2015. *Aquaculture Technologies in Bangladesh: An Assessment of Technical and Economic Performance and Producer Behavior*. Program Report: 2015-52. Penang: WorldFish.

Khaleduzzaman, A. B. M., and Z. H. Khandaker. 2009. "Commercial Feed Production and Quality Control: Present Status and Future Prospects in Bangladesh." In *Proceedings of the Sixth International Poultry Show and Seminar*. WPSA-BB, 5-7 March 2009, Dhaka, Bangladesh.

Lele, Uma, and Steven W. Stone. 1989. *Population Pressure, the Environment and Agricultural Intensification: Variations on the Boserup Hypothesis.* MADIA Discussion Paper No. 4. Washington, D.C.: World Bank Group.

Lewis, David J., Rick Gregory, and Geoffrey D. Wood. 1993. "Indigenising Extension: Farmers, Fish-Seed Traders and Poverty-Focused Aquaculture in Bangladesh." *Development Policy Review* 11, no. 2: 185-194. https://doi.org/ 10.1111/j.1467-7679.1993.tb00036.x.

Macfadyen, G., Ahmed Mohamed Nasr-Alla, Diaa Al-Kenawy, Mohamed Fathi, Hussien Hebicha, Ahmed Mohammed Diab, Samy Mohmed Hussein, Ramadan Mohamed Abou-Zeid, and Gamal El-Naggar. 2012. "Value-Chain Analysis—An Assessment Methodology to Estimate Egyptian Aquaculture Sector Performance." *Aquaculture* 362-363: 18-27. https://doi.org/10.1016/j.aquaculture.2012.05.042.

Mamun-Ur-Rashid, M., B. Belton, M. Phillips, and K. A. Rosentrater. 2013. *Improving Aquaculture Feed in Bangladesh: From Feed Ingredients to Farmer Profit to Safe Consumption*. Working Paper No. 2013-34. Penang: WorldFish.

Marschke, Melissa, and Ann Wilkings. 2014. "Is Certification a Viable Option for Small Producer Fish Farmers in the Global South? Insights from Vietnam." *Marine Policy* 50, Part A: 197-206. https://doi.org/10.1016/j.marpol.2014.06.010.

Paprocki, Kasia, and Jason Cons. 2014. "Life in a Shrimp Zone: Aqua- and Other Cultures of Bangladesh's Coastal Landscape." *Journal of Peasant Studies* 41, no. 6: 1109-1130. https://doi.org/10.1080/03066150.2014.937709.

Ponte, Stefano, and Timothy Sturgeon. 2014. "Explaining Governance in Global Value Chains: A Modular Theory-Building Effort." *Review of International Political Economy* 21, no. 1: 195-223. https://doi.org/10.1080/09692290.2013.809596.

Primavera, J. H. 2006. "Overcoming the Impacts of Aquaculture on the Coastal Zone." *Ocean and Coastal Management* 49, no. 9&10: 531-545. https://doi.org/10.1016/j.ocecoaman.2006.06.018.

Rauniyar, Ganesh P. 1998. "Adoption of Management and Technological Practices by Fishpond Operators in Nepal." *Aquaculture Economics and Management* 2, no. 3: 89-99. https://doi.org/10.1080/13657309809380221.

Reardon, Thomas, Kevin Z. Chen, Bart Minten, and Lourdes Adriano. 2012. *The Quiet Revolution in Staple Food Value Chains in Asia: Enter the Dragon, the Elephant, and the Tiger*. Mandaluyong City: ADB and IFPRI.

Reardon, Thomas, Kevin Z. Chen, Bart Minten, Lourdes Adriano, The Anh Dao, Jianying Wang, and Sunipa Das Gupta. 2014. "The Quiet Revolution in Asia's Rice Value Chains." *Annals of the New York Academy of Science* 1331, no. 1: 106-118. http://dx.doi.org/10.1111/nyas.12391.

Rigg, Jonathan, and Peter Vandergeest, eds. 2012. *Revisiting Rural Places: Pathways to Poverty and Prosperity in southeast Asia*. Singapore: NUS Press.

Toufique, Kazi Ali, and Ben Belton. 2014. "Is Aquaculture Pro-poor? Empirical Evidence of Impacts on Fish Consumption in Bangladesh." *World Development* 64: 609-620. https://doi.org/10.1016/j.worlddev.2014.06.035.

Toufique, Kazi Ali, and Rick Gregory. 2008. "Common Waters and Private Lands: Distributional Impacts of Floodplain Aquaculture in Bangladesh." *Food Policy* 33, no. 6: 587-594. https://doi.org/10.1016/j.foodpol.2008.04.001.

Veliu, Adthe, Nebiyeluel Gessese, Catherine Ragasa, and Christine Okali. 2009. *Gender Analysis of Aquaculture Value Chain in northeast Vietnam and Nigeria*. World Bank Agriculture and Rural Development Discussion Paper No. 44. Washington, D.C.: World Bank. http://hdl.handle.net/10986/28276.

PART 4

POVERTY, FOOD SECURITY, AND WOMEN'S EMPOWERMENT

Chapter 13

Climbing Up the Ladder and Watching Out for the Fall: Poverty Dynamics in Rural Bangladesh

Akhter U. Ahmed and Salauddin Tauseef

13.1 Introduction

In Bangladesh, the pace of economic growth accelerated in recent years, with real GDP growing at a rate of 6.5 percent on average per year between 2010 and 2016, reaching 7.3 percent in 2017—the highest in the country's history. The incidence of poverty in Bangladesh was cut in half in the past 16 years, dropping from 48.9 percent in 2000 to 24.3 percent in 2016. In rural areas, poverty headcount declined from 52.3 percent to 26.4 percent over the same period (BBS 2017).

These static poverty estimates from cross-sectional survey data are important to examine the underlying factors of poverty reduction, such as the effects of economic growth and public policy. However, if there has been substantial mobility into and out of poverty in the country, then identifying the enabling factors to escape poverty and the events that drive one into poverty through longitudinal studies such as the present one can be instrumental in formulating poverty alleviation policies and programs.

Although there are numerous poverty studies in Bangladesh, most of these studies are based on cross-sectional data. There are only a few studies that have used panel data to examine poverty dynamics in Bangladesh, of which, some are based on general purpose surveys while others focus on the impact of some targeted programs for the poor. The most notable contribution in the first category are the papers by Sen (2003), Nargis and Hossain (2006), and Hossain and Bayes (2009). Using a "livelihoods" framework and using data from a 21-village survey in Bangladesh conducted in 1987-1988 and 2000, Sen (2003) finds that households moved out of poverty by pursuing multiple strategies such as crop intensification, agricultural diversification,

off-farm activity, and migration, which led to accumulating a variety of assets. On the other hand, households who fell into poverty experienced crises such as ill health and flooding. Nargis and Hossain (2006), and Hossain and Bayes (2009) used a nationally representative panel data from 62 villages spanning from 1988 to 2004 for their analysis. Nargis and Hossain (2006) identified occupational shift from farm to nonfarm sector, expansion of cultivated area through tenancy, overseas migration income, and enhancement of human and physical capital endowments as pathways out of poverty.

Based on a panel dataset generated for evaluating targeted programs, remarkable work has been done by Quisumbing (2011), Quisumbing and Baulch (2009) and Davis and Baulch (2009) concerning the impact of three targeted interventions in three different locations in rural Bangladesh, covering the period from 1994 to 2007. For instance, Quisumbing (2011) finds that years of schooling of household head, the value of non-land assets, and having more dependents in the households are negatively associated with chronic poverty. Shocks arising from an income earner falling sick are also an important contributor to poverty. Drawing from life history interviews to investigate poverty dynamics in Bangladesh, Davis (2006) finds that most improvements tend to only happen gradually, whereas declines are often more sudden.

This paper aims to fill the gap in understanding the determinants of poverty dynamics in rural Bangladesh using a nationally representative longitudinal survey of 5,260 households—the Bangladesh Integrated Household Survey (BIHS)—employing a multinomial logit, logit, and simultaneous quantile regression models. Previous studies, like Sen (2003) and Nargis and Hossain (2006), although based on a nationally representative panel dataset, only used descriptive analysis to examine the characteristics of poverty dynamics categories, while others like Quisumbing (2011) analysed poverty dynamics for targeted programs using sub-samples of the rural population. Thus, this paper is a pioneer in the sense that it identifies the factors that determine households' movements into and out of poverty and helps explain why some households remain poor. By drawing on the findings of this research, policymakers will be better equipped to design appropriate policies to address persistent poverty such as enabling the poor to accumulate assets, and policies that focus on transient poverty by building resilience through insurance and social protection mechanisms.

The chapter is organized in six sections. Section 13.2 describes the data collected in 2011-2012 and 2015 through the BIHS. In Section 13.3, we describe the method of measuring poverty used in this study. In Section 13.4, we

provide a descriptive analysis of poverty dynamics in rural Bangladesh. Section 13.5 presents the results from estimated multivariate models—multinomial logit, logit, and simultaneous quantile regressions. Section 13.6 summarizes the results and discusses their policy implications.

13.2 The Data

The data for this study came from a two-round panel survey, the Bangladesh Integrated Household Survey (BIHS), which was designed and supervised by researchers at the International Food Policy Research Institute (IFPRI), including the authors of this paper. The sample is nationally representative of rural Bangladesh and representative of rural areas of each of the seven administrative divisions of the country. BIHS is the only nationally representative survey in Bangladesh that collects detailed data on (1) plot-level agricultural production and practices, (2) dietary intake of individual household members, (3) anthropometric measurements (height and weight) of all household members, and (4) data to measure the Women's Empowerment in Agriculture Index (WEAI).

IFPRI conducted the first round of the BIHS from November 2011 to March 2012, and the second round from January to June 2015, which was administered on the same sample of households surveyed in 2011-2012, creating a two-round panel (that is, longitudinal surveys). The periods of both survey rounds were normal according to major indicators: national yields of *boro* rice—the dominant crop grown during the November-June period—were 3.94 tons per hectare in 2011-2012 and 3.97 tons per hectare in 2015-2016; there were no significant changes in prices of agricultural inputs and outputs; and weather-related factors were normal. Even though the timing of the two rounds of surveys did not exactly overlap, this is unlikely to cause any bias in the results because seasonal factors have become much less pronounced in rural Bangladesh in the past two decades, mainly due to irrigation-induced stability in rice production and prices and remarkable improvements in infrastructure, such as roads, bridges, and electricity supply.

The sample design of the BIHS followed a stratified sampling in two stages—selection of primary sampling units (PSUs) and selection of households within each PSU—using the sampling frame developed from the community series of the 2001 Population and Housing Census of Bangladesh. The total sample size in Round 1 is 5,503 households in 275 PSUs, which were allocated among the seven strata (that is, seven divisions) with probability proportional to the number of households in each stratum. Sampling weights were adjusted based on the latest population census of 2011. Taking attrition and split households

into account, the total sample size in Round 2 is 5,447 households, which includes a panel of 5,260 households. Sampling weights for the second round were updated to retain representativeness of the sample at the rural national level and each of the seven administrative divisions of the country.

13.2.1 Attrition and Split Households

From the Round 1 survey sample in 2011-2012 to Round 2 in 2015, there was 4.41 percent attrition overall, or 1.26 percent attrition per year, which is an acceptable level of attrition in survey data. Table 13.1 shows the status of the households interviewed from the 2015 Round 2 survey. After accounting for attrition, the sample of 5,260 households was used to construct the panel to analyze poverty dynamics.

Table 13.1: Status of Households Surveyed in 2011-2012 and 2015 BIHS

Interview status	Frequency (no. of households)	Percentage of Round 1	Cumulative percentage
Completed in 2015	5,260	95.58	95.58
Refused	11	0.20	95.78
Not at home	26	0.47	96.26
Migrated	206	3.74	100.00
Completed in 2011-2012	5,503	100.00	

Source: IFPRI Bangladesh Integrated Household Survey (BIHS), 2011-2012 and 2015 longitudinal surveys.

13.3 Measuring Prevalence of Poverty

The prevalence of poverty is measured as the percentage of individuals living below the poverty line. Poverty prevalence is sometimes referred to as the poverty incidence or poverty headcount ratio. This paper uses the international poverty line of $1.25 per person per day, converted into the local currency equivalent (LCE) at 2005 "Purchasing Power Parity" (PPP) exchange rates, then adjusted for cumulative inflation from 2005 to the month and year the population-based survey data were collected using a consumer price index. The 2005 PPP exchange rate for Bangladesh is $1 = 25.49389.[1] For the price index, we used the rural food consumer price index (FCPI) estimated by the Bangladesh Bureau of Statistics (BBS). The rationale for using the FCPI is that food expenditure is the major part of

[1] Retrieved from http://databank.worldbank.org/data/home.aspx

the rural household's consumption basket. According to BBS (2011), rural households spend 58.9 percent of their monthly consumption expenditure on food and beverages. The FCPI (base year 2005-2006) used for 2011-2012 data is 185.01 and for 2015 is 224.34. The LCE is calculated as:

$$LCE = \left[\frac{1.25 \times PPP_{2005}}{100}\right] \times FCPI$$

This study uses consumption expenditures as the principal indicator of household welfare and uses per capita expenditure as a proxy for income for two reasons. First, expenditures are likely to reflect permanent income and, hence, are a better indicator of consumption behavior (Friedman 1957). Second, data on expenditures are generally more reliable and stable than income data. Since expenditures are intended to serve as a proxy for income, the terms "expenditure" and "income" are used interchangeably.

The measure of total consumption expenditure is quite extensive and draws upon responses to several sections of the household survey. In brief, consumption is measured as the sum of total food consumption and total nonfood (nondurable and durable) expenses. Expenditures on individual consumption items were aggregated to construct total expenditures. Quantities of goods produced by the household for home consumption were valued at the average unit market prices of commodities.

The poverty rate is estimated by dividing the number of household members in poor households in the sample by the total number of household members in the households in the sample.

Using the $1.25 (2005 PPP) per person per day international poverty line, we find that poverty went down from 32.1 percent in 2011-2012 to 27.2 percent in 2015—a reduction of 4.9 percentage points over the three-and-a-half-year period. This rate of reduction of poverty per year is similar to the national estimates released by BBS.

13.4 Poverty Dynamics

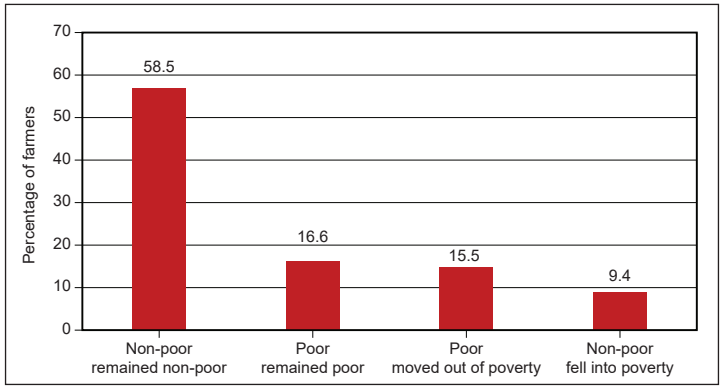
The state of being poor or non-poor can be temporary, as the household can escape or fall back into the clutches of impoverishment in subsequent time periods. Baulch and Hoddinott (2000) describe this temporal component of impoverishment as a dynamic of poverty. It is important to examine the factors that affect both chronic and transitory states of poverty, since different policies may have different implications for each state (Jalan and Ravallion 2000; Hulme and Shepherd 2003; McKay and Lawson 2003). If different factors drive the two states of poverty, then different policies may well be called for (Jalan and Ravallion 2000). Thus, the use of panel data

to examine the determinants of poverty dynamics of rural households in Bangladesh provides unique insights into the causes driving persistent and transitory poverty, and enables us to recommend policies to address the two states of poverty for poverty alleviation.

For this paper, we have broken down transitory poverty into two categories: (i) falling into poverty, and (ii) moving out of poverty. This disaggregation of transitory poverty enables us to understand whether factors driving households to move out or fall into poverty are different. Thus, between the two survey rounds, for our analysis, we have four states of poverty dynamics that a household can belong to: (i) always poor, (ii) fell into poverty, (iii) moved out of poverty, or (iv) never poor. Always poor households can be viewed as persistently poor or chronically poor, whereas households that moved out of or fell into poverty can be considered transient poor.

Figure 13.1 shows the percentage of the rural population in each of the poverty dynamics categories. According to BIHS data, 58.5 percent of the rural population was never poor between the two rounds of the BIHS, while 16.6 percent of the population was persistently poor during this time. There is evidence of a remarkable degree of longitudinal mobility in both directions, with 15.5 percent of the population moving out of poverty and 9.4 percent falling into poverty between the two rounds of the BIHS.

Figure 13.1: Poverty Dynamics Categories as Percentage of the Total Rural Population



Source: IFPRI Bangladesh Integrated Household Survey (BIHS), 2011-2012 and 2015 longitudinal surveys.

We present a poverty transition matrix in Table 13.2 to describe the upward or downward mobility of households based on their consumption expenditure levels in 2011-2012 and 2015. We track the movement of

households from below the poverty line to between poverty line and twice the poverty line or to above twice the poverty line. Similar methods have been used in Haddad and Ahmed (2002) and McCulloch, Weisbrod, and Timmer (2007).

In the BIHS panel sample, of the 1,468 households that were below the poverty line in 2011-2012, 64 households (4.4 percent) have consumption levels more than twice the poverty line in 2015, and 672 households (45.8 percent) have moved up to consumption levels above the poverty line but below two times the poverty line. On the other hand, of the 1,255 households below the poverty line in 2015, 523 households (41.7 percent) were above the poverty line in 2011-2012. We see that 3,086 households have not moved between categories, which are 58.7 percent of the total sample. Consumption improved in 1,295 households (24.6 percent of our total sample), whereas it worsened in 879 households (16.7 percent of total sample).[2]

Table 13.2: Poverty Transition Matrix, 2011-2012 to 2015 (Raw Number of Households, Not Weighted)*

Households with per capita expenditure in 2011-2012	Households with per capita expenditure in 2015			
	Below z	Between z and 2z	Above 2z	Total
Below z	732	672	64	1,468
Between z and 2z	485	1,739	559	2,783
Above 2z	38	356	615	1,009
Total	1,255	2,767	1,238	5,260

* z is the estimated poverty line of $1.25 converted to local currency equivalent as described earlier.

Source: IFPRI Bangladesh Integrated Household Survey (BIHS), 2011-2012 and 2015 longitudinal surveys.

13.4.1 Measurement Error

Baulch and Hoddinott (2000) point out that it is critical for any poverty dynamics or economic mobility study to look at the issue of measurement error. This is particularly important for empirical measurement of poverty dynamics in the short-term and for households with consumption expenditures close to the poverty line. Errors in estimating consumption expenditure may arise

[2] The percentages presented in this discussion are unweighted percentages generated from the figures in Table 13.2.

because of difficulties in recall and imputed values for own production. Such errors can show households above or below the poverty line when in fact their poverty status has remained unchanged. Thus, the extent of entry and exit from poverty is likely to be overstated if poverty dynamics are measured in the short-term or for households with consumption expenditures close to the poverty line (Dercon and Shapiro 2007).

Since measurement errors can have confounding effects on conclusions drawn from inflated variances in poverty status, we followed the approach of Alderman and Garcia (1993) to treat the measurement error. Their theoretical analysis regressed the changes in the value of assets (which can be assumed to be well-measured) to changes in consumption expenditure to see if there is any relation between asset changes and income changes. If measured changes in welfare are caused by measurement error, then no relationship should exist between the variables. In a similar manner, we regressed change in daily per capita expenditure on change in household size, the change in value of assets owned by the household and change in cultivable land owned by the household, and found that there are statistically significant variations in a first difference (fixed effects) regression. The coefficient of determination (R-squared) value for the first difference regression is 0.24. This means that variations in expenditure in our data between 2011-2012 and 2015 are due to variations in productive assets and probably not due to measurement error.

13.5 Determinants of Poverty Components

13.5.1 Regression Models

Studies analyzing poverty dynamics usually use models that assess the risk of a household or an individual remaining poor for a given period of time (Jenkins 2000). However, such models require many panel waves. For studies with fewer data points, discrete choice models are used, as are models that use changes in continuous welfare measures like income or expenditure.

Among discrete choice models used in studies of poverty dynamics, the Multinomial Logit Model (MNL) is the most commonly used model (Baulch 2011). Since our dataset on Bangladesh has two time periods and we are interested in examining factors driving persistent and transient poverty, we resort primarily to a multinomial logit model for our analyses. Though ordered logit or probit models are also used in similar circumstances, we chose MNL because "although poverty status is based on an underlying welfare measure (per capita expenditure) defined on an interval scale, it is not always appropriate to assume that persistent poverty represents a higher level of deprivation than transient poverty, as would be implied by treating

it as an ordinal variable" (Bhatta and Sharma 2011). Thus, it is reasonable to assume poverty dynamic categories as nominal variables and to use a MNL model to examine factors influencing persistent and transitory poverty (Edig and Schwarze 2011; Bhatta and Sharma 2011).

In our MNL model, the probability P_{ij} that a household (i), is in a poverty status (j), can be expressed as a function of the independent variables (x_i) as follows:

$$P_{ij} = \frac{e^{x'i\beta j}}{1 + \sum_{k=1}^{3} e^{x'i\beta j}} \text{ for j = 0, 1, 2, 3,}$$

where β_j are the set of coefficients to be estimated. To identify the model β_0 is set to zero (the base category), since if unidentified there is more than one solution for $\beta_1 \ldots \beta_j$ that leads to the same probabilities for P_{ij} (Greene 2003).

Since the coefficients of the MNL model cannot be interpreted directly (Greene 2003), we report the relative risk ratios or log-odds ratio. Suppose,

$$P(y_i = j) = p_{ij}$$

where P is the probability that a household i is in a poverty state j. As everything in a MNL model is stated relative to a base category (say 0),

$$\frac{p_{ij}}{p_{i0}} = \exp(x_{ij}\beta_j)$$

where p_{i0} is the probability of $j = 0$, which is relative risk to the base category. The log-odds or exponentiated coefficient in MNL is the ratio of two relative risks. For example, given $X_{ij} + 1$ and X_{ij} the relative risk would be:

$$\frac{p'_{ij}}{p'_{i0}} = \exp((x_{ij} + 1)\beta_j), \text{ such that}$$

$$\exp(\beta_j) = \frac{p'_{ij}/p'_{i0}}{p_{ij}/p_{i0}}$$

is the relative risk ratio (RRR) (Edig and Schwarze 2011). The RRR shows how the probability favoring an outcome—that is, a poverty state j (compared to the base state) is multiplied per unit increase in the value of the associated explanatory variable x, when we control for the other variables in the model (Bhatta and Sharma 2011; Wooldridge 2010). Hence, an RRR value greater than 1 indicates a positive relationship between the explanatory variable and the poverty outcome under consideration (the probability of becoming chronic or transient poor increases), while an RRR less than 1 indicates a

negative association (the probability of becoming chronic or transient poor decreases) (Bhatta and Sharma 2011; Edig and Schwarze 2011).

One of the most important assumptions underlying the MNL model is the independence of irrelevant alternatives (IIA). IIA implies that inclusion or exclusion of categories in the MNL does not affect the probabilities associated with the regressors in the remaining categories—that is, the various outcomes must happen independent of each other (Justino and Litchfield 2003; Edig and Schwarze 2011). Hausman and McFadden (1984) proposed a test for this assumption using the *hausman* command. However, the standard Hausman test has several limitations (StataCorp 2013). For example, the test requires access to a fully efficient estimator, which may not be available when analyzing complex survey data, as is the case in our model. Thus, to test whether the IIA assumption holds for our dataset, we utilized the *suest* (seemingly unrelated estimations) command in the STATA 14 statistical software package, followed by the test command to test the equality of estimates. We found that there are no significant differences in the coefficients from each alternative in the model—that is, the IIA was found to be satisfied.

We used explanatory variables only from the first survey round (2011-2012) because we are interested in how initial endowments of human and physical capital, and occupational and social choices affect the evolution of the state of poverty over time. The use of lagged explanatory variables also helps to solve the issue of endogeneity (reverse causality) in the model (Baulch and Dat 2011; Hansen and Singleton 1982).

The primary criticism against using a discrete choice model like the MNL model is that it reduces a continuous variable like income or expenditure to discrete categories. This shift from a quantitative continuous variable (expenditure) to qualitative discrete variable (poverty status) also leads to loss of information (Deaton 1997). There is evidence in the literature to use continuous variable models to cross check the results of discrete choice models (Baulch 2011). To check the robustness of our results, we first employ a logit regression on the transient poverty categories using the same explanatory variables as used in the MNL model. We then employ a simultaneous quantile regression to see if the dependent variable (in this case, the log per capita daily expenditure) responds differently to the explanatory variables across the expenditure distribution for expenditure quintile corresponding to the persistently poor, never poor, those who moved out of poverty, and those who fell into poverty.

13.5.2 Results

This section presents the results from three types of regression models—MNL, logit regression, and simultaneous quantile regression. The MNL model

allows us to estimate the correlate of poverty dynamics categories, while the simultaneous quantile regression model examines if the expenditure generating function for the four categories of poverty dynamics differ (Quisumbing 2011). The logit regression of the transient poverty categories serves as a robustness test to the results obtained from the MNL model. Since our data are nationally representative and involve a two-stage sampling method, the estimates are generated using the *svy* prefix command of the STATA 14 statistical programming to account for sampling stratification.

The explanatory variables used in the regressions from the 2011-2012 BIHS data are summarized in Table 13.3. Due to non-response to some questions used to construct the variables—the Women's Empowerment in Agriculture Index (WEAI) and the share of nonfarm income in total income—the final sample size used in the regressions has been reduced from 5,260 to 4,873.

Table 13.3: Summary Statistics of Variables Used for Analysis, 2011-2012 BIHS Data

Variables	Obs.	Mean	Std. Dev.	Min	Max
Age (in years) of household head	5,260	44.21	13.92	16	102
Household size	5,260	4.23	1.65	1	17
Child dependency ratio (0-18 years)	5,176	0.76	0.71	0	6
Aged dependency ratio (60+ years)	5,176	0.13	0.30	0	3
Categories of average years of education of members 18+ (male)					
No schooling	5,260	0.49	0.50	0	1
Less than primary	5,260	0.26	0.44	0	1
Primary	5,260	0.17	0.38	0	1
Secondary or above	5,260	0.08	0.27	0	1
Categories of average years of education of members 18+ (female)					
No schooling	5,260	0.40	0.49	0	1
Less than primary	5,260	0.35	0.48	0	1
Primary	5,260	0.22	0.41	0	1
Secondary or above	5,260	0.03	0.17	0	1
Value of savings (in thousand BDT)	5,260	7.44	28.09	0	593.71
Value of asset (in thousand BDT)	5,260	19.42	45.60	0	1858.35
ln (household's owned land+1)	5,260	1.87	2.13	0	7.78

Continued

Continued from Table 13.3

Variables	Obs.	Mean	Std. Dev.	Min	Max
Number of dairy cows owned	5,260	0.48	1.04	0	20
Number of poultry owned	5,260	5.49	31.39	0	1950
Owns a mobile phone; dummy (1=yes, 0=no)	5,260	0.73	0.44	0	1
Access to electricity; dummy (1=yes, 0=no)	5,260	0.46	0.50	0	1
No access to sanitary latrine; dummy (1=yes, 0=no)	5,260	0.03	0.18	0	1
Female-headed household with no living spouse (1=yes, 0=no)	5,260	0.07	0.25	0	1
Receives safety net transfer of BDT 1,000-1,500/month; dummy (1=yes, 0=no)	5,260	0.00	0.07	0	1
Receives safety net transfer of at least BDT 1,500/month; dummy (1=yes, 0=no)	5,260	0.01	0.08	0	1
Share of nonfarm income in total income	5,223	0.62	0.40	0	1
5DE score of WEAI	4,988	0.63	0.19	0	1
Primary female decisionmaker faces domestic violence; dummy (1=yes, 0=no)	5,260	0.34	0.47	0	1
Division dummies					
Barisal	5,260	0.08	0.26	0	1
Chittagong	5,260	0.17	0.38	0	1
Dhaka	5,260	0.31	0.46	0	1
Khulna	5,260	0.10	0.30	0	1
Rajshahi	5,260	0.11	0.31	0	1
Rangpur	5,260	0.10	0.30	0	1
Sylhet	5,260	0.13	0.34	0	1

Source: IFPRI Bangladesh Integrated Household Survey (BIHS), 2011-2012 survey.

Table 13.4 shows results from the MNL model, with the base category as the never poor group of the poverty dynamics categories. As mentioned before, since the coefficients of the MNL regression cannot be interpreted directly, we present the RRR in the tables. The dependent variables in the MNL regression are the four categories of poverty dynamics: always poor, moved out of poverty, fell into poverty, and never poor (base category).

We find that household demographics is an important driver affecting poverty dynamics. Households with older household heads are less likely to fall into poverty and to retain their state of impoverishment. Consistent with findings in other poverty dynamics studies, larger household size and

higher child dependency ratio increase the likelihood of persistent poverty and households are more likely to fall into poverty over time (Quisumbing 2007; Baulch and Dat 2011; Edig and Schwarze 2011). In rural Bangladesh, there is typically one adult earning member in the household—the male household head. Therefore, having many household members, particularly children, strains income.

Table 13.4: Results of the Multinomial Logit Model with Base Equal to "Never Poor", 2011-2012 to 2015

Variables	Model with base NPNP		
	Always poor	Moved out of poverty	Fell into poverty
	(1)	(2)	(3)
Age (in years) of household head	0.97***	0.99**	0.98***
	(0.01)	(0.00)	(0.01)
Household size	2.15***	1.62***	1.24***
	(0.11)	(0.07)	(0.06)
Child dependency ratio (0-18 years)	1.00***	1.00***	1.00
	(0.00)	(0.00)	(0.00)
Aged dependency ratio (60+ years)	1.00**	1.00	1.00**
	(0.00)	(0.00)	(0.00)
Categories of average years of education of members 18+ (male)			
Less than primary	0.67***	0.88	1.00
	(0.10)	(0.11)	(0.14)
Primary	0.48***	0.71**	0.73*
	(0.09)	(0.12)	(0.13)
Secondary or above	0.28***	0.48**	0.60
	(0.11)	(0.17)	(0.20)
Categories of average years of education of members 18+ (female)			
Less than primary	1.00	0.88	0.83
	(0.12)	(0.10)	(0.11)
Primary	0.65**	0.86	0.73*
	(0.12)	(0.14)	(0.13)
Secondary or above	0.14*	0.64	0.53
	(0.15)	(0.34)	(0.25)
Value of savings (in thousand BDT)	0.96***	0.98***	0.99**
	(0.01)	(0.01)	(0.01)
Value of asset (in thousand BDT)	0.89***	0.94***	0.99
	(0.01)	(0.01)	(0.01)
ln (household's owned_land+1)	0.80***	0.86***	0.85***
	(0.03)	(0.03)	(0.03)

Continued

Continued from Table 13.4

Variables	Model with base NPNP		
	Always poor	Moved out of poverty	Fell into poverty
	(1)	(2)	(3)
Number of dairy cows owned	0.97	0.86*	0.98
	(0.07)	(0.07)	(0.07)
Number of poultry owned	0.98*	0.99	1.00
	(0.01)	(0.01)	(0.01)
Owns a mobile phone; dummy (1=yes, 0=no)	0.35***	0.47***	0.65***
	(0.04)	(0.05)	(0.08)
Access to electricity; dummy (1=yes, 0=no)	0.45***	0.67***	0.50***
	(0.06)	(0.08)	(0.07)
No access to sanitary latrine; dummy (1=yes, 0=no)	1.64*	0.95	1.90**
	(0.45)	(0.29)	(0.57)
Female headed household with no living spouse (1=yes, 0=no)	1.73**	1.96***	1.27
	(0.42)	(0.42)	(0.31)
Receives safety net transfer of BDT 1,000-1,500/month; dummy (1=yes, 0=no)	1.56	2.69	1.75
	(0.82)	(1.74)	(1.14)
Receives safety net transfer of at least BDT 1,500/month; dummy (1=yes, 0=no)	0.15***	0.39	0.17*
	(0.10)	(0.38)	(0.16)
Share of nonfarm income in total income	1.00**	0.99***	1.00***
	(0.00)	(0.00)	(0.00)
Five DE score of WEAI	0.48**	0.52**	0.89
	(0.16)	(0.15)	(0.25)
Primary female decision-maker faces domestic violence; dummy (1=yes, 0=no)	1.30*	1.17	1.12
	(0.18)	(0.16)	(0.14)
Division dummies included	yes	yes	yes
Constant	0.10***	0.18***	0.59
	(0.05)	(0.07)	(0.23)
Observations	4,873	4,873	4,873
F (90, 179)	12.57		
Prob > F	0.00		

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey (BIHS), 2011-2012 and 2015 longitudinal surveys.

Increasing the level of education is vital to sustainable poverty eradication. We find a statistically significant reduction in the likelihood of being chronically poor as the level of education goes up. On average, male household members need to have at least some level of education to decrease the likelihood of

persistent poverty, whereas at least primary level of education is required to prevent falling into poverty over time. For females, at least primary level of education is required to prevent persistent and transitory poverty. Interestingly, for both categories, the estimated RRR values are lower as the level of education goes up, meaning stronger reductions in the likelihood of persistent poverty as educational attainment progresses from primary to secondary level.

All the wealth indicators—value of savings, value of assets, and decimals of owned agricultural land—have a negative association with persistent poverty with savings and owned land, which is particularly important to decrease the likelihood of falling into poverty over time. Wealth or assets cushions households facing adversities, which are essential for mitigating negative shocks. This is particularly important for Bangladesh because of frequent occurrences of natural calamities like flooding in the mainland, and cyclones or hurricanes along the coastal region.

Owning a mobile phone and having access to electricity are statistically significant factors in reducing the likelihood of persistent and transitory poverty. Having access to information on critical issues such as agricultural production techniques and market prices are important for increased farm income. Mobile phones are an avenue to such information. Access to electricity catalyzes rural development, which is beneficial for rural communities. For example, access to electricity has a considerable positive effect on educational attainment and performance of children. Rural electrification not only extends hours of teaching at school but also improved quality of light at home, which allows more time for reading and homework (WB IEG 2008).

Access to a sanitary latrine is vital for hygiene and healthy living, which in turn can facilitate income generation for household members. If households do not have access to sanitary latrine, the likelihood of remaining in persistent poverty is higher, as is the likelihood of falling into poverty over time.

Social safety net transfers, which may include cash or in-kind transfers, can mitigate and protect poor and vulnerable families from economic shocks, natural disasters, and other crises. Our findings show an important aspect of such transfers—the size of safety net transfers matter. There is a statistically significant reduction in the likelihood of households remaining in persistent poverty when households receive safety net transfers of at least BDT 1,500 per month. This transfer amount also decreases the likelihood of households falling into poverty over time. The model was run with various other transfer amounts below BDT 1,500, but we see a statistically significant reduction in persistent and transitory poverty only when a household receives a monthly safety net transfer of at least BDT 1,500 per month.

In many developing countries, the rural economy transforms with more opportunities in the nonfarm sector as agriculture growth slows down due to land constraints and increased labor productivity due to technological innovations (Mellor 2017). Recent studies in Bangladesh show such trends (Nargis and Hossain 2006), with substantial economic diversification taking place in rural areas in the recent past with rural households earning more from nonfarm activities than agriculture due to the low price of farm products and lack of an appropriate marketing system (BBS 2015). Income from agriculture is subject to risks arising from market forces and weather, which can make the households engaged in agriculture vulnerable. This is substantiated by our findings, which show that involvement in the rural nonfarm sector, measured as the share of nonfarm income out of total income, reduces the likelihood of households remaining in or falling into poverty over time.

Our results suggest that women's empowerment is a critical factor in poverty alleviation efforts in rural Bangladesh. We used the Women's Empowerment in Agriculture Index (WEAI) as a measure of empowerment. WEAI is a weighted average of two sub-indexes: (1) the five domains of empowerment (5DE), and (2) the Gender Parity Index (GPI). The 5DE sub-index shows how empowered women are, capturing the roles and extent of women's engagement in the agricultural sector in five domains: (1) decisions over agricultural production, (2) access to and decision-making power over productive resources, (3) control over use of income, (4) leadership in the community, and (5) time use (for more information see Alkire et al. 2013). Using the 5DE score of WEAI, we find that an increase in women's empowerment reduces the likelihood of households remaining in persistent poverty.

Not only is women's empowerment vital to poverty alleviation, so is the need to free women from violence and subjugation, and to ensure harmony in the household. Our findings suggest that households where the primary female decision-maker faces domestic violence are more likely to remain in poverty over time, that is, remain persistently poor.

Some of the RRRs of the regressors in the moving out of poverty category (Model 2 in Table 13.4) are difficult to interpret, owing to the counter-intuitive signs of the statistically significant variables. A possible explanation offered by Quisumbing (2011) is that the probabilities associated with the moving up category are conditional probabilities—that is, the probability of being non-poor is now conditional of being poor in the previous round. The resulting RRRs estimated reflects a combination of the likelihood of being non-poor now as well as poor in the previous round.

It is imperative for policymakers and academics to not only look at the factors driving persistent poverty, but also to understand the factors behind transient poverty. In sub-section 13.5.2.1, we look at the two categories of transient poverty—falling into and moving out—in separate logit regressions using the same covariates as was in the MNL.

Furthermore, as noted previously, there exists some degree of arbitrariness as a result of using a poverty cut-off and converting it to a categorical dependent variable (that is, the poverty dynamics variable). Therefore, in sub-section 13.5.2.2, we also look at a continuous dependent variable—per capita expenditure—to elicit the relationship between the regressors and the dependent variable using a simultaneous quantile regression.

13.5.2.1 Determinants of Transient Poverty: Logistic Regression Results

In this section, we separately look at the determinants of the two categories of transient poverty—namely, falling into and moving out of poverty—using a logit regression model. In Table 13.5, we present the elasticity (ey/ex) of the regressors against the dependent variable. This enables us to estimate the magnitude of the effect on transient poverty category for 1 percent change in the value of the regressors. All the results in the logit regression are consistent with findings from the MNL regression.

Older household head, smaller household size, lower dependency ratio, and higher savings and assets tend to prevent households from falling into poverty. Households with adult males and females who have completed at least primary education are 6 percent and 7 percent more likely not to fall into poverty, respectively. Households owning a mobile phone and having access to electricity are 31 percent and 36 percent less likely to fall into poverty, respectively. Receiving a social safety net transfer of at least BDT 1,500 per month and involvement in the rural nonfarm sectors are also found to be significant in preventing households from falling into poverty. Households who have some share of income coming from the nonfarm sector are 25 percent less likely to fall into poverty.

Next, for households that have moved out of poverty, education is again found to be a crucial factor for this graduation. At least primary level of education for adult male and secondary or more education for adult female members of the household help households move out of poverty. Higher levels of savings, assets, and agricultural landholding have statistically significant positive association with movement out of poverty. Moreover, owning a mobile phone and access to electricity increases the likelihood of moving out of poverty by 9 percent and 4 percent, respectively.

Table 13.5: Logit Regression of Transient Poverty Categories, 2011-2012 to 2015

Variables	Marginal effects (ey/ex)	
	Fell into poverty	Moved out of poverty
	(1)	(2)
Age (in years) of household head	-0.68***	0.35**
	(0.21)	(0.14)
Household size	0.67***	-0.76***
	(0.16)	(0.15)
Child dependency ratio (0-18 years)	0.05	0.02
	(0.05)	(0.05)
Aged dependency ratio (60+ years)	0.05**	-0.02
	(0.02)	(0.01)
Categories of average years of education of members 18+ (male)		
Less than primary	-0.00	0.04**
	(0.03)	(0.02)
Primary	-0.06*	0.01*
	(0.03)	(0.01)
Secondary or above	-0.06*	0.00
	(0.04)	(0.00)
Categories of average years of education of members 18+ (female)		
Less than primary	-0.06	-0.02
	(0.04)	(0.03)
Primary	-0.07*	0.01
	(0.04)	(0.01)
Secondary or above	-0.03	0.00***
	(0.02)	(0.00)
Value of savings (in thousand BDT)	-0.13**	0.01**
	(0.06)	(0.01)
Value of asset (in thousand BDT)	-0.24	0.10***
	(0.21)	(0.02)
ln (household's owned_land+1)	-0.33***	0.04*
	(0.07)	(0.02)
Number of dairy cows owned	-0.01	-0.03
	(0.04)	(0.02)
Number of poultry owned	-0.01	0.02
	(0.03)	(0.02)
Owns a mobile phone; dummy (1=yes, 0=no)	-0.31***	0.09***
	(0.09)	(0.03)
Access to electricity; dummy (1=yes, 0=no)	-0.36***	0.04***
	(0.07)	(0.02)

Continued

Continued from Table 13.5

Variables	Marginal effects (ey/ex)	
	Fell into poverty	Moved out of poverty
	(1)	(2)
No access to sanitary latrine; dummy (1=yes, 0=no)	0.01**	-0.02*
	(0.00)	(0.01)
Female headed household with no living spouse; dummy (1=yes, 0=no)	0.01	0.00
	(0.01)	(0.01)
Receives safety net transfer of BDT 1,000-1,500/ month; dummy (1=yes, 0=no)	0.00	0.00
	(0.00)	(0.00)
Receives safety net transfer of at least BDT 1,500/ month; dummy (1=yes, 0=no)	-0.01*	0.00**
	(0.01)	(0.00)
Share of nonfarm income in total income	-0.25***	-0.03
	(0.08)	(0.04)
5DE score of WEAI	-0.07	0.05
	(0.16)	(0.11)
Primary female decision-maker faces domestic violence; dummy (1=yes, 0=no)	0.03	-0.02
	(0.03)	(0.03)
Division dummies included	yes	yes
Observations	3,481	1,392
F statistics	F (30,239)=12.57	F (30,227)=5.16
Prob > F	0.00	0.00

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey (BIHS), 2011-2012 and 2015 longitudinal surveys.

13.5.2.2 Determinants of Log Per Capita Expenditure: Simultaneous Quantile Regression

Table 13.6 shows the simultaneous quantile regression estimates using the logarithm of per capita expenditure in 2011-2012 calibrated to the 11th, 15th, 44th and 67th percentiles of the expenditure distribution, which are the mean expenditures of the persistently poor, falling into poverty, moving out of poverty, and never poor categories, respectively. Additionally, we estimate an interquantile regression for the difference between coefficients at the 11th and 67th percentile of the expenditure distribution—that is, percentiles corresponding to the persistently poor and never poor categories. As before, to avoid endogeneity, all the regressors are from the first survey round (2011-2012 BIHS).

Table 13.6: Simultaneous Quantile Regression Estimates of Log Per Capita Expenditure in 2015

Variables	Persistently poor	Fell into poverty	Moved out of poverty	Never poor	Inter-quantile regression
	(11th percentile)	(15th percentile)	(44th percentile)	(67th percentile)	
Age (in years) of household head	0.23***	0.23***	0.43***	0.63***	0.40***
	(0.05)	(0.05)	(0.06)	(0.09)	(0.09)
Household size	-3.31***	-3.27***	-6.40***	-9.00***	-5.69***
	(0.44)	(0.52)	(0.50)	(0.66)	(0.72)
Child dependency ratio (0-18 years)	-0.02	-0.02*	-0.03***	-0.03*	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Aged dependency ratio (60+ years)	-0.05**	-0.05**	-0.08***	-0.06*	-0.01
	(0.02)	(0.02)	(0.03)	(0.04)	(0.04)
Categories of average years of education of members 18+ (male)					
Less than primary	0.59	1.24	-3.18**	-2.73	-3.32
	(1.17)	(1.24)	(1.62)	(2.27)	(2.28)
Primary	1.52	3.35	-0.32	-1.73	-3.25
	(1.96)	(2.32)	(1.84)	(2.65)	(2.97)
Secondary or above	9.97***	12.81***	11.68***	9.78*	-0.19
	(3.20)	(3.40)	(4.28)	(5.71)	(6.03)
Categories of average years of education of members 18+ (female)					
Less than primary	2.47**	2.66**	1.78	2.82	0.35
	(1.11)	(1.22)	(1.53)	(2.08)	(2.16)
Primary	6.65***	7.06***	8.98***	11.75***	5.10
	(1.78)	(1.77)	(1.97)	(3.09)	(3.23)

Continued

Continued from Table 13.6

Variables	Persistently poor (11th percentile)	Fell into poverty (15th percentile)	Moved out of poverty (44th percentile)	Never poor (67th percentile)	Inter-quantile regression
Secondary or above	18.12*** (3.87)	17.82*** (4.15)	16.37** (6.48)	30.27*** (11.56)	12.14 (11.76)
Value of savings (in thousand BDT)	0.19*** (0.03)	0.19*** (0.03)	0.24*** (0.04)	0.26*** (0.08)	0.08 (0.08)
Value of asset (in thousand BDT)	0.10** (0.05)	0.12** (0.05)	0.34*** (0.07)	0.50*** (0.08)	0.40*** (0.06)
ln (household's owned land+1)	2.56*** (0.32)	2.66*** (0.38)	2.89*** (0.38)	2.96*** (0.53)	0.40 (0.54)
Number of dairy cows owned	0.05 (0.64)	0.17 (0.74)	1.28** (0.60)	2.00** (0.95)	1.95* (1.02)
Number of poultry owned	0.01 (0.05)	0.01 (0.05)	0.00 (0.06)	-0.04 (0.10)	-0.05 (0.07)
Owns a mobile phone; dummy (1=yes, 0=no)	6.71*** (1.11)	7.16*** (1.17)	12.70*** (1.42)	17.16*** (1.89)	10.45*** (2.04)
Access to electricity; dummy (1=yes, 0=no)	7.04*** (1.15)	7.70*** (1.43)	11.76*** (1.41)	16.38*** (1.99)	9.34*** (2.07)
No access to sanitary latrine; dummy (1=yes, 0=no)	-4.46* (2.46)	-4.89** (2.43)	-8.13*** (2.56)	-5.68 (4.04)	-1.22 (4.19)
Female headed household with no living spouse; dummy (1=yes, 0=no)	-2.58 (2.05)	-3.39 (2.07)	-6.51** (3.26)	-2.89 (4.39)	-0.31 (4.57)

Continued

Continued from Table 13.6

Variables	Persistently poor (11th percentile)	Fell into poverty (15th percentile)	Moved out of poverty (44th percentile)	Never poor (67th percentile)	Inter-quantile regression
Receives safety net transfer of BDT 1,000-1,500/month; dummy (1=yes, 0=no)	-2.38 (5.08)	-4.53 (4.84)	-5.41 (6.74)	-14.12 (10.26)	-11.74 (10.61)
Receives safety net transfer of at least BDT 1,500/month; dummy (1=yes, 0=no)	13.83** (6.66)	9.22* (5.26)	2.04 (5.29)	-4.02 (9.12)	-17.85* (9.97)
Share of nonfarm income in total income	0.03** (0.01)	0.03** (0.01)	0.07*** (0.02)	0.12*** (0.02)	0.09*** (0.02)
5DE score of WEAI	4.58* (2.51)	4.42 (2.99)	5.76* (3.17)	6.05 (4.33)	1.47 (4.65)
Primary female decision maker faces domestic violence; dummy (1=yes, 0=no)	-1.94 (1.23)	-2.09* (1.21)	-4.18*** (1.33)	-5.80*** (1.81)	-3.86** (1.92)
Constant	52.39*** (3.53)	55.90*** (3.64)	81.74*** (3.93)	96.44*** (5.55)	44.05*** (5.63)
Division dummies included	yes	yes	yes	yes	yes
Observations	4,873	4,873	4,873	4,873	4,873
Pseudo R-squared	0.13	0.13	0.19	0.22	-

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey (BIHS), 2011-2012 and 2015 longitudinal surveys.

All the results from the simultaneous quantile regressions are consistent with the results obtained from the MNL and the logit regressions. The comparison of the results across the three models indicates that the findings of the poverty dynamics study are robust.

The results of the interquantile regression indicate that age of household head, household size, value of assets, number of dairy cows owned, ownership of mobile phone, access to electricity, receiving a safety net transfer of at least BDT 1,500 per month, share of nonfarm income out of total income, and domestic violence have statistically significant differences of responsiveness between persistently poor and never poor categories. For example, household size has a greater expenditure depressing effect for the never poor than for the persistently poor, maybe because household members in poor families, even children, are likely to be engaged in various income-generating activities. The cost of education for children in well-off households is also reflected here (Kumar 2015).

13.6 Summary and Policy Implications

Using panel data from the BIHS 2011-2012 and 2015, this paper analyses poverty dynamics in rural Bangladesh. Results of the descriptive analysis suggest that a substantial share of the rural population (16.6 percent) are trapped in persistent poverty (average consumption over time is below the poverty line) over the two rounds of the survey. There is also evidence of considerable churning between the categories, with 15.5 percent of the population moving out of poverty and 9.4 percent falling into poverty.

We estimated different regression models to analyze the correlates of persistent and transient poverty in rural Bangladesh. Using the multinomial logit model, we find that households with low levels of education, savings, physical assets, lack of access to electricity and mobile phones, no engagement in nonfarm sector, not receiving safety net transfers of at least BDT 1,500 per month, and higher levels of women's disempowerment are more likely to be persistently poor. Initial conditions such as larger household size, higher proportion of dependent members compared to working age members, and a younger household head are also associated with persistent poverty.

For transient poverty, a larger household size with more dependents, low level of human and physical assets, lack of savings, no access to mobile phones and electricity, and small size of safety net transfers (that is, less than BDT 1,500 per month) increase the likelihood that households will fall into poverty *and* prevent households from moving out of poverty. Engagement in the nonfarm sector is important in preventing households

from falling into poverty. These results are consistent across the models estimated in this paper.

Our results point to some important areas for policy intervention. First, similar to findings in other poverty dynamics studies in Bangladesh and other countries, education is critical to sustaining poverty reduction, providing a base to not only break out of persistent poverty, but also to prevent sliding back into it. Higher levels of education, at least to the secondary level, and educating female members of the household are particularly essential for poverty reduction. Quality education enables greater access to salaried jobs in the formal sector and creates opportunities for women to engage in income-generating activities. Given the strength of relationships between poverty and education, investments in children's schooling may determine whether they will be poor in the future. Numerous studies in Bangladesh and elsewhere provide evidence that conditional cash or food transfer programs effectively promote school attendance of children from poor families. Continued emphasis needs to be on such programs, along with preventing dropouts and improving the quality of education through effective teachers' training, especially in rural areas. Because the real value of cash transfers has been depleting over time, the effectiveness of education incentive interventions such as primary and secondary education stipend programs in enticing children from poor households to school and retaining them in school should be evaluated. Moreover, the transfer amount should be determined on the basis of estimates of education costs for the poor (direct, indirect, and opportunity costs) for different grade levels and for boys and girls.

Second, our results show that higher levels of savings and physical assets help households move out of poverty and prevent them from falling into poverty. However, the poor have the thinnest asset base and it is very difficult for them to accumulate enough savings to invest in physical assets and enter new activities with higher returns. Interventions to aid savings could require safety net participants to deposit a portion of cash transfers into mandatory savings funds. Research has shown that asset transfers by BRAC's Targeted Ultra Poor program led to sustained food security and livelihood improvements (Ahmed, Rabbani, Sulaiman, and Das 2009). Similar asset transfer programs include the Char Livelihoods Project and SHOUHARDO. However, asset transfer programs tend to be much more costly than other safety net programs; therefore, the apparent trade-off between program coverage and sustainability needs to be carefully addressed. Given the encouraging results, these programs can be scaled up in economically lagging and disaster-prone regions.

Third, we find that an increased share of nonfarm income out of total income enables households to break out of persistent poverty and prevents them from falling back into poverty. Promoting rural nonfarm employment through agriculture-driven nonfarm activities (for example, vocational training in repairs and servicing of agricultural machineries, particularly for rural youth) and strengthening agricultural value chains to gainfully employ rural youth (for example, in packaging and transport) hold promise. The Government of Bangladesh recognizes this and has prioritized strengthening support for nonfarm job creation, rural mobility, and infrastructure in the Seventh Five Year Plan (GED 2015a). In Bangladesh, the capacity to absorb the growing rural labor force in agriculture is very limited since there are land constraints holding back expansion. Further, the growth of crop production now depends almost entirely on technological progress, resulting in low employment response of increased output. Therefore, a shift of rural labor force out of agriculture, accompanied by faster agricultural growth, are key for boosting rural incomes.

Fourth, rural infrastructure development is crucial for sustained poverty eradication. Access to mobile phones and electricity are important determinants of all four poverty dynamics categories. Access to a mobile phone is a gateway to essential information and services. New information and knowledge are critical inputs for improved agricultural practices and marketing of agricultural products. Mobile phone technology holds great promise in delivering information to resource-poor farmers and thereby integrating them into agricultural value chains. Clear policies need to be formulated that account for the critical role of the private sector in this context.

Access to electricity is a composite indicator of development. In addition to being an indicator of wealth, an electricity connection also indicates the extent to which a household is "connected" in a broader sense to roads, markets, and communications infrastructure (information technology in particular), and the resulting income-earning opportunities. Access to electricity leads to the use of radio, television, and other appliances. Besides being used for entertainment, radio and television are major sources of information for the poor, particularly for illiterate people.

Fifth, our analysis suggests that the size of social safety net transfers matter—the transfer amount needs to be at least BDT 1,500 (about $18) per month to break persistent poverty or prevent households from falling into poverty. This amount accounted for about one-fourth of total consumption expenditure of the poorest 20 percent of all rural households in the 2011-2012

BIHS sample. The average size of various safety net transfers in Bangladesh is quite small and has been falling in real terms, an issue that is recognized in the National Social Security Strategy (NSSS) of the Government of Bangladesh (GED 2015b). Using a randomized control trial on a sample of the ultra-poor in Bangladesh, Ahmed, Rabbani, Sulaiman, and Das (2016) found that a cash transfer of BDT 1,500 per month combined with nutrition behavior change communication, improved the recipients' nutrition, health, and overall well-being.

Finally, the role of social norms and values is important when addressing poverty alleviation. We find that when women are empowered and face less violence at home, households are more likely to move out of persistent poverty. Engagement of women in productive activities helps increase household income and, as a result, households are better able to withstand shocks and other vulnerabilities. Thus, policies and social campaigns need to be in place to promote gender sensitization and prevent violence against women. While programs specifically designed to address gender dynamics are important, addressing the many determinants of violence requires a broader approach and an openness to discovering relationships, patterns, and solutions in seemingly extraneous places. For example, a randomized controlled trial in Bangladesh targeting mothers of young children found that safety net transfers combined with intensive nutrition behavior change communication reduced intimate partner violence by 26 percent—an unintended, yet positive consequence of a program primarily focused on improving household food security and child nutrition (Roy et al. 2017). Thus, empowering and safeguarding women from violence is not only a moral imperative, but evidence clearly indicates that it is a common-sense approach to accelerating poverty reduction and achieving complementary development goals in Bangladesh.

IFPRI research in Bangladesh, using data from the BIHS, reveals that women's empowerment plays a key role in improving household food security and dietary diversity of children, women, and other household members (Sraboni, Malapit, Quisumbing, and Ahmed 2014; Malapit, Sraboni, Quisumbing, and Ahmed 2015). Therefore, promoting women's empowerment should remain paramount in the policy arena.

In conclusion, Bangladesh has made considerable progress in lowering the rate of poverty in the last decade. However, poverty alleviation strategies should be multifaceted to deal with the interlinked factors affecting vulnerability and impoverishment in the country. A new generation of interventions for sustainable poverty alleviation needs to be in place that

will not only deal with building the human and physical capital of the poor, but would also play a transformative role in development which will provide access to new forms of employment, have broad-based investments in education and effective social safety net policies, and will also change social norms and institutions.

References

Ahmed, Akhter U., John F. Hoddinott, Shalini Roy, Esha Sraboni, Wahidur R. Quabili, and Amy Margolies. 2016. *Which Kinds of Social Safety Net Transfers Work Best for the Ultra Poor in Bangladesh? Operation and Impacts of the Transfer Modality Research Initiative.* Dhaka: International Food Policy Research Institute (IFPRI).

Ahmed, Akhter U., M. Rabbani, M. Sulaiman, and N. Das. 2009. *The Impact of Asset Transfer on Livelihoods of the Ultra-poor in Bangladesh.* Research Monograph Series No. 39. Dhaka: BRAC and IFPRI.

Ahmed, Akhter U. 2013. *Bangladesh Integrated Household Survey (BIHS) 2011-2012.* Washington, D.C.: International Food Policy Research Institute (datasets). http://hdl.handle.net/1902.1/21266.

Alderman, Harold, and Marito Garcia. 1993. *Poverty, Household Food Security, and Nutrition in Rural Pakistan.* Research Report No. 96. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Alkire, Sabina, Ruth Meinzen-Dick, Amber Peterman, Agnes R. Quisumbing, G. Seymour, and Ana Vaz. 2013. "The Women's Empowerment in Agriculture Index." *World Development* 52: 71-91. https://doi.org/10.1016/j.worlddev. 2013.06.007.

Baulch, Bob., and Vu Hoang Dat. 2011. "Poverty Dynamics in Vietnam, 2002 to 2006." In *Why Poverty Persists: Poverty Dynamics in Asia and Africa*, edited by Bob Baulch, 219-254. Cheltenham: Edward Elgar Publishing Limited.

Baulch, Bob, and John F. Hoddinott. 2000. "Economic Mobility and Poverty Dynamics in Developing Countries." *The Journal of Development Studies* 36, no. 6: 1-24. https://doi.org/10.1080/00220380008422652.

Baulch, B. 2011. "Overview: Poverty Dynamics and Persistence in Asia and Africa." In *Why Poverty Persists: Poverty Dynamics in Asia and Africa*, edited by Bob Baulch, 1-28. Cheltenham: Edward Elgar Publishing Limited.

BBS (Bangladesh Bureau of Statistics). 2011. *Report of the Household Income and Expenditure Survey 2010*. Dhaka: Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

___. 2015. *Report of the Rural Credit Survey 2014*. Dhaka: Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

___. 2017. *Preliminary Report on Household Income and Expenditure Survey 2016*. Dhaka: Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Bhatta, Saurav Dev, and Suman K. Sharma. 2011. "The Determinants and Consequences of Chronic and Transitory Poverty in Nepal, 1995-96 to 2003-04." *Why Poverty Persists: Poverty Dynamics in Asia and Africa*, edited by Bob Baulch, 96-144. Cheltenham: Edward Elgar Publishing Limited.

Davis, Peter. 2006. "Poverty in Time: Exploring Poverty Dynamics from Life History Interviews in Bangladesh." Chronic Poverty Research Centre Working Paper No. 69. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1753018.

Davis, Peter, and Bob Baulch. 2011. "Parallel Realities: Exploring Poverty Dynamics using Mixed Methods in Bangladesh." *The Journal of Development Studies* 47, no. 1: 118-142. https://doi.org/10.1080/00220388.2010.492860.

Deaton, Angus. 1997. *The Analysis of Household Surveys: A Microeconomic Approach to Development Policy*. Baltimore and London: Published for the World Bank by the Johns Hopkins University Press.

Dercon, Stefan, and Joseph S. Shapiro. 2007. "Moving On, Staying Behind, Getting Lost: Lessons on Poverty Mobility from Longitudinal Data." In *Cross-Disciplinary Perspectives on Mobility*, edited by Deepa Narayan and Patti Petesch, 77-126. Vol. 1 of *Moving Out of Poverty*. New York, N.Y.: Palgrave MacMillan, and Washington, D.C.: The World Bank.

Edig, Xenia van, and Stefan Schwarze. 2011. "Short-term poverty dynamics of rural households: Evidence from Central Sulawesi, Indonesia." *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 112, no. 2: 141-155.

Friedman, M. 1957. *A Theory of the Consumption Function.* Princeton, N.J.: Princeton University Press.

GED (General Economics Division). 2015a. *Seventh Five Year Plan FY2016-FY2020: Accelerating Growth, Empowering Citizens.* Dhaka: General Economics Division (GED), Bangladesh Planning Commission, Government of the People's Republic of Bangladesh.

___. 2015b. *National Social Security Strategy (NSSS) of Bangladesh.* Dhaka: General Economics Division (GED), Bangladesh Planning Commission, Government of the People's Republic of Bangladesh.

Greene, William H. 2003. *Econometric Analysis.* 5th ed. Upper Saddle River, N.J.: Pearson Education.

Haddad, Lawrence, and Akhter U. Ahmed. 2002. "Chronic and Transitory Poverty: Evidence from Egypt, 1997-99." *World Development* 31, no. 1: 71-85. https://doi.org/10.1016/S0305-750X(02)00180-8.

Hansen, Lars Peter, and Kenneth J. Singleton. 1982. "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models." *Econometrica* 50, no. 5: 1269-1286. https://doi.org/10.2307/1911873.

Hausman, Jerry A., and Daniel L. McFadden. 1984. "Specification Tests for the Multinomial Logit Model." *Econometrica* 52, no. 5: 1219-1240. https://doi.org/10.2307/1910997.

Hossain, Mahabub, and Abdul Bayes. 2009. *Rural Economy and Livelihoods: Insights from Bangladesh.* Dhaka: AH Development Publishing House.

Hulme, David, and Andrew Shepherd. 2003. "Conceptualizing Chronic Poverty." *World Development* 31, no. 3: 403-423. https://doi.org/10.1016/S0305-750X (02)00222-X.

IFPRI (International Food Policy Research Institute). 2016. *Bangladesh Integrated Household Survey (BIHS) 2015.* Washington, D.C.: International Food Policy Research Institute (IFPRI) [dataset]. http://dx.doi.org/10.7910/DVN/BXSYEL.

Jalan, Jyotsna, and Martin Ravallion. 2000. "Is Transient Poverty Different? Evidence for Rural China." *The Journal of Development Studies* 36, no. 6: 82-99. https://doi.org/10.1080/00220380008422655.

Jenkins, Stephen P. 2000. "Modelling Household Income Dynamics." *Journal of Population Economics* 13: 529-567. https://doi.org/10.1007/s001480050151.

Justino, Patricia, and Julie Litchfield. 2003. *Poverty Dynamics in Rural Vietnam: Winners and Losers during Reform.* PRUS Working Papers No. 10. Poverty Research Unit at Sussex. Sussex: University of Sussex.

Kumar, Alok. 2015. "One More Year of Schooling or Work: Grade-transition and Child Labor in Rural Bangladesh." *Journal of Developing Areas* 49, no. 3: 27-48. Tennessee State University College of Business. Retrieved August 14, 2018, from Project MUSE database.

Malapit, Hazel Jean L., Esha Sraboni, Agnes R. Quisumbing, and Akhter U. Ahmed. 2015. *Gender Empowerment Gaps in Agriculture and Children's Well-Being in Bangladesh.* IFPRI Discussion Paper No. 01470. Washington, D.C.: International Food Policy Research Institute (IFPRI).

McCulloch, Neil, Julian Weisbrod, and C. Peter Timmer. 2007. *Pathways Out of Poverty during an Economic Crisis: An Empirical Assessment of Rural Indonesia.* World Bank Policy Research Working Paper No. 4173. Washington, D.C.: The World Bank. http://hdl.handle.net/10986/7217.

McKay, Andrew, and David Lawson. 2003. "Assessing the Extent and Nature of Chronic Poverty in Low Income Countries: Issues and Evidence." *World Development* 31, no. 3: 425-439. https://doi.org/10.1016/S0305-750X(02)00221-8.

Mellor, John W. 2017. *Agricultural Development and Economic Transformation: Promoting Growth with Poverty Reduction.* Cham: Palgrave Macmillan.

Nargis, Nigar, and Mahabub Hossain. 2006. "Income dynamics and pathways out of rural poverty in Bangladesh, 1988-2004." *Agricultural Economics* 35, no. 3: 425-435. https://doi.org/10.1111/j.1574-0862.2006.00188.x.

Quisumbing, Agnes R. 2007. *Poverty Transitions, Shocks, and Consumption in Rural Bangladesh: Preliminary Results from a Longitudinal Household Survey*. CPRC Working Paper No. 105. Manchester: Chronic Poverty Research Centre (CPRC). http://dx.doi.org/10.2139/ssrn.1629178.

Quisumbing, Agnes R. 2011. "Poverty Transitions, Shocks and Consumption in Rural Bangladesh, 1996-97 to 2006-07." In *Why Poverty Persists: Poverty Dynamics in Asia and Africa*, edited by Bob Baulch, 29-64. Cheltenham: Edward Elgar Publishing Limited.

Quisumbing, Agnes R., and Bob Baulch. 2009. *Assets and Poverty Traps in Rural Bangladesh.* CPRC Working Paper No. 143. London: Chronic Poverty Research Centre (CPRC).

Roy, Shalini, Melissa Hidrobo, John F. Hoddinott, and Akhter U. Ahmed. 2017. *Transfers, Behavior Change Communication, and Intimate Partner Violence: Post-program Evidence from Rural Bangladesh.* IFPRI Discussion Paper No. 01676. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Sen, Binayak. 2003. "Drivers of Escape and Descent: Changing Household Fortunes in Rural Bangladesh." *World Development* 31, no. 3: 513-534. https://doi.org/10.1016/S0305-750X(02)00217-6.

Sraboni, Esha, Hazel J. Malapit, Agnes R. Quisumbing, and Akhter U. Ahmed. 2014. "Women's Empowerment in Agriculture: What Role for Food Security in Bangladesh?" *World Development* 61: 11-52. https://doi.org/10.1016/j.worlddev.2014.03.025.

StataCorp. 2013. *Stata 13 Base Reference Manual.* College Station, TX: Stata Press.

WB IEG (World Bank Independent Evaluation Group). 2008. *The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits.* Washington, D.C.: World Bank Independent Evaluation Group. http://hdl.handle.net/10986/ 6519.

Wooldridge, Jeffrey M. 2010. *Econometric Analysis of Cross-Section and Panel Data*. 2nd ed. Cambridge, M.A.: MIT Press.

Chapter 14

Women Empowerment in Agriculture: What Role for Food Security in Bangladesh?[1]

Esha Sraboni, Agnes Quisumbing, and Akhter Ahmed

14.1 Introduction

While Bangladesh has experienced steady advances in food production through the adoption of agricultural technologies, chronic food insecurity remains a challenge. Similar to other countries in South Asia, there is a strong gender dimension to food insecurity and malnutrition in Bangladesh. In South Asia, the low status of women and gender gaps in health and education contribute to chronic child malnutrition (Smith et al. 2003) and food insecurity (von Grebmer et al. 2009), even as other determinants of food security, such as per capita incomes, have improved. Renewed interest in agriculture as an engine of inclusive growth and specifically in women's empowerment has highlighted the need to develop indicators for measuring women's empowerment, to examine its relationship to various food security outcomes, and to monitor the impact of interventions to empower women.

This chapter presents how the recently developed Women's Empowerment in Agriculture Index (WEAI) (Alkire et al. 2013) can be used to assess the extent of women's empowerment in agriculture, diagnose areas where gaps in empowerment exist, and examine the extent to which improvements in the underlying indicators in these areas can improve food security in rural Bangladesh. The WEAI is a new survey-based index that uses individual-level data collected from primary male and female respondents within the same households, and is similar in construction to the Alkire and Foster (2011) group of multidimensional poverty indices.

[1] An earlier version of the chapter was published in *World Development,* 61:11-52, September 2014. This is reproduced with the permission of the publisher.

Although it was initially developed as a monitoring and evaluation tool for the US Government's Feed the Future programs, the WEAI has broader applicability as a diagnostic tool for policymakers, development organizations, and academics seeking to inform efforts to increase women's empowerment. The WEAI was developed and tested between 2011 and 2012 using three country pilots in Bangladesh, Guatemala, and Uganda (Alkire et al. 2013); this chapter presents the results using a nationally representative survey.

Using nationally representative data from the 2012 Bangladesh Integrated Household Survey (BIHS) conducted by the International Food Policy Research Institute (IFPRI), this chapter examines the relationship between women's empowerment in agriculture and three measures of food security in rural Bangladesh: per capita calorie availability, household dietary diversity, and adult body-mass index (BMI). We use six measures of women's empowerment—the aggregate women's empowerment score, based on five domains of empowerment in agriculture (5DE)—as well as four individual indicators derived by decomposing the 5DE to identify in which of the five domains disempowerment is most acute, and using the specific indicators that comprise those domains. Our sixth measure, women's empowerment relative to men, is reflected by another component of the WEAI, the gender parity gap. Because empowerment itself is endogenous, we use instrumental variables regression to examine the relationship between various measures of women's empowerment and measures of household food security.

Increases in women's empowerment scores are found to increase both calorie availability and household dietary diversity. Empowerment gaps for women in rural Bangladesh are found to be greatest in terms of leadership in the community and control and access to resources. Analyzing these two domains further in terms of their component indicators, we find that the number of groups in which women actively participate and women's greater control of assets are positively associated with both food security outcomes. Narrowing the gap in empowerment between men and women within households is also positively associated with calorie availability and household dietary diversity, consistent with the growing literature arguing that reducing intra-household gender inequality contributes positively to household welfare. Most of the indicators for women's empowerment do not have any significant impact on adult BMI, suggesting that other factors, such as household wealth, education and occupation, are more important determinants of adult male and female nutritional status. However, women's group membership and decision-making concerning credit are negatively

and significantly associated with adult male BMI, suggesting possible trade-offs within the household. The impacts of women's empowerment appear to vary by household wealth, as proxied by the size of owned land. Our results suggest that the positive effect of different dimensions of female empowerment on food security outcomes is greater for smaller landowners, that is, for less well-off households, pointing to the potential positive redistributive effect of focusing women's empowerment efforts on poorer households.

14.2 Background

14.2.1 Agriculture, Women's Empowerment and Food Security

Agriculture is closely linked to food security, by providing a source of food and nutrients, a broad-based source of income, and by directly influencing food prices (Arimond et al. 2010). Women account for 43 percent of the agricultural labor force in developing countries (FAO 2011a); yet considerable gender bias exists in the agriculture sector, both in terms of quantities of assets, agricultural inputs and resources that women control (see, Agarwal 1994 on land in South Asia; Deere, Oduro, Swaminathan, and Doss 2013 on assets; and Peterman, Behrman, and Quisumbing, 2010 on non-land inputs), as well as returns to those inputs (Kilic, Palacios-Lopez, and Goldstein 2013). Similar to the recognition of women's contribution to agriculture worldwide, women's role in Bangladeshi agriculture tends to be underappreciated, owing to the commonly held view that women are not involved in agricultural production, especially outside the homestead, because of cultural norms that value female seclusion and undervalue female labor (Kabeer 1994; Rahman 2000). Nevertheless, participation of women in the agriculture sector has increased over time (Asaduzzaman 2010 citing Bangladesh Bureau of Statistics, various years). Between 1999-2000 and 2005-2006, the number of employed persons in agriculture increased from 19.99 to 22.93 million—by about 15 percent. For male labor, there has been an absolute decrease of about 6 percent, while for females the number has increased from 3.76 to 7.71 million—that is, by more than 100 percent. As a result of such changes, the proportion of women in the agricultural labor force has increased from less than 20 percent to 33.6 percent of the total. This is indeed a phenomenal change, although it is not yet clear how much of this change resulted from a true secular increase as opposed to better measurement of women's participation.

Women in poor households, who are at greater risk of being food-insecure, are more likely to be involved in the agriculture sector, particularly

as wage laborers, because women's earnings are important to their families' subsistence. Zaman (1995) provides evidence that the gender division of labor in agriculture is not as strictly demarcated as assumed, with women being involved in agricultural work both inside and outside the household. Rahman (2010) shows that female agricultural labor contributes significantly to productivity as well as technical efficiency, but finds, similar to Zaman (1995), that gender bias exists in the agricultural labor market. Remunerative employment of labor remains skewed in favor of men, since female labor is engaged only when the male labor supply is exhausted.

Women's ability to generate income in the agriculture sector is severely constrained by their limited use, ownership, and control of productive physical and human capital. Bangladeshi women are disadvantaged relative to men with respect to assets brought to marriage (Quisumbing and Maluccio 2003), current productive assets (including land, livestock, and agricultural machinery) (Quisumbing et al. 2013), and human capital. Women lag behind in terms of education in Bangladesh—with more than one in three women having no schooling, compared to one in four men. A recent analysis also shows that lack of education in adult women in Bangladesh is a strong correlate of being "ultra-poor": 80 percent of adult women with no education live below half a dollar a day (Ahmed et al. 2007).

The rationale for paying attention to gender inequality in agriculture is rooted in a body of empirical evidence that demonstrates the ways in which women are essential to improvements in household agricultural productivity, food security and nutrition security. Considerable evidence exists that households do not act in a unitary manner when making decisions or allocating resources (Alderman et al. 1995; Haddad, Hoddinott, and Alderman 1997). This means that men and women within households do not *always* have the same preferences nor pool their resources. The non-pooling of agricultural resources within the household creates a gender gap in control of agricultural inputs, which has important implications for productivity. Several empirical studies have found that redistributing inputs between men and women in the household has the potential for increasing productivity (Udry, Hoddinott, Alderman, and Haddad 1995; Peterman, Behrman, and Quisumbing 2010; Kilic, Palacios-Lopez and Goldstein 2013). A growing body of empirical evidence suggests that increasing women's control over resources has positive effects on a number of important development outcomes. For Côte d'Ivoire, Hoddinott and Haddad (1995) and Duflo and Udry (2004) find that increasing women's share of cash income significantly increases the share of household budget allocated to food. Doss (2006) shows that, in Ghana, women's share

of assets, particularly farmland, significantly increases budget shares on food expenditure.

Considerable evidence also suggests that mothers' greater control over resources improves child outcomes—in particular, nutrition and education (Hallman 2003; Quisumbing 2003; Quisumbing, and Maluccio 2003; Skoufias 2005). Although much of the above-mentioned evidence has emerged from observational studies, a systematic review of programs targeting transfers to women (Yoong, Rabinovich, and Diepeveen 2012) has found that these improve children's well-being, especially in the form of investments in children's health and education.

The linkages between women's *empowerment* and food security have been more difficult to quantify owing to the difficulty of measuring empowerment. Despite these difficulties, there is evidence that *dis*empowerment in one of its most extreme forms—being a victim of intimate partner violence (IPV)—is associated with poor nutritional outcomes both for children and their mothers. Ziaei, Naved, and Ekström (2012), using data from the 2007 Bangladesh Demographic and Health Survey (BDHS), investigate the association between women's exposure to IPV and their children's nutritional status. Of 2,042 women in the BDHS survey with at least one child under five years of age, 49.4 percent report lifetime experience of physical partner violence, while 18.4 percent report experience of sexual partner violence. They find that women are more likely to have a stunted child if they had lifetime experience of physical IPV or had been exposed to sexual IPV. A study based on a longitudinal dataset following up three sites in Bangladesh where agricultural technologies have been introduced finds that experience of domestic abuse (particularly verbal abuse) has a significant negative impact on women's current BMI and on improvements in BMI over time (Quisumbing, Bhagowalia, Menon, and Soundararajan 2009).

Current efforts to define and measure empowerment have drawn heavily on Kabeer's (1999) definition of empowerment as expanding people's ability to make strategic life choices, particularly in contexts in which this ability has been denied to them. In Kabeer's definition, the ability to exercise choice encompasses three dimensions: resources, agency, and achievements (well-being outcomes). The WEAI focuses on the "agency" aspect, which is far less studied than resources such as income, or achievements such as educational levels. Moreover, while nationally representative surveys such as some demographic and health surveys (DHS) include a range of questions about decision making within the household, these are typically confined to the domestic sphere and do not encompass decisions in the productive and

economic spheres, nor do the surveys have identical questions for men and women (Alkire et al. 2013). The WEAI also departs from previous measures of women's empowerment in that it captures control over resources or agency within the agriculture sector, something which existing indices have not done.

14.2.2 Measuring Women's Empowerment using WEAI

The WEAI is an aggregate index, reported at the country or regional level, which is based on individual-level data on men and women within the same households. The WEAI is a weighted average of two sub-indexes: (i) five domains of women's empowerment (5DE) and (ii) gender parity (Gender Parity Index, GPI).[2] The 5DE sub-index shows how empowered women are, capturing the roles and extent of women's engagement in the agriculture sector in five domains: (1) decisions over agricultural production, (2) access to and decision-making power over productive resources, (3) control over use of income, (4) leadership in the community, and (5) time use. Table 14.1 describes the five domains and their corresponding ten indicators. The 5DE assesses the degree to which women are empowered in these domains, and for those who are not empowered, the percentage of domains in which they are empowered. 'Empowerment' within a domain means that the person has adequate achievements or has "achieved adequacy" for that domain (specific thresholds used to determine whether a person has adequate achievements will be discussed subsequently). Because the survey method goes beyond the traditional practice of interviewing only a household "head" (often a male) to interview both a principal male and principal female, 5DE measures can be computed for both the principal male and the principal female in a dual adult household, although the 5DE component of the WEAI only includes women's 5DE. Computation of men's 5DE scores and their comparison to women's 5DE enables the comparison of the agricultural empowerment of men and women living in the same household. This comparison is embodied in the GPI (gender parity index), a relative inequality measure that reflects the inequality in 5DE profiles between the primary adult male and female in each household. The aggregate WEAI uses the mean GPI value of dual-adult households. GPI combines two key pieces of information: (1) the percentage of women who lack gender parity relative to their male-household counterparts and (2) the extent of the inequality in empowerment between those women who lack parity and the men with whom they live (see Alkire et al. 2013 for details).

[2] This description draws from Alkire et al. (2013).

Table 14.1: Five Domains of Empowerment in WEAI

Domain	Indicator	Definition of indicator	Weight
Production	Input in productive decisions	Sole or joint decision-making over food and cash-crop farming, livestock, and fisheries	1/10
	Autonomy in production	Autonomy in agricultural production (e.g., what inputs to buy, crops to grow, what livestock to raise, etc.). Reflects the extent to which the respondent's motivation for decision-making reflects his/her values rather than a desire to please others or avoid harm.	1/10
Resources	Ownership of assets	Sole or joint ownership of major household assets	1/15
	Purchase, sale, or transfer of assets	Whether respondent participates in decision to buy, sell, or transfer his/her owned assets	1/15
	Access to and decisions on credit	Access to and participation in decision-making concerning credit	1/15
Income	Control over use of income	Sole or joint control over income and expenditures	1/5
Leadership	Group member	Whether respondent is an active member in at least one economic or social group (e.g., agricultural marketing, credit, water users' groups)	1/10
	Speaking in public	Whether the respondent is comfortable speaking in public concerning various issues such as intervening in a family dispute, ensure proper payment of wages for public work programs, etc.	1/10
Time	Workload	Allocation of time to productive and domestic tasks	1/10
	Leisure	Satisfaction with the available time for leisure activities	1/10

Source: Alkire et al. 2013.

Both measures, taken together, make up the WEAI.[3] The aggregate index therefore shows the degree to which women are empowered in their households and communities (5DE) and the degree of inequality between women and men in their households (GPI). Details regarding the construction and

[3] The WEAI is a weighted sum of the 5DE and GPI with weights 0.9 and 0.1, respectively.

validation of the index can be found in Alkire et al. (2013). In this chapter, we use individual measures of (women's) 5DE and its component indicators to investigate the relationship between women's empowerment in agriculture and food security; additionally, we examine the relationship between inequality in empowerment and food security in dual adult households using the gender parity gap, a component of the GPI.

14.3 Data, Empirical Specifications and Variables

14.3.1 Data

The Bangladesh Integrated Household Survey (BIHS) was conducted from December 2011 to March 2012. The BIHS sample is nationally representative of rural Bangladesh and representative of rural areas of each of the seven administrative divisions of the country. To estimate the total sample size of 5,503 households in 275 primary sampling units (PSUs), BIHS followed a stratified sampling design in two stages—selection of PSUs and selection of households within each PSU—using the sampling frame developed from the community series of the 2001 population census. In the first stage, a total sample of 275 PSUs were allocated among the seven strata (seven divisions) with probability proportional to the number of households in each stratum. Sampling weights were adjusted using the sampling frame of the 2011 population census.

The BIHS questionnaires include several modules that provide an integrated data platform to answer a variety of research questions, as well as separate questionnaires for self-identified primary male and female decision-makers in sampled households. Our study relied primarily on information concerning household demographics, educational attainment, occupation and employment, food and nonfood consumption and expenditures, household-level agricultural production and livestock holding, household assets, housing and amenities, community infrastructure and facilities, individual anthropometric measurements, and a detailed module on the WEAI.

The BIHS sample consists of 1,608 nonfarm and 3,895 farm households; since WEAI aims to measure agency in the agriculture sector, we restrict our analysis to farm households, including households relying on agricultural wage labor. The WEAI relies on information collected from both primary male and female adults in the household, and thus, our estimation samples depend on valid responses from these household members. For the household-level analysis using women's 5DE alone, we use data from the self-identified primary female adults. Of this data, 424 observations were

dropped, because the primary female respondent was either unavailable on the day of the interview or did not respond to all of WEAI survey questions. In addition, 192 observations were dropped because a female other than the primary female was interviewed, and six additional cases were dropped because of possible data entry errors in the demographic data. Our final estimation sample consists of 3,273 households. For the analysis that examines women's relative empowerment within the household, we restrict the analyses to households where both the primary male and female decision makers have been interviewed, reducing our sample size to 3,213 households.

For the individual-level analysis using women's 5DE, BMI values were obtained for 3,150 primary adult males and 3,263 primary adult females from farm households. For the analysis examining women's relative empowerment using the gender parity gap, the sample sizes for men and women are reduced to 3,094 and 3,203, respectively.

14.3.2 Empirical Specifications

To examine the relationship between women's empowerment in agriculture and household food security, we estimate the following equation:

$$\mathbf{f} = \beta_0 + \beta_1\, empowerment + \beta_{2\mathbf{x}} + \beta_{3\mathbf{h}} + \beta_{4\mathbf{c}} + \varepsilon, \tag{14.1}$$

where $\mathbf{f}$ is a vector of food security outcomes, β_i are coefficients to be estimated, $\mathbf{x}$ is a vector of individual-level characteristics, $\mathbf{h}$ is a vector of household-level characteristics, $\mathbf{c}$ is a vector of community or village characteristics, and ε is an error term.

In addition to the base regression described in equation (14.1), we also examine how the relationship between women's empowerment in agriculture and household food security varies by the size of cultivable land owned by the household. We therefore estimate the augmented equation:

$$\begin{aligned}\mathbf{f} = {} & \beta_0 + \beta_1\, empowerment + \beta_2 \ln(land\ area + 1) \\ & + \beta_3\,[empowerment \times \ln(land\ area + 1)] \\ & + \beta_{4\mathbf{x}} + \beta_5\, \mathbf{h}_{\text{aug}} + \beta_6\, \mathbf{c} + \nu,\end{aligned} \tag{14.2}$$

where β_3 represents the interaction effect of empowerment and land area, $\mathbf{h}_{\text{aug}}$ is a vector of household-level characteristics excluding land, and ν is an error term.[4]

We use two measures of women's empowerment in alternative specifications. In the first main specification, estimated for the full estimation sample, our

[4] We add the integer 1 to the land area variable to avoid losing observations for households that do not own land but are involved in agriculture, such as cultivators who rent in land or agricultural wage laborers.

measure of empowerment is the women's 5DE score; in the second main specification, estimated for a subsample of households in which we have both men's and women's empowerment scores, our measure of empowerment consists of the gender parity gap, computed by taking the difference between the men's and women's 5DE scores for households that do not have gender parity.[5] Because it is likely that women's empowerment within the household might be affected by the same factors affecting the availability of food and dietary diversity, we apply standard instrumental variables techniques to correct for potential endogeneity bias, using the ivreg2 procedure in Stata12 (Baum, Schaffer, and Stillman 2010; StataCorp 2011).

14.3.3 Outcome Variables

Per capita calorie availability: A commonly-used indicator for food security at the household level is calorie availability, constructed by converting quantities of food consumed into corresponding energy units. Food consumption data, covering around 300 food items, was collected at the household level. The data capture quantities consumed from market purchases, home production, and from other sources outside the house, e.g., relatives, government/nongovernment aid or food received in exchange for labor. Agricultural seasonality is of concern when working with food consumption data, since lack of labor market activities during the lean season might affect household income, food expenditure, and consequently food consumption. The survey period, however, does not coincide with any of the two lean seasons prevalent in Bangladesh, thus allaying concerns about seasonality. The seven-day data were converted to daily calorie equivalents and the resulting calorie values were divided by the household size to obtain per capita calorie availability values (Ahmed and Shams 1994).[6]

Household dietary diversity: One of the criticisms of the use of calorie availability indicators is that they do not reflect the quality of foods available to households (Ruel 2003). This is particularly relevant to developing countries where diets are heavily dependent on starchy staples, contain little animal products, and may be high in fats and sugars (Carletto, Zezza,

[5] As discussed below, the gender parity gap is equal to zero if the women's score is equal to or exceeds the man's 5DE score.

[6] Alternatively, calorie availability can be expressed in terms of per adult equivalents. Results for both per capita and per adult equivalent calorie availability are qualitatively similar, hence we focus our discussion on the per capita indicator. Results for per adult equivalent calorie availability are in the Appendix, and available upon request.

and Banerjee 2013). In recent years, household dietary diversity measures have gained importance as measures of household food security, especially as several studies have demonstrated a strong association between dietary diversity and household per capita consumption and daily caloric availability (Hoddinott and Yohannes 2002; Hatlôy, Hallund, Diarra, and Oshaug 2000). Household dietary diversity is defined as the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals, white tubers and roots, vegetables, fruits, meat, eggs, fish and other seafood, legumes and nuts, milk and milk products, oils and fats, sweets, and spices, condiments, and beverages (FAO 2011b); this measure has been validated as a measure of household food security and is being increasingly used.

Adult BMI: Per capita calorie availability only measures what is available at the household level, given household size, but not its intrahousehold distribution or utilization by individuals. It is not a sufficient indicator of food energy deficiency, which requires comparing calorie availability against the energy requirement of households, which, in turn, depends on the age and sex composition of households, and their individual height, weight, and activity levels (Carletto, Zezza, and Banerjee 2013). Moreover, measures of short-term nutritional status, such as BMI, also reflect current energy expenditure, health status, and access to health services and sanitation (UNICEF 1990). Gender disparities in BMI can be affected by the intrahousehold distribution of food, work effort, and health inputs; for women, BMI is also affected by pregnancy and lactation status. In the absence of data on activity levels, we use BMI values to indicate food energy deficiency. BMI values were calculated for the primary adult male and female decision makers and analysed separately for men and women.

14.3.4 Key Independent Variables

Women's Empowerment in Agriculture Index: To measure women's empowerment in agriculture, we use the WEAI, computed using individual-level data collected from primary male and female respondents within the same households.

Table 14.1 presents the five domains, which comprise ten indicators. Each domain is weighted equally, as are each of the indicators within a domain. The 5DE sub-index is a measure of empowerment that shows the number of domains in which women are empowered. A woman is defined as empowered in 5DE if she has adequate achievements in four of the five domains or is empowered in some combination of the weighted indicators

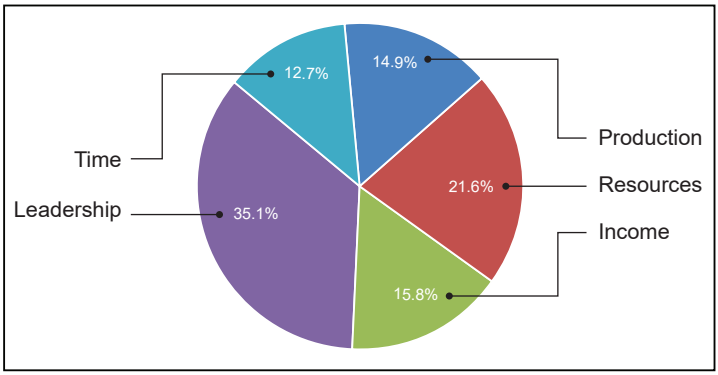
that reflect 80 percent total adequacy. The five domains of empowerment are defined as follows:

- *Production:* This domain concerns decisions over agricultural production, and refers to sole or joint decision making over food and cash-crop farming, livestock, and fisheries, as well as autonomy in agricultural production.
- *Resources:* This domain concerns ownership, access to, and decision-making power over productive resources such as land, livestock, agricultural equipment, consumer durables, and credit.
- *Income:* This domain concerns sole or joint control over the use of income and expenditures
- *Leadership:* This domain concerns leadership in the community, here measured by membership in economic or social groups and comfort in speaking in public.
- *Time:* This domain concerns the allocation of time to productive and domestic tasks and satisfaction with the available time for leisure activities.

A key innovation of the Index is that it identifies the domains in which women are disempowered as well as the relative degree of disempowerment. We use the diagnostic results on the WEAI, which describes the overall pattern of women's disempowerment across the five domains in rural Bangladesh, to guide our choice of empowerment indicators. We first identify the key domains that contribute the most to disempowerment, and then within each key domain, identify the indicators that contribute the most to disempowerment. We then construct a continuous measure of empowerment that draws on the individual-level data for the identified indicators.

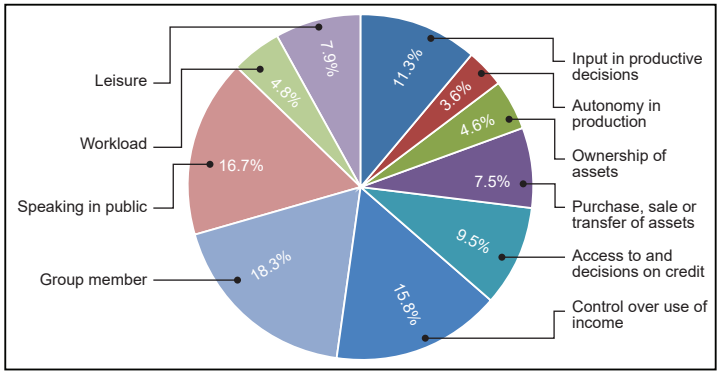
Figure 14.1 shows that the leadership and *resources* domains contribute the most to women's disempowerment in rural Bangladesh, while Figure 14.2 shows the contribution of each domain indicator. *Group membership* emerges as the indicator that contributes most to disempowerment in the leadership domain and *access to and decisions on credit* as the most critical indicator for the resources domain. The credit indicator, however, may be problematic, since it is not clear whether non-borrowers are truly credit constrained (they may not avail of credit because they have sufficient liquidity). In light of this issue, we also analyze the two other indicators for the resources domain, namely, *asset ownership* and *rights over assets*. Based on this information, we use the following alternative measures of empowerment.

Figure 14.1: Contribution of Each of the 5 Domains to the Disempowerment of Women



Source: Sraboni, Quisumbing, and Ahmed (2013).

Figure 14.2: Contribution of Each of the 10 Domain Indicators to Disempowerment of Women



Source: Sraboni, Quisumbing, and Ahmed (2013).

Model 1: Aggregate empowerment score of primary female respondent is the 5DE empowerment score of the female respondent in the household, which is the weighted average of her achievements in the ten indicators that comprise the five domains of empowerment in agriculture. This measure is increasing in empowerment, and ranges from zero to one.

Model 2: (Leadership domain, group membership indicator) Number of groups in which woman is an active member is the total number of groups in which the female respondent reports being an active member.

Model 3: (Resources domain, access to and decisions on credit indicator) Average number of decisions, concerning credit, taken by female is the number of credit decisions that the female respondent has made solely or jointly, averaged over the lending sources used. For each of the five possible lending sources (NGOs, informal, formal, friends/family, and ROSCAs), the survey asks who made the decision to borrow and who made the decision on how to use the money/item borrowed.

Model 4: (Resources domain, asset ownership indicator) Number of assets woman has sole/joint ownership is the total number of asset types for which the female respondent reports sole or joint ownership.

Model 5: (Resources domain, rights over assets indicator) Number of sole/joint decisions, concerning purchase/sale/transfer of assets, taken by woman is the total number of decisions made solely or jointly by the female respondent, summed over all asset types. For each asset type, the survey asks who can decide whether to sell, give away, mortgage/rent, and purchase the asset.

Considerable evidence exists in support of the need to pay attention to intra-household gender inequality for attaining development objectives (Alderman et al. 1995; Haddad, Hoddinott, and Alderman 1997; Quisumbing 2003). Therefore, it is interesting to examine whether women's *relative* empowerment within the household is associated with household food security. The Gender Parity Index (GPI) is a composite index that reflects the percentage of women who have gender parity as well as the empowerment gap between men and women in households not having gender parity. Because we are interested in examining how differences between empowerment levels of men and women affect household food security outcomes, we use the gender parity gap component of the GPI as our measure of empowerment. Since we need both male and female scores to compute the gender parity gap, we use the smaller estimation sample of 3,213 households where both the primary male and female decision makers have been interviewed.

Model 6: (Gender parity gap) According to Alkire et al. (2013), a household enjoys parity if woman is empowered or her empowerment score is greater than or equal to that of the male in her household. Thus, the gender parity gap is zero if the household enjoys gender parity. Otherwise, the gap equals the difference in male and female aggregate empowerment scores.

14.3.5 Instruments

We use the difference in ages between the primary male and female decision makers and number of types of informal credit sources in the village as instruments for all empowerment indicators. The survey collected information on whether the following types of informal credit sources are present in the community—moneylender within/outside village, shopkeepers who offer credit, agricultural input dealers who sell on credit, and large farmers/traders who buy crops at a fixed forward price. We do not include formal credit sources, because obtaining credit from these sources typically require collateral (which could be correlated with household wealth and could directly affect the outcomes being considered), nor NGOs, because obtaining credit from NGOs is membership-based. The existence of a large number of informal credit sources could be indicative of both greater social capital within the community, which could influence a woman's decision to actively participate in a group, as well as the size of the informal credit market. The availability of a large pool of funds could thus facilitate decision making concerning credit, and accumulation of assets by the borrowers. The differences in ages can reflect differences in human capital between the primary female and her spouse, and therefore reflect relative bargaining strengths (Quisumbing and Hallman 2005).[7]

We also instrument empowerment scores, gender parity gap as well as group membership using information on the number of community activities woman participated during the previous year; a woman who is more active in the community is more likely to be an active participant in groups. The survey collected information on whether woman has contributed money or time to the following community activities—building/maintenance of small wells or irrigation facilities, roads, development projects, local mosque or other religious structure, helping out other families with childcare, agricultural labor, or care of a patient—during the last year. The difference in recall period implies that the decision to participate in the mentioned activities was already given (exogenous) prior to current decision to join (or maintain membership in) a group.

An additional variable—whether the homestead land has been inherited by woman, is used to instrument for both ownership of and rights over assets. Inherited assets have been previously used as a bargaining measure in the literature (Quisumbing 1994; Quisumbing and Maluccio 2003). While

[7] For households where information on the woman's spouse was not available (in female-headed households—where the male spouse is a migrant, or the female is widowed/separated), we considered the age difference to be zero.

inherited land is arguably endogenous, inherited homestead land is much less likely to be correlated with the error term.

14.3.6 Other Independent Variables

Our analysis controls for a number of household and community characteristics, as well as individual characteristics for the BMI regressions. Household characteristics include age, age-squared and years of schooling of the household head,[8] household size, and proportion of males and females in various age groups (with males aged 60 and above as the excluded category). The occupation of the household head is accounted for using dummy variables for two types of primary occupation: farming and trading. We also include the price of rice as a control variable, since rice is the staple food in Bangladesh, accounting for a fifth of all spending of an average rural household, 35 percent of food expenditure, and 71 percent of total calorie intake (Ahmed et al. 2013). The number of dairy cows owned by a household is expected to affect food security outcomes through the pathway of production and consumption of milk and milk products, as well as household wealth. Three other variables are used as indicators of the socioeconomic status of the household: amount, in decimals, of cultivable land owned by the household, a dummy for whether the household has access to electricity, and a dummy for whether it owns at least one tube well.[9] Taken together these socioeconomic characteristics represent the most important assets owned by rural households in Bangladesh. We also include diversity in food crop production (that is, total number of food crops produced by the household) as a regressor; if households consume some of the food that they produce, then more diverse agricultural production is expected to increase dietary diversity at the household level. A change in total number of food crops produced may also alter calorie availability of producer households through explicit or implicit changes in household income. A household's crop production decisions may be affected by the same factors that influence its calorie availability and dietary diversity, which could lead to endogeneity bias in our analysis. We use the following instruments at the farm level to identify food crop production diversity: (i) whether or not the soil type is clay-loam, (ii) whether or not the soil type is sandy-loam, and (iii) percentage of cropped land that is irrigated. Division dummies are included to control for location-specific

[8] The household head is the self-identified primary decisionmaker (in most cases, male) in the sample household.

[9] 100 decimals = 1 acre.

effects. For the regressions with adult male and female BMI as dependent variables, we include age and years of education of the primary male and female. For the primary female, we add two dummy variables indicating whether she is pregnant or lactating. Summary statistics of all the variables used are presented in Table 14.2.

Table 14.2: Summary Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Dependent variables					
Per capita calorie availability	3,273	2,487	688	979	7,115
Per adult equivalent calorie availability	3,273	3,185	813	1,186	9,530
Household dietary diversity	3,273	9.54	1.58	4	12
Body Mass Index (BMI) of primary male respondent	3,150	20.13	2.74	12.65	32.79
Body Mass Index (BMI) of primary female respondent	3,263	20.75	3.36	12.94	34.69
Empowerment variables					
Empowerment score of women	3,273	0.67	0.23	0.07	1
Number of groups woman is an active member of	3,273	0.33	0.49	0	3
Average number of decisions over credit	3,273	0.96	0.98	0	2
Number of assets woman has self/joint ownership of	3,273	1.96	1.50	0	10
Number of self/joint decisions over purchase, sale or transfer of assets made by women	3,273	11.90	9.76	0	48
Gender parity gap	3,213	0.17	0.20	0	0.89
Other controls					
Age (in years) of household head	3,273	45.26	13.39	20	95
Age-squared of household head	3,273	2,228	1,303	400	9,025
Years of education of household head	3,273	2.97	3.82	0	16
Age (in years) of primary male respondent	3,150	45.27	13.42	20	95
Age-squared of primary male respondent	3,150	2,230	1,307	400	9,025
Years of education of primary male respondent	3,150	2.99	3.84	0	16
Age (in years) of primary female respondent	3,263	37.21	11.70	18	80
Age-squared of primary female respondent	3,263	1,522	949	324	6,400
Years of education of primary female respondent	3,263	2.93	3.42	0	16
Female respondent is pregnant (=1, 0 otherwise)	3,263	0.04	0.18	0	1
Female respondent is lactating (=1, 0 otherwise)	3,263	0.18	0.39	0	1

Continued

Continued from Table 14.2

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Household head is farmer (=1, 0 otherwise)	3,273	0.31	0.46	0	1
Household head is trader (=1, 0 otherwise)	3,273	0.08	0.27	0	1
Household size	3,273	4.36	1.57	2	17
Proportion of males 0-4 years old	3,273	0.05	0.10	0	0.6
Proportion of males 5-10 years old	3,273	0.07	0.12	0	0.6
Proportion of males 11-18 years old	3,273	0.07	0.12	0	0.67
Proportion of males 19-59 years old	3,273	0.25	0.14	0	0.75
Proportion of females 0-4 years old	3,273	0.05	0.10	0	0.6
Proportion of females 5-10 years old	3,273	0.07	0.12	0	0.5
Proportion of females 11-18 years old	3,273	0.07	0.12	0	0.6
Proportion of females 19-59 years old	3,273	0.28	0.12	0	0.75
Proportion of females 60 years and older	3,273	0.04	0.10	0	0.67
Number of food crops produced by household	3,273	1.27	1.42	0	11
Number of dairy cows owned	3,273	0.74	1.20	0	9
Price of rice (in taka)	3,273	29.90	3.38	20	50
Ln (owned cultivable land+1)	3,273	0.70	1.55	0	6.98
Access to electricity (=1, 0 otherwise)	3,273	0.44	0.50	0	1
Owns hand tube well (=1, 0 otherwise)	3,273	0.25	0.43	0	1
Division dummy 1	3,273	0.06	0.23	0	1
Division dummy 2	3,273	0.10	0.29	0	1
Division dummy 3	3,273	0.29	0.45	0	1
Division dummy 4	3,273	0.14	0.35	0	1
Division dummy 5	3,273	0.20	0.40	0	1
Division dummy 6	3,273	0.16	0.37	0	1
Instruments					
Age difference (male-female)	3,273	8.08	4.60	-15	40
Types of informal credit sources in village	3,273	2.36	1.50	0	5
Whether female has participated in any community activity during last 1 year (=1, 0 if otherwise)	3,273	0.46	0.50	0	1
Number of community activities woman has participated in last year	3,273	0.86	1.18	0	7
Whether homestead land has been inherited by woman (=1, 0 if otherwise)	3,273	0.03	0.18	0	1
Clay-loam soil (=1, 0 if otherwise)	3,273	0.28	0.45	0	1
Sandy-loam soil (=1, 0 if otherwise)	3,273	0.18	0.38	0	1
Percent of land irrigated by household	3,273	46.26	42.29	0	100

Source: IFPRI Bangladesh Integrated Household Survey, 2011-2012.

14.4 Results

14.4.1 Women's Empowerment and Food Security

Tables 14.3-14.8 present the OLS and IV regression results for the determinants of household food security. IV diagnostics are presented at the end of each table. First-stage results are available upon request. We first discuss results on calorie availability and dietary diversity, and then discuss results on adult BMI.

For the regressions involving per capita calorie availability and household dietary diversity (columns 1-4), the Anderson-Rubin and endogeneity test results imply that the endogenous variables are relevant and, in fact, endogenous. The over-identification and under-identification test results confirm that the instruments are valid and the models identified. The Kleibergen-Paap F-statistics show that the null hypothesis for weak instruments is rejected at the 5-percent (Tables 14.3, 14.6, 14.7, and 14.8) and 10-percent-level thresholds (Table 14.4). However, the F-statistic in Table 14.5 fails to exceed the critical value of 4.79, which is associated with a bias relative to OLS of less than 30 percent (Stock and Yogo 2005). This suggests that the instruments used for women's decisions on credit may be weak.

Columns 1 and 3 of Table 14.3 present the OLS coefficient estimates of the determinants of per capita calorie availability and household dietary diversity, respectively. These estimates show that the female empowerment score is highly significant and positively correlated with both these food security indicators at the household level. In columns 2 and 4, after instrumenting for both potentially endogenous variables (empowerment and food crop production), the estimates show a similar pattern, with the IV estimates being larger than the OLS estimates. These results, together with the good performance of the instruments in general, suggest that household diet diversity and per capita calorie availability increase if the primary female decision maker is more empowered; the larger IV coefficients suggest that neglecting endogeneity of empowerment may underestimate the impact of increasing women's empowerment on these food security outcomes.

Moving on to the individual indicators in Table 14.4, we find that women's group membership is positively and significantly correlated with the calorie availability measures and dietary diversity. This implies that increasing the number of groups in which women actively participate has a positive impact on household food security outcomes. In Table 14.5, the

OLS coefficient estimates (columns 1 and 3) for women's decision making concerning credit are insignificant, but IV estimates emerge as positive and significant, suggesting that women's decision making concerning credit is significant and positively correlated with food security outcomes (columns 2 and 4). Since the weak-identification test results suggest that the instruments used for this particular model are weak, we take these results with caution. An underlying problem with using decisions on credit as an indicator of empowerment in this context is that wealthier people may not need to avail of credit (because they can self-finance) and that many microfinance activities are targeted to poorer women in Bangladesh.

The OLS and IV coefficient estimates of women's ownership of assets (presented in Table 14.6) and rights over assets (Table 14.7) are significantly positive, implying that female ownership of and control over major household assets has a role to play in improving household food security. Previous work in Bangladesh has demonstrated that greater resource control by women is associated with improved child health (Hallman 2003); evaluations of the long-term impact of agricultural interventions have similarly showed that interventions targeted to women's groups have increased women's assets and improved nutritional status of women and girls (Kumar and Quisumbing 2010).

Table 14.8 presents the regression results for the gender parity gap and food security outcomes. The OLS and IV coefficient estimates of the gender parity gap are significant and negative, implying that a reduction in the gap is associated with an increase in calorie availability and household dietary diversity. Reducing the gender gap in empowerment or improving women's relative empowerment is associated with greater food security at the household level, consistent with the existing literature on female bargaining power within the household and household welfare outcomes.

In most IV models, the effect of number of food crops produced by household on calorie availability at the household level is insignificant, but a strong and significant positive association between crop diversity and dietary diversity is evident; the more food crops the households produce, the higher their dietary diversity. The number of dairy cows owned has a significant positive impact on both household food energy availability and household dietary diversity in all models. Rice price is not significantly associated with household level food energy availability, but is strongly and positively associated with the household-level dietary diversity. The latter

finding is similar to that of Rashid, Smith, and Rahman (2011), who argue that households may respond to an increase in rice price by partially shifting consumption away from rice to other food items, which results in an increase in dietary diversity. Owned cultivable land is strongly associated with both household food energy availability and household dietary diversity in all models; larger areas of cultivable land may increase household-level calorie availability and dietary diversity both through an income or wealth effect, as well as by making available a larger stock of productive assets. However, other two income-related variables—ownership of hand tube well and access to electricity—appear to significantly influence household-level food energy availability and dietary diversity only in certain models.

Consistent with the existing literature on human capital and household food security, education of the household head has a positive and significant relationship with both calorie availability and dietary diversity. Having a household head whose primary occupation is farming significantly increases both calorie availability and dietary diversity in most of the regression models. The positive relationship between farming as the main occupation with both calorie availability and dietary diversity is consistent with our other result that diversity in agricultural production increases dietary diversity at the household level. Having a household head who is primarily involved in trade improves only dietary diversity, not calorie availability.

Household size has a significant negative impact on per capita calorie availability in all regressions, but has a positive and significant correlation with diet diversity. Since a household member may have access to food from a variety of sources (home production, purchased outside the house, received in exchange for labor, etc.), a larger household size may simply be a reflection of the greater variety in food consumption patterns as a result of having more people living in the household. Coefficients on demographic categories indicate that household demographic composition significantly affects calorie availability across different specifications of the empowerment variable, but only a few demographic categories significantly affect dietary diversity. In the (preferred) IV specification, households with a larger proportion of females between 19-59 years of age have more diverse diets; these coefficients are weakly significant in the specifications using the overall empowerment score and asset-based empowerment indicators.

Table 14.3: Model 1: Women's Empowerment Score and Household Food Security Outcomes

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Empowerment score of women	235.364***	891.858***	0.493***	1.938***	-0.119	-0.447	-0.256	0.021
	(47.705)	(172.793)	(0.120)	(0.411)	(0.212)	(0.775)	(0.264)	(0.885)
Age (in years) of household head	14.282**	9.929	-0.010	-0.023				
	(6.178)	(6.644)	(0.015)	(0.016)				
Age-squared of household head	-0.110	-0.067	0.000	0.000				
	(0.067)	(0.072)	(0.000)	(0.000)				
Years of education of household head	8.639***	8.514**	0.074***	0.072***				
	(3.284)	(3.347)	(0.007)	(0.008)				
Age (in years) of member					0.059**	0.061**	0.238***	0.239***
					(0.030)	(0.031)	(0.035)	(0.036)
Age-squared of member					-0.001**	-0.001**	-0.003***	-0.003***
					(0.000)	(0.000)	(0.000)	(0.000)
Years of education of member					0.118***	0.118***	0.119***	0.119***
					(0.015)	(0.015)	(0.021)	(0.021)
Pregnant (=1, 0 otherwise)							1.105***	1.123***
							(0.286)	(0.286)
Lactating (=1, 0 otherwise)							-0.861***	-0.850***
							(0.184)	(0.185)

Continued

Continued from Table 14.3

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)	OLS (7)	2SLS (8)
Household head is farmer (=1, 0 otherwise)	79.132***	95.092***	0.220***	0.174**	0.137	0.123	-0.040	0.077
	(26.165)	(34.737)	(0.064)	(0.081)	(0.122)	(0.148)	(0.143)	(0.180)
Household head is trader (=1, 0 otherwise)	39.311	15.330	0.547***	0.514***	0.977***	0.992***	0.452*	0.419*
	(38.856)	(40.629)	(0.097)	(0.100)	(0.213)	(0.214)	(0.246)	(0.247)
Household size	-75.922***	-71.063***	0.078***	0.081***	0.073*	0.069*	0.035	0.046
	(8.606)	(9.149)	(0.020)	(0.022)	(0.040)	(0.042)	(0.047)	(0.048)
Proportion of males 0-4 years old	-1,533.389***	-1,564.817***	0.396	0.400	0.020	0.045	0.181	0.056
	(199.816)	(208.895)	(0.473)	(0.489)	(0.868)	(0.871)	(1.002)	(1.016)
Proportion of males 5-10 years old	-960.172***	-1,021.892***	0.379	0.284	0.605	0.636	1.050	0.971
	(187.744)	(195.191)	(0.421)	(0.436)	(0.806)	(0.808)	(0.921)	(0.929)
Proportion of males 11-18 years old	-301.962	-363.127*	-0.151	-0.275	0.215	0.244	1.518*	1.486*
	(185.377)	(192.144)	(0.414)	(0.428)	(0.792)	(0.791)	(0.895)	(0.898)
Proportion of males 19-59 years old	165.236	163.044	0.542*	0.534	1.220*	1.216*	1.854***	1.860***
	(153.994)	(158.439)	(0.314)	(0.326)	(0.659)	(0.656)	(0.676)	(0.674)
Proportion of females 0-4 years old	-1,604.705***	-1,596.603***	0.495	0.599	0.137	0.141	0.705	0.579
	(198.528)	(206.674)	(0.474)	(0.490)	(0.864)	(0.868)	(1.015)	(1.018)
Proportion of females 5-10 years old	-813.647***	-892.625***	0.573	0.425	0.964	1.005	0.610	0.546
	(192.091)	(198.954)	(0.424)	(0.438)	(0.833)	(0.837)	(0.925)	(0.936)

Continued

Continued from Table 14.3

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)	OLS (7)	2SLS (8)
Proportion of females 11-18 years old	-153.315	-260.023	0.498	0.267	0.273	0.328	1.637*	1.590*
	(199.495)	(205.349)	(0.432)	(0.450)	(0.822)	(0.823)	(0.948)	(0.961)
Proportion of females 19-59 years old	30.101	-22.283	0.944*	0.855*	1.121	1.140	1.787	1.747
	(226.492)	(232.903)	(0.501)	(0.519)	(1.012)	(1.011)	(1.098)	(1.095)
Proportion of females 60 years and older	-319.497	-357.407	0.300	0.254	1.040	1.055	2.269*	2.210*
	(250.737)	(257.477)	(0.519)	(0.539)	(1.095)	(1.096)	(1.228)	(1.228)
Number of food crops produced by household	36.259***	24.510	0.075***	0.142**	-0.086**	-0.071	0.040	-0.087
	(9.009)	(23.556)	(0.020)	(0.057)	(0.038)	(0.102)	(0.047)	(0.126)
Number of dairy cows owned	49.536***	44.001***	0.126***	0.095***	0.078*	0.080*	0.035	0.058
	(10.399)	(11.409)	(0.024)	(0.026)	(0.044)	(0.048)	(0.057)	(0.060)
Price of rice (in taka)	-4.194	-1.502	0.021**	0.027***	0.059***	0.057***	0.043**	0.044**
	(3.952)	(4.083)	(0.009)	(0.010)	(0.018)	(0.018)	(0.022)	(0.022)
Ln (owned cultivable land+1)	28.398***	29.720***	0.038**	0.042**	0.154***	0.153***	0.132***	0.132***
	(8.488)	(8.678)	(0.017)	(0.018)	(0.039)	(0.039)	(0.044)	(0.044)
Owns hand tube well (=1, 0 otherwise)	100.024***	45.094	0.286***	0.143**	0.044	0.068	0.089	0.095
	(26.863)	(29.281)	(0.063)	(0.070)	(0.122)	(0.135)	(0.146)	(0.160)
Access to electricity (=1, 0 otherwise)	10.708	-14.117	0.411***	0.355***	0.512***	0.525***	0.626***	0.620***
	(22.838)	(24.523)	(0.056)	(0.060)	(0.105)	(0.108)	(0.127)	(0.129)
Division level fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Continued

Continued from Table 14.3

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)	OLS (7)	2SLS (8)
Constant	2,691.208*** (219.368)	2,339.944*** (243.215)	7.291*** (0.530)	6.537*** (0.587)	15.248*** (1.015)	15.434*** (1.097)	11.971*** (1.179)	11.822*** (1.213)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	41.928	38.481	26.628	25.084	12.722	12.404	15.078	15.007
Adjusted R^2	0.275	0.230	0.175	0.130	0.113	0.112	0.106	0.103
Hansen J p, Ho: instruments valid		0.470		0.640		0.311		0.192
Under ID test p, Ho: underidentified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		41.798		41.798		39.627		40.325
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.456		0.352
A-R Wald Chi2 test, p-value		0.000		0.000		0.449		0.345
Endogeneity test p, Ho: exogenous		0.000		0.000		0.925		0.582
First stage Adjusted R^2 (Empowerment score of women)		0.180		0.180		0.181		0.183
First stage Adjusted R^2 (Number of food crops produced by household)		0.314		0.314		0.310		0.313

Note: Estimates from base regression without interaction with land. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Table 14.4: Model 2: Women's Group Membership and Household Food Security Outcomes

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Number of groups woman is an active member of	39.109*	813.559***	0.109*	1.673***	-0.264**	-0.134	0.032	0.501
	(22.939)	(186.928)	(0.057)	(0.424)	(0.103)	(0.664)	(0.125)	(0.753)
Age (in years) of household head	15.426**	6.450	-0.008	-0.029*				
	(6.125)	(7.423)	(0.015)	(0.017)				
Age-squared of household head	-0.120*	-0.016	0.000	0.000*				
	(0.066)	(0.081)	(0.000)	(0.000)				
Years of education of household head	8.837***	11.529***	0.074***	0.078***				
	(3.304)	(3.922)	(0.007)	(0.009)				
Age (in years) of member					0.062**	0.060*	0.235***	0.231***
					(0.030)	(0.031)	(0.035)	(0.037)
Age-squared of member					-0.001**	-0.001**	-0.003***	-0.003***
					(0.000)	(0.000)	(0.000)	(0.000)
Years of education of member					0.117***	0.117***	0.118***	0.119***
					(0.015)	(0.015)	(0.021)	(0.021)
Pregnant (=1, 0 otherwise)							1.105***	1.123***
							(0.285)	(0.284)
Lactating (=1, 0 otherwise)							-0.856***	-0.853***
							(0.184)	(0.184)

Continued

Continued from Table 14.4

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Household head is farmer (=1, 0 otherwise)	80.475***	201.120***	0.226***	0.387***	0.102	0.113	-0.030	0.166
	(26.353)	(51.229)	(0.064)	(0.114)	(0.122)	(0.193)	(0.144)	(0.234)
Household head is trader (=1, 0 otherwise)	45.881	10.528	0.559***	0.509***	0.983***	0.980***	0.442*	0.395
	(39.175)	(50.801)	(0.097)	(0.115)	(0.212)	(0.214)	(0.246)	(0.249)
Household size	-77.840***	-82.949***	0.073***	0.056**	0.075*	0.074*	0.037	0.046
	(8.671)	(10.772)	(0.020)	(0.023)	(0.040)	(0.041)	(0.047)	(0.047)
Proportion of males 0-4 years old	-1,528.809***	-1,643.825***	0.402	0.245	0.053	0.042	0.137	-0.098
	(199.730)	(234.459)	(0.473)	(0.531)	(0.865)	(0.874)	(1.002)	(1.043)
Proportion of males 5-10 years old	-943.952***	-1,051.360***	0.410	0.234	0.633	0.619	1.007	0.839
	(187.720)	(220.073)	(0.421)	(0.477)	(0.802)	(0.809)	(0.921)	(0.950)
Proportion of males 11-18 years old	-289.250	-469.103**	-0.131	-0.483	0.274	0.243	1.479*	1.332
	(185.171)	(215.354)	(0.414)	(0.468)	(0.789)	(0.806)	(0.895)	(0.932)
Proportion of males 19-59 years old	164.890	141.817	0.540*	0.491	1.227*	1.226*	1.839***	1.792***
	(153.762)	(171.874)	(0.314)	(0.354)	(0.655)	(0.655)	(0.676)	(0.685)
Proportion of females 0-4 years old	-1,606.313***	-1,560.295***	0.494	0.674	0.124	0.141	0.685	0.521
	(198.999)	(234.269)	(0.474)	(0.525)	(0.860)	(0.864)	(1.015)	(1.024)
Proportion of females 5-10 years old	-791.767***	-913.201***	0.615	0.396	0.992	0.976	0.563	0.415
	(191.789)	(220.747)	(0.424)	(0.475)	(0.830)	(0.836)	(0.924)	(0.953)
Proportion of females 11-18 years old	-129.198	-408.405*	0.539	-0.021	0.355	0.307	1.572*	1.364
	(199.970)	(232.738)	(0.432)	(0.505)	(0.820)	(0.846)	(0.948)	(1.018)

Continued

Continued from Table 14.4

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Proportion of females 19-59 years old	45.373	-17.950	0.974*	0.873	1.134	1.129	1.760	1.666
	(226.539)	(255.454)	(0.500)	(0.549)	(1.009)	(1.008)	(1.097)	(1.104)
Proportion of females 60 years and older	-310.409	-390.661	0.316	0.193	1.074	1.061	2.240*	2.095*
	(250.924)	(283.066)	(0.518)	(0.575)	(1.092)	(1.099)	(1.228)	(1.251)
Number of food crops produced by household	38.339***	18.129	0.079***	0.133**	-0.086**	-0.078	0.037	-0.109
	(9.092)	(27.980)	(0.020)	(0.064)	(0.038)	(0.104)	(0.047)	(0.128)
Number of dairy cows owned	52.596***	69.454***	0.132***	0.147***	0.072*	0.073	0.034	0.071
	(10.426)	(14.079)	(0.024)	(0.031)	(0.044)	(0.050)	(0.057)	(0.064)
Price of rice (in taka)	-4.851	1.351	0.020**	0.033***	0.057***	0.058***	0.045**	0.048**
	(3.975)	(4.827)	(0.010)	(0.011)	(0.018)	(0.019)	(0.022)	(0.022)
Ln (owned cultivable land+1)	28.612***	42.641***	0.038**	0.069***	0.149***	0.152***	0.134***	0.142***
	(8.513)	(10.334)	(0.017)	(0.021)	(0.039)	(0.040)	(0.044)	(0.047)
Owns hand tube well (=1, 0 otherwise)	115.792***	32.833	0.316***	0.126	0.064	0.047	0.064	0.046
	(26.784)	(35.942)	(0.063)	(0.080)	(0.120)	(0.137)	(0.147)	(0.160)
Access to electricity (=1, 0 otherwise)	18.498	-3.726	0.427***	0.381***	0.517***	0.512***	0.617***	0.607***
	(22.946)	(27.953)	(0.056)	(0.065)	(0.104)	(0.107)	(0.127)	(0.128)
Division level fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2,818.102***	2,841.667***	7.558***	7.625***	15.178***	15.180***	11.868***	11.926***
	(220.021)	(256.485)	(0.529)	(0.592)	(1.004)	(1.000)	(1.180)	(1.188)

Continued

Continued from Table 14.4

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	40.377	29.168	25.837	21.037	13.151	12.488	15.092	14.952
Adjusted R^2	0.270	-0.017	0.171	-0.052	0.115	0.114	0.105	0.098
Hansen J p, Ho: instruments valid		0.247		0.914		0.151		0.137
Under ID test p, Ho: underidentified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		9.545		9.545		9.059		9.782
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.296		0.255
A-R Wald Chi2 test, p-value		0.000		0.000		0.289		0.249
Endogeneity test p, Ho: exogenous		0.000		0.000		0.900		0.524
First stage Adjusted R^2 (Number of groups woman is an active member of)		0.106		0.106		0.108		0.106
First stage Adjusted R^2 (Number of food crops produced by household)		0.321		0.321		0.317		0.320

Note: Estimates from base regression without interaction with land. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Table 14.5: Model 3: Women's Decisions on Credit and Household Food Security Outcomes

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Average number of decisions over credit	-0.127	806.335**	-0.020	0.940*	-0.135***	-0.580	-0.059	-0.882
	(11.102)	(313.472)	(0.028)	(0.543)	(0.051)	(0.771)	(0.061)	(0.991)
Age (in years) of household head	15.914***	-17.073	-0.006	-0.049*				
	(6.135)	(16.396)	(0.015)	(0.028)				
Age-squared of household head	-0.126*	0.224	0.000	0.001*				
	(0.066)	(0.175)	(0.000)	(0.000)				
Years of education of household head	8.713***	17.340***	0.073***	0.082***				
	(3.304)	(6.538)	(0.007)	(0.011)				
Age (in years) of member					0.064**	0.082*	0.238***	0.280***
					(0.030)	(0.045)	(0.035)	(0.060)
Age-squared of member					-0.001**	-0.001**	-0.003***	-0.004***
					(0.000)	(0.000)	(0.000)	(0.001)
Years of education of member					0.116***	0.111***	0.117***	0.115***
					(0.015)	(0.017)	(0.021)	(0.022)
Pregnant (=1, 0 otherwise)							1.099***	1.017***
							(0.286)	(0.328)
Lactating (=1, 0 otherwise)							-0.853***	-0.814***
							(0.184)	(0.194)
Household head is farmer (=1, 0 otherwise)	75.134***	307.092***	0.207***	0.380*	0.108	-0.042	-0.048	-0.209
	(26.390)	(112.967)	(0.064)	(0.195)	(0.122)	(0.287)	(0.143)	(0.371)

Continued

Continued from Table 14.5

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Household head is trader (=1, 0 otherwise)	47.475	15.810	0.564***	0.552***	0.974***	0.994***	0.445*	0.455*
	(39.196)	(68.466)	(0.098)	(0.116)	(0.212)	(0.214)	(0.246)	(0.257)
Household size	-77.518***	-58.839***	0.074***	0.087***	0.070*	0.055	0.036	0.020
	(8.636)	(16.989)	(0.020)	(0.028)	(0.040)	(0.049)	(0.046)	(0.057)
Proportion of males 0-4 years old	-1,523.630***	-2,048.095***	0.428	-0.103	0.095	0.415	0.186	0.729
	(199.666)	(390.761)	(0.474)	(0.666)	(0.870)	(1.029)	(1.001)	(1.297)
Proportion of males 5-10 years old	-938.865***	-1,282.772***	0.432	0.074	0.646	0.846	1.048	1.494
	(187.610)	(329.839)	(0.422)	(0.553)	(0.806)	(0.882)	(0.920)	(1.127)
Proportion of males 11-18 years old	-280.204	-735.363**	-0.095	-0.622	0.291	0.588	1.528*	2.076*
	(185.283)	(339.529)	(0.415)	(0.579)	(0.793)	(0.940)	(0.894)	(1.135)
Proportion of males 19-59 years old	166.093	99.133	0.545*	0.462	1.228*	1.254*	1.859***	2.085***
	(153.762)	(230.437)	(0.314)	(0.376)	(0.658)	(0.663)	(0.676)	(0.744)
Proportion of females 0-4 years old	-1,609.422***	-1,903.357***	0.491	0.250	0.178	0.366	0.712	1.026
	(198.590)	(348.876)	(0.474)	(0.612)	(0.864)	(0.924)	(1.013)	(1.178)
Proportion of females 5-10 years old	-785.832***	-1,086.839***	0.639	0.313	1.003	1.197	0.600	0.997
	(191.973)	(332.238)	(0.426)	(0.553)	(0.834)	(0.895)	(0.924)	(1.081)
Proportion of females 11-18 years old	-115.074	-477.554	0.588	0.160	0.317	0.535	1.620*	2.092*
	(199.732)	(336.649)	(0.432)	(0.568)	(0.825)	(0.900)	(0.945)	(1.134)

Continued

Continued from Table 14.5

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Proportion of females 19-59 years old	48.339	-76.428	0.985**	0.870	1.134	1.217	1.781	1.997*
	(226.709)	(354.347)	(0.501)	(0.592)	(1.011)	(1.027)	(1.098)	(1.176)
Proportion of females 60 years and older	-306.680	-560.668	0.332	0.078	1.088	1.291	2.277*	2.694*
	(251.198)	(391.181)	(0.519)	(0.643)	(1.095)	(1.155)	(1.227)	(1.405)
Number of food crops produced by household	38.471***	-37.308	0.080***	0.108	-0.085**	-0.021	0.038	0.022
	(9.088)	(54.556)	(0.020)	(0.094)	(0.038)	(0.133)	(0.047)	(0.173)
Number of dairy cows owned	51.920***	91.177***	0.130***	0.153***	0.072*	0.045	0.031	0.010
	(10.443)	(24.800)	(0.024)	(0.043)	(0.044)	(0.064)	(0.057)	(0.083)
Price of rice (in taka)	-5.169	6.870	0.019**	0.033**	0.057***	0.051**	0.043**	0.031
	(3.988)	(7.605)	(0.009)	(0.014)	(0.018)	(0.021)	(0.022)	(0.026)
Ln (owned cultivable land+1)	27.889***	18.896	0.037**	0.028	0.156***	0.161***	0.134***	0.138***
	(8.524)	(13.731)	(0.017)	(0.022)	(0.039)	(0.040)	(0.044)	(0.045)
Owns hand tube well (=1, 0 otherwise)	120.209***	30.360	0.331***	0.196**	0.054	0.105	0.075	0.185
	(26.698)	(53.824)	(0.063)	(0.090)	(0.121)	(0.158)	(0.146)	(0.183)
Access to electricity (=1, 0 otherwise)	19.639	-37.329	0.431***	0.362***	0.520***	0.561***	0.622***	0.679***
	(22.978)	(44.644)	(0.056)	(0.078)	(0.104)	(0.128)	(0.127)	(0.146)
Division level fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2,816.747***	2,679.870***	7.557***	7.419***	15.210***	15.309***	11.863***	11.880***
	(220.321)	(354.557)	(0.529)	(0.627)	(1.006)	(1.035)	(1.181)	(1.232)

Continued

Continued from Table 14.5

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	40.253	14.729	25.562	17.980	12.860	11.896	15.076	14.149
Adjusted R^2	0.269	-1.001	0.170	-0.168	0.115	0.090	0.106	0.051
Hansen J p, Ho: instruments valid		0.592		0.397		0.244		0.263
Under ID test p, Ho: underidentified		0.031		0.031		0.012		0.032
Weak ID test stat (Kleibergen-Paaprk Wald F)		2.134		2.134		2.594		2.125
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.356		0.314
A-R Wald Chi2 test, p-value		0.000		0.000		0.349		0.307
Endogeneity test p, Ho: exogenous		0.000		0.001		0.848		0.320
First stage Adjusted R^2 (Average number of decisions over credit)		0.059		0.059		0.063		0.057
First stage Adjusted R^2 (Number of food crops produced by household)		0.320		0.320		0.317		0.319

Note: Estimates from base regression without interaction with land. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Table 14.6: Model 4: Women's Ownership of Assets and Household Food Security Outcomes

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Number of assets woman has self/joint ownership of	33.263***	146.085***	0.104***	0.178**	0.032	-0.069	0.051	-0.137
	(8.323)	(33.343)	(0.019)	(0.078)	(0.036)	(0.148)	(0.043)	(0.173)
Age (in years) of household head	14.621**	10.146	-0.011	-0.018				
	(6.161)	(6.614)	(0.014)	(0.015)				
Age-squared of household head	-0.113*	-0.068	0.000	0.000				
	(0.067)	(0.072)	(0.000)	(0.000)				
Years of education of household head	7.654**	4.012	0.070***	0.066***				
	(3.257)	(3.452)	(0.007)	(0.008)				
Age (in years) of member					0.057*	0.060**	0.232***	0.248***
					(0.030)	(0.030)	(0.035)	(0.037)
Age-squared of member					-0.001**	-0.001**	-0.003***	-0.003***
					(0.000)	(0.000)	(0.000)	(0.000)
Years of education of member					0.117***	0.120***	0.114***	0.128***
					(0.015)	(0.016)	(0.021)	(0.024)
Pregnant (=1, 0 otherwise)							1.103***	1.126***
							(0.286)	(0.287)
Lactating (=1, 0 otherwise)							-0.849***	-0.870***
							(0.184)	(0.186)

Continued

Continued from Table 14.6

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)	OLS (7)	2SLS (8)
Household head is farmer (=1, 0 otherwise)	76.609***	78.643**	0.216***	0.115	0.139	0.136	-0.031	0.052
	(26.218)	(34.327)	(0.064)	(0.078)	(0.122)	(0.144)	(0.143)	(0.175)
Household head is trader (=1, 0 otherwise)	39.113	11.481	0.538***	0.545***	0.962***	0.995***	0.433*	0.451*
	(38.802)	(41.059)	(0.097)	(0.099)	(0.213)	(0.220)	(0.246)	(0.249)
Household size	-75.261***	-67.855***	0.081***	0.078***	0.076*	0.069	0.041	0.036
	(8.512)	(9.154)	(0.020)	(0.021)	(0.040)	(0.043)	(0.046)	(0.050)
Proportion of males 0-4 years old	-1,519.595***	-1,503.062***	0.429	0.532	0.025	-0.005	0.121	0.138
	(199.323)	(208.246)	(0.473)	(0.479)	(0.868)	(0.873)	(1.003)	(1.011)
Proportion of males 5-10 years old	-950.629***	-988.932***	0.387	0.413	0.595	0.599	0.982	1.067
	(187.730)	(196.402)	(0.422)	(0.430)	(0.804)	(0.807)	(0.921)	(0.931)
Proportion of males 11-18 years old	-306.015*	-392.922**	-0.187	-0.230	0.191	0.239	1.440	1.620*
	(185.826)	(195.517)	(0.414)	(0.425)	(0.790)	(0.794)	(0.896)	(0.910)
Proportion of males 19-59 years old	162.392	149.777	0.532*	0.520	1.228*	1.211*	1.825***	1.907***
	(153.699)	(158.473)	(0.314)	(0.320)	(0.659)	(0.658)	(0.675)	(0.679)
Proportion of females 0-4 years old	-1,621.661***	-1,660.018***	0.447	0.530	0.137	0.152	0.641	0.719
	(198.185)	(207.263)	(0.474)	(0.482)	(0.863)	(0.869)	(1.016)	(1.039)
Proportion of females 5-10 years old	-802.075***	-856.122***	0.581	0.577	0.945	0.966	0.536	0.648
	(192.398)	(200.614)	(0.425)	(0.433)	(0.831)	(0.836)	(0.925)	(0.935)
Proportion of females 11-18 years old	-158.353	-304.838	0.443	0.351	0.224	0.317	1.511	1.795*
	(200.579)	(210.733)	(0.432)	(0.451)	(0.820)	(0.827)	(0.949)	(0.981)

Continued

Continued from Table 14.6

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Proportion of females 19-59 years old	18.455	-81.933	0.889*	0.856*	1.108	1.135	1.712	1.892*
	(227.380)	(239.440)	(0.502)	(0.519)	(1.010)	(1.013)	(1.100)	(1.113)
Proportion of females 60 years and older	-343.769	-468.114*	0.211	0.176	1.025	1.066	2.182*	2.389*
	(250.994)	(261.353)	(0.520)	(0.539)	(1.094)	(1.098)	(1.231)	(1.256)
Number of food crops produced by household	35.492***	28.672	0.070***	0.183***	-0.090**	-0.076	0.033	-0.058
	(9.097)	(23.999)	(0.020)	(0.056)	(0.038)	(0.102)	(0.047)	(0.123)
Number of dairy cows owned	48.602***	36.671***	0.120***	0.089***	0.073*	0.084*	0.028	0.068
	(10.464)	(12.087)	(0.024)	(0.026)	(0.044)	(0.049)	(0.057)	(0.061)
Price of rice (in taka)	-4.833	-3.687	0.020**	0.021**	0.060***	0.058***	0.045**	0.042**
	(3.957)	(4.061)	(0.009)	(0.010)	(0.018)	(0.018)	(0.022)	(0.021)
Ln (owned cultivable land+1)	27.584***	26.615***	0.035**	0.037**	0.154***	0.154***	0.133***	0.132***
	(8.533)	(8.890)	(0.017)	(0.017)	(0.039)	(0.039)	(0.044)	(0.044)
Owns hand tube well (=1, 0 otherwise)	110.866***	78.456***	0.299***	0.250***	0.025	0.052	0.053	0.131
	(26.577)	(28.379)	(0.062)	(0.064)	(0.121)	(0.127)	(0.146)	(0.155)
Access to electricity (=1, 0 otherwise)	12.291	-12.634	0.407***	0.389***	0.502***	0.520***	0.609***	0.644***
	(22.890)	(25.116)	(0.056)	(0.059)	(0.105)	(0.108)	(0.127)	(0.130)
Division level fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2,799.797***	2,743.056***	7.501***	7.488***	15.147***	15.254***	11.872***	11.805***
	(218.773)	(226.553)	(0.528)	(0.535)	(1.006)	(1.017)	(1.180)	(1.177)

Continued

Continued from Table 14.6

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	41.121	37.357	27.427	24.975	12.792	12.437	15.119	14.884
Adjusted R^2	0.274	0.218	0.179	0.166	0.113	0.110	0.106	0.098
Hansen J p, Ho: instruments valid		0.574		0.518		0.277		0.343
Under ID test p, Ho: under-identified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		32.199		32.199		32.288		30.094
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.415		0.425
A-R Wald Chi2 test, p-value		0.000		0.000		0.407		0.418
Endogeneity test p, Ho: exogenous		0.001		0.013		0.755		0.206
First stage Adjusted R^2 (Number of assets woman has self/joint ownership of)		0.128		0.128		0.132		0.135
First stage Adjusted R^2 (Number of food crops produced by household)		0.320		0.320		0.316		0.319

Note: Estimates from base regression without interaction with land. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Table 14.7: Model 5: Women's Rights over Assets and Household Food Security Outcomes

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Number of self/joint decisions over purchase, sale or transfer of assets made by woman	5.737***	19.637***	0.018***	0.016	-0.005	0.002	0.006	0.002
	(1.243)	(5.135)	(0.003)	(0.013)	(0.006)	(0.023)	(0.007)	(0.028)
Age (in years) of household head	13.646**	8.675	-0.014	-0.017				
	(6.124)	(6.473)	(0.015)	(0.015)				
Age-squared of household head	-0.104	-0.056	0.000	0.000				
	(0.066)	(0.070)	(0.000)	(0.000)				
Years of education of household head	7.625**	5.217	0.070***	0.069***				
	(3.255)	(3.368)	(0.007)	(0.008)				
Age (in years) of member					0.060**	0.058*	0.232***	0.238***
					(0.030)	(0.031)	(0.035)	(0.038)
Age-squared of member					-0.001**	-0.001**	-0.003***	-0.003***
					(0.000)	(0.000)	(0.000)	(0.000)
Years of education of member					0.119***	0.117***	0.115***	0.118***
					(0.015)	(0.015)	(0.021)	(0.023)
Pregnant (=1, 0 otherwise)							1.109***	1.125***
							(0.285)	(0.286)
Lactating (=1, 0 otherwise)							-0.850***	-0.848***
							(0.184)	(0.187)

Continued

Continued from Table 14.7

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Household head is farmer (=1, 0 otherwise)	71.321***	75.632**	0.200***	0.102	0.144	0.146	-0.038	0.082
	(26.184)	(34.346)	(0.064)	(0.078)	(0.121)	(0.145)	(0.142)	(0.175)
Household head is trader (=1, 0 otherwise)	34.877	0.964	0.525***	0.554***	0.985***	0.966***	0.431*	0.413
	(39.204)	(43.539)	(0.096)	(0.101)	(0.214)	(0.225)	(0.247)	(0.254)
Household size	-74.161***	-64.884***	0.084***	0.075***	0.070*	0.075*	0.041	0.048
	(8.566)	(9.564)	(0.020)	(0.022)	(0.040)	(0.045)	(0.046)	(0.051)
Proportion of males 0-4 years old	-1,546.846***	-1,615.209***	0.346	0.441	0.031	-0.001	0.102	0.037
	(199.041)	(206.383)	(0.471)	(0.479)	(0.868)	(0.878)	(1.002)	(1.036)
Proportion of males 5-10 years old	-971.520***	-1,057.285***	0.324	0.382	0.618	0.583	0.974	0.955
	(187.126)	(194.103)	(0.419)	(0.430)	(0.806)	(0.818)	(0.921)	(0.942)
Proportion of males 11-18 years old	-325.653*	-437.470**	-0.245	-0.219	0.239	0.194	1.437	1.469
	(185.415)	(194.681)	(0.412)	(0.428)	(0.792)	(0.806)	(0.895)	(0.922)
Proportion of males 19-59 years old	166.953	169.525	0.546*	0.542*	1.214*	1.224*	1.839***	1.860***
	(153.243)	(154.577)	(0.313)	(0.315)	(0.660)	(0.655)	(0.675)	(0.673)
Proportion of females 0-4 years old	-1,630.065***	-1,694.354***	0.422	0.532	0.153	0.125	0.650	0.560
	(197.888)	(205.187)	(0.473)	(0.483)	(0.864)	(0.873)	(1.014)	(1.038)
Proportion of females 5-10 years old	-821.326***	-911.444***	0.523	0.564	0.978	0.939	0.530	0.532
	(191.731)	(197.929)	(0.422)	(0.435)	(0.833)	(0.842)	(0.922)	(0.944)
Proportion of females 11-18 years old	-155.518	-253.923	0.455	0.470	0.281	0.244	1.542	1.578
	(199.050)	(203.938)	(0.429)	(0.443)	(0.821)	(0.825)	(0.946)	(0.962)

Continued

Continued from Table 14.7

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Proportion of females 19-59 years old	16.339	-65.496	0.885*	0.925*	1.129	1.108	1.729	1.734
	(226.667)	(234.410)	(0.498)	(0.512)	(1.013)	(1.011)	(1.097)	(1.104)
Proportion of females 60 years and older	-340.188	-427.584*	0.224	0.279	1.052	1.026	2.203*	2.193*
	(250.662)	(257.228)	(0.518)	(0.530)	(1.096)	(1.098)	(1.227)	(1.245)
Number of food crops produced by household	34.134***	8.077	0.066***	0.181***	-0.083**	-0.098	0.033	-0.096
	(9.093)	(27.137)	(0.020)	(0.063)	(0.038)	(0.116)	(0.048)	(0.140)
Number of dairy cows owned	47.587***	40.221***	0.117***	0.096***	0.081*	0.078	0.028	0.058
	(10.465)	(11.727)	(0.024)	(0.026)	(0.044)	(0.048)	(0.057)	(0.061)
Price of rice (in taka)	-4.737	-3.757	0.020**	0.021**	0.059***	0.060***	0.045**	0.044**
	(3.969)	(4.057)	(0.009)	(0.010)	(0.018)	(0.018)	(0.022)	(0.021)
Ln (owned cultivable land+1)	26.100***	21.487**	0.031*	0.034*	0.155***	0.153***	0.132***	0.131***
	(8.498)	(8.830)	(0.017)	(0.018)	(0.039)	(0.039)	(0.044)	(0.045)
Owns hand tube well (=1, 0 otherwise)	117.479***	114.594***	0.320***	0.294***	0.036	0.036	0.065	0.097
	(26.503)	(27.182)	(0.062)	(0.063)	(0.121)	(0.122)	(0.146)	(0.149)
Access to electricity (=1, 0 otherwise)	12.156	-5.785	0.407***	0.408***	0.514***	0.506***	0.611***	0.618***
	(22.890)	(24.534)	(0.056)	(0.059)	(0.104)	(0.108)	(0.127)	(0.129)
Division level fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2,822.341***	2,832.715***	7.571***	7.593***	15.188***	15.178***	11.890***	11.841***
	(219.334)	(222.547)	(0.528)	(0.530)	(1.007)	(0.999)	(1.179)	(1.178)

Continued

Continued from Table 14.7

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	41.058	37.590	28.025	25.513	12.761	12.490	15.086	15.011
Adjusted R^2	0.275	0.240	0.181	0.172	0.113	0.112	0.106	0.103
Hansen J p, Ho: instruments valid		0.061		0.131		0.251		0.259
Under ID test p, Ho: underidentified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		23.334		23.334		23.340		21.822
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.415		0.425
A-R Wald Chi2 test, p-value		0.000		0.000		0.407		0.418
Endogeneity test p, Ho: exogenous		0.012		0.070		0.941		0.386
First stage Adjusted R^2 (Number of self/joint decisions over purchase, sale or transfer of assets made by woman)		0.181		0.181		0.190		0.188
First stage Adjusted R^2 (Number of food crops produced by household)		0.320		0.320		0.316		0.319

Note: Estimates from base regression without interaction with land. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Table 14.8: Model 6: Gender Parity Gap and Household Food Security Outcomes

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gender parity gap (=0 if woman enjoys gender parity, 'gap' if not)	-163.834***	-1,282.089***	-0.401***	-2.583***	0.220	0.785	0.318	0.252
	(52.646)	(256.600)	(0.133)	(0.601)	(0.241)	(1.110)	(0.301)	(1.242)
Age (in years) of household head	15.976**	9.845	-0.009	-0.025				
	(6.217)	(7.016)	(0.015)	(0.016)				
Age-squared of household head	-0.126*	-0.066	0.000	0.000				
	(0.067)	(0.076)	(0.000)	(0.000)				
Years of education of household head	9.238***	10.081***	0.074***	0.074***				
	(3.330)	(3.523)	(0.007)	(0.008)				
Age (in years) of member					0.056*	0.059*	0.238***	0.240***
					(0.030)	(0.031)	(0.036)	(0.037)
Age-squared of member					-0.001**	-0.001**	-0.003***	-0.003***
					(0.000)	(0.000)	(0.000)	(0.000)
Years of education of member					0.119***	0.118***	0.116***	0.117***
					(0.015)	(0.015)	(0.021)	(0.021)
Pregnant (=1, 0 otherwise)							1.159***	1.178***
							(0.294)	(0.295)
Lactating (=1, 0 otherwise)							-0.890***	-0.884***
							(0.184)	(0.184)
Household head is farmer (=1, 0 otherwise)	74.163***	84.660**	0.223***	0.151*	0.130	0.110	-0.038	0.056
	(26.352)	(35.405)	(0.064)	(0.082)	(0.122)	(0.146)	(0.144)	(0.177)

Continued

Continued from Table 14.8

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Household head is trader (=1, 0 otherwise)	43.092	4.451	0.556***	0.505***	0.940***	0.967***	0.488*	0.464*
	(39.325)	(42.673)	(0.099)	(0.103)	(0.213)	(0.216)	(0.251)	(0.253)
Household size	-76.559***	-68.532***	0.073***	0.080***	0.063	0.057	0.038	0.047
	(8.692)	(9.552)	(0.020)	(0.023)	(0.041)	(0.043)	(0.047)	(0.050)
Proportion of males 0-4 years old	-1,544.764***	-1,594.009***	0.474	0.468	-0.168	-0.123	0.146	0.059
	(204.887)	(224.046)	(0.477)	(0.506)	(0.877)	(0.883)	(1.017)	(1.030)
Proportion of males 5-10 years old	-967.151***	-1,043.160***	0.439	0.343	0.488	0.531	1.195	1.147
	(191.741)	(206.927)	(0.422)	(0.452)	(0.812)	(0.815)	(0.935)	(0.943)
Proportion of males 11-18 years old	-328.485*	-425.453**	-0.121	-0.292	0.011	0.057	1.566*	1.553*
	(190.186)	(205.314)	(0.418)	(0.443)	(0.802)	(0.804)	(0.909)	(0.915)
Proportion of males 19-59 years old	142.865	135.830	0.590*	0.579*	1.176*	1.171*	1.886***	1.893***
	(157.756)	(168.143)	(0.316)	(0.336)	(0.666)	(0.665)	(0.688)	(0.686)
Proportion of females 0-4 years old	-1,613.382***	-1,597.564***	0.525	0.662	0.013	0.026	0.617	0.517
	(203.070)	(220.178)	(0.479)	(0.506)	(0.874)	(0.880)	(1.027)	(1.029)
Proportion of females 5-10 years old	-839.164***	-969.284***	0.582	0.363	0.869	0.935	0.697	0.663
	(197.619)	(213.360)	(0.429)	(0.459)	(0.843)	(0.851)	(0.942)	(0.959)
Proportion of females 11-18 years old	-149.120	-289.433	0.553	0.291	0.237	0.304	1.522	1.511
	(204.730)	(217.506)	(0.436)	(0.467)	(0.831)	(0.833)	(0.962)	(0.977)
Proportion of females 19-59 years old	8.155	-80.391	0.983*	0.846	0.928	0.964	1.823	1.797
	(231.876)	(248.583)	(0.506)	(0.541)	(1.017)	(1.017)	(1.112)	(1.111)

Continued

Continued from Table 14.8

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Proportion of females 60 years and older	-357.547	-435.890	0.310	0.206	0.781	0.814	2.409*	2.367*
	(256.315)	(273.060)	(0.523)	(0.561)	(1.099)	(1.100)	(1.244)	(1.248)
Number of food crops produced by household	36.659***	40.145*	0.080***	0.195***	-0.080**	-0.062	0.040	-0.067
	(9.105)	(23.874)	(0.020)	(0.057)	(0.038)	(0.100)	(0.048)	(0.122)
Number of dairy cows owned	50.519***	44.513***	0.128***	0.095***	0.073*	0.073	0.039	0.060
	(10.434)	(11.663)	(0.024)	(0.026)	(0.044)	(0.048)	(0.058)	(0.060)
Price of rice (in taka)	-3.700	-0.469	0.021**	0.028***	0.059***	0.057***	0.044**	0.044**
	(3.868)	(4.191)	(0.009)	(0.010)	(0.018)	(0.018)	(0.022)	(0.022)
Ln (owned cultivable land+1)	29.223***	35.044***	0.038**	0.051***	0.154***	0.151***	0.134***	0.133***
	(8.609)	(9.058)	(0.017)	(0.019)	(0.039)	(0.039)	(0.045)	(0.045)
Owns hand tube well (=1, 0 otherwise)	110.282***	46.695	0.307***	0.157**	0.046	0.073	0.062	0.083
	(26.994)	(30.367)	(0.063)	(0.071)	(0.122)	(0.134)	(0.147)	(0.159)
Access to electricity (=1, 0 otherwise)	12.421	-13.203	0.408***	0.357***	0.519***	0.532***	0.632***	0.632***
	(23.142)	(25.453)	(0.057)	(0.061)	(0.105)	(0.108)	(0.127)	(0.129)
Division level fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2,821.997***	3,085.689***	7.585***	8.115***	15.336***	15.220***	11.699***	11.699***
	(222.972)	(245.743)	(0.535)	(0.585)	(1.016)	(1.036)	(1.212)	(1.269)
Observations	3,213	3,213	3,213	3,213	3,094	3,094	3,203	3,203
F	40.077	34.102	26.200	23.094	12.467	12.048	15.215	15.136

Continued

Continued from Table 14.8

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Adjusted R^2	0.270	0.170	0.173	0.091	0.111	0.110	0.107	0.106
Hansen J p, Ho: instruments valid		0.553		0.423		0.425		0.255
Under ID test p, Ho: underidentified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		27.216		27.216		25.550		25.764
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.566		0.446
A-R Wald Chi2 test, p-value		0.000		0.000		0.559		0.439
Endogeneity test p, Ho: exogenous		0.000		0.000		0.860		0.646
First stage Adjusted R^2 (Gender parity gap)		0.121		0.121		0.118		0.121
First stage Adjusted R^2 (Number of food crops produced by household)		0.314		0.314		0.310		0.313

Note: Estimates from base regression without interaction with land. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

For regressions involving male and female BMI, we fail to reject the exogeneity of women's empowerment and household crop production in the adult male and female BMI equations (columns 6 and 8); hence the OLS results (columns 5 and 7) are our preferred estimates for this sample.

Most indicators for women's empowerment do not have any significant impact on adult male (column 5 of Tables 14.3, 14.6, 14.7, and 14.8) and adult female BMI (column 7 of Tables 14.3, 14.4, 14.5, 14.6, 14.7, and 14.8), suggesting that other factors, such as household wealth, education, and occupation (discussed below), are more important determinants of adult male and female nutritional status. However, women's group membership and decision-making concerning credit are negatively and significantly associated with adult male BMI (column 5 of Tables 14.4 and 14.5). Taken together with our findings on calorie availability and dietary diversity, these results suggest that adults in households where the primary female has larger social networks and greater access to credit may have increased energy requirements beyond that which is provided by the increased access to food. The insignificant impacts on females and significant and negative impact on males may result from higher demands on male labor, resulting in higher activity levels and therefore greater energy deficiencies for men. Our findings on credit may also be reflecting poverty, given that credit is typically targeted to women in poor households. These hypotheses deserve further investigation in future work. We find that the number of food crops produced by the household has a strongly significant negative association with adult male BMI in all models, possibly because growing more crops increases the intensity of labor inputs in the field, which is primarily a male domain. Rice price is strongly and positively associated with male and female BMI in all models, possibly working through two pathways. First, an increase in the rice price would increase the income of net sellers of rice (who would typically be farming households), hence BMI of household members is expected to improve. Second, an increase in the rice price may also induce a shift towards higher quality diets, possibly from staple- to protein-based diets.

Household wealth indicators such as owned cultivable land and access to electricity are strongly and positively associated with both male and female BMI in all models; however, the number of dairy cows has a positive and significant impact on adult male BMI only. Dairying is very intensive in female labor (Quisumbing et al. 2013), although we do not find any significant impact on female BMI of dairy cow ownership.

The education of primary male and female also has significant and positive impact on their BMIs. Primary males and females also have higher

BMIs in households where the primary male (household head) is engaged in trading, possibly because trading is less physically strenuous than farming. Household size is significantly and positively associated with male BMI in most models. Pregnancy and lactation status significantly affect women's BMI, with pregnant women having significantly higher BMI, but with lactating women having significantly *lower* BMIs. The latter finding highlights the biological demands of lactation, and indicates that lactating women are a nutritionally vulnerable group in the Bangladeshi context.

14.4.2 Household Wealth and Impact of Women's Empowerment on Food Security

There is suggestive evidence from India (Eswaran, Ramaswami, and Wadhwa 2013) that the relationship between women's empowerment and status (as determined by caste and wealth) may not be positive. Using time allocation data, Eswaran, Ramaswami, and Wadhwa (2013) show that women's market work relative to males is lower in the higher castes, suggesting that greater family status may result in lower autonomy for women. Because land is the most important asset for rural Bangladeshi households, we examine how the relationship between women's empower-ment in agriculture and household food security varies by the size of owned cultivable land. As shown in equation 14.2 (section 14.3.2), we estimate the interaction effect of empowerment and land area, with selected regression results presented in Table 14.9. The IV diagnostics for the regressions involving calorie availability and dietary diversity (Models 1, 2, 4 and 6) show that while the results of the Anderson Rubin, over-identification, and under-identification tests deteriorate to some extent, endogenous variables are still relevant, null hypotheses of exogeneity can be rejected, instruments remain valid, and models are identified. However, for Models 3 and 5, we fail to reject the null that the model is under-identified; the weak-identification test results for Models 3, 4, and 5 suggest that our instruments are weak. For the regressions involving male and female BMI, we fail to reject the exogeneity of women's empowerment and household crop production in the adult male and female BMI equations; hence the OLS results (columns 5 and 7) are taken to be valid for this sample. Given the weak performance of the 2SLS estimates in Models 3, 4, and 5 in the regressions with interactions (compared to base regression), we treat the results of the augmented regressions with appropriate caveats, and focus on the discussion of the interaction terms rather than the main effects, for which the impacts are qualitatively similar to base regressions.

Table 14.9: Estimates from Household Food Security Outcome Regressions with Land Interactions

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model 1: Women's empowerment score								
Empowerment score of woman	236.420***	878.890***	0.575***	2.244***	-0.222	-0.432	-0.253	-0.577
	(50.699)	(184.769)	(0.131)	(0.460)	(0.225)	(0.841)	(0.282)	(0.948)
Ln (owned cultivable land+1)	29.371	-3.467	0.113**	0.181	0.059	-0.082	0.136	-0.494
	(23.518)	(75.926)	(0.050)	(0.150)	(0.104)	(0.312)	(0.131)	(0.385)
Empowerment score of woman× Ln (owned cultivable land+1)	-1.438	49.081	-0.112	-0.206	0.140	0.349	-0.005	0.926
	(31.270)	(112.493)	(0.068)	(0.219)	(0.141)	(0.460)	(0.180)	(0.564)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	40.566	37.049	25.761	24.237	12.348	12.153	14.587	14.472
Adjusted R^2	0.274	0.225	0.176	0.122	0.113	0.112	0.105	0.093
Hansen J p, Ho: instruments valid		0.231		0.446		0.526		0.630
Under ID test p, Ho: underidentified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		20.703		20.703		19.911		19.682
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.643		0.562
A-R Wald Chi2 test, p-value		0.000		0.000		0.633		0.551
Endogeneity test p, Ho: exogenous		0.000		0.000		0.962		0.192

Continued

Continued from Table 14.9

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model 2: Women's group membership								
Number of groups woman is an active member of	48.466**	692.446***	0.162***	1.719***	-0.301***	-0.320	0.173	-0.262
	(24.499)	(170.405)	(0.063)	(0.433)	(0.109)	(0.645)	(0.132)	(0.758)
Ln (owned cultivable land+1)	32.219***	32.722	0.059***	0.092*	0.135***	0.111	0.189***	-0.042
	(9.388)	(27.536)	(0.018)	(0.053)	(0.044)	(0.104)	(0.049)	(0.127)
Number of groups woman is an active member of	-15.431	34.626	-0.088**	-0.101	0.061	0.165	-0.232**	0.756
× Ln (owned cultivable land+1)	(18.423)	(119.194)	(0.038)	(0.214)	(0.077)	(0.407)	(0.091)	(0.519)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	39.023	30.405	25.014	20.564	12.741	12.188	14.875	13.992
Adjusted R^2	0.270	0.050	0.173	-0.045	0.115	0.114	0.107	0.063
Hansen J p, Ho: instruments valid		0.108		0.368		0.313		0.473
Under ID test p, Ho: underidentified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		5.229		5.229		4.380		5.327
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.497		0.407
A-R Wald Chi2 test, p-value		0.000		0.000		0.485		0.394
Endogeneity test p, Ho: exogenous		0.000		0.000		0.992		0.117

Continued

Continued from Table 14.9

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model 3: Women's decisions on credit								
Average number of decisions over credit	4.529	705.155***	-0.006	0.659	-0.112**	-0.655	0.005	-1.139
	(11.728)	(253.810)	(0.031)	(0.462)	(0.053)	(0.718)	(0.066)	(0.945)
Ln (owned cultivable land+1)	33.918***	152.357*	0.056**	0.155	0.185***	0.289	0.217***	-0.003
	(12.219)	(88.380)	(0.023)	(0.132)	(0.052)	(0.376)	(0.062)	(0.400)
Average number of decisions over credit × Ln (owned cultivable land+1)	-6.854	-149.154	-0.022	-0.139	-0.034	-0.143	-0.094**	0.160
	(8.167)	(97.669)	(0.016)	(0.147)	(0.037)	(0.411)	(0.043)	(0.445)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	39.136	18.759	24.735	21.297	12.426	10.937	14.740	13.267
Adjusted R^2	0.269	-0.539	0.171	0.030	0.115	0.065	0.107	0.019
Hansen J p, Ho: instruments valid		0.334		0.032		0.415		0.533
Under ID test p, Ho: underidentified		0.269		0.269		0.452		0.190
Weak ID test stat (Kleibergen-Paaprk Wald F)		1.000		1.000		0.794		1.135
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.516		0.501
A-R Wald Chi2 test, p-value		0.000		0.000		0.506		0.490
Endogeneity test p, Ho: exogenous		0.000		0.029		0.878		0.279

Continued

Continued from Table 14.9

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model 4: Women's ownership of assets								
Number of assets woman has self/joint ownership of	38.631***	174.917***	0.118***	0.231***	0.042	-0.012	0.066	-0.141
	(9.214)	(35.279)	(0.021)	(0.083)	(0.039)	(0.154)	(0.047)	(0.183)
Ln (owned cultivable land+1)	42.827***	156.687**	0.074***	0.164	0.181***	0.311	0.175**	-0.037
	(13.099)	(76.327)	(0.029)	(0.112)	(0.065)	(0.254)	(0.073)	(0.333)
Number of assets woman has self/joint ownership of × Ln (owned cultivable land+1)	-6.962	-59.385*	-0.018*	-0.058	-0.013	-0.075	-0.019	0.078
	(4.683)	(33.890)	(0.010)	(0.050)	(0.024)	(0.118)	(0.028)	(0.150)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	39.678	34.728	26.469	24.045	12.349	11.876	14.717	14.383
Adjusted R^2	0.274	0.201	0.180	0.164	0.113	0.107	0.106	0.096
Hansen J p, Ho: instruments valid		0.703		0.243		0.465		0.580
Under ID test p, Ho: underidentified		0.010		0.010		0.008		0.013
Weak ID test stat (Kleibergen-Paaprk Wald F)		2.085		2.085		2.261		2.052
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.001		0.623		0.656
A-R Wald Chi2 test, p-value		0.000		0.001		0.612		0.646
Endogeneity test p, Ho: exogenous		0.000		0.059		0.899		0.274

Continued

Continued from Table 14.9

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model 5: Women's rights over assets								
Number of self/joint decisions over purchase, sale or transfer of assets made by woman	6.045***	23.091***	0.019***	0.027**	-0.007	0.012	0.004	0.009
	(1.337)	(5.225)	(0.003)	(0.013)	(0.006)	(0.023)	(0.007)	(0.028)
Ln (owned cultivable land+1)	30.912**	126.288	0.061**	0.334*	0.128**	0.481*	0.088	0.226
	(12.666)	(78.503)	(0.027)	(0.184)	(0.060)	(0.284)	(0.068)	(0.405)
Number of self/joint decisions over purchase, sale or transfer of assets made by woman×Ln (owned cultivable land+1)	-0.351	-7.580	-0.002	-0.022*	0.002	-0.024	0.003	-0.007
	(0.789)	(5.522)	(0.001)	(0.013)	(0.004)	(0.020)	(0.004)	(0.029)
Observations	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263
F	39.768	35.436	27.011	22.323	12.319	11.515	14.612	14.541
Adjusted R^2	0.275	0.223	0.181	0.131	0.113	0.088	0.106	0.100
Hansen J p, Ho: instruments valid		0.165		0.316		0.583		0.474
Under ID test p, Ho: underidentified		0.238		0.238		0.134		0.234
Weak ID test stat (Kleibergen-Paaprk Wald F)		1.156		1.156		1.376		1.164
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.001		0.623		0.656
A-R Wald Chi2 test, p-value		0.000		0.001		0.612		0.646
Endogeneity test p, Ho: exogenous		0.006		0.086		0.633		0.553

Continued

Continued from Table 14.9

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model 6: Women's gender parity gap								
Gender parity gap (=0 if woman enjoys gender parity, 'gap' if not)	-161.629***	-1,335.018***	-0.380***	-2.855***	0.342	0.876	0.268	1.200
	(54.641)	(281.034)	(0.145)	(0.694)	(0.258)	(1.227)	(0.321)	(1.361)
Ln (owned cultivable land+1)	29.784***	37.863	0.044**	0.040	0.186***	0.252**	0.121**	0.366***
	(10.399)	(28.102)	(0.022)	(0.054)	(0.050)	(0.114)	(0.058)	(0.136)
Gender parity (=0 if woman enjoys gender parity, 'gap' if not) × Ln (owned cultivable land+1)	-3.094	-14.139	-0.030	0.068	-0.174	-0.541	0.071	-1.285*
	(37.327)	(144.634)	(0.076)	(0.296)	(0.154)	(0.576)	(0.211)	(0.718)
Observations	3,213	3,213	3,213	3,213	3,094	3,094	3,203	3,203
F	38.725	32.434	25.290	22.113	12.065	11.746	14.718	14.468
Adjusted R^2	0.270	0.158	0.173	0.077	0.111	0.109	0.107	0.090
Hansen J p, Ho: instruments valid		0.473		0.213		0.607		0.770
Under ID test p, Ho: underidentified		0.000		0.000		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		11.450		11.450		10.940		10.691
Anderson-Rubin, Ho: endogvars irrelevant								
A-R Wald test, p-value		0.000		0.000		0.689		0.640
A-R Wald Chi2 test, p-value		0.000		0.000		0.679		0.629
Endogeneity test p, Ho: exogenous		0.000		0.000		0.890		0.147

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

The interactions of the women's empowerment indicators with the size of owned land are significant only in some models, and these results should also be taken with caution, given the performance of the instruments. Calorie availability tends to decrease in larger landowner households where women own more assets (column 2 of Model 4, Table 14.9) and diet diversity decreases in larger landowner households where women take more decisions concerning assets (column 4 of Model 5, Table 14.9).[10] For households owning more land, women who are involved in a greater number of groups and make more decisions on credit tend to have lower BMI (column 7 of Models 2 and 3). With appropriate caveats, these results appear to indicate that the positive effect of different dimensions of female empowerment on food security outcomes is greater for smaller landowners, that is, for less well-off households. While these results are broadly consistent with the findings of Eswaran, Ramaswami, and Wadhwa (2013), they also point to the potential positive redistributive effect of focusing women's empowerment efforts on poorer households.

14.4.3 Magnitudes of Women's Empowerment Effects

Table 14.10 presents the elasticities of per capita calorie availability, household dietary diversity, and adult BMI with respect to the empowerment indicators and three household characteristics—number of food crops produced by household, years of education of household head, and area of cultivable land owned by household. Although the endogeneity tests lead to the rejection of the null hypothesis that the empowerment variables are exogenous, the IV diagnostics lead us to doubt the validity of our 2SLS estimates for some of the measures of empowerment.[11] Moreover, although the empowerment indicators emerged as significant in the 2SLS base regressions, because the elasticities computed from the 2SLS specification use predicted values of both dependent and explanatory variables, the standard errors of the IV elasticities are quite large. These large standard errors lead to the inability to estimate elasticities precisely using the IV specification, and lead one to accept the null hypotheses that these elasticity estimates are insignificant, even if they are larger in magnitude than the OLS estimates. We therefore base our discussion of the elasticity estimates mostly on the OLS results, treating them as a lower bound, given the imprecision of the IV elasticity estimates. We find that the magnitude of the impact on calorie availability (column 1) and dietary diversity (column 3)

[10] However, both of these regressions have weak instruments, and the model is underidentified in the diet diversity regression with land interactions.

[11] For Models 2 and 3 (group membership and credit decisions, respectively), instruments are weak in the calorie availability and diet diversity regressions; in Model 5 (women's rights over assets), the Hansen J test rejects the null hypothesis that instruments are valid in the calorie availability regression.

of the overall empowerment score is the highest—a 10 percent increase in the empowerment score leads to a 6.3 percent increase in calorie availability and a 3.5 percent increase in dietary diversity in the OLS regressions. After controlling for the potential endogeneity of empowerment and crop production diversity, the magnitudes are even higher; a 10 percent increase in the empowerment score leads to a 24 percent increase in calorie availability (column 2) and a 13.6 percent increase in dietary diversity (column 4), although as mentioned above, these elasticities are imprecisely estimated. Among the component indicators, the largest elasticities are with respect to women's rights over assets (0.027 for calorie availability and 0.022 for diet diversity) and women's ownership of assets (0.026 for calorie availability and 0.021 for diet diversity) for the OLS estimates.[12] We also find that most empowerment indicators have larger effects on calorie availability and dietary diversity than selected household variables, for both OLS and IV estimates. For example, based on the OLS estimates, we find that a 10 percent increase in the assets owned by woman has an effect of increasing calorie availability by 2.6 percent. However, the same proportional increase in the number of food crops, years of education of household head, and area of land owned lead to respective increases of 1.8, 0.09, and 0.11 percent in calorie availability. The relative magnitudes of empowerment elasticities compared to household characteristics are similar for the IV elasticities.

The magnitudes of the effects of the empowerment indicators on adult BMI are relatively smaller than the effects on other food security outcomes; OLS elasticities range from 0.001 (effect of number of groups women is active in on female BMI) to 0.008 (effect of overall empowerment on female BMI). For both OLS and IV estimates, we also find that the impacts of various indicators of empowerment on BMI are relatively smaller than that of other household characteristics.

Although the results of elasticities analysis point to the importance of women's empowerment in general, and women's asset ownership in particular, for improving household food security, they do not yield conclusive evidence that prioritizing women's empowerment alone should take precedence over improving other determinants of food security. The magnitudes of the elasticity estimates, even where significant, are small. Moreover, one must recognize the limitations of elasticity analyses in general, because elasticities isolate the effects of a single variable, whereas food security is determined by the interaction of many variables, not just women's empowerment. This analysis also does not indicate, in practice, how increases in these underlying variables are to be achieved. Because our elasticity estimates are computed at the sample means, they may not be indicative of differential responses across the empowerment or wealth distribution. This can be explored in future work.

[12] For the 2SLS elasticities, the largest are with respect to credit, however, the instruments are weak.

Table 14.10: Elasticities of Calorie Availability, Dietary Diversity, and Adult BMI with respect to Empowerment Indicators and Other Household Characteristics

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)	OLS (8)	2SLS (9)
Empowerment score of woman	0.063*** (0.013)	0.240 (224.877)	0.035*** (0.008)	0.136 (139.752)	-0.004 (0.007)	-0.015 (125.432)	-0.008 (0.009)	0.001 (138.552)
Number of groups woman is an active member of	0.005* (0.003)	0.107 (118.956)	0.004* (0.002)	0.058 (70.462)	-0.004** (0.002)	-0.002 (52.659)	0.001 (0.002)	0.008 (57.681)
Average number of decisions over credit	-0.000 (0.004)	0.310 (584.159)	-0.002 (0.003)	0.094 (264.171)	-0.006*** (0.002)	-0.028 (179.205)	-0.003 (0.003)	-0.041 (221.669)
Number of assets woman has self/joint ownership of	0.026*** (0.007)	0.115 (126.640)	0.021*** (0.004)	0.037 (77.334)	0.003 (0.003)	-0.007 (68.572)	0.005 (0.004)	-0.013 (78.939)
Number of self/joint decisions over purchase, sale or transfer of assets made by woman	0.027*** (0.006)	0.094 (118.856)	0.022*** (0.004)	0.020 (75.924)	-0.003 (0.003)	0.001 (64.359)	0.004 (0.004)	0.001 (77.964)
Gender parity (=0 if woman enjoys gender parity, 'gap' if not)	-0.011*** (0.004)	-0.086 (83.338)	-0.007*** (0.002)	-0.045 (51.081)	0.002 (0.002)	0.007 (45.363)	0.003 (0.002)	0.002 (48.585)
Range of elasticity estimates for other household characteristics								
Number of food crops produced by household	0.017*** -0.020*** (0.005)	-0.019 - 0.021 (134.99-58.31)	0.009*** -0.011*** (0.003)	(0.018-0.026) (35.957-60.373)	-0.006** - -0.005** (0.002)	-0.006 - 0.001 (31.487-36.018)	0.002 - 0.003 (0.003)	-0.007-0.001 (37.044-51.617)

Continued

Continued from Table 14.10

Variable	Per capita calorie availability		Household dietary diversity		Male BMI		Female BMI	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(8)	(9)
Years of education of household head	0.009*** -0.011*** (0.004)	0.005-0.021 (19.39-36.018)	0.022*** - 0.023*** (0.002)	0.021-0.026 (11.434-16.385)	0.017*** - 0.018*** (0.002)	0.017-0.018 (10.652-12.662)	0.016*** - 0.017*** (0.003)	0.016-0.018 (14.342-16.210)
Area of cultivable land owned by household (in decimals)	0.010*** -0.012*** (0.003)	0.008-0.017 (16.887-26.744)	0.003* - 0.004** (0.002)	0.003-0.007 (8.864-11.183)	0.007*** - 0.008*** (0.002)	0.008 (9.369 - 9.762)	0.006*** (0.002)	0.006 -0.007 (10.255-10.844)
Observations*	3,273	3,273	3,273	3,273	3,150	3,150	3,263	3,263

Note: Calculated from base regressions without land interactions, and evaluated at the mean. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.For analyses involving the gender parity variable, the number of observations is reduced to 3,213 for calorie availability and household dietary diversity, 3,094 for male BMI, and 3,203 for female BMI.

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Table 14.11: Model 1: Women's Empowerment Score and Per Adult Equivalent Calorie Availability

Variable	Per adult equivalent calorie availability	
	OLS	2SLS
	(1)	(2)
Empowerment score of woman	288.921***	1,100.588***
	(62.155)	(222.549)
Age (in years) of household head	15.973*	10.402
	(8.263)	(8.878)
Age-squared of household head	-0.125	-0.070
	(0.091)	(0.098)
Years of education of household head	10.697**	10.458**
	(4.301)	(4.359)
Household head is farmer (=1, 0 otherwise)	113.970***	128.657***
	(34.050)	(44.806)
Household head is trader (=1, 0 otherwise)	59.686	31.296
	(49.750)	(51.950)
Household size	-96.703***	-91.121***
	(11.207)	(11.835)
Proportion of males 0-4 years old	-944.962***	-979.262***
	(262.404)	(273.466)
Proportion of males 5-10 years old	-957.435***	-1,031.235***
	(245.035)	(254.336)
Proportion of males 11-18 years old	-1,067.528***	-1,142.455***
	(239.740)	(248.049)
Proportion of males 19-59 years old	-1,333.262***	-1,336.144***
	(201.741)	(207.133)
Proportion of females 0-4 years old	-962.667***	-947.325***
	(261.802)	(271.576)
Proportion of females 5-10 years old	-502.199**	-598.276**
	(251.845)	(259.839)
Proportion of females 11-18 years old	-401.619	-533.342**
	(258.228)	(265.836)
Proportion of females 19-59 years old	-647.129**	-710.284**
	(293.254)	(301.181)
Proportion of females 60 years and older	-22.718	-67.253
	(328.560)	(336.961)

Continued

Continued from Table 14.11

Variable	Per adult equivalent calorie availability	
	OLS	2SLS
	(1)	(2)
Number of food crops produced by household	46.953***	38.191
	(11.552)	(30.280)
Number of dairy cows owned	61.363***	53.355***
	(13.387)	(14.755)
Price of rice (in taka)	-4.741	-1.389
	(5.073)	(5.225)
Ln (owned cultivable land+1)	37.980***	39.720***
	(10.885)	(11.116)
Owns hand tube well (=1, 0 otherwise)	119.506***	50.227
	(34.431)	(37.775)
Access to electricity (=1, 0 otherwise)	11.354	-19.400
	(29.507)	(31.497)
Division level fixed-effects	Yes	Yes
Constant	4,008.168***	3,575.073***
	(282.009)	(309.563)
Observations	3,273	3,273
F	18.594	17.909
Adjusted R^2	0.187	0.142
Hansen J p, Ho: instruments valid		0.249
Under ID test p, Ho: underidentified		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		41.798
Anderson-Rubin, Ho: endogvars irrelevant		
A-R Wald test, p-value		0.000
A-R Wald Chi2 test, p-value		0.000
Endogeneity test p, Ho: exogenous		0.000

14.5 Conclusions and Policy Implications

This chapter demonstrates that the recently-developed WEAI can be used not only to assess the extent of women's empowerment in agriculture, but also to identify areas where the gaps in empowerment are greatest. By breaking down the WEAI into its component domains and indicators, we have identified that the domains of leadership in the community and

control of resources are the most promising areas for policy intervention. Our analysis also highlights the importance of increasing the number of groups in which women actively participate and increasing women's control of assets. To what extent are the strategic and programmatic priorities of government and civil society aligned with closing empowerment gaps, specifically in these areas of greatest disempowerment? Because the NGOs sector has emerged as an important alternative delivery channel for social services, and provides complementary avenues for poor women to access basic services alongside state-run services (Nazneen, Hossain, and Sultan 2011), we consider both government and civil society initiatives in answering this question.

These empowerment gaps must be taken in the context of the country's impressive gains in women's health and girls' education relative to comparator countries in the past two decades (Nazneen, Hossain, and Sultan 2011), with rapid reduction in fertility rates, infant and child mortality, and maternal mortality, and the closing of the gender gap in primary and secondary enrollment. Women's economic and social advancement are also stated goals of public policy, falling under the purview of the Ministry of Women and Children Affairs (MOWCA). In assessing progress in implementing the government's policy commitments to gender equality, MOWCA (2010) finds that the greatest emphasis of government ministries is on improving the gender balance of staff and working conditions of women. However, less than a third of the ministries (14 out of 47 responding to a questionnaire) identify economic advancement as a programmatic area, and within this area, women's economic participation in the labor force is emphasized, not increasing control over assets or income derived from economic activities. Protection of legal rights focused on birth registration, eliminating child labor, and combating early marriage and dowry-related violence, not on equal rights to own assets. The only program that explicitly mentions strengthening women's rights to assets is a program of the Ministry of Land that leases out *khas* (government-owned) land to wives and husbands on an equal rights basis in the Model Village and Cluster Village Project (MOWCA 2010, 42).

With regards to leadership in the community, despite the two top political leaders being women, Bangladeshi women in general have fared far less well with respect to participation in national politics than women in comparator countries (Nazneen, Hossain, and Sultan 2011, 12). The established political parties tend to focus on conventional and uncontroversial women's issues such as maternal healthcare, girl's education, political participation, violence against women in the public sphere, and certain forms of domestic violence

such as dowry-related violence (Nazneen, Hossain, and Sultan 2011, 24). Policy documents and pronouncements on strengthening women's leadership in the community are quite vague, although MOWCA (2011, authors' translation) mentions the role of District Women Affairs Officers and Upazila Women Affairs Officers in implementing programs undertaken for development of women in economic advancement ministries, as well as a move to organize women into self-sustained groups at the village and union levels, with the possibility of registering these groups as formal organizations under different government organizations.

Donor policy documents do not highlight women's participation in mass party politics as a route to women's empowerment, but make greater reference to working with civil society as a route to strengthening women's voice at the local levels (Nazneen, Hossain, and Sultan 2011). Nevertheless, civil society efforts need a supportive policy environment to be effective, and often work against deep-seated economic and social barriers to women's empowerment. While NGOs have been active in increasing their membership base among poor rural women, women with more bargaining power within their households (owing to greater schooling or assets brought to marriage) are more likely to participate in NGOs (Quisumbing 2009). Group-based efforts have often been unable to reach the ultra-poor, because many group-based activities, such as those in microfinance, require a minimum level of resources for participation, such as funds for compulsory savings requirements.

Long-seated systems of property rights that favor men in terms of inheritance, and the difficulty that women face in accumulating assets that they can control, need to be addressed so that women can build up their control of assets. This suggests that reforms of inheritance and property rights law more broadly, and specific interventions to increase women's control of assets, would be important parts of the policy agenda to reduce gender inequality. These could include targeted asset transfers to poor women (similar to those implemented by BRAC through its Targeting the Ultra Poor [TUP] Program) as well as efforts to improve women's access to financial instruments (both savings and credit) so they can accumulate assets. However, even if assets are transferred to women, a recent impact evaluation of BRAC's TUP program shows that there is no guarantee that they will retain control of the transferred assets or other assets acquired from incomes generated from the transferred assets (Das et al. 2013). While the National Women's Development Policy formulated by the Ministry of Women and Children Affairs aims to 'ensure full control of women of the property earned through own labor, inheritance, debt, land

and market management' (MOWCA 2011, authors' translation), it does not offer specific pronouncements about efforts to reform property law to improve gender equity. Our finding that not only absolute empowerment, but relative empowerment of women within households, also positively affects household food security provides additional support for policies to narrow the gender gap in Bangladesh.

Our results also highlight the importance of investing in the agriculture sector as a whole to increase production diversity. The BIHS results show that about 77 percent of the total cropped area in Bangladesh is under rice cultivation, implying very little crop diversity. Significant advances in agricultural research have focused mainly on rice. Our findings call for increased investment in agricultural research to enhance productivity of non-rice food crops such as pulses, vegetables and fruits. The positive impacts of tube well ownership and access to electricity also suggest that investments in complementary infrastructure will be important to increase household level food energy availability and dietary diversity. Lastly, continued investments in schooling, particularly of women and girls, will be important not only to increase food security, but also to narrow the gender gap in human capital.

References

Agarwal, Bina. 1994. *A Field of One's Own: Gender and Land Rights in South Asia*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO 9780511522000.

Ahmed, A. U., Ahmad Kaikaus, Victoria Chou, Ricardo Hernandez, Purnima Menon, Farria Naeem, Firdousi Naher, Wahid Quabili, Esha Sraboni, and Bingxin Yu. 2013. *The Status of Food Security in the Feed the Future Zone and Other Regions of Bangladesh: Results from the 2011-2012 Bangladesh Integrated Household Survey*. Project report submitted to the U.S. Agency for International Development. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/singleitem/collection/p15738coll2/id/127518/rec/2.

Ahmed, Akhter U., Ruth Vargas Hill, Lisa C. Smith, Doris M. Wiesmann, and Tim Frankenberger. 2007. *The World's Most Deprived: Characteristics and Causes of Extreme Poverty and Hunger. 2020 Vision for Food.* Agriculture, and the Environment Discussion Paper No. 43. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.2499/0896297705.

Ahmed, Akhter U., and Yawar Shams. 1994. "Demand Elasticities in Rural Bangladesh: An Application of the AIDS Model." *Bangladesh Development Studies* 22, no. 1: 1-26.

Alderman, Harold, Pierre-André Chiappori, Lawrence Haddad, John F. Hoddinott, and Ravi Kanbur. 1995. "Unitary versus Collective Models of the Household: Is It Time to Shift the Burden of Proof?" *World Bank Research Observer* 10, no. 1: 1-19.

Alkire, Sabina, and James Foster. 2011. "Counting and Multidimensional Poverty Measurement." *Journal of Public Economics* 95, no. 7-8: 476-487. https://doi.org/10.1016/j.jpubeco.2010.11.006.

Alkire, Sabina, Ruth Meinzen-Dick, Amber Peterman, Agnes R. Quisumbing, Greg Seymour, Ana and Vaz. 2013. "The Women's Empowerment in Agriculture Index." *World Development* 52: 71-91. https://doi.org/10.1016/j.worlddev.2013.06.007.

Arimond, M., C. Hawkes, M. T. Ruel, Z. Sifri, P. R. Berti, J. L. Leroy, J. W. Low, L. R. Brown, and E. A. Frongillo. 2010. "Agricultural Interventions and Nutrition: Lessons from the Past and New Evidence." In *Combating Micronutrient Deficiencies: Food-Based Approaches*, edited by B. Thompson and L. Amoroso, 41-75. Rome: Food and Agriculture Organization of the United Nations and CAB International.

Asaduzzaman, M. 2010. "The Next Agricultural Transition in Bangladesh: Which Transition, Why, and How." In conference on Understanding the Next Generation in Asia. Bangkok (Vol. 23).

Baum, Christopher F., Mark E. Schaffer, and Steven Stillman. 2010. "IVREG2: Stata Module for Extended Instrumental Variables/2SLS and GMM and AC/HAC, LIML and k-class Regression." http://ideas.repec.org/c/boc/bocode/s425401.html.

Carletto, Calogero, Alberto Zezza, and Raka Banerjee. 2013. "Towards Better Measurement of Household Food Security: Harmonising Indicators and the Role of Household Surveys." *Global Food Security* 2, no. 1: 30-40. https://doi.org/10.1016/j.gfs.2012.11.006.

Das, Narayan, Rabeya Yasmin. Jinnat Ara, Md. Kamruzzaman, Peter Davis, Shalini Roy, and Agnes R. Quisumbing. 2013. *How Do Intra household Dynamics Change When Assets are Transferred to Women? Evidence from BRAC's Challenging the Frontiers of Poverty Reduction—Targeting the Ultra-Poor Programme in Bangladesh*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Deere, Carmen Diana, Abena D. Oduro, Hema Swaminathan, and Cheryl Doss. 2013. "Property Rights and the Gender Distribution of Wealth in Ecuador, Ghana and India." *The Journal of Economic Inequality* 11, no. 2: 249-265. https://doi.org/10.1007/s10888-013-9241-z.

Doss, Cheryl. 2006. "The Effects of Intra-household Property Ownership on Expenditure Patterns in Ghana." *Journal of African Economies* 15, no. 1: 149-180. https://doi.org/10.1093/jae/eji025.

Duflo, Esther, and Christopher Udry. 2004. *Intrahousehold Resource Allocation in Cote d'Ivoire: Social Norms, Separate Accounts, and Consumption Choices.* Working Paper No. 10498. Cambridge, M.A.: National Bureau of Economic Research. https://doi.org/10.3386/w10498.

Eswaran, Mukesh, Bharat Ramaswami, and Wilima Wadhwa. 2013. "Status, Caste, and the Time Allocation of Women in Rural India." *Economic Development and Cultural Change* 61, no. 2: 311-333. https://doi.org/10.1086/668282.

FAO (Food and Agriculture Organization of the United Nations). 2011a. *The State of Food and Agriculture 2010-2011. Women in Agriculture: Closing the Gender Gap for Development*. Rome: FAO.

___. 2011b. *Guidelines for Measuring Household and Individual Dietary Diversity.* Rome: FAO.

Haddad, Lawrence James, John F. Hoddinott, and Harold Alderman. 1997. *Intrahousehold Resource Allocation in Developing Countries: Models, Methods, and Policy*. Baltimore, M.D.: Johns Hopkins University Press for the International Food Policy Research Institute (IFPRI).

Hallman, Kelly. 2003. "Mother-Father Resources, Marriage Payments, and Girl-Boy Health in Rural Bangladesh." In *Household Decisions, Gender, and Development: A Synthesis of Recent Research*, edited by A. R. Quisumbing, 115-120). Washington, D.C.: International Food Policy Research Institute (IFPRI).

Hatlôy, Anne, Jesper Hallund, Modibo M. Diarra, and Arne Oshaug. 2000. "Food Variety, Socioeconomic Status, and Nutritional Status in Urban and Rural Areas in Koutiala (Mali)." *Public Health Nutrition* 3, no. 1: 57-65. https://doi.org/10.1017/S1368980000000628.

Hoddinott, John, and Lawrence Haddad. 1995. "Does Female Income Share Influence Household Expenditures? Evidence from Côte d'Ivoire." *Oxford Bulletin of Economics and Statistics* 57, no. 1: 77-96. https://doi.org/10.1111/ j.1468-0084.1995.tb00028.x.

Hoddinott, John, and Yisehac Yohannes. 2002. *Dietary Diversity as a Food Security Indicator*. Food Consumption and Nutrition Division Discussion Paper No. 136. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Kabeer, Naila. 1994. "Women's Labor in the Bangladesh Garment Industry: Choices and Constraints." In *Muslim Women's Choices. Religious Belief and Social Reality*, edited by C. Fawzi El-Solh and J. Mabro, 164-183). Oxford, UK: Berg Publishers.

___. 1999. "Resources, Agency, Achievements: Reflections on the Measurement of Women's Empowerment." *Development and Change* 30, no. 3: 435-464. https://doi.org/10.1111/ 1467-7660.00125.

Kilic, Talip, Amparo Palacios-Lopez, and Markus Goldstein. 2013. *Caught in a Productivity Trap: A Distributional Perspective on Gender Differences in Malawian Agriculture*. World Bank Policy Research Working Paper No. 6381. Washington, D.C.: World Bank. http://hdl.handle.net/10986/13182.

Kumar, Neha, and Agnes R. Quisumbing. 2010. *Does Social Capital Build Women's Assets? The Long-Term Impacts of Group-Based and Individual Dissemination of Agricultural Technology in Bangladesh*. CAPRi Working Paper No. 97. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.2499/CAPRiWP97.

MOWCA (Ministry of Women and Children Affairs). 2010. *Gender Equality in Bangladesh: Progress and Road Ahead*. Dhaka: Ministry of Women and Children Affairs, Government of Bangladesh.

___. 2011. National Women Development Policy 2011 (in Bangla). Dhaka: Ministry of Women and Children Affairs, Government of Bangladesh. http://www.mowca.gov.bd/?p=436.

Nazneen, Sohela, Naomi Hossain, and Maheen Sultan. 2011. *National Discourses on Women's Empowerment in Bangladesh: Continuities and Change*. IDS Working Paper No. 368. Brighton, UK: Institute of Development Studies. https://doi.org/10.1111/j.2040-0209. 2011.00368_2.x.

Peterman, Amber, Julia A. Behrman, and Agnes R. Quisumbing. 2010. *A Review of Empirical Evidence on Gender Differences in Non land Agricultural Inputs, Technology, and Services in Developing Countries*. Discussion Paper No. 975. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Quisumbing, Agnes R. 1994. "Intergenerational Transfers in Philippine Rice Villages: Gender Differences in Traditional Inheritance Customs." *Journal of Development Economics* 43, no. 2: 167-195. https://doi.org/10.1016/0304-3878(94)90003-5.

Quisumbing, Agnes R., ed. 2003. *Household Decisions, Gender, and Development: A Synthesis of Recent Research*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Quisumbing, Agnes R. 2009. *Beyond the Bari: Gender, Groups, and Social Relations in Rural Bangladesh*. CAPRi Working Paper No. 96. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.2499/ CAPRiWP96.

Quisumbing, Agnes R., and John A. Maluccio. 2003. "Resources at Marriage and Intra-Household Allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa." *Oxford Bulletin of Economics and Statistics* 65, no. 3: 283-327. https://doi.org/10.1111/1468-0084.t01-1-00052.

Quisumbing, Agnes R., and Kelly Hallman. 2005. "Marriage in Transition: Evidence on Age, Education, and Assets from Six Developing Countries." In *The Changing Transitions to Adulthood in Developing Countries: Selected Studies, Panel on Transitions to Adulthood in Developing Countries*, edited by C. B. Lloyd, J. R. Behrman, N. P. Stromquist, and B. Cohen, 200-269. Washington, D.C.: Committee on Population, Division of Behavioural and Social Sciences and Education, National Academies Press.

Quisumbing, Agnes R., P. Bhagowalia, P. Menon, and V. Soundararajan. 2009. "Understanding the Dynamics of Gender-Nutrition Linkages in Bangladesh: Evidence from Nationally Representative and Panel Data Sets." Unpublished manuscript, June 30, 2009. International Food Policy Research Institute (IFPRI).

Quisumbing, Agnes, Shalini Roy, Jemimah Njuki, Kakuly Tanvin, and Elizabeth Waithanji. 2013. *Can Dairy Value Chain Projects Change Gender Norms in Rural Bangladesh? Impacts on Assets, Gender Norms, and Time Use.* Discussion Paper No. 1311. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Rahman, Sanzidur. 2000. "Women's Employment in Bangladesh Agriculture: Composition, Determinants, and Scope." *Journal of Rural Studies* 16, no. 4: 497-507. https://doi.org/10.1016/S0743-0167(00)00006-1.

___. 2010. "Women's Labor Contribution to Productivity and Efficiency in Agriculture: Empirical Evidence from Bangladesh." *Journal of Agricultural Economics* 61, no. 2: 318-342. https://doi.org/10.1111/j.1477-9552.2010.00243.x.

Rashid, Dewan Arif, Lisa C. Smith, and Tauhidur Rahman. 2011. "Determinants of Dietary Quality: Evidence from Bangladesh." *World Development* 39, no. 12: 2221-2231. https://doi.org/10.1016/j.worlddev.2011.05.022.

Ruel, Marie T. 2003. "Operationalising Dietary Diversity: A Review of Measurement Issues and Research Priorities." *Journal of Nutrition* 133, no. 11: 3911S-3926S. https://doi.org/10.1093/jn/133.11.3911S.

Skoufias, Emmanuel. 2005. *PROGRESA and Its Impacts on the Welfare of Rural Households in Mexico*. Food Consumption and Nutrition Division Discussion Paper No. 139. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Smith, Lisa C., Usha Ramakrishnan, Aida Ndiaye, Lawrence James Haddad, and Reynaldo Martorell. 2003. "The Importance of Women's Status for Child Nutrition in Developing

Countries." IFPRI Research Report Abstract No. 131. *Food & Nutrition Bulletin* 24, no. 3: 287-288. https://doi.org/10.1177/ 156482650302400309.

Sraboni, Esha, Agnes R. Quisumbing, and Akhter U. Ahmed. 2013. *The Women's Empowerment in Agriculture Index: Results from the 2011-2012 Bangladesh Integrated Household Survey*. Project report submitted to the U.S. Agency for International Development. Dhaka: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/127504.

StataCorp. 2011. "Stata Statistical Software: Release 12." College Station, TX: StataCorp LP.

Stock, James H., and Motoiro Yogo. 2005. "Testing for Weak Instruments in Linear IV Regression." In *Identification and Inference for Econometric Models: Essays in Honour of Thomas Rothenberg*, edited by D. W. K. Andrew and J. H. Stock, 80-108). New York, N.Y.: Cambridge University Press. https://doi.org/10.1017/CBO9780511614491.006.

Udry, Christopher, John F. Hoddinott, Harold Alderman, and Lawrence Haddad. 1995. "Gender Differentials in Farm Productivity: Implications for Household Efficiency and Agricultural Policy." *Food Policy* 20, no. 5: 407-423. https://doi.org/10.1016/0306-9192(95)00035-D.

UNICEF (United Nations Children's Fund). 1990. *Strategy for Improved Nutrition of Women and children in Developing Countries*. New York, N.Y.: UNICEF.

von Grebmer, Klaus, Bella Nestorova, Agnes R. Quisumbing, Rebecca Fertziger, Heidi Fritschel, Rajul Pandya-Lorch, and Yisehac Yohannes. 2009. *2009 Global Hunger Index: The Challenge of Hunger: Focus on Financial Crisis and Gender Inequality.* Bonn/Washington, D.C./Dublin: Deutsche Welthungerhilfe (German AgroAction), International Food Policy Research Institute, and Concern Worldwide.

Yoong, Joanne, Lila Rabinovich, and Stephanie Diepeveen. 2012. *The Impact of Economic Resource Transfers to Women versus Men: A Systematic Review.* Technical Report. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Zaman, Habiba. 1995. "Patterns of Activity and Use of Time in Rural Bangladesh: Class, Gender, and Seasonal Variations." *Journal of Developing Areas* 29, no. 3: 371-388.

Ziaei, Shirin, Ruchira Tabassum Naved, and Eva-Charlotte Ekström. 2012. Women's Exposure to Intimate Partner Violence and Child Malnutrition: Findings from Demographic and Health Surveys in Bangladesh. *Maternal and Child Nutrition* 10, no. 3: 347-359. https://doi.org/10.1111/j.1740-8709. 2012.00432.x.

Chapter 15

Transfers, Behavior Change Communication, and Intimate Partner Violence: Post-program Evidence from Rural Bangladesh[1]

Shalini Roy, Melissa Hidrobo, John Hoddinott, and Akhter U. Ahmed

15.1 Introduction

Intimate partner violence (IPV) is a major global public health problem with economic costs ranging from 1-4 percent of GDP (García-Moreno et al. 2015; Ribero and Sánchez 2005). IPV has multiple malign consequences for women's physical and mental health (Ellsberg et al. 2008; Kapiga et al. 2017) and is the leading cause of women's death by homicide (Devries et al. 2013). Adverse effects are transmitted inter-generationally, with IPV linked to poorer child development, nutrition, and health outcomes, as well as a greater likelihood of children also entering into abusive relationships (Aizer 2010; Fulu et al. 2017; Hasselmann and Reichenheim 2006; Karamagi et al. 2007; Koenen et al. 2003; Pollak 2004; Yount et al. 2011). Using data from 141 studies from 81 countries, Devries et al. (2013) estimate that 30 percent of all adult women have experienced physical or sexual IPV. There is considerable regional variation in this prevalence, with South Asia (41 percent)—the region of our study—among the highest in the world.

Recent interest has grown in the potential of social transfer programs, and in particular cash transfers, to reduce IPV. Transfer programs are a promising platform, in that they are widely used as anti-poverty tools worldwide and are potentially scalable. A growing body of work—largely from Latin America—finds that transfers targeted to women, often conditioned on trainings or

[1] An earlier version of this chapter was published in *The Review of Economics and Statistics,* 101:5, 865-877, Posted Online November 05, 2018. This is reproduced with permission of the publisher.

other activities, reduce the prevalence of physical violence against women by 5 to 11 percentage points (Angelucci 2008 and Bobonis et al. 2013 in Mexico; Hidrobo et al. 2016 in Ecuador; Perova and Vakis 2013 in Peru; Haushofer and Shapiro 2016 in Kenya). While this literature finds some subgroups to be at greater risk of violence—see Angelucci (2008) and Hidrobo and Fernald (2013)—little quantitative evidence has been found of transfer programs leading to increased IPV on average.

The existing literature focuses on two mechanisms as driving the reductions in IPV from transfer programs. First, transfers made to women may improve their bargaining position within the household. Early theoretical models of the economic behavior underlying IPV (Farmer and Tiefenthaler 1997; Tauchen et al. 1991), as well as later variants, view IPV as part of non-cooperative Nash bargaining between partners. In these models, a male's utility increases in the violence he inflicts on his partner, for example because he derives esteem from doing so or because it releases frustration. Constraining his behavior is the female partner's "threat point": her ability to leave the relationship or settle on a non-cooperative equilibrium if unhappy; a social transfer targeted to a woman that remains in her control increases her threat point. While this effect could be reversed if males use IPV to either extract resources from their partners (Bloch and Rao 2002; Bobonis et al. 2013) or ensure that resource allocation is aligned with their preferences (Eswaran and Malhotra 2011), or if males increase violence as backlash against the change in power dynamics (Chin 2012), the existing literature has found limited evidence of increases in IPV playing out as a result of transfers. A second mechanism is that transfers increase total household income and reduce poverty-related stress; this in turn may reduce the conflict within the household that precipitates violence (Buller et al. 2018; Ellsberg et al. 2015; Fox et al. 2002).

Although the literature is encouraging regarding the potential for transfer programs to reduce IPV, it leaves several knowledge gaps. First, what happens to IPV after transfer programs end? Existing studies provide evidence of impacts on IPV while programs are ongoing, but none has post-program quantitative data on IPV. To the extent that qualitative evidence exists, it points to pre-existing levels of IPV reverting as soon as the program ends (Buller et al. 2016). As most programs do not provide transfers indefinitely, this issue is central to whether transfer programs can be a sustainable solution to reducing IPV.

Second, what role do the complementary activities in these transfer programs play, and do these shape post-program effects on IPV? When considering mechanisms, existing studies have focused on the receipt of

transfer income itself. However, most of the transfer programs studied also involve other activities or conditionalities accompanying the transfer. While some of the literature acknowledges that complementary activities might play a role (see Buller et al. 2016), this mechanism is usually viewed as secondary to the transfer itself. Moreover, none of the existing studies can empirically distinguish the effects of transfers from other activities, as they are bundled. Meanwhile, these complementary activities could independently affect IPV. For example, group-based trainings or other activities could strengthen a woman's threat point by improving her self-efficacy and self-esteem, increasing her perceived ability to change her situation (Brody et al. 2017). Group-based activities could also build social capital (Brody et al. 2017) that may persist after the intervention ends (Feigenberg et al. 2013). Social ties could reduce IPV victimization by improving women's threat point as well, providing outlets for victims to escape violent relationships (Stets 1991). Social capital could also increase the social cost of men's violent behavior, by increasing the chances that violence is recognized by others and increasing "social control" in the form of others' disapproval (Stets 1991; Van Wyk et al. 2003). For policy, it is critical to understand which features of transfer programs are needed to reduce IPV and whether adding certain features to transfers leads to more sustainable reductions.

Third, do existing findings generalize globally? The empirical literature on transfers and IPV is dominated by studies from Latin America, with fewer studies from other parts of the developing world where gender dynamics may differ. In rural Bangladesh, where patriarchal norms and female seclusion are prevalent, existing work on violence finds an ambiguous relationship between IPV and women's autonomy as well as other factors typically seen as improving women's threat point (Fakir et al. 2016; Schuler et al. 2013). For example, evidence from Bangladesh is inconclusive regarding effects on IPV of participating in microcredit groups (Bates et al. 2004; Bhuiya et al. 2003; Hadi 2000) and of women's employment (Bates et al. 2004; Hadi 2005). The relationship between women's economic empowerment and IPV in Bangladesh has also been found to depend on community characteristics, with evidence suggesting that as women's autonomy becomes more accepted at the community level, it may no longer trigger violence (Koenig et al. 2003; World Bank 2008). If the relationship between IPV and its determinants is shaped by different contextual factors across regions, then context could alter how transfer programs affect IPV as well.

This study contributes to filling these knowledge gaps: we investigate what happens to IPV after social transfers end; we disentangle the effects of a transfer from the effects of other accompanying features on IPV; and

we situate our study in Bangladesh, a South Asian country where IPV is high and social norms are conservative. Our analysis uses data from the Transfer Modality Research Initiative (TMRI), a pilot safety net program in rural Bangladesh in which women in very poor households were randomly assigned to receive cash or food, with or without intensive nutrition behavior change communication (BCC). Although baseline, midline, and endline surveys did not collect IPV data, a "post-endline" round of data was collected approximately 6-10 months after the program ended and included an IPV module. Drawing on the randomized design, we assess impacts on IPV at post-endline, separately estimating the effect of receiving only transfers from the effect of receiving transfers linked to nutrition BCC.

We find that, 6-10 months after the program, women that had received only transfers experienced no significant difference in any dimension of IPV relative to the control group; however, women that had received transfers with BCC experienced significantly less physical violence than either the transfer-only group or the control group. This result is robust to a number of alternate specifications. Suggestive evidence on mechanisms indicates that the post-program effect of transfers linked to BCC may occur through sustained increases in women's threat points, greater social costs to men of inflicting violence, or long-term improvements in household well-being. Although we cannot give conclusive evidence on whether there were differences in impacts on IPV *during* the program between transfers with or without BCC, we discuss descriptive evidence suggesting that transfers alone reduced IPV during the program, but this reverted once the program ended.

Section 15.2 outlines our study context and the intervention that we assess. We then describe the data available to us in Section 15.3 and our estimation strategy in Section 15.4. Section 15.5 presents our main results, while in Section 15.6 we explore plausible mechanisms that underlie these. Section 15.7 discusses our findings and concludes.

15.2 Study Context and Study Design

15.2.1 Gender Context

Reports of IPV are high in Bangladesh. A Violence Against Women survey in 2015 found that 72.6 percent of currently married women reported having ever experienced any type of violence by their current husbands; 49.6 percent reported ever experiencing physical violence from their current husbands, and 20.8 percent reported physical violence in the past 12 months (Bangladesh Bureau of Statistics, 2016). In a module administered to men in the Bangladesh Demographic Health Survey 2004, 74 percent of men

reported ever being violent against their wives (Johnson and Das 2009). A survey between 2000-2003 using the same WHO Violence Against Women instrument used in this study found that 41.7 percent of Bangladeshi women in the rural province of Matlab reported ever experiencing physical violence from an intimate partner (García-Moreno et al. 2006).

Many studies link IPV in rural Bangladesh to gender norms (e.g., Koenig et al. 2003). Although gender equality in Bangladesh has improved in some dimensions over the past four decades, patriarchal gender norms persist in much of rural Bangladesh (World Bank 2008). *Purdah*—the practice of female seclusion (Amin 1997)—is common, and restrictions remain on women's movements outside the home without accompaniment by a male family member. While women in very poor households tend to work outside the home out of economic necessity, they often face harassment and social stigma (Roy et al. 2015). Group membership among women is low (Alkire et al. 2013), which combined with seclusion norms, limits social contact. Women's asset ownership is also low (Alkire et al. 2013; Roy et al. 2015), and women have limited direct control over money, as men typically visit markets to purchase food and other household items. Mothers-in-law have considerable influence over decisions on food purchases and childcare.

An implication is that many poor rural Bangladeshi married women—including participants in our study, prior to intervention—may have low threat points within their marriages. Given little resource control, limited voice in the home, societal challenges without male protection, and scarce social ties, there are significant costs to losing husbands' support.

15.2.2 Transfer Modality Research Initiative

Study Design

The Transfer Modality Research Initiative (TMRI) was a pilot safety net program based on two cluster randomized control trials (RCTs) in rural Bangladesh: one in the northwest region (the "North") and one in the coastal southern region (the "South"). In the North, study villages were randomly assigned to a control group or to one of four treatment arms in which beneficiaries received a cash transfer ("Cash"), a food ration ("Food"), a half cash transfer and half food ration ("Cash & Food"), or a cash transfer along with nutrition BCC ("Cash+BCC"). In the South, study villages were also randomly assigned to a control group or to one of four treatment arms; the first three treatment groups were the same as in the North. In the fourth treatment group in the South, instead of a cash transfer

along with nutrition BCC, beneficiaries received a food ration along with nutrition BCC ("Food+BCC").[2]

All beneficiaries were poor households with a child aged 0-24 months in March 2012. The mother of the child aged 0-24 months was the designated beneficiary—both the cardholder for receiving transfers and the target participant in BCC activities. Transfer payments and BCC were undertaken for 24 months, from May 2012 to April 2014.

The program was designed and evaluated by the International Food Policy Research Institute (IFPRI) and implemented by the United Nations' World Food Programme (WFP). The WFP managed the procurement and delivery of transfers, as well as the nutrition BCC training, and routinely monitored the program. An NGO contracted by WFP, the Eco-Social Development Organization (ESDO), was responsible for the field implementation of project activities, including distributing the monthly food and cash transfers, and delivering the nutrition BCC.

Randomization and Sample Design

To implement TMRI's cluster randomized control trial design, analogous sampling processes were followed in the North and in the South. In each region, five sub-districts (*upazilas*) were selected from a list of *upazilas* where, according to the 2010 Bangladesh Poverty Map prepared by the Bangladesh Bureau of Statistics, the proportion of households living below the lower poverty line in Bangladesh was 25 percent or more. All villages within these five *upazilas* were listed. Villages with fewer than 125 households or villages that were considered peri-urban were dropped. In each region, simple random sampling was used to assign 50 villages from this list to each of the four treatment groups and to the control group, and to assign 25 villages as reserve. In the 250 selected villages in each region, a village census was carried out, which collected information on household demographics, poverty indicators, and whether households were participating in social safety net and other targeted interventions.

From these data, a list of households was constructed that were considered poor (i.e., estimated to have consumption below the lower poverty line in Bangladesh); had a child aged 0-24 months in March 2012; and were not receiving benefits from any other social safety net interventions. These were the eligible households for participation in the pilot study. From each village, 10 households meeting these three conditions were randomly

[2] A pure BCC arm was not included, as a large RCT focusing solely on the impacts of BCC on child and maternal nutrition ("Alive and Thrive"; see Menon et al. (2016)) was concurrently underway in Bangladesh.

selected using simple random sampling, giving a total sample size of 5,000 targeted households.

Transfers

Beneficiaries in the "Cash" arms received a monthly payment of BDT 1,500 (approximately USD19) per household. Beneficiaries in the "Food" arms received a monthly food ration of 30 kilograms (kg) of rice, 2 kg of *mosoor* pulse (a lentil), and 2 liters of micronutrient-fortified cooking oil. These quantities were chosen so that the initial value of the food ration was equal to the value of the cash transfer of the beneficiaries in the "Cash" treatment arms. Beneficiaries in the "Cash &Food" treatment arms received half of each of the two types of transfers: BDT 750, 15 kg of rice, 1 kg of *mosoor* pulse, and 1 liter of micronutrient-fortified cooking oil.

Cash and food transfers were delivered to women during the second week of every month. Cash was delivered using a mobile phone cash transfer system, in which women collected cash from designated distribution sites using mobile verification of identity.[3] Food transfers were handed to beneficiaries at designated food distribution points. Cash and food distribution points were no more than 2 kilometers from participants' homes (Ahmed et al. 2016).

Behavior Change Communication

The beneficiaries of the "Cash+BCC" arm in the North and of the "Food+BCC" arm in the South received the same transfer as in the "Cash" only and "Food" only treatment groups, respectively, as well as a suite of intensive nutrition BCC interventions focused on education and behavior change at the household and community level (Ahmed et al., 2016). The BCC intervention involved three complementary activities: (1) weekly group BCC trainings—some with beneficiaries only (i.e., the target women in the Food+BCC or Cash+BCC groups) and some that invited other family members to attend along with beneficiaries, (2) twice-a-month visits to the beneficiaries' homes, and (3) monthly group meetings between program staff and influential community leaders.

The group BCC trainings only for beneficiaries occurred on the day of the transfer distribution, once a month. For the remaining group BCC trainings each month, other household members—particularly mothers-in-law, husbands, and other pregnant or lactating women—were invited to

[3] Since this method used a mobile phone handset and SIM card, to preserve the design of the experiment, these were provided to all women in the study (in all treatment and control arms).

attend along with beneficiaries, with the intention of creating a supportive household atmosphere and behavior change at the household level. These combined sessions served to facilitate women's ability to participate in the BCC, as household members could see what women were participating in and reduce restrictions on attendance, and to increase uptake of BCC messages as husbands and mothers-in-law are also key decision makers on food purchases, infant and young child feeding (IYCF), and child-rearing in the household.

About 9-15 beneficiaries were part of each group. The group trainings took place no further than 2 kilometers from beneficiaries' homes and lasted approximately one hour, on average. Monitoring data showed that beneficiaries assigned to a BCC intervention attended on average 48 of the scheduled 52 sessions per year in the North and 49 of the scheduled 52 sessions per year in the South. Trainings covered the following topics: basic nutrition, control and prevention of micronutrient deficiencies, IYCF practices, health care, maternal nutrition, and hygiene. The BCC training was led by Community Nutrition Workers (CNWs), engaged by ESDO. CNWs were all women from the same villages as TMRI beneficiaries. They were trained by WFP and ESDO to impart the BCC content using a variety of methods including question and answer, flashcards, real-life examples, discussions, practical demonstrations, role-playing, and songs.[4] Anecdotally, the interactive nature of the sessions led to a lively atmosphere and solidarity among participants. On field visits, researchers observed women arriving early at sessions and leaving late in order to talk with other members.

CNWs also conducted the twice-per-month home visits to observe household-level practice and encourage the adoption of positive behaviors, as well as followed up with home visits for individual counseling to beneficiaries on an as-needed basis. Attendance at the group BCC sessions was a soft condition of receipt of the transfers; when a mother missed a session, a CNW would follow up with a home visit to uncover what the reason was for missing the session and to convey the missed information, and no beneficiaries were dropped from the study for failing to attend sessions.

The monthly group meetings with influential community members (such as village heads, religious leaders, school teachers, community elected persons, and local health and family planning staff) were conducted by CNWs and ESDO staff, without the beneficiaries present, to explain the purpose and importance of the BCC and to provide them with the information being conveyed to study

[4] The BCC component was designed specifically for TMRI by WFP in consultations with IFPRI and local technical experts. Session materials were derived in part from material developed for Alive & Thrive (A&T) in Bangladesh.

participants. The aim of these meetings was, similar to inviting other household members to group BCC trainings, to facilitate women's participation and to increase uptake of messages through a supportive community environment.

Of note, there was no explicit focus on violence or gender issues in any of the BCC components. Interactive exercises included negotiating the purchase and consumption of non-traditional foods for pre-school children, but the emphasis was on how to acquire nutritious foods for the child rather than how to resolve conflict more generally.

15.3 Data

15.3.1 Data Collection

Quantitative data collection for TMRI included four rounds of longitudinal surveys: a baseline survey in March-April 2012 prior to the start of intervention in May 2012, a midline survey in June 2013, an endline survey in April 2014 just before the end of intervention, and a post-endline survey from October 2014 to February 2015, 6 to 10 months after the intervention ended. From October-December 2012, a qualitative and quantitative process evaluation was conducted, collecting information on the implementation of the interventions and beneficiaries' experience with the program.

The baseline, midline, and endline surveys attempted to interview all 5,000 households that were included in TMRI treatment or control groups in the North or South. Surveys were multi-topic, including extensive modules on household demographic and socioeconomic characteristics, knowledge and practices regarding child nutrition and hygiene, and women's status. In the baseline survey, the youngest child in the household aged 0-24 months in March 2012 was identified as an "index" child. Modules were designated as to be answered by either a male (usually the household head), who was interviewed by a male enumerator, or a female (the index child's primary female caregiver, almost always the index child's mother and referred to hereafter as the "mother"), who was interviewed by a female enumerator. The women's status module was part of the female questionnaire administered to the index child's mother. IPV questions were not the focus of the women's status module in these rounds, although some descriptive questions about violence were asked of transfer recipients.

The post-endline round had not been part of the original evaluation design but, with supplemental funding, was designed to center around two objectives: assessing post-program impacts on IPV, as well as measuring early childhood development (ECD) of the index child. Due to budget constraints, the post-endline survey included only a subset of the TMRI

intervention arms: in the North, (1) Cash, (2) Cash+BCC, and (3) Control; and in the South, (1) Food, (2) Food+BCC, and (3) Control. Because the specific ECD test used was for children 30 months or older, the post-endline sample was restricted to children who would be at least 30 months by October 2014 and their mothers. This sample consisted of 2,830 pairs of children and mothers. Of these, 2,749 pairs were successfully interviewed.[5]

Mothers were asked to bring the index child for ECD testing to a village center (usually a school or community club). This location, chosen primarily due to the need for tables and chairs in the ECD testing, had the additional advantage of bringing mothers outside the home so that they could be interviewed privately, away from other household members. Prior to the ECD testing, mothers were told what would be covered in the interview, including the IPV questions, and asked for consent. After testing, interviewers administered a short instrument to mothers on several topics including the child's home environment and the mother's experience with IPV.

15.3.2 Violence Measures

The violence questions were drawn from the internationally validated standardized IPV modules in the WHO Violence Against Women instrument (Ellsberg and Heise, 2005) and were administered following the WHO protocol on ethical guidelines for conducting research on women's experience with IPV (World Health Organization 2001).[6] These modules ask multiple behaviorally specific questions on a range of abusive acts, a technique shown to maximize disclosure (Ellsberg et al. 2001). We focused on two types of violence: emotional (4 questions) and physical (6 questions). For each act of violence, women were first asked if their current husband had ever done this. If they reported "yes," they were asked if it had occurred in the past 6 months; if they responded that it had, they were asked whether in the past 6 months it had occurred once, a few times, or many times. The reference period of 6 months was chosen to capture women's experiences after the TMRI interventions had ended.

The primary outcome measures we construct from these questions are indicators of (1) any emotional violence experienced in the past 6 months,

[5] Reasons for incomplete interviews were respondents not being home (1%), migrating (1%), or refusing (<1%).

[6] This included ensuring adequate training of interviewers, guaranteeing privacy during interviews, ensuring informed consent and confidentiality of responses, and interviewing only one woman per household so that other household members were not aware that survey questions involved IPV. Referral services could not be arranged.

(2) any physical violence experienced in the past 6 months, and (3) any emotional or physical violence experienced in the past 6 months. Each is coded as 1 if the woman responded that she had experienced any of the acts categorized as the respective type of violence (see Appendix A for the questions and categorizations) and 0 otherwise.

15.3.3 Estimation Sample

Our sample for estimating the post-program impacts of TMRI on IPV draws on the subset of women that participated in the post-endline survey. This means women who were the mothers of an index child aged at least 30 months as of October 2014 and who were drawn from the Cash, Cash+BCC, or Control arms in the North, or the Food, Food+BCC, or Control arms in the South. Because we wish to have information on baseline characteristics of these respondent women and their husbands, we further restrict the sample to those who were already part of their household and married at baseline and who had non-missing information for their husbands at baseline. We also restrict the sample to those who were the respondents for the women's status modules at midline and endline, in order to relate our primary outcomes at post-endline to measures of women's status in previous rounds.[7] Our final estimation sample consists of 2,231 women across North and South. In this estimation sample, there are no cases of non-response to any of the IPV questions. Appendix B shows that attrition between the 2,830 women in the sample design and the 2,231 women in the estimation sample does not differ significantly across intervention arms. Appendix C shows that baseline characteristics of the respondent women in the estimation sample, their husbands, and their households also do not differ significantly across arms.

15.4 Estimation Strategy

We take advantage of the randomized experimental design and conduct an intent-to-treat (ITT) analysis using single difference estimation with post-endline data. The randomized assignment and balance in baseline characteristics minimize concerns of bias in the single difference treatment estimates. We pool the RCTs in the North and South to increase the statistical power of the study (Bourey et al. ,2015) and create three intervention arms: a "transfer only" treatment (cash in the North or food in the South), a "transfer+BCC" treatment (Cash+BCC in the North or Food+BCC in the South), and a pooled control group (control in the North or the South).

[7] We do not restrict to baseline respondents, as these measures were not collected at baseline.

In our base estimation, we take into account the study design and control for the level of stratification. Given that the main IPV indicators of interest are binary, we estimate the following probit model:

$$Prob(Y_{iv} = 1) = \Phi(\propto + \beta_1 Transfer_v + \beta_2 TransferBCC_v + \acute{o}R_{iv}) \quad (15.1)$$

where Φ is the cumulative distribution function of the standard normal distribution. Y_{iv} is the IPV outcome of interest for woman i from village v at post-endline, and R_{iv} is an indicator for the study region which is the level of stratification. $Transfer_v$ is an indicator that equals one if village v is assigned to the food or cash treatment arms, and β_1 represents the ITT estimator, or the effect of being assigned to a transfer arm relative to the control group. *Transfer* BCC_v is an indicator that equals one if village v is assigned to the Food+BCC or Cash+BCC treatment arms, and β_2 represents the ITT estimator, or the effect of being assigned to a Transfer+BCC arm relative to the control group.

We then estimate a specification with extended baseline control variables, adding baseline socioeconomic characteristics to increase the precision of the estimates and control for any minor differences between treatment and control arms at baseline. These extended baseline control variables include the female respondent's characteristics (whether she is the spouse of the household head, whether she can read and write, her years of education, her number of children 0-5 years old, her number of children 6-15 years old, and her age); her husband's characteristics (whether he can read and write, his years of education, and his age); and household characteristics (household size). Equation (15.1) is extended to the following probit model:

$$Prob(Y_{iv} = 1) = \Phi(\propto + \beta_1 Transfer_v + \beta_2 TransferBCC_v + X_{iv}'\gamma + \acute{o}R_{iv}) \quad (15.2)$$

where X_{iv} is a vector of control variables.

To test whether β_1 and β_2 are statistically different from each other, we conduct Wald tests of equality and report the p-values. Coefficients from probit models are converted to marginal effects evaluated at the mean of the independent variable. In all regressions, we adjust standard errors for clustering at the village level, which was the level of randomization.

15.5 Results

Table 15.1 presents the main impact estimates of TMRI on IPV 6-10 months after the program ended. The first three columns present base estimates (equation 15.1), and the last three columns present estimates with extended controls (equation 15.2). Table 15.1 reveals that transfers alone have no

significant impact on emotional or physical IPV 6-10 months after the program ended. However, Transfers+BCC cause a statistically significant reduction in physical violence, by 6-7 percentage points. This impact represents a 26 percent decrease in physical violence relative to the mean of the control group. The difference in coefficients between transfers and Transfers+BCC is significant for physical violence, suggesting that linking the transfers to BCC is required for post-program impacts. In all cases, the inclusion of control variables has very little impact on the size or significance of coefficients; hereafter, we present estimates only for specifications with extended controls.[8] Results are also robust to relaxing the sample restrictions to using all women who responded to the IPV module at post-endline, using linear probability models, and adjusting for multiple testing (see Appendix D).

We explore the robustness of our results in several additional ways in Tables 15.2 to 15.4. Table 15.2 examines post-program impacts on the *frequency* of violence, using an additive scale and a maximum scale.[9] Results reveal that impacts on this intensive margin are similar to those on the extensive margin; 6-10 months after the program ends, transfers have no impact on the frequency of violence using either scale. However, Transfers+BCC have a large and negative impact on the frequency of physical violence according to both scales.

Table 15.3 reveals post-program impacts on the individual acts of violence used to construct the aggregate indicators in Table 15.1. Disaggregating impacts by individual acts allows us to better understand which acts of violence are being affected and to assess whether aggregation masks a more nuanced pattern. The first four rows in Table 15.3 correspond to indicators of emotional violence, and the last 6 rows correspond to indicators of physical violence. Results are consistent with the aggregate impacts in Table 15.1. Six to ten months after the program ended, transfers have no impact on any of the ten emotional or physical violence indicators. Transfers+BCC have no significant impact on any of the four emotional violence indicators, but have a significant (or weakly significant) negative impact on *each* of the isx physical violence indicators.

---

[8] The base specifications and extended controls produce similar results on all subsequent estimates as well; the extended controls improve precision.

[9] The additive scale sums up the frequency reported for each individual act of physical or emotional violence, respectively. The maximum scale considers the maximum frequency reported over all acts of physical or emotional violence, respectively.

Table 15.1: Impact of Treatment Arms on Prevalence of IPV in Past 6 Months, Post-Endline, Pooled North and South

	Emotional or physical	Emotional	Physical	Emotional or physical	Emotional	Physical
Transfer	0.01	0.03	0.00	0.02	0.03	0.00
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.02)
Transfer+BCC	-0.04	-0.02	-0.06	-0.04	-0.02	-0.07
	(0.04)	(0.04)	(0.03)**	(0.04)	(0.04)	(0.03)**
N	2,231	2,231	2,231	2,231	2,231	2,231
Mean of Control	0.67	0.63	0.27	0.67	0.63	0.27
Strata Indicator	X	X	X	X	X	X
Extended Controls				X	X	X
P-value: Transfer=Transfer+BCC	0.12	0.19	0.01	0.10	0.16	0.01

Note: Marginal effects of probit models. Extended controls include baseline characteristics of woman and husband. Standard errors clustered at village level. * p<0.1; ** p<0.05; *** p<0.01.

Table 15.2: Impact of Treatment Arms on Frequency of IPV in Past 6 Months, Post-Endline, Pooled North and South

	Emotional or physical (0-30)	Emotional (0-12)	Physical (0-18)	Any emotional or physical (0-3)	Any emotional (0-3)	Any physical (0-3)
Transfer	0.11	0.18	-0.07	0.06	0.08	-0.01
	(0.36)	(0.27)	(0.15)	(0.10)	(0.10)	(0.05)
Transfer+BCC	-0.47	-0.05	-0.42	-0.09	-0.06	-0.14
	(0.33)	(0.25)	(0.13)***	(0.10)	(0.10)	(0.05)***
R^2	0.02	0.01	0.03	0.01	0.01	0.03
N	2,231	2,231	2,231	2,231	2,231	2,231
Mean of Control	3.78	2.68	1.10	1.45	1.37	0.45
Strata Indicator	X	X	X	X	X	X
Extended Controls	X	X	X	X	X	X
P-value: Transfer=Transfer+BCC	0.10	0.40	0.01	0.13	0.18	0.01

Note: Extended controls include baseline characteristics of woman and husband. Standard errors clustered at village level. * p<0.1; **p<0.05; *** p<0.01.

Table 15.3: Impact of Treatment Arms on Prevalence of IPV Acts in Past Six months, Post-Endline, Pooled North and South

	Mean of control	Coefficient of transfer	Coefficient of transfer +BCC	P-value: Transfer= Transfer+BCC
Insulted you or made you feel bad about yourself	0.36	-0.01 (0.04)	-0.03 (0.04)	0.64
Belittled or humiliated you in front of other people	0.23	0.02 (0.04)	0.02 (0.04)	0.98
Done things to scare or intimidate you on purpose	0.56	0.01 (0.04)	-0.02 (0.04)	0.37
Threatened to hurt you or someone you care about	0.14	0.02 (0.03)	-0.01 (0.03)	0.28
Slapped you or thrown something at you that could hurt you	0.26	-0.00 (0.02)	-0.06 (0.03)**	0.02
Pushed you or shoved you or pulled your hair	0.13	-0.01 (0.02)	-0.03 (0.02)*	0.20
Hit you with his fist or with something else that could hurt you	0.12	-0.02 (0.02)	-0.05 (0.02)***	0.05
Kicked you, dragged you or beat you up	0.10	-0.01 (0.01)	-0.04 (0.01)***	0.04
Choked or burnt you on purpose	0.03	-0.01 (0.01)	-0.02 (0.01)**	0.11
Threatened to use or actually used a gun, knife or other weapon against you	0.02	-0.01 (0.01)	-0.02 (0.01)**	0.12

Note: Marginal effects of probit models. Extended controls include baseline characteristics of woman and husband. Standard errors clustered at village level. * p<0.1; ** p<0.05; *** p<0.01.

Table 15.4 disaggregates impacts by the North and South, allowing us to see if the pooled impacts in Table 15.1 mask differential patterns by region or modality. Results reveal similar impacts across the North and South. In particular, 6-10 months after the program ends, neither cash alone in the North nor food alone in the South have an impact on emotional or physical IPV. However, Cash+BCC in the North and Food+BCC in the South have a weakly significant negative impact on physical violence of 7 and 6 percentage points, respectively; neither has any significant impact on emotional violence.[10] The last two rows in Table 15.4 reveal that, based

[10] Lower statistical significance of coefficients relative to pooled estimates is expected, given smaller sample sizes.

on p-values from nonlinear Wald tests on cross-model hypotheses, the impacts on IPV of cash in the North are not significantly different from those of food in the South, nor are the impacts of Cash+BCC in the North significantly different from those of Food+BCC in the South.

Table 15.4: Impact of Treatment Arms on Prevalence of IPV in Past Six Months, Post-Endline, North vs. South

	Emotional or physical	Emotional	Physical
North			
Cash	-0.01	0.01	0.00
	(0.05)	(0.05)	(0.03)
Cash + BCC	-0.02	0.01	-0.07
	(0.05)	(0.05)	(0.04)*
Mean of control	0.67	0.63	0.30
P-value: Cash=Cash+BCC	0.83	0.92	0.05
South			
Food	0.04	0.06	0.01
	(0.06)	(0.06)	(0.03)
Food + BCC	-0.06	-0.05	-0.06
	(0.05)	(0.06)	(0.03)*
Mean of control	0.68	0.63	0.23
P-value: Food=Food+BCC	0.05	0.05	0.08
North vs. South			
P-value: Cash=Food	0.48	0.45	0.91
P-value: Cash+BCC=Food+BCC	0.52	0.44	0.88

Note: Marginal effects of probit models. Extended controls include baseline characteristics of woman and husband. Standard errors clustered at village level. * p<0.1; ** p<0.05; *** p<0.01.

A final concern may relate to social desirability bias driving these impacts (Saunders 1991). Since our estimates are based on self-reports, this could affect our results if the BCC caused women to perceive reporting physical violence as less socially desirable. While we cannot rule out this possibility, we believe it is unlikely to drive our results. First, the BCC did not discuss emotional or physical IPV; in general, it touched very little on gender or spousal dynamics and would not be expected to change women's perceptions of social desirability related to these issues. Second, if the BCC were to have changed women's perceptions of the social desirability of reporting IPV, one might have expected this to occur for both emotional

IPV and physical IPV; however, we see effects only on physical IPV and not on emotional IPV.[11]

15.6 Mechanisms

We explore three possible mechanisms to explain why Transfers+ BCC led to decreases in IPV 6-10 months after the program ended, while Transfers alone did not. All are related to the different theories posited in the introduction for why transfers and BCC may reduce IPV. The first mechanism, which supports household economic bargaining models, is that Transfers+BCC (more so than Transfers alone) led to improvements in a woman's threat point that were sustained even after the program ended; this increased her bargaining power within the household and made her less willing to accept violent behavior through post-endline. The second mechanism, which supports social control theories, is that Transfers+BCC (more so than Transfers alone) led to increased interactions with community members that were sustained even after the program ended; this increased the probability of detection and social cost to men of inflicting violence through post-endline. The last mechanism is that Transfers+BCC (more so than Transfers alone) led to decreases in poverty that were sustained even after the program ended; this reduced stress and conflict within the household. The three mechanisms are complementary, and we cannot empirically disentangle them. Moreover, they are not exhaustive of all possible channels but instead reflect the main pathways for which we have evidence.

15.6.1 Improvements in a Woman's Threat Point

To explore whether Transfers+BCC improved a woman's threat point during and after the program ended, we analyse the impact of the program on three empowerment domains (Kabeer 2001): a woman's economic resources, agency, and social resources. All three domains would improve her perception of out-of-marriage options and make it more feasible for her to leave the relationship or settle on a non-cooperative equilibrium. For economic resources, we have quantitative data across all rounds of the survey, while for agency we have only endline data; for social resources, we rely on qualitative evidence, descriptive evidence, and supportive evidence from related work.

Table 15.5 shows the impact of the program across midline, endline, and post-endline on a woman's economic resources: specifically, her perceived control over resources (panel A) and whether she does any work that brings

[11] Using List experiments on IPV in Peru, Agüero and Frisancho (2017) find misreporting bias to be associated with women's completed tertiary education but not with any other measure of empowerment. In our sample, respondents' average education is low and does not significantly differ by intervention arm (Appendix Table A.2).

in cash, increases food available, or builds assets for the household (panel B).[12] Transfers alone have no impact across any round on a woman's economic resources, while Transfers+BCC lead to significant improvements across all three rounds. Statistically significant differences between Transfers and Transfers+BCC begin to emerge at endline for the probability that a woman works and at post-endline for a woman's control over resources. These results suggest that in Bangladesh, targeting transfers to women may not be enough for women to increase their control over money or economic resources. The finding is consistent with other evidence from Bangladesh, including that asset transfers targeted to women did not increase women's overall resource control (Roy et al. 2015) and that loans targeted to and taken out by women were often controlled by their husbands (Goetz and Gupta 1996; Hashemi et al. 1996). However, the addition of BCC changes this, possibly through strengthening their claim to the transfer or increasing their options for work opportunities.

Table 15.5: Impact of Treatment Arms on a Woman's Economic Resources, across Rounds, Pooled North and South

	Midline	Endline	Post-endline
Panel A: Control over money			
Transfer	0.02 (0.03)	0.03 (0.03)	0.04 (0.03)
Transfer + BCC	0.06 (0.03)*	0.08 (0.03)***	0.10 (0.03)***
N	2,231	2,231	2,231
Mean of Control	0.71	0.71	0.38
P-value: Transfer=Transfer+BCC	0.16	0.14	0.06
Panel B: Probability that a woman works			
Transfer	0.02 (0.03)	0.02 (0.02)	0.00 (0.02)
Transfer + BCC	0.06 (0.03)**	0.09 (0.02)***	0.05 (0.02)**
N	2,231	2,231	2,231
Mean of Control	0.75	0.82	0.81
P-value: Transfer=Transfer+BCC	0.27	0.00	0.03

Note: Marginal effects of probit models. Extended controls include baseline characteristics of woman and husband. Standard errors clustered at village level. * p<0.1; ** p<0.05; *** p<0.01. Control over money defined as controlling money needed to buy food, clothes, medicine, toiletries. Woman working defined as working or doing business that brings in cash, food, or assets.

[12] These measures could be outcomes of intra-household bargaining as well as determinants, e.g., the share of household resources the woman "controls" might be negotiated between the couple.

Table 15.6 presents results on the impact of the program on a woman's agency or self-efficacy, representing her ability to make and act on her choices (Kabeer 2005; Sen 2001). We analyze four different endline indicators that represent a woman's internal locus of control (Levenson 1974) and her perception of her ability to change her life. Transfers and Transfers+BCC lead to significant improvements in a woman's ranking of herself compared to others on having rights/power and the ability to change her life. However, only Transfers+BCC lead to significant improvements in a woman's internal locus of control.

Table 15.6: Impact of Treatment Arms on Agency, Endline, Pooled North and South

	Mean of control	Coefficient of transfer	Coefficient of transfer +BCC	P-value: Transfer= Transfer+BCC
Internal locus of control (first factor)	-0.06	0.04 (0.07)	0.19 (0.07)***	0.02
Self-ranking on 9-step ladder of having rights	2.52	0.30 (0.11)***	0.38 (0.11)***	0.45
Self-ranking on 9-step ladder of ability to change life	2.78	0.27 (0.12)**	0.27 (0.12)**	1.00
Perceive success/failure as own responsibility vs. destiny	0.37	-0.05 (0.03)	-0.01 (0.03)	0.27

Note: Extended controls include baseline characteristics of woman and husband. Standard errors clustered at village level. * p<0.1; ** p<0.05; *** p<0.01.

Lastly, we provide qualitative and descriptive evidence from the process evaluation regarding the effects of Transfers and Transfers+BCC on women's social capital. As suggested by the quotes below, while the program was ongoing, transfers alone were able to improve women's social capital, by providing them with the resources that social customs required for interacting with others in their community and gaining respect. However, given the reliance on resources, it is plausible that these effects faded once the program ended and the woman no longer received the transfer.

> "People respect me now. In the past, when I tried to socialize with them, they were not too friendly. They acted as if they were worried I might ask them for a loan."
>
> "You must at least take some biscuits, if nothing else, for the family you are going to visit, but we could not even afford to do that. That's why we would not visit anyone."'
>
> —*Cash recipient*

> "It is embarrassing to visit someone empty-handed. But now I can go to someone's house when invited."
>
> —*Food recipient*

The BCC component was likely to increase social capital in other ways. By nature of its design, the BCC led to frequent (weekly) interaction with community members for women who were previously socially isolated. Consistent with the literature on self-help groups (Brody et al. 2017), this is likely to have increased social ties and social capital. The BCC community meetings also made the importance of nutrition knowledge more salient in communities. The process evaluation (Ahmed et al. 2014) reveals that women's increased knowledge of nutrition led them to experience greater interaction and respect in the community. One Food+BCC recipient reported that the BCC training boosted their family's status, saying that "neighbors regularly come over to hear what the family learned in the latest training session" and that this had facilitated a position for them within the community.

A companion paper (Hoddinott et al. 2017b) provides quantitative evidence that BCC increased interaction between BCC participants and their non-participant neighbors, showing that these neighbors also improved nutrition knowledge and practices through spillover effects. Another companion paper (Hoddinott et al. 2017a) finds that increased nutrition knowledge persisted 6-10 months after the program ended, suggesting increases in interaction and respect may have also persisted after the program ended.

15.6.2 Social Cost of Physical Violence

Increased social ties due to BCC can also increase the social cost to men of inflicting violence, particularly in Bangladesh. Ahmed (2005) describes that, in the context of a group-based microcredit intervention in Bangladesh, greater visibility of women in the public domain due to participation in program activities made it "less possible for husbands to get away with violence without incurring social scorn." Brody et al. (2017) document eight qualitative studies from South Asia (including from Bangladesh) in which women report that self-help group members put social pressure on men to stop beating their wives.

Section 15.6.1 provides evidence that Transfers+BCC led to sustained increases in women's social interaction (weekly group meetings, twice-a-month home visits, contact with non-participant neighbors) and social status (fostered by community meetings). Increased interaction may make physical violence more visible, thereby increasing the probability that men are caught. Women's improved social status may also make it more likely that the community frowns upon violence inflicted on them, representing

"social control." Such factors increase the cost to men of inflicting physical violence (but possibly not emotional violence, which is less visible and perhaps more accepted in communities). Although we do not have direct evidence on community members' responses to IPV, the existing evidence from Bangladesh suggests that women's sustained increases in visibility, social ties, and social status induced by BCC may have increased men's social costs of violence even after the program ended.

15.6.3 Poverty-related Stress

Table 15.7 reveals that, at endline, both the Transfers and Transfers+BCC arms lead to significant increases in household wealth as measured by per capita consumption and assets. Improvements in wealth may lead to decreases in IPV if they lead to decreases in poverty-related stress and disputes. Qualitative evidence from the process evaluation supports this hypothesis, with disputes over food and money reported to decrease as a result of the transfer (Ahmed et al., 2014). However, Table 15.7 also shows that endline improvements are significantly larger for the Transfers+BCC arm than for the Transfers arm. Ahmed et al. (2017) show that this difference is driven by greater use of transfer resources for investment and income generation in the Transfers+BCC arm, suggesting that larger increases in wealth from Transfers+BCC are likely to persist after the intervention ends. Thus, post-program reductions in IPV from Transfers+BCC could plausibly be due to this group continuing to experience significantly less poverty-related stress than the Transfers group at post-endline. Supporting this mechanism, we find at post-endline that Transfers+BCC (but not Transfers only) significantly reduce violence against children, which Bobonis et al. (2013) view as a marker of stress in the household (Appendix E).

Table 15.7: Impact of Treatment Arms on Household Resources, Endline, Pooled North and South

	Mean of control	Coefficient of transfer	Coefficient of transfer+BCC	P-value: Transfer= Transfer+BCC
Monthly total expenditure per capita (nominal)	1,669.04	217.64 (47.51)***	420.77 (45.09)***	0.00
Total assets & cash in hand (nominal)	23,716.79	3,674.57 (1,665.09)**	9,058.11 (2,031.20)***	0.01

Note: Extended controls include baseline characteristics of woman and husband. Standard errors clustered at village level. * p<0.1; ** p<0.05; *** p<0.01.

15.7 Discussion and Conclusions

Our results show that, 6-10 months after a transfer program ended, women that had received transfers with BCC experienced significantly less physical violence than either the transfer-only group or the control group. Meanwhile, women receiving only transfers experienced no significant difference in any dimension of IPV relative to the control group. This result is robust to alternate specifications. We present suggestive evidence that the post-program effect of transfers linked to BCC may have occurred through sustained increases in women's threat points, greater social costs to men of inflicting violence, or long-term improvements in household well-being.

Several limitations to our findings are worth noting. Because the three components of the BCC were bundled, we are unable to identify which components or combination thereof drive our results. We believe that all served complementary roles—e.g., group meetings built status and social capital, home visits increased visibility of violence, community meetings affected men's social costs and attitudes toward women's participation in the other components—but these cannot be disentangled. Similarly, because BCC was always provided in combination with transfers, we cannot identify the effect of BCC alone on IPV. We hypothesize that BCC would not have had comparable effects absent the transfers. Conditioning transfers on BCC likely led to the high rates of BCC participation; women's restrictions on mobility and opportunity costs in terms of time would have plausibly limited BCC involvement without the incentive of transfers. The importance of transfers is also signaled by our suggestive evidence that women's increased control over economic resources increased their threat points and that households' increased well-being reduced conflict. Finally, we cannot disentangle the contributions of each of our proposed three mechanisms—women's threat points, men's social costs, and household poverty-related conflict. Our suggestive evidence suggests that all three played complementary roles; however, we cannot empirically distinguish these.

Bearing in mind these caveats, our findings have important policy relevance. Cash transfers are widely-used policy tools in the developing world, and there is growing interest in their potential to reduce IPV. However, most programs do not provide transfers indefinitely and thus cannot be a sustainable solution to reducing IPV if their effects dissipate as soon as the program ends. Moreover, many transfer programs include other complementary activities, and thus it is important to understand whether these complementary activities shape post-program effects on IPV. Nutrition BCC is often included in transfer programs that aim to improve household food security and child nutrition; our results suggest that, even

if project objectives focus on households and children rather than women specifically, nutrition-sensitive social protection programming could have the "unintended" benefit of post-program reductions in IPV.

To our knowledge, our results are the first rigorous evidence showing impacts of a transfer program on IPV after the program has ended. One may wonder how these post-program impacts on IPV compare to impacts during the program. Is it the case that, in the setting of rural Bangladesh, transfers alone had no impact on IPV even while the transfers were being provided—implying that the BCC was essential for any reduction in IPV? Or is it that transfers alone reduced IPV while provided, but these reductions were not sustained afterward except with the addition of BCC? As noted in Section 14.1, we are unable to rigorously distinguish these. However, evidence detailed in Appendix F suggests it was likely the latter. First, we find that questions at endline on changes in physical abuse since the start of transfers reflect decreases in the frequency of physical abuse in both the Transfer and the Transfer+BCC arms (24% and 17% report decreases, respectively); fewer than 1 percent report increases in either arm. Second, women in both the Transfers and Transfers+BCC arms report improvements in relationships with husbands compared to the control group at endline and post-endline; although the proportion reporting improvements is significantly higher in the Transfers+BCC arm at post-endline, there is no significant difference in these proportions between the two arms at endline. Finally, in the process evaluation, we find qualitative support from an interview of a beneficiary woman receiving transfers only (Ahmed et al. 2014), who says that she feels that their improved economic status has led to better relations between her and her husband. Previously, if she asked her husband to buy food when there was none in the house, he would become angry and hit her; at the time of the process evaluation, she says he is generally quite pleasant and does not fight with her anymore.

An implication of our findings is that, while transfers alone may cause a contemporaneous reduction in IPV, sustained reductions in IPV beyond the end of transfers may require additional program activities that lead to sustained improvements in women's status in the household and community. What will sustainably achieve this may differ by context. In rural Bangladesh, we find that having recently been the target beneficiary of food or cash transfers is not sufficient. However, having recently been the target beneficiary of transfers as well as intensive nutrition BCC appears to improve a woman's status. In light of mixed evidence from rural Bangladesh on the relationship between women's economic empowerment and IPV, we provide evidence that providing women with transfers while also engaging them and their

household and community members through BCC decreases IPV beyond the end of the program.

Our findings prompt several questions. For policy decisions, it would be important to understand whether our results generalize to a post-program period of more than 6-10 months after the end of transfers; to a program exposure shorter than two years; to a different type of BCC (e.g., one that was less intensive, involved different combinations of components or topics, or differently targeted members of the household and community); to a different type of transfer program (e.g., one that challenged gender norms by not just targeting transfers *to* women, but also targeting them *for* women instead of for the household and child); to a different sociocultural or geographic context; or to a different target group among women. These questions remain for future research.

References

Agüero, Jorge M., and Veronica Frisancho. 2017. *Misreporting in Sensitive Health Behaviors and Its Impact on Treatment Effects: An Application to Intimate Partner Violence*. IDB Working Paper Series No. IDB-WP-853. Washington, D.C.: Inter-American Development Bank.

Ahmed, Akhter, John F. Hoddinott, Shalini Roy, Esha Sraboni, Wahidur R. Quabili, and Amy Margolies. 2016. *Which Kinds of Social Safety Net Transfers Work Best for the Ultra Poor in Bangladesh? Operation and Impacts of the Transfer Modality Research Initiative*. Dhaka, Bangladesh: International Food Policy Research Institute (IFPRI).

Ahmed, Akhter U., John F. Hoddinott, and Shalini Roy. 2017. *The Effects of Transfers and Nutrition Behavior Change Communication on Household Well-Being: Experimental Evidence from Bangladesh*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Ahmed, Akhter U., Esha Sraboni, and Fiona K. Shaba. 2014. *Safety Nets in Bangladesh: Which Form of Transfer Is Most Beneficial?* Dhaka, Bangladesh: International Food Policy Research Institute (IFPRI).

Ahmed, Syed Masud. 2005. "Intimate Partner Violence against Women: Experiences from a Woman-Focused Development Programme in Matlab, Bangladesh." *Journal of Health, Population and Nutrition* 23, no. 1: 95-101.

Aizer, Anna. 2010. "The Gender Wage Gap and Domestic Violence." *American Economic Review* 100, no. 4: 1847-1859.

Alkire, Sabina, Ruth Meinzen-Dick, Amber Peterman, Agnes Quisumbing, Greg Seymour, and Ana Vaz. 2013. "The Women's Empowerment in Agriculture Index." *World Development* 52: 71-91.

Amin, Sajeda. 1997. "The Poverty-Purdah Trap in Rural Bangladesh: Implications for Womens Roles in the Family." *Development and Change* 28, no. 2: 213-233.

Angelucci, Manuela. 2008. "Love on the Rocks: Domestic Violence and Alcohol Abuse in Rural Mexico." *The B.E. Journal of Economic Analysis & Policy* 8, no. 1.

Bangladesh Bureau of Statistics (BBS). 2016. *Report on Violence Against Women (VAW) Survey 2015*. Dhaka: BBS.

Bates, Lisa M, Sidney Ruth Schuler, Farzana Islam, and Md Khairul Islam. 2004. "Socioeconomic Factors and Processes Associated with Domestic Violence in Rural Bangladesh." *International Family Planning Perspectives* 30, no. 4: 190-199.

Bhuiya, Abbas, Tamanna Sharmin, and S. M. A. Hanifi. 2003. "Nature of Domestic Violence against Women in a Rural Area of Bangladesh: Implication for Preventive Interventions." *Journal of Health Population and Nutrition* 21, no. 1: 48-54.

Bloch, Francis, and Vijeyandra Rao. 2002. "Terror as a Bargaining Instrument: A Case Study of Dowry Violence in Rural India." *The American Economic Review* 92, no. 4: 1029-1043.

Bobonis, Gustavo J, Melissa González-Brenes, and Roberto Castro. 2013. "Public Transfers and Domestic Violence: The Roles of Private Information and Spousal Control." *American Economic Journal: Economic Policy* 5, no. 1: 179-205.

Bourey, Christine, Whitney Williams, Erin Bernstein, and Rob Stephenson. 2015. "Systematic Review of Structural Interventions for Intimate Partner Violence in Low- and Middle-Income Countries: Organizing Evidence for Prevention." *BMC Public Health* 15, no. 1, 1165. https://doi.org/10.1186/s12889-015-2460-4.

Brody, Carinne, Thomas de Hoop, Martina Vojtkova, Ruby Warnock, Megan Dunbar, Padmini Murthy, and Shari L Dworkin. 2017. "Can Self-Help Group Programs Improve Women's Empowerment? A Systematic Review." *Journal of Development Effectiveness* 9, no. 1: 15-40.

Buller, Ana Maria, Melissa Hidrobo, Amber Peterman, and Lori Heise. 2016. "The Way to a Man's Heart Is through His Stomach?: A Mixed Methods Study on Causal Mechanisms through which Cash and in-Kind Food Transfers Decreased Intimate Partner Violence." *BMC Public Health* 16, no. 488: 1-13.

Buller, Ana Maria, Amber Peterman, Meghna Ranganathan, Alexandra Bleile, Melissa Hidrobo, and Lori Heise. 2018. *A Mixed-Method Review of Cash Transfers and Intimate Partner Violence in Low and Middle-Income Countries*. UNICEF Office of Research Innocenti Working Paper No. WP-2018-02. New York, N.Y.: UNICEF.

Chin, Yoo-Mi. 2012. "Male Backlash, Bargaining, or Exposure Reduction?: Women's Working Status and Physical Spousal Violence in India." *Journal of Population Economics* 25, no. 1: 175-200.

Devries, K. M., J. Y. T. Mak, C. García-Moreno, M Petzold, J C Child, G Falder, S Lim, L J Bacchus, R E Engell, L Rosenfeld, C Pallitto, T Vos, N Abrahams, and C H Watts. 2013. "The Global Prevalence of Intimate Partner Violence Against Women." *Science* 340, no. 6140: 1527-1528.

Ellsberg, Mary, Diana J Arango, Matthew Morton, Floriza Gennari, Sveinung Kiplesund, Manuel Contreras, and Charlotte Watts. 2015. "Prevention of Violence against Women and Girls: What Does the Evidence Say?" *The Lancet* 385, no. 9977: 1555-1566.

Ellsberg, Mary Carroll, and Lori Heise. 2005. *Researching Violence Against Women: A Practical Guide for Researchers and Activists*. Washington, D.C.: World Health Organization, PATH.

Ellsberg, Mary, Lori Heise, Rodolfo Pena, Sonia Agurto, and Anna Winkvist. 2001. "Researching Domestic Violence Against Women: Methodological and Ethical Considerations." *Studies in Family Planning* 32, no. 1: 1-16.

Ellsberg, Mary, Henrica A. F. M. Jansen, Lori Heise, Charlotte H. Watts, and Claudia García-Moreno. 2008. "Intimate Partner Violence and Women's Physical and Mental Health in the WHO Multi-Country Study on Women's Health and Domestic Violence: An Observational Study." *The Lancet* 371, no. 9619: 1165-1172.

Eswaran, Mukesh, and Nisha Malhotra. 2011. "Domestic Violence and Women's Autonomy in Developing Countries: Theory and Evidence." *Canadian Journal of Economics/Revue canadienne d'économique* 44, no. 4: 1222-1263.

Fakir, Adnan M. S., Anika Anjum, Fabiha Bushra, and Nabilah Nawar. 2016. "The Endogeneity of Domestic Violence: Understanding Women Empowerment through Autonomy." *World Development Perspectives* 2: 34-42. https://doi.org/10.1016/j.wdp.2016.09.002.

Farmer, Amy, and Jill Tiefenthaler. 1997. "An Economic Analysis of Domestic Violence." *Review of Social Economy* 55, no. 3: 337-358.

Feigenberg, Benjamin, Erica Field, and Rohini Pande. 2013. "The Economic Returns to Social Interaction: Experimental Evidence from Microfinance." *The Review of Economic Studies* 80, no. 4: 1-55.

Fox, Greer Litton, Michael L. Benson, Alfred A. DeMaris, and Judy Wyk. 2002. "Economic Distress and Intimate Violence: Testing Family Stress and Resources Theories." *Journal of Marriage and Family* 64, no. 3: 793-807.

Fulu, Emma, Stephanie Miedema, Tim Roselli, Sarah McCook, Ko Ling Chan, Regine Haardörfer, and Rachel Jewkes. 2017. "Pathways between Childhood Trauma, Intimate Partner Violence, and Harsh Parenting: Findings from the UN Multi-Country Study on Men and Violence in Asia and the Pacific." *The Lancet. Global Health* 5, no. 5: e512-522.

García-Moreno, Claudia, Henrica Jansen, Mary Ellsberg, Lori Heise, and Charlotte H Watts. 2006. "Prevalence of Intimate Partner Violence: Findings from the WHO Multi-Country Study on Women's Health and Domestic Violence." *The Lancet* 368, no. 9543: 1260-1269.

García-Moreno, Claudia, Cathy Zimmerman, Alison Morris-Gehring, Lori Heise, Avni Amin, Naeemah Abrahams, Oswaldo Montoya, Padma Bhate-Deosthali, Nduku Kilonzo, and Charlotte Watts. 2015. "Addressing Violence against Women: A Call to Action." *The Lancet* 385, no. 9978: 1685-1695.

Goetz, Anne Marie, and Rina Sen Gupta. 1996. "Who Takes the Credit? Gender, Power, and Control over Loan Use in Rural Credit Programs in Bangladesh." *World Development* 24, no. 1: 45-63.

Hadi, Abdullahel. 2000. "Prevalence and Correlates of the Risk of Marital Sexual Violence in Bangladesh." *Journal of Interpersonal Violence* 15, no. 8: 787-805.

___. 2005. "Women's Productive Role and Marital Violence in Bangladesh." *Journal of Family Violence* 20, no. 3: 181-189.

Hashemi, Syed M., Sidney Ruth Schuler, and Ann P. Riley. 1996. "Rural Credit Programs and Women's Empowerment in Bangladesh." *World Development* 24, no. 4: 635-653.

Hasselmann, Maria H., and Michael E. Reichenheim. 2006. "Parental Violence and the Occurrence of Severe and Acute Malnutrition in Childhood." *Paediatric and Perinatal Epidemiology* 20, no. 4: 299-311. https://doi.org/10.1111/j.1365-3016.2006.00735.x.

Haushofer, Johannes, and Jeremy Shapiro. 2016. "The Short-Term Impact of Unconditional Cash Transfers to the Poor: Experimental Evidence." Princeton University.

Hidrobo, Melissa, and Lia Fernald. 2013. "Cash Transfers and Domestic Violence." *Journal of Health Economics* 32, no. 1: 304-319.

Hidrobo, Melissa, Amber Peterman, and Lori Heise. 2016. "The Effect of Cash, Vouchers, and Food Transfers on Intimate Partner Violence: Evidence from a Randomized Experiment in Northern Ecuador." *American Economic Journal: Applied Economics* 8, no. 3: 284-303.

Hoddinott, John, Akhter Ahmed, Naureen Karachiwalla, and Shalini Roy. 2017a. "Nutrition Behaviour Change Communication Causes Sustained Effects on IYCN Knowledge in Two Cluster-Randomised Trials in Bangladesh." *Maternal and Child Nutrition* 14, no. 1: e12498. https://doi.org/10.1111/mcn.12498.

Hoddinott, John, Ishita Ahmed, Akhter Ahmed, and Shalini Roy. 2017b. "Behavior Change Communication Activities Improve Infant and Young Child Nutrition Knowledge and Practice of Neighboring Nonparticipants in a Cluster-Randomized Trial in Rural Bangladesh." *PLoS ONE* 12, no. 6: e0179866. https://doi.org/10.1371/journal.pone.0179866.

Johnson, Kiersten Blair, and Maitreyi Bordia Das Das. 2009. "Spousal Violence in Bangladesh as Reported by Men." *Journal of Interpersonal Violence* 24, no. 6: 977-995.

Kabeer, Naila. 2001. "Reflections on the Measurement of Women's Empowerment." In *Discussing Women's Empowerment-Theory and Practice*, edited by Naila Kabeer. *Sida Studies No. 3.* Stockholm: Novum Grafiska AB.

___. 2005. "Gender Equality and Women's Empowerment: A Critical Analysis of the Third Millennium Development Goal 1." *Gender & Development* 13, no. 1: 13-24.

Kapiga, Saidi, Sheila Harvey, Abul Khalie Muhammad, Heidi Stockl, Gerry Mshana, Ramadhan Hashim, Christian Hansen, Shelley Lees, and Charlotte Watts. 2017. "Prevalence of Intimate Partner Violence and Abuse and Associated Factors among Women Enrolled into a Cluser Randomised Trial in Northwestern Tanzania." *BMC Public Health* 17, no. 190: 1-11.

Karamagi, Charles AS, James K Tumwine, Thorkild Tylleskar, and Kristian Heggenhougen. 2007. "Intimate Partner Violence and Infant Morbidity: Evidence of an Association from a Population-Based Study in Eastern Uganda in 2003." *BMC Pediatrics* 7, no. 1: 34. https://doi.org/10.1186/1471-2431-7-34.

Koenen, Karestan C., Terrie E. Moffitt, Avshalom Caspi, Alan Taylor, and Shaun Purcell. 2003. "Domestic Violence Is Associated with Environmental Suppression of IQ in Young Children." *Development and Psychopathology* 15, no. 2: 297-311.

Koenig, Michael, Saifuddin Ahmed, Mian Bazle Hossain, and ABM Khorshed Alam Mozumder. 2003. "Women's Status and Domestic Violence in Rural Bangladesh: Individual- and Community-Level Effects." *Demography* 40, no. 2: 269-283.

Levenson, Hanna. 1974. "Activism and Powerful Others: Distinctions within the Concept of Internal-External Control." *Journal of Personality Assessment* 38, no. 4: 377-383.

Menon, Purnima, Phuong Hong Nguyen, Kuntal Kumar Saha, Adiba Khaled, Tina Sanghvi, Jean Baker, Kaosar Afsana, Raisul Haque, Edward A. Frongillo, Marie T. Ruel, and Rahul Rawat. 2016. "Combining Intensive Counseling by Frontline Workers with a Nationwide Mass Media Campaign Has Large Differential Impacts on Complementary Feeding Practices

but Not on Child Growth: Results of a Cluster-Randomized Program Evaluation in Bangladesh." *Journal of Nutrition* 146, no. 10: 2075-2084.

Perova, Elizaveta, and Renos Vakis. 2013. *Improving Gender and Development Outcomes through Agency: Policy Lessons From Three Peruvian Experiences*. Washington, D.C.: World Bank.

Pollak, Robert A. 2004. "An Intergenerational Model of Domestic Violence." *Journal of Population Economics* 17, no. 2: 311-329.

Ribero, Rocio, and Fabio Sánchez. 2005. *Determinants, Effects, and Costs of Domestic Violence*. Documentos Cede 000339. Bogota, Colombia: Universidad de Los Andes.

Roy, Shalini, Jinnat Ara, Narayan Das, and Agnes R. Quisumbing. 2015. "'Flypaper Effects' in Transfers Targeted to Women: Evidence from BRAC's 'Targeting the Ultra Poor' Program in Bangladesh." *Journal of Development Economics* 117, November: 1-19.

Saunders, Daniel G. 1991. "Procedures for Adjusting Self-Reports of Violence for Social Desirability Bias." *Journal of Interpersonal Violence* 6, no. 3: 336-344.

Schuler, Sidney Ruth, Rachel Lenzi, Sohela Nazneen, and Lisa M. Bates. 2013. "Perceived Decline in Intimate Partner Violence Against Women in Bangladesh: Qualitative Evidence." *Studies in Family Planning* 44, no. 3: 243-257.

Sen, Amartya. 2001. *Development as Freedom*. Oxford Paperbacks. New York, N.Y.: Ancher Books.

Stets, Jan E. 1991. "Cohabiting and Marital Aggression: The Role of Social Isolation." *Journal of Marriage and the Family* 53, no. 3: 669-680.

Tauchen, Helen V., Ann Dryden Witte, and Sharon K. Long. 1991. "Domestic Violence : A Nonrandom Affair." *International Economic Review* 32, no. 2: 491-511.

World Bank. 2008. *Whispers to Voices: Gender and Social Transformation in Bangladesh.* Bangladesh Development Series (22). Washington, D.C.: World Bank.

World Health Organization (WHO). 2001. *Putting Women First: Ethical and Safety Recommendations for Research on Domestic Violence Against Women*. Geneva: WHO.

Van Wyk, Judy A, Michael L Benson, Greer Litton, and Fox Alfred Demaris. 2003. "Detangling Individual-, Partner-, and Community-Level Correlates of Partner Violence." *Crime & Delinquency* 49, no. 3: 412-438.

Yount, Kathryn M., Ann M. DiGirolama, and Usha Ramakrishnan. 2011. "Impacts of Domestic Violence on Child Growth and Nutrition: A Conceptual Review of the Pathways of Influence." *Social Science & Medicine* 72, no. 9: 1534-1554.

Appendix A

IPV Module in TMRI Post-Endline (English translation)

Emotional					
W2_1	The next questions are about things that happen to many women, and that your current partner, or any other partner may have done to you Has your current husband ever	A 1 Yes, 2 No>> Next Question	B Has this happened in the last six months? 1 Yes, 2 No>>D	C In the past 6 months would you say that this has happened once, a few times or many times Once 1 A few times 2 Many times 3	D Before the last 6 months would you say that this has happened once, a few times or many times One 1 A few times 2 Many times 3 Never happened before last 6 months 9
W2_1a	Insulted you or made you feel bad about yourself?				
W2_1b	Belittled or humiliated you in front of other people?				
W2_1c	Done things to scare or intimidate you on purpose (e.g. by the way he looked at you, by yelling and smashing things)?				
W2_1d	Threatened to hurt you or someone you care about?				

Continued

Continued from Appendix A

Physical					
W3_1	Has he ever:	A 1 Yes, 2 No>> Next Question	B Has this happened in the last six months? 1 Yes, 2 No>>D	C In the past 6 months would you say that this has happened once, a few times or many times Once 1 A few times 2 Many times 3	D Before the last 6 months would you say that this has happened once, a few times or many times One 1 A few times 2 Many times 3 Never happened Before last 6 months 9
W3_1a	Slapped you or thrown something at you that could hurt you				
W3_1b	Pushed you or shoved you or pulled your hair?				
W3_1c	Hit you with his fist or with something else that could hurt you?				
W3_1d	Kicked you, dragged you or beat you up?				
W3_1e	Choked or burnt you on purpose?				
W3_1f	Threatened to use or actually used a gun, knife or other weapon against you				

Appendix B

Attrition Analysis

As described in Section 15.3.1, of the 2,830 pairs of mothers and children included in our post-endline sample design, 2,749 pairs were successfully interviewed. After we imposed the sample restrictions described in Section 15.3.3—keeping only the mothers who were already part of their households at baseline, who were married at baseline, who had non-missing information for their husbands at baseline, and who were respondents for the midline and endline women's status modules—2,231 women remained in our estimation sample.

To assess whether attrition from our intended sample of 2,830 to our final estimation sample of 2,231 was systematically different across intervention arms, we use OLS to regress an indicator for whether a woman stayed in the estimation sample on the intervention arms:

$$\text{Stay}_{iv} = \propto + \beta_1 \text{Transfer}_v + \beta_2 \text{TransferBCC}_v + 6\varepsilon_{iv} \quad (1)$$

Table 15.A.1 shows that there was no significant difference in the probability of staying in the estimation sample across intervention arms, in the full sample or disaggregated by region. Results are also robust to using the full sample of 2,749 women that were successfully interviewed at post-endline (Table 15.A.3).

Appendix C

Baseline Characteristics of Estimation Sample

We present descriptive statistics on our sample and assess balance in these characteristics at baseline. Table 15.A.2 presents baseline characteristics of the estimation sample, pooled over North and South, disaggregated into "transfer only," "transfer+BCC," and control arms. Female respondents in our sample are on average 27 years old, while their husbands are on average 34 years old. About 90 percent of female respondents are wives of the household head. In nearly all of the remaining 10 percent of cases, they are the daughters-in-law of the head. More than 10% however live with their in-laws (around 25 percent live with their mothers-in-law, and about 15 percent live with their fathers-in-law[13]), reflecting the common arrangement of a married male head's parents living with him in old age. Female respondents have just over 3 years of education on average; slightly over 50 percent can read and write. This compares to just over 2 years of education on average for their husbands, with fewer than 40 percent able to read and write.[14] Female respondents have on average 1.3 children aged 0-5 years at baseline (by construction of the sample, all have at least one child 0-24 months) and about 0.9 children 6-15 years old. In terms of all of these characteristics, differences in means between the three intervention arms are not statistically significant at the 5 percent level.

[13] The discrepancy is likely due to mothers-in-law who are widows.

[14] A pro-female educational gender gap is consistent with recent evidence on Bangladesh (Chowdhury et al., 2002).

Appendix D

Robustness Checks for Main Results

We conduct several robustness checks of the results in Table 15.2, including relaxing the sample restrictions to using all women who responded to the IPV module at post-endline, using linear probability models, and adjusting for multiple testing. Table 15.A.3 shows that results are very similar when all 2,749 women who responded to the IPV module at post-endline are included in the estimation, rather than excluding those for whom we do not have baseline information. Table 15.A.4 shows that results are also very similar when linear probability models using OLS are estimated, rather than probit models. Table 15.A.5 shows that conclusions about statistical significance do not change when adjustments are made for multiple testing, computing q-values to control the false detection rate using two alternative methods (Benjamini et al. 2006; Benjamini and Hochberg 1995): the impacts of Transfer+BCC on any post-program physical violence that are significant at the 5 percent level without adjustment are significant at the 10 percent level with adjustment.

Appendix E

Violence against Children

Bobonis et al. (2013) show impacts on violence against children as a proxy for impacts on stress and conflict in the household. In our post-endline survey, we administered part of the Home Observation Measurement of the Environment (HOME) Inventory adapted for Bangladesh (Nahar et al. 2012) to the mother of the index child. We assess responses to two questions: (1) "In the last week have you had to hit the child?"—with response options "did not hit at all / hit only once with hand," "hit with hand more than once in the last week," and "hit with an object at least once in the last week" where the latter two responses are coded as harsh physical punishment; and (2) "If the child hits parents, what do they do?" with response options "do not hit the child back" or "hit the child back or other physical punishment." We use probit models to estimate impacts of Transfers and Transfers+BCC on "Harsh physical punishment last week" and "Hit child back when child hits parent" (see Table 15.A.6) and find that both are significantly reduced at post-endline by Transfers+BCC (by 12 percentage points and 8 percentage points, respectively) but not by Transfers only. The differences in effects between Transfers+BCC and Transfers are statistically significant at the 5 percent and 1 percent levels respectively.

Appendix F

Descriptive Evidence on IPV Impacts during Program Exposure

Given that we did not collect the requisite IPV data at midline or endline, we cannot rigorously assess whether transfers alone had an impact on IPV while transfers were being provided. However, several pieces of evidence in our data suggest it was likely that transfers alone reduced IPV while provided, although these reductions were not sustained afterward. One is the set of descriptive questions on physical violence asked of transfer recipients at endline (see Table 15.A.7): "Has your husband, another family member, or household resident (ever) physically abused you?" and "Has the frequency of this abuse increased / decreased / remained the same ever since you started receiving the transfer?" 95 percent of the Transfers arm and 96 percent of the Transfers+BCC arm report that they either have never experienced physical abuse as of endline or that the frequency has decreased since starting to receive transfers (with 24 percent of Transfers and 17 percent of Transfers+BCC reporting a decrease); 4 percent of each arm reports the same frequency as before receiving transfers; 1 percent and 0 percent of the Transfers and Transfers+BCC arm respectively report an increase in frequency. None of these differences between Transfers and Transfers+BCC is statistically significant. Although we interpret these cautiously given that the questions may be leading and we do not know what the control group would have reported, they indicate that bothTransfers and Transfers+BCC may have experienced reduced physical violence during the program.

A second set of suggestive results (see Table 15.A.8) comes from endline and post-endline questions to all female respondents, asking "Did you notice any change in relationship/attitude (good or bad) towards you of your husband?" and "If, yes what has changed? Less conflict/more respect now, or more conflict/less respect now?" At endline, relative to the control groups, Transfers and Transfers+BCC cause significant 41 and 39 percentage point increases respectively in the share reporting an improvement in relationship, with no significant difference between the two. At post-endline, Transfers and Transfers+BCC cause significant 21 and 41 percentage point increases respectively in the share reporting an improvement in relationship, now with a statistically significant difference between the two. Although these questions do not pertain directly to physical violence and again may be leading, they point to comparable improvements in spousal relations during the program from Transfers and Transfers+BCC, but significantly greater improvements at 6-10 months post-program from Transfers+BCC.

Appendix References

Benjamini, Yoav, and Yosef Hochberg. 1995. "Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing." *Source Journal of the Royal Statistical Society. Series B (Methodological)* 57, no. 1: 289-300.

Benjamini, Yoav, Abba M. Krieger, and Daniel Yekutieli. 2006. "Adaptive Linear Step-up Procedures that Control the False Discovery Rate." *Biometrika* 93, no. 3): 491-507.

Bobonis, Gustavo J., Melissa González-Brenes, and Roberto Castro. 2013. "Public Transfers and Domestic Violence: The Roles of Private Information and Spousal Control." *American Economic Journal: Economic Policy* 5, no. 1: 179-205.

Chowdhury, A. M. R., Samir Ranjan Nath, and Rasheda K. Choudhury. 2002. "Enrolment at Primary Level: Gender Difference Disappears in Bangladesh." *International Journal of Educational Development* 22, no. 2: 191-203. https://doi.org/10.1016/S0738-0593(01)00027-X.

Nahar, Baitun, Md. Iqbal Hossain, Jena D. Hamadani, Tahmeed Ahmed, Sally Grantham-McGregor, and Lars-Ake Persson. 2012. "Effects of Psychosocial Stimulation on Improving Home Environment and Child-rearing Practices: Results from a Community-based Trial among Severely Malnourished Children in Bangladesh." *BMC Public Health* 12, no. 1: 622.

Appendix Tables

Table 15.A.1: Attrition by intervention arm, post-endline

	Full sample	North	South
Transfer	0.01	0.02	0.00
	(0.02)	(0.03)	(0.04)
Transfer+BCC	0.03	0.03	0.02
	(0.02)	(0.02)	(0.04)
Constant	0.74	0.81	0.74
	(0.02)***	(0.02)***	(0.03)***
R^2	0.01	0.00	0.00
N	2,830	1,406	1,424
P-value: Transfer=Transfer+BCC	0.57	0.78	0.61

* p<0.1; ** p<0.05; *** p<0.01.

Table 15.A.2: Baseline Summary Statistics by Intervention Arm, Pooled North and South

	N	Means			P-value of diff.		
		Transfer	Transfer+ BCC	Control	Transfer-Control	Transfer+ BCC-Control	Transfer-Transfer+ BCC
Respondent's age	2,231	27.41	27.11	27.33	0.84	0.57	0.46
Respondent is household head	2,231	0.00	0.00	0.00	0.31	0.32	1.00
Respondent is spouse of head	2,231	0.91	0.89	0.92	0.63	0.22	0.44
Respondent is daughter-in-law	2,231	0.08	0.09	0.08	0.96	0.56	0.61
Respondent can read and write	2,231	0.53	0.57	0.56	0.36	0.81	0.26
Respondent's education (yrs)	2,231	3.08	3.23	3.39	0.14	0.50	0.47
Respondent lives with mother-in-law	2,231	0.26	0.27	0.27	0.62	0.92	0.55
Respondent lives with father-in-law	2,231	0.15	0.17	0.17	0.24	0.93	0.32
Number of children 0-5 years of respondent	2,231	1.37	1.34	1.37	0.99	0.38	0.40
Number of children 6-15 years of respondent	2,231	0.97	0.90	0.94	0.62	0.58	0.32
Husband's age	2,231	34.21	33.62	33.98	0.63	0.48	0.25
Husband can read and write	2,231	0.37	0.39	0.37	0.98	0.61	0.63
Husband's education (yrs)	2,231	2.00	2.26	2.09	0.63	0.45	0.21

Note: P-values reported from Wald tests on the equality of means of control and each treatment for each variable. Standard errors clustered at the village level.

Table 15.A.3: Impact of Treatment Arms on IPV, Post-Endline, Pooled North and South, Full Sample of Women Who Were Successfully Interviewed at Post-Endline

	Any emotional or physical	Emotional	Physical
Transfer	0.01	0.02	0.01
	(0.04)	(0.04)	(0.02)
Transfer+BCC	-0.04	-0.02	-0.06
	(0.03)	(0.04)	(0.02)***
N	2,749	2,749	2,749
Mean of Control	0.64	0.60	0.25
Strata Indicator	X	X	X
Extended Controls			
P-value: Transfer=Transfer+BCC	0.13	0.25	0.00

Marginal effects of probit models. Standard errors clustered at the village level. * p<0.1; ** p<0.05; *** p<0.01.

Table 15.A.4: Impact of Treatment Arms on IPV, Post-Endline, Pooled North and South, OLS

	Any emotional or physical	Emotional	Physical	Any emotional or physical	Emotional	Physical
Transfer	0.01	0.03	0.00	0.01	0.03	0.00
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)
Transfer+BCC	-0.04	-0.02	-0.06	-0.04	-0.02	-0.07
	(0.04)	(0.04)	(0.03)**	(0.04)	(0.04)	(0.03)**
R^2	0.00	0.00	0.01	0.02	0.01	0.03
N	2,231	2,231	2,231	2,231	2,231	2,231
Mean of Control	0.67	0.63	0.27	0.67	0.63	0.27
Strata Indicator	X	X	X	X	X	X
Extended Controls				X	X	X
P-value: Transfer= Transfer+BCC	0.13	0.19	0.01	0.11	0.16	0.01

Ordinary Least Squares (OLS) regressions. Extended controls include baseline characteristics of woman and husband.

Standard errors clustered at the village level. * p<0.1; ** p<0.05; *** p<0.01.

Table 15.A.5: Multiple Testing Adjustment for Impacts on IPV in Last 6 Months

		Basic specification			Extended controls		
		p-val	q-val BKY	q-val BH	p-val	q-val BKY	q-val BH
Any emotional or physical	Transfer	0.702	1.000	0.843	0.683	1.000	0.820
	Transfer+BCC	0.270	1.000	0.811	0.247	1.000	0.741
Any emotional	Transfer	0.425	1.000	0.843	0.410	1.000	0.820
	Transfer+BCC	0.642	1.000	0.843	0.607	1.000	0.820
Any physical	Transfer	0.877	1.000	0.877	0.948	1.000	0.948
	Transfer+BCC	0.014	0.090	0.083	0.013	0.086	0.079

Note: p-val is the p-value for the impact estimate, unadjusted for multiple testing. q-val BKY and q-val BH are the q-values controlling the false detection rate, per Benjamini, Krieger and Yekutieli (2006) and Benjamini and Hochberg (1995) respectively.

Table 15.A.6: Impact of Treatment Arms on Violence against Children, Post-Endline, Pooled North and South

	Harsh physical punishment last week	Hit child back when child hits parent
Transfer	-0.04	0.01
	(0.03)	(0.02)
Transfer+BCC	-0.12	-0.08
	(0.03)***	(0.02)***
N	2,226	2,226
Mean of Control	0.48	0.21
Strata Indicator	X	X
Extended Controls	X	X
P-value: Transfer=Transfer+BCC	0.02	0.00

Note: Marginal effects of probit models. Extended controls include baseline characteristics of woman and husband. Standard errors clustered at the village level. * p<0.1; ** p<0.05; *** p<0.01.

Table 15.A.7: Reported Change in Frequency of Physical Abuse Since May 2012, Endline

	Means		P-value of diff. (Wald test)
	Transfer	Transfer+ BCC	
Never experienced or decreased frequency of physical abuse	0.95	0.96	0.37
Never experienced physical abuse	0.71	0.79	0.01
Decreased frequency of physical abuse	0.24	0.17	0.01
Increased frequency of physical abuse	0.01	0.00	0.17
Same frequency of physical abuse	0.04	0.04	0.74

Note: Standard errors clustered at the village level. * p<0.1; ** p<0.05; *** p<0.01.

Index

Accelerated Failure Time (AFT), xix, 48-49, 61

agricultural
diversification, 453; formal credit institutions, 8; input use and productivity, 1, 13; labor productivity, xvii, 364; production technologies, 13, 87; production, 109; research, 11, 46, 80, 169, 246, 248, 256, 265, 271, 544; sector, 2, 4, 123, 175, 186-188, 247, 249, 369, 437, 468; sustainable growth, 19, 199; technology adoption, 1, 13, 20, 248; technology, v, 19-20, 22-38, 40-48, 50-52, 87, 273-274

Agro-Ecological Zone (AEZ), x, xv, xix, 87-88, 90, 92-93, 99-100, 102; technology Improvements by, x, 90

aman, x, 27-29, 35, 39, 41, 43-45, 89, 91-93, 95, 99, 103-104, 110, 115-116, 118, 120-124, 132, 134, 166, 170, 187, 198, 209, 233, 257-259, 263, 279, 281, 290-292, 299, 305, 326. *See also* fertilizer

aquaculture, 111, 113, 123-125, 412-417, 419, 421-422, 426, 430-431, 433-435, 438, 440-442, 445-449; domestic, 415; Quiet Revolution in, vi, 412, 415, 449-450

aus, 27-28, 35-36, 43-44, 89, 91-93, 95, 99, 103-104, 110, 120-124, 133-134, 209, 299, 305, 326. *See also* fertilizer

Bangladesh Agricultural Development Corporation (BADC), xi, xix, 69, 111, 125, 130, 137, 139-146, 157, 159, 161-164, 190, 196, 203, 205, 248-250, 252-255, 262, 264-265, 268-270, 273

Bangladesh Agricultural University (BAU), xix, 39

Bangladesh Chemical Industries Corporation (BCIC), xix, 130, 135, 146-147, 149-150, 152-154, 156-157, 159

Bangladesh Institute of Nuclear Agriculture (BINA), xix, 39-40, 46, 254, 260

Bangladesh Integrated Household Survey (BIHS), xiii, xix, 35, 66, 67, 74, 84, 91, 92, 93, 94, 99, 100, 104, 110, 112, 113, 187, 248, 257, 261, 266, 272, 375, 385, 386, 387, 388, 430, 439, 440, 454-456, 458-459, 463-464, 466, 471, 474-475, 478-479, 481, 484, 490, 544

Bangladesh Krishi Bank (BKB), xix, 8, 196

Bangladesh Rice Research Institute (BRRI), xix, 39-40, 42, 44-45, 69-70, 72-73, 254, 256, 258, 260, 273

Bangladesh
agricultural production in, 110, 127; agriculture input management system in, 129; Article 18(1) of the Constitution of, 1; dairy market in, 8; framework for water resource management in, xvi, 200; marketing of rice in, 302; national water planning in, 195; real wages in, 369; safety net system in, 12; seed system in, 14, 242; water policies in, 196

Basic Needs Price Index (BNPI), 351-352, 353

Behaviour Change Communication (BCC), 14, 552-573, 576, 581-584, 586-590; trainings, 555, 557

boro, x, 5, 27-29, 35-36, 39, 41, 43-45, 54, 70, 72-73, 82, 89, 91-93, 95, 97, 99-100, 110-111, 115-116, 118, 120-125, 132, 134, 147, 149, 152, 158-159, 170, 187, 211, 214, 233, 248, 257-259, 261, 263, 267, 279, 299, 305, 326, 455; season, 41, 45, 70, 73, 91, 99, 111, 121-123, 147, 159, 326. *See also* fertilizer

carp cultivation, 438

cereal
chronic deficits, 278; distribution, vi, 277; impact of public stocks, 14, 278. See also *aus; aman; boro*

Child Benefit Program (CBP), 13

Community Nutrition Workers (CNWs), 556

Cost of Basic Needs (CBN) method, 353

credit, xiii, 8, 138, 166, 341, 479, 512, 575; rural market, 166

crop(s)
barriers to cultivation, 223; high-value, 12, 128; intensification, 453; simulation algorithm, 95; statistics, 268

Data Analysis and Technical Assistance (DATA), xx, 21-22, 380-382, 387

decision problem, 244, 247

Department of Agriculture Extension, 214, 248, 250-252; role of agriculture extension, 271

District Fertilizer and Seed Monitoring Committee (DFSMC), xx, 154-155

drought and cold tolerant varieties, 94

duration models, 60

early marriage, 13-14, 542

economic
development, 183, 201, 345-346, 369-370, 373; growth, 2, 112, 200, 281, 304, 373, 453; transformation, 343-344, 346, 371, 417

economy
changing, 2; dual, 344; rural, 3, 238, 480

education, 6, 9, 21, 48-49, 52-53, 55, 57, 74, 114, 117, 119, 165, 168, 175, 186, 244, 277, 287, 294, 304, 306-307, 316, 359, 371, 463, 465-467, 469-470, 472, 475-476, 479, 483-484, 486-487, 499, 503-504, 508, 512, 516, 520, 524, 528, 536-537, 539-540, 542, 547-548, 555, 560, 566, 581, 587

employment
non-farm opportunities, 11; opportunities, 3, 8, 346, 446

Erosion Productivity Impact Calculator (EPIC), xx, 95

family coping strategies, 10

farm
interactions, 412; new technologies, 46, 49, 53, 55, 57; off-farm activity, 454; size, 25, 49, 176, 258, 260; technologies, 57, 412. *See also* fish

farmer(s)
incomes of small commercial, 10; marginal farmers, 26, 29, 39, 54, 128, 160, 169, 175, 187, 198-199, 242, 260-261; small, 4, 8, 10-11, 24-26, 29-30, 35, 38, 57, 73, 166, 168-169, 175-176, 182, 231, 253, 260, 298, 332, 336, 413, 431

Feed the Future zone, 19-30, 32-37, 39-43, 46-47, 50-51, 53-54, 88, 90, 93, 95, 99, 102-104; tenurial arrangement in, 26

feed
commercialization, 433; dealer segment, 426; mills, 416, 419, 424, 430, 433-434, 444

fertilizer market, 129-131, 136-138, 143, 146, 159-161, 177, 184, 186; deregulation of, 142. *See also* fertilizer

fertilizer marketing, 136; changes in, xi, 137; privatization of, 142. *See also* fertilizer

fertilizer(s)
chemical, 131, 136, 226, 299; consumption, 129, 131, 136; contribution of, xi, 132; crisis, 147, 155, 168, 171, 186; demand and supply of, 134; distribution of, 129-130, 136, 139, 144-145, 160, 184; liberalization of trade, 146; policy in Bangladesh, 14, 130; price, 129-130, 137, 140, 143, 146, 150, 158, 166, 169-170, 172, 178, 186; subsidy, 134, 138, 167-169, 171-175, 177-179, 186; technology, 53, 55, 131. *See also* fertilizer market; fertilizer marketing

fish
farm commercialization, 434; farm segment, 426; farmed, 413-415, 418, 431, 434, 439, 446; natural habitat of fisheries, 194; trader segment, 436; wholesale segment, 431

food insecurity, 5, 9-10, 12, 62, 173, 277, 306, 483. *See also* food; food security

food security, xxv, 1-2, 4-7, 10, 12-14, 19, 62, 75, 90, 106, 131, 133, 167, 171, 183, 199, 242, 244, 247-248, 271-272, 277-279, 293-294, 297-299, 302, 304-307, 309-310, 335-339, 371, 412, 446, 476, 478, 483-487, 490-493, 496, 498, 501-503, 529, 536-537, 544, 571; improvement, 4, 10; narrow production focus, 339; sustainable improvement in, 10. *See also* food; food insecurity

food
access, 5; availability, 4-6, 62, 109, 306; fundamental human rights, 1; production, 4-5, 166-167, 171-173, 178-181, 183-184, 186, 188, 304, 409, 483; securing, 1; transfer programs of, 476; utilization, 6. *See also* food insecurity; food security

gender
inequality, 9, 484, 486, 496, 543; parity, 484, 488, 490-492, 496-497, 502, 524, 535, 539

General Consumer Price Index (GCPI), xx, 351-352

Great Bengal Famine, 277

green revolution, 90, 166, 273, 280, 299, 369, 421; technologies, 5, 87, 109

groundwater
development, 112, 208, 215; sustainability of, xi, 212, 238

Guti urea, 13, 19, 21, 28-30, 32-38, 46-47, 49-50, 52-54, 58; information about, ix, 30; technology, 46

hatchery segment restructuring, 422. *See also* fish

hazard rate, 60

heterosis, 66, 76, 80, 245

High Yielding Variety(-ies) (HYV), x, xv-xvi, xx, 34, 44, 89-94, 96, 99, 102-104, 110, 129, 134, 136, 176, 262, 279, 305; rice cultivation, xv, 92

Household Income and Expenditure Survey (HIES), xii, xx, 6, 22, 351-352, 354-356, 358-359, 362-363, 365-370, 391-393

households
dietary diversity, 492-493, 499, 504, 508-509, 511-513, 515-517, 519-521, 523-525, 527, 530-535, 538; farm, 20-25, 35, 43, 53-54, 58, 62, 226, 231-232, 234-237, 266, 387-388, 412, 447, 490-491; female-headed, 49

hybrid rice, 13, 62-63, 67-84, 124, 250-251, 254, 256, 261; adoption, 63, 75; quality of, x, 72; technologies, 63, 80. *See also* hybrid; rice

hybrid(s)
background of technologies, 63; vigor, 66. *See also* hybrid rice

hybridization, 67, 68, 76, 83; benefits of, 67

income
nonfarm, 360, 362, 366, 463-464, 466, 468, 471, 474-475, 477; sources, xiii, 367-368

informal sector, 272, 354, 360, 363

input markets, 5, 178, 185, 188, 256, 261

international donor community, 78

Intimate Partner Violence (IPV), xiv, xx, 14, 487, 549-553, 557-566, 570-573, 578, 582, 584, 588-589. *See also* transfer programs

IPR protection, 81, 247. *See also* hybrid(s)

irrigation, xi, xiv, 27, 55, 105, 110-111, 121, 125-127, 139, 176, 191, 193-194, 206-207, 212, 225, 230, 235, 237-240, 319, 411; benefits of, v, 109, 226; costs of, xi, 228; groundwater, 111, 121, 183, 197, 202, 211, 215, 223; pricing policy for, 196; privatization in equipment, 197; scarcity of water, xi, 234-235; sources, 27, 122

labor
physical, 315, 345; productivity, 11, 357, 364, 370, 468; rural marginal product of, 346-347

land, ix, xi, xiv, xvi, xxv, 8, 23, 25-26, 28, 109, 126-127, 135, 195, 199-200, 204, 212, 224, 231-233, 237-238, 240, 341, 530, 542, 544; arable, 5, 220, 396; operated, ix, xiv, 23-25; tenure, ix, 25-26

Lewis Turning Point, 344; model of, xvii, 347

malnutrition, 6, 9, 483; chronic child, 483. *See also* nutrition

market
failures, 10, 63, 159, 187, 245-246; liberalization, 145-146, 148, 156, 168, 170, 184; output, 1, 14, 64, 71, 185, 187

marketing margin, xi-xii, xvii, xx-xxi, 148, 325, 327, 329-330; analysis, 310-311, 330-331

Marshallian framework, 409

micro socioeconomics, 412-413

microfinance institutions (MFIs), 186, 366, 370

microfinance
activities, 502; impacts of, 367; programs, 370

Mukta BR-11, 40-42, 45, 259, 261. *See also* rice

Multinomial Logit Model (MNL), 460-464, 469, 475

narrow germplasm base, 76-77. *See also* hybrid rice

National Seed Policy 1993, 249, 264. *See also* seed(s); seed system

National Social Security Strategy (NSSS), 13, 478, 480

National Water Plan (NWP-I), 196

National Water Plan (NWP-II), 196

National Water Policy, 196, 202, 238

National Water Strategy (NWS), 199-200

National Women's Development Policy, 543. *See also* women

New Marketing System (NMS), xxi, 137, 139-140

Nitrogen-Phosphorous-Potassium (N-P-K) ratio, 170

nonfarm-sector expansion, 356. *See also* wage(s)

northwest region, 210

nutrition
during pregnancy, 13; nutritional outcomes, 6, 12, 487; poor, 9. *See also* malnutrition

Old Marketing System (OMS), xxi, 140
onion(s)
consumption, xviii, 391-392; demand for, 392; farmers, 387; hoarding by traders, 380; importers and traders, 375; imports, xviii, 388, 390, 394; Indian, xvii, 377, 379, 382; price analysis, 376; prices of Bangladeshi, xvii, 17, 378-381; prices, 375-376, 378-380, 383, 389, 394-395; production, xvii-xviii, 383-385, 392; supply of, 382
Open Market Sales (OMS), xxi, 183, 285-286, 290, 302; price stabilization of, 183

Plant Variety Protection (PVP), xxi, 81; laws, 81
poverty
change in, 367; components, 460; determinants of, 454, 458; dynamics, vi, xviii, 453, 457-458, 479-481; prevalence of, 456; related stress, 570; transient, xiii, 469-470, 481; transition matrix, xiii
prilled urea, xv, 36-37. *See also* Guti urea
Primary Distribution Points (PDPs), 139-142, 144-145, 147
private investment, 5, 77, 80-81, 83-84, 129, 178, 209, 242-243, 246-247, 251, 256, 265, 271
private trade, vi, 189, 274, 277, 294, 296
product delivery, 82
public distribution, 277, 285
Public Foodgrain Distribution System (PFDS), xii, xvi, xxi, 277-281, 283-284, 286-287, 289-291, 293, 302-303, 306, 311, 340; supply chain, 311
public-private partnerships, 80, 268, 272

rabi season, 131, 152
Rajshahi Krishi Unnayan Bank (RAKUB), 8
regulatory issue, 65, 81
remittances, 281, 358-359, 366-367, 370
rice market
actors influencing, xii, 321; competition in, 332. *See also* rice
rice supply chain
modern (packed), 311; traditional (bulk), 310. *See also* rice
rice value chain, 297-298, 304, 308, 310-311, 313, 316, 318, 321, 325-327, 331-333, 335-339; and food security policy, xvi, 310; characteristics of, 316; management, 305, 307. *See also* rice
rice
farm area, ix, 35; farmers, xiv-xv, 31, 33-34, 42, 341; husking mills, 315; marketing margins of, xii, 325; popular varieties, ix, 40, 42, 45; production system of, 299; productivity, v, 36, 109; sector, 298, 333, 341; stress-tolerant varieties, ix, xv, 20, 38-41, 43, 50-54, 91, 94; trading, 302; varieties, xii, xvi, 39, 42, 44, 105, 259, 273, 301. *See also* hybrid rice; rice market; rice supply chain; rice value chain
rural
development, 3, 467; infrastructure development, 302, 447, 477; workers, 371; youth, 11, 477

salinity tolerance variety, 99, 103. *See also* rice
scientific discovery, 76
seed system, 14, 241-250, 253-254, 261, 264-268, 270, 272; development, 241, 274; elements of, xvi, 243; formal, 248; performance, 253. *See also* National Seed Policy 1993; seed(s)

seed(s)
bed, ix, 45; commercialization, 433; market, 68-70, 81-82, 246, 249, 256, 265, 268-269, 272; multiplication, 254; patterns of, 44; phytosanitary certificate for import, 270-271; purchasing, 243, 254; quality control, 270; requirement, xii, 256; sources of, xvi, 262. *See also* National Seed Policy 1993; seed system

smart subsidies, 177. *See also* fertilizer(s)

social safety nets, 12, 178, 359, 365

Soil and Water Assessment Tool (SWAT), xxi, 90-91

southwest region, 215, 218

ST&I framework, 64; stages and strategies in, x, 65

stock(s)
public intervention system, 152; public, vi, 277, 284, 288

structural transformation, vi, 16, 343. *See also* wages(s)

Sub-Assistant Associated Officers (SAAOs), 153-154

submergence tolerance variety, 101, 103. *See also* rice

supply chain actors, xii, 323

Transfer Modality Research Initiative (TMRI), 552-554, 556-560, 578

transfer programs, 365, 549-551, 571. *See also* Intimate Partner Violence (IPV)

transitional adjustment problems, 146

Transportation Discount Points (TDPs), 141

United States Agency for International Development (USAID), xxii, xxv, 19-20, 28, 53, 55, 87-88, 139-140, 190, 260

urea deep placement (UDP), xxi, 13, 19-20, 28-29, 89; technology, 20, 28-29; usage of technology, 28

value chains, 11, 19, 68, 331-333, 338, 412-413, 415-417, 435-436, 477

value creation, 308, 321

wage(s)
female, 355; national patterns, 356; nominal and real, xii, 351; rates, 344, 351, 367, 370; urban and rural, 348; urban nominal, 355

Water Management Cooperative Associations (WMCAs), 205, 217

water resource(s)
development potential, 210; development projects, 205; development, 193, 208; management, 193, 195, 237-238, 240; planning, 195

Water Resources Planning Organization (WARPO), xxii, 196, 205, 208-209, 215-216, 218-219, 240

water
conservation, 178, 201, 203; cost recovery of supply, 203; management, 113, 123, 169, 194-196, 202, 205, 207-208, 214, 216-217, 220, 223, 236, 445; policy on pricing, 203; private sector management, 200; public sector management, 201; scarcity, 231; sustainable management, 214-215

women
five domains of empowerment, 488; physical violence against, 569; violence against, 552-553, 558, 574-575, 577. *See also* National Women's Development Policy

Women's Empowerment in Agriculture Index (WEAI), xiii, 14, 455, 463-464, 466, 468, 471, 474, 483-484, 487-491, 493-494, 541

world price shocks, 284, 292

Akhter U. Ahmed is a Senior Research Fellow, Country Representative for Bangladesh, and led the Policy Research and Strategy Support Program (PRSSP) in Bangladesh under the International Food Policy Research Institute (IFPRI). He works on strategies for agricultural and rural development, social protection, women's empowerment, food insecurity, and undernutrition of the poor in developing countries. He received a PhD from Colorado State University and an MS from Cornell University in Agricultural Economics.

Nurul Islam is an Emeritus Fellow at the International Food Policy Research Institute (IFPRI). He served as the Assistant Director General of the UN Food and Agriculture Organization (FAO), was the first Deputy Chairman of the Bangladesh Planning Commission, first Chairman of the Bangladesh Institute of Development Studies (BIDS), Chairman of the Economics Department at Dhaka University, among other titles. He received an MA from Dhaka University and an MA and a PhD from Harvard University in Economics.

Mustafa K. Mujeri is currently the Executive Director, Institute for Inclusive Finance and Development (InM) and is a former Director General, Bangladesh Institute of Development Studies (BIDS), and Chief Economist, Bangladesh Bank. He works on public and monetary policy analysis, sustainable development, among other areas. He received his MA and PhD from McMaster University and an MA from Rajshahi University in Economics.

ISBN 978 984 506 371 5



ISBN 978 984 506 371 5