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IFPRI Discussion Paper 01576

November 2016

**Does a “Blue Revolution” Help the Poor?
Evidence from Bangladesh**

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ABSTRACT

The impressive growth in aquaculture is now commonly dubbed a “blue revolution.” In some Asian countries, fish availability has increased at a faster rate in recent decades than did cereal availability during the Green Revolution. As an example, Bangladesh is one country where aquaculture has increased almost eightfold since the early 1990s. This growth has important implications for food and nutrition securities. Yet, there is little research on the determinants and impacts of this growth to document the lessons, identify evolving issues, and guide policy discussions. This paper attempts to fill that gap. Using several rounds of nationally representative household survey data, the authors conducted microsimulations to generate disaggregated estimates. The results show that, between 2000 and 2010, about 12 percent of Bangladesh’s overall poverty reduction can be attributed to aquaculture growth. In other words, of the 18 million Bangladeshis who escaped poverty during this period, more than 2 million of them managed to do so because of the growth in aquaculture. However, the results vary widely across income groups, with households in the third income quintile (which is not the poorest) benefiting the most. The implications of the results, methodological issues, and areas of future research are also discussed.

Keywords: aquaculture, Bangladesh, poverty, prices and welfare analysis, microsimulations

ACKNOWLEDGMENTS

The fieldwork and conceptualization of this research was funded by the US Agency for International Development through the International Food Policy Research Institute's (IFPRI's) Policy Research and Strategy Support Program in Bangladesh. The subsequent works have been supported by IFPRI and CGIAR's Consortium Research Program. The authors have benefited from discussions with Nurul Islam, Xiaobo Zhang, Paul Dorosh, Akhter Ahmed, and Shahidur R. Khandker. The usual disclaimer applies.

1. INTRODUCTION

Aquaculture is one of the world's fastest growing food sectors, and its share in global fish consumption by humans is projected to grow to more than 60 percent by 2030 (FAO 2014). This growth is remarkable given that the sector was almost nonexistent in the 1950s and its share in total fish production remained below 20 percent until the early 1990s. The underlying implications of this trend are considered to be so significant that they are now commonly termed a “blue revolution,” and there are good reasons for using such terms. Aquaculture holds the promise of meeting most of the world's fish demand without ruining the environment (*Economist* 2003; Sachs 2007); it also will be able to help reduce poverty while improving food security and nutritional well-being.¹ If aquaculture had stopped growing in 1980—that is, if growth in the world's fish supply depended only on marine and inland capture fisheries—per capita annual fish availability in 2013 would have been only 14.0 kg, which is 17 percent lower than the availability in 1980 and about half of the actual availability of 26.8 kg in 2013. The consequences of such a scenario are easy to imagine: higher prices, lower consumption, and far greater pressure on marine and inland capture fisheries. The adverse consequences would have been particularly severe for the developing countries of Asia, where fish is an important part of the diet, providing more than 60 percent of animal source protein (FAO 2005), and where fish production and marketing provide the livelihoods for millions of poor households.

Thanks to technological innovation and some deliberate policy actions, the world did not have to live through such a reality. Calculations from the Food and Agriculture Organization's (FAO's) *Aquastat* database indicate that Asian countries increased their aquaculture production from 10.8 million tons in 1990 to 58.9 million tons in 2012, with developing countries accounting for about 86 percent of the total production. While China has led the way in this growth, some other countries in Asia have also experienced impressive growth in aquaculture since the 1990s. For example, farmed fish production in Bangladesh increased from about 240,000 tons in 1992/1993 to 1.86 million tons in 2012/2013, with growth in fish availability far exceeding growth in cereal availability during the Green Revolution.² Until the mid-1990s, aquaculture had been the smallest of the three main types of fisheries—marine, inland capture, and aquaculture—in the country, representing only 16 percent of total fish production; but it has grown to become the largest type, accounting for 55 percent of total fish production in 2013.³ This growth and structural change have contributed to increasing fish availability, reducing the real price of fish, and generating employment, with important implications for poverty reduction and nutritional well-being.⁴

Thus, there has been increasing interest in the poverty and income distribution implications of aquaculture growth in Bangladesh.⁵ However, empirical studies have only recently begun to emerge. Even though the literature provides important insights, there remain significant gaps in terms of both conceptual understanding and empirical methodologies.⁶ Conceptually, the aquaculture-poverty linkage literature closely resembles the agricultural growth linkage literature in that almost all available studies hypothesize aquaculture to have both direct and indirect benefits on poverty. However, there are ambiguities regarding the definition and quantification of these direct and indirect benefits. Existing

¹ There is a body of literature on the relationship between aquaculture and food security, poverty, and environment. For further reference, see Ahmed and Lorica (2002) on food security; Toufique and Belton (2014) and Belton et al. (2012) on poverty impacts, and Naylor et al. (2000) and Pingali (2001) on environmental impacts.

² According to official data, production of aquaculture fish grew by about 15 percent in the 1990s, as compared with a growth in rice production of about 3 percent during the Green Revolution.

³ These estimates are based on the Department of Fisheries (DoF) data, which are further discussed in Section 4.

⁴ The nutritional implications are particularly important for Bangladesh because fish accounts for 63 percent of animal source protein (FAO 2005) in Bengali diets; it is the most important source of high-quality protein, essential fatty acids, and micronutrients (Roos et al. 2007); and it is the most frequently consumed, nutrient-rich, animal-source food among all income groups in Bangladesh (Toufique and Belton 2014).

⁵ Another reason for increased interests on the aquaculture-poverty linkage is that donors have taken an active interest in promoting aquaculture.

⁶ Ahmed and Lorica (2002) presented a conceptual framework and Toufique and Belton (2014) presented a good summary of available studies of the aquaculture-poverty linkages in Bangladesh.

literature also has important methodological weaknesses, as almost all available studies are based on nonrepresentative samples. As a result, although these studies provide important insights into selected issues, no generalizable conclusions can be drawn from them. Perhaps the most important gap is that none of the available studies answer the basic question: to what extent has aquaculture growth contributed to poverty reduction?

This paper attempts to fill these gaps in the literature. In particular, it uses microsimulations to analyze the impacts of aquaculture growth on income distribution and poverty in Bangladesh using an expanded version of Deaton's (1989) model and several rounds of nationally representative household survey data. The estimates are disaggregated by sex, rural-urban, administrative divisions, and income quintile. The rest of the paper is organized as follows: The next section presents an overview of the concepts and previous research. Section 3 describes the data and methods used in the paper. Section 4 presents the key trends in aquaculture production, consumptions, and prices. The results of the welfare impacts of real price decline and productivity growth are presented in Section 5. The paper concludes with a summary and implications.

2. CONCEPTS AND PREVIOUS RESEARCH

The conceptual framework for analyzing the welfare implications of aquaculture growth is no different from that for any other economic sector. Following Hirschman's (1957) work in Latin America, many studies have examined linkages between economic sectors. The agricultural growth linkage literature made a distinction between direct and indirect effects in terms of improving rural employment and household well-being (Johnston and Mellor 1961; Mellor and Lele 1972; Adelman and Morris 1973). This literature was a strong force in changing the then-prevailing views—mainly emerging from Latin America—that public investment should be directed toward the industrial sector; this view was based on the presumption that public investment had greater linkages to the overall economy. The underlying ideas of this strand of literature continue to be relevant, as reflected in the recommendations of the World Bank's (2008) *World Development Report* and de Janvry and Sadoulet's (2010) studies of China.

The central premise of the agricultural growth linkage literature is that the growth in agriculture resulting from the alleviation of supply constraints—such as technological innovation or infrastructural improvement—generates higher multiplier effects (or growth linkages) through increased demand of nontradable goods outside of agriculture.⁷ The existing aquaculture poverty linkage literature diverges significantly from this conceptual framework, as is evident in several studies. This paper considers two studies to illustrate the conceptual issues and their implications for empirical methods and interpretation of results. Ahmed and Lorica (2002; hereafter, AL) argued that adoption of new aquaculture technology could affect food security through three distinct pathways: income linkages, employment linkages, and consumption linkages. Although it is not obvious from the conceptual framework figure, they also suggested that aquaculture technology adoption could have both direct effects (through consumption from own production) and indirect effects (through higher income, leading to increased consumption).

The major weakness of AL's conceptual framework is that it does not account for the linkages between fish and nonfish sectors. The framework also has other ambiguities. For instance, price effects and high consumption from own production are listed as two distinct channels of consumption linkages; however, it is easy to argue that both channels are linked with income. In addition, consumption from own production has opportunity costs; therefore, increased consumption may not be due to own production but to higher income from the adoption of new aquaculture technology. Similarly, some of the employment linkages (for example, consuming nutrient-rich food and the ability to earn wage income) can also fall under income linkages. It is true that increased intake of nutrient-rich food can increase labor productivity, which can lead to higher income and to a shift in the demand curve for fish. Therefore, it appears that three linkages in AL's framework are not as distinct, which, from an empirical standpoint, means the linkages are not identifiable.

A recent study by Toufique and Belton (2014; hereafter, TB) extends the AL framework in two ways: (1) it provides more nuance to direct and indirect linkages, and (2) it adapts a framework for assessing the pro-poorness of aquaculture growth. The study defines the following four linkages: direct consumption links (increased consumption from own production), indirect consumption links (increased availability and accessibility of fish), direct income links (increased income for aquaculture producers), and indirect income links (employment in the fish value chain and consumption linkages).

⁷ To illustrate the point, suppose that (1) a rural economy is divided into two sectors, agriculture and nonagriculture; (2) marginal propensity to consume (MPC) is low, at 0.5, for agricultural commodities; and (3) MPC is high, at 0.9, for nonagricultural commodities. The second and third assumptions are particularly realistic for poor economies in that a large share of incremental income is likely to be spent on nonagricultural goods and services (for example, housing, clothing, education, and other nontradables) than on agricultural goods (for example rice and wheat). Given these assumptions, multiplier effects for nonagriculture, given by $M_{na} = \frac{1}{(1-0.9)} = 10$, will be five times larger than the multiplier effects of agriculture, given by $M_a = \frac{1}{(1-0.5)} = 2$. This was the key insight of Johnston and Mellor's (1961) seminal study, as well as of many subsequent studies, on the role of agriculture in economic development.

TB's framework is nicely presented and easier to understand, but like AL's framework, it limits linkages only to the fish sector. Hence, it suffers from some of the same weaknesses. The other contribution of TB is that it presents a conceptual framework for assessing whether aquaculture growth is pro-poor. Drawing from the pro-poor growth literature proposed in Ravallion (2004, 2009) and Kakwani et al. (2004), TB classifies four types of pro-poorness: benchmarked, weakly pro-poor, strong relative pro-poor, and strong absolute pro-poor. Growth in aquaculture is defined as benchmarked pro-poor if it is associated with an increase in fish consumption by households below the poverty line; weakly pro-poor, if fish consumption by the poor increases at a faster rate than in the past; strong relative, if fish consumption by the poor increases at a faster rate than by the non-poor; and strong absolute, if the amount of fish consumed by the poor is higher than by the non-poor.

Although TB's characterization helps illustrate the pro-poorness of aquaculture, it has serious pitfalls. The pro-poor economic growth classification is applied to the entire economy, not to any particular sector within an economy. More specifically, pro-poor growth literature compares two measurable outcomes—growth and poverty—that are identifiable. This is not the case for a given sector, as both growth and overall poverty reduction can be influenced by the economy's other sectors. In addition, the key variable in TB's framework—that is, fish consumption—can also be affected by economic factors outside of aquaculture. Not accounting for these conceptual issues has major implications for the way results are interpreted. For example, one conclusion in TB states “aquaculture has proven unequivocally pro-poor in terms of the ‘indirect consumption’ pathway.” An implicit assumption of this conclusion is that the increase in fish consumption resulted from the growth in aquaculture alone. This conclusion is flawed, as an increase in fish consumption can be caused by a host of other factors, including growth in other sectors and subsectors. In this paper's assessment, all of the available evidence confirms that there has been an increase in fish consumption by all income groups and that the real prices have declined due to technological innovation and a rightward shift in the supply curve. However, neither of these can be attributed to the growth in aquaculture alone, as there are other contributing factors, including years of overall economic growth.

3. DATA AND METHODS

Data

This study uses three rounds of Household Income and Expenditure Survey (HIES), conducted by the Bangladesh Bureau of Statistics (BBS) in collaboration with the World Bank. The sampling methods and the key results from various rounds of the HIES are presented in HIES reports produced after the completion of each round.⁸ Although this paper uses three rounds of surveys (2000, 2005, 2010) to explore trends in aquaculture, the microsimulation analysis is based on the latest round (2010). The sampling of this round was based on the Integrated Multipurpose Sample, which consisted of 1,000 primary sampling units. This unit is defined as two or more contiguous enumeration areas used in the 2001 Bangladesh census. Following a two-stage stratified random sampling method, a total of 12,240 households were sampled, of which 7,840 were from rural areas and 4,400 were from urban areas.

In addition, secondary data from other sources were used. Production data, disaggregated by location and sources, were compiled from the *Fisheries Yearbook* published by the Ministry of Fisheries and Livestock. This yearbook is based on the Fisheries Resources Survey System administered by the Department of Fisheries (DoF). Historical data on fish prices, disaggregated by location and varieties, and on export-import data were also obtained from the DoF. These data were particularly helpful in analyzing the trends and triangulating the estimates generated from the HIES data.

Methodology

This study employs an expanded version of Deaton's (1989) model for analyzing the welfare implications of food price changes. Since its publication, Deaton's model has been used to analyze the welfare effects of price shocks, most notably following the 2007/2008 global food crisis.⁹ Theoretically, the model is derived from the fact that the welfare impact of price changes can be defined in terms of compensating variation (CV), which is defined as the monetary compensation needed to offset the effects of price and income changes, leaving household utility at the same level as it was before the changes. Formally, CV can be expressed as

$$CV = e(p_0^c, u_0) - e(p_1^c, u_0) + \pi(p_1^p, w_1) - \pi(p_0^p, w_0), \quad (1)$$

where $e(\cdot)$ is an expenditure function; p^c is a vector of consumer prices; u is the utility that the consumer derives from the fish; $\pi(\cdot)$ is the profit function income-generating activities of the household; p^p is the price received for goods and services sold by the household; and w is the price of goods and services that a household buys as input into productive activities, including labor and a set of assets that are fixed in the short run. The subscripts 0 and 1 refer to times: before and after price changes, respectively. This study focuses on aquaculture as the income-generating activity; thus, p^p is the producer price of fish, and w is the price of aquaculture inputs.

With some algebraic manipulations, the welfare implications of price changes can be expressed in terms of elasticities:

$$\frac{CV}{Y} = \sum_{i=1}^N -q_{i0} \hat{p}_i + \frac{1}{2} \sum_{i=1}^N \sum_{j=1}^N \varepsilon_{ij} \hat{p}_i \hat{p}_j + \sum_{i=1}^M s_{i0} \hat{p}_i^p + \frac{1}{2} \sum_{i=1}^M \sum_{j=1}^M \theta_{ij} \hat{p}_i \hat{p}_j + \sum_{i=1}^P x_{i0} \hat{w}_i + \frac{1}{2} \sum_{i=1}^P \sum_{j=1}^P \gamma_{ij} \hat{w}_i \hat{w}_j, \quad (2)$$

where q_{i0} is the budget share of the consumer good i ; s_{i0} is the value of output as a share of income; x_{i0} is the value of spending on input I as a proportion of income; ε_{ij} is the absolute value of Hicksian cross-

⁸ The report on the 2010 round of the HIES is available at <http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/LatestReports/HIES-10.pdf>.

⁹ See Ivanic and Martin (2008) for a review.

price elasticities between good i and good j ; θ_{ij} is the cross-price elasticity of supply between good I and good J ; γ_{ij} is the elasticity of demand for good i with respect to the price of good j ; and the “hat” operator indicates the proportion of change in the respective variables.

Deaton’s (1989) model is derived from equation (2) with four simplifying assumptions: (1) there is no change—or only negligible change—in input prices, thus eliminating the last two terms on the right side of the equation; (2) consumers do not respond to price changes in the short run, thus eliminating the second term on the right side; (3) farmers do not respond to price changes in the short run, thus removing the fourth term on the right; and (4) changes in consumer and producer prices are proportional, which allows for a combination of the first and the third terms on the right. With these simplifying assumptions, Deaton (1989) expressed equation (2) as follows:

$$\frac{CV}{Y} = \sum_{i=1}^N (s_{i0} - q_{i0}) \hat{p}_i \quad (3)$$

where $(s_{i0} - q_{i0})$ represents the net benefit ratio (NBR), defined as the value of net sales of commodity i as a proportion of household income. Equation (3) has been the workhorse in examining the welfare implications of price shocks. Following the 2007/2008 global food crisis, several studies used this approach to examine the welfare implications of food price increase.¹⁰

In the context of aquaculture in Bangladesh, however, it is important to examine whether these simplifying assumptions can have a significant effect on the magnitudes of welfare change. Based on the available secondary data, it is evident that the assumption of proportional changes in consumer and producer prices does not hold in the case of aquaculture. Similarly, the real price of aquaculture fish in Bangladesh has declined over time, implying that supply responded (a rightward shift) to technological innovation. In other words, the fourth term in equation (2), representing second order approximation of the welfare change, will not be equal to zero.¹¹

¹⁰ Notable examples include Ivanic and Martin (2008) and Wodon and Zaman (2010).

¹¹ Following Minot and Goletti (1998) and Minot and Dewina (2013 and 2015), we conducted sensitivity analysis for robustness. These results are available from the authors upon request.

4. TRENDS IN AQUACULTURE IN BANGLADESH

Production

Bangladesh has made remarkable progress in promoting aquaculture. From 1983/1984 to 1992/1993, the average annual production of aquaculture fish was only about 178,000 tons; this number jumped to about 1.3 million tons in the most recent decade (Table 4.1). Production of capture and marine fisheries also increased in absolute terms since 1983/1984, but their average shares in total production declined from 53 to 36 percent and from 26 to 19 percent, respectively. In 2012/2013, the latest year for which data are available, total aquaculture production was 1.6 million metric tons, equivalent to 55 percent of the total fish production of 3.4 million tons.

Table 4.1 Trends in fish production in Bangladesh, 1983/1984–2012/2013

Sources	Annual average production (metric tons) and production shares					
	1983/1984– 1992/1993	Shares (%)	1993/1994– 2002/2003	Shares (%)	2003/2004– 2012/2013	Shares (%)
A. Inland fisheries						
Capture						
River	175,285	20.6	151,561	10.0	140,552	5.1
Sunder ban	6,852	0.8	9,865	0.6	18,220	0.7
Beel (lake)	47,397	5.6	67,403	4.4	79,136	2.9
Kaptai lake	3,714	0.4	6,490	0.4	8,096	0.3
Flood lands	220,170	25.8	404,291	26.5	728,193	26.4
Total	453,418	53.2	639,610	42.0	974,197	35.3
Culture						
Ponds	153,258	18.0	479,867	31.5	1,010,184	36.6
Semiclose	1,293	0.2	3,277	0.2	5,261	0.2
Baors/culture	--	--	--	--	107,782	3.9
Shrimp	23,378	2.7	79,611	5.2	151,610	5.5
Total	177,929	20.9	562,755	37.0	1,274,837	46.1
B. Marine fisheries						
Industrial	11,393	1.3	17,411	1.1	42,805	1.5
Artisanal	210,092	24.6	303,123	19.9	471,245	17.1
Total	221,485	26.0	320,534	21.0	514,050	18.6
National total	852,832	100.0	1,522,899	100.0	2,763,084	100.0

Source: Based on data compiled by the authors from *Fisheries Statistical Year Book of Bangladesh*, 1983–2013 (Ministry of Fisheries and Livestock various years).

Of the four subcategories of culture fisheries, pond culture has experienced the fastest growth. Average annual pond fish production increased from about 150,000 tons in the 1980s to more than 1.0 million tons in the past decade, equivalent to about 80 percent of the total culture production of 1.3 million tons. The growth has been faster in recent years, with production from pond culture jumping from 750,000 tons in 2007/2008 to 1.45 million tons in 2012/2013. Shrimp production, which receives much more attention in policy discussion, increased only by about 65,000 tons during the same period. Another new development in aquaculture in Bangladesh is the seasonal production of cultured fish in *haors* and *baors* (the depressions that get flooded during the monsoon season). The DoF began collecting data on seasonal culture fish production in 2009/2010, when it recorded a total production of about 46,000 tons;

this number increased to 201,000 tons by 2012/2013. Thus, this appears to be another growth area for Bangladesh aquaculture.

Exports

Bangladesh exports seven categories of fish products—frozen shrimp, frozen fish, dry fish, salted fish, shark fin, turtle, and others; shrimp is by far the largest export in terms of value and volume. Of the total export of 85,000 tons in 2012/2013, more than 50,000 tons (or about 60 percent) was shrimp produced by large commercial farmers with the primary objective of exporting. The share of shrimp in the total export value was even larger, at 81 percent of the total export of \$533 million. By contrast, the total volume of frozen fish was only about 11,000 tons, which included not only farm-raised fish but also marine and other capture fisheries. Therefore, the actual volume of aquaculture fish export was much smaller than 11,000 tons, which is less than 1 percent of the 1.3 million tons of cultured fish. These numbers imply that the growth in the production of common aquaculture fish varieties is overwhelmingly driven by domestic demand. This is a key point because multiplier effects are much larger, in terms of both nutrition and income generation, for aquaculture than for other fish subsectors not considered in this study.

Consumption

The small volume of nonshrimp aquaculture exports indicates that the growth in production has translated into increased consumption at the aggregate level. However, it tells little about the patterns of consumption by location, gender, and income groups, which are central to drawing welfare implications. To this end, this paper analyzes three rounds of HIES data. The only problem in carrying out this analysis is that HIES does not clearly disaggregate nonshrimp aquaculture from other types of fish consumption, especially from inland capture fisheries. The authors follow Toufique and Belton's (2014) strategy of categorizing fish into four major groups: (1) primarily aquaculture, (2) inland capture and culture, (3) primarily inland capture, and (4) primarily marine. Table 4.2 presents the results of the analysis. The aggregate estimates of rural and urban consumption are fairly similar to those in Toufique and Belton (2014), though two additional dimensions are added to this analysis—disaggregation by gender and by income quintile.

Three main points can be drawn from the results. First, fish consumption has increased for every category of household shown—rural, urban, male, female—as well as for each income quintile. At the national level, per capita annual fish consumption increased from 13.4 kg in 2000 to 18.1 kg in 2010, implying 35 percent growth over the decade or 3 percent per year. This achievement is remarkable because, not too long ago, achieving 18.0 kg per capita annual consumption was a national target and seen as a potential for aquaculture growth. This goal is reflected in an FAO (2005) report: “The present per capita annual fish consumption in Bangladesh stands at about 14 kg/year against a recommended minimum requirement of 18 kg/year; hence there is still need to improve fish consumption in the country.” Now that the country has achieved the target, perhaps a different set of questions needs to be asked. In particular, policies can now focus on improving distribution across income groups and perhaps accessing international markets.

Table 4.2 Changes in annual per capita fish consumption (kg/person/yr) in Bangladesh, 2000–2010

Year	Fish sources	Location		Sex of the household head*		Income quintile					
		Rural	Urban	Male	Female	1st	2nd	3rd	4th	Richest	All
2000	Primarily aquaculture	3.4	3.9	3.3	3.5	1.6	2.3	3.0	3.9	6	3.5
	Inland capture and culture	4.5	3.8	5.1	4.3	3.2	4.0	4.5	4.8	5.1	4.4
	Primarily inland capture	3.6	3.5	3.6	3.6	2.8	3.6	3.5	4.0	3.9	3.6
	Primarily marine	2.0	3.6	3.0	2.3	0.8	1.3	2.3	3.0	3.6	2.3
	Total	13.6	14.9	15.0	13.7	8.4	11.2	13.3	15.7	18.5	13.4
2005	Primarily aquaculture	5.5	6.2	6.5	5.6	3.2	4.0	4.8	6.3	8.7	5.7
	Inland capture and culture	5.1	4.6	5.7	4.9	4.6	4.5	4.7	5.1	5.5	4.9
	Primarily inland capture	2.7	3.4	2.8	2.9	2.3	2.4	2.7	3.1	3.4	2.9
	Primarily marine	1.5	4.1	2.5	2.1	1.3	1.6	2.0	2.2	3.1	2.1
	Total	14.7	18.3	17.5	15.5	11.4	12.4	14.2	16.8	20.8	15.6
2010	Primarily aquaculture	7.5	7.8	8.2	7.5	5.3	6.2	6.7	8.5	10	7.5
	Inland capture and culture	5.3	6.4	6.4	5.5	4.7	4.9	5.3	5.9	6.7	5.6
	Primarily inland capture	2.4	3.2	2.9	2.6	2.0	2.2	2.5	2.8	3.3	2.6
	Primarily marine	1.6	4.5	2.8	2.3	1.3	1.4	1.9	2.7	4.0	2.4
	Total	16.7	21.9	20.2	17.8	13.2	14.6	16.4	19.8	23.9	18.1
Change since 2000 (%)		23.8	46.9	34.7	29.9	57.1	30.4	23.3	26.1	29.2	35.1

Source: Authors' calculations from HIES rounds 2000, 2005, 2010 (BBS 2010).

Note: * The differences between mean consumptions are statistically significant.

Second, in relative terms, households in the bottom two income quintiles experienced the fastest growth in fish consumption between 2000 and 2010. The poorest households increased their consumption by more than 57 percent, which is larger than any other income groups in Table 4.2. This finding is consistent with studies that suggest that both price and income elasticity of demand for fish are higher (in absolute value) for the poor than for richer households (Dey, Alam, and Bose 2010).

Finally, the results show that levels of fish consumption are diverging between urban and rural households. In 2000, per capita consumption in urban households was 14.9 kg, which was only about 10 percent higher than consumption by rural households. In 2010, per capita annual consumption by urban households jumped to almost 22.0 kg, which is about 31 percent higher than for rural households.

Price Trends

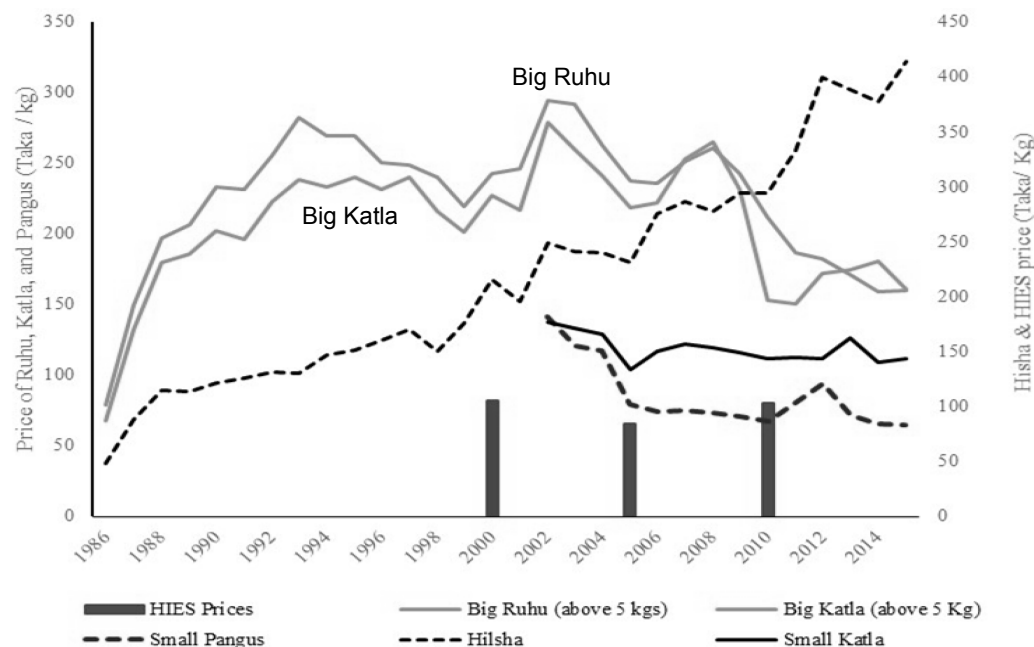
Since the main way that the boom in Bangladeshi aquaculture helps nonproducers is through the price effect, it is important to explore trends in fish prices over this period. Estimates from the HIES data suggest that fish prices declined between 2000 and 2005 but increased again in 2010. The HIES data refer to unit values, not prices per se, and may be influenced by seasonality and changes in quality.

More reliable data are collected by the DoF on a regular basis in multiple markets. Figure 4.1 presents price trends of a few popular varieties, along with three point estimates from the HIES data. Except for Hilsha, which is primarily a marine fish, all prices have been declining in real terms since 2002, which is consistent with growth of aquaculture.¹² For instance, commercial production of nonnative pangusius catfish began in Mymensingh in 1993 (Belton et al. 2012), and DoF began collecting high-frequency price data for pangusius and other cultured fish only in the early 2000s. The prices of both pangusius and smaller carps, two main varieties of culture fish, have been declining ever since DoF began

¹² Hilsha is primarily a marine fish from the shad family. In monsoon, they swim toward the upstream rivers, like the Padma. The fish are caught at both the Bay of Bengal and the large river. This popular fish in Bengal has a rapidly growing market in the countries of Europe, the Middle East, and North America, where there are Bengali immigrants or migrants.

recording prices in early 2000s. Finally, real prices of all fish varieties, both inland and marine, were increasing rapidly in the 1980s, which was when the Green Revolution was taking root, rice prices were falling, and the economy was enjoying overall growth.

Figure 4.1 Real prices (2010 = 100) of selected fish varieties in Bangladesh, 1986–2014



Source: Authors' construction based on DoF price series and HIES data (BBS 2010).

This last point was the subject of much debate in the 1990s. One set of studies argued that income growth was not sufficient to improve nutrition (see, for example, Behrman and Deolalikar 1987; Bouis and Haddad 1992); another strand refuted it (see, for example, Subramanian and Deaton 1996). A recurrent observation at the time was that although the Green Revolution resulted in declining rice prices, prices of other food items, such as pulses, vegetables, fish, and animal products, were increasing around the same time. For instance, Bouis (2000) reported that although rice prices in selected Asian countries declined by 40 percent, the real prices of pulses, vegetables, and animal products had increased 25–50 percent since the onset of the Green Revolution. Figure 4.1 demonstrates that this is no longer a concern in Bangladesh, at least in the case of fish; real prices have been declining for all fish varieties, except marine fish, which is largely consumed by the rich and middle-income groups.

The empirical evidence presented suggests that demand has increased with population growth and higher incomes, but supply has increased even more rapidly, resulting in a decline in real price. Because Bangladesh has experienced sustained economic growth, and because aquaculture is a small part of the country's overall economy, it is safe to assume that the shift in demand curve has resulted mainly from overall growth, not aquaculture per se. Given that aquaculture's share in gross domestic product is small, its contribution to the shift in demand should also be relatively small, suggesting that the shift in the supply curve has been the main channel through which aquaculture has contributed to welfare. This is the point of departure of our analysis.

5. WELFARE IMPLICATIONS OF AQUACULTURE GROWTH

Market Positions and Net Benefit Ratios

Based on data from the 2000 HIES survey, Table 5.1 shows descriptive statistics for the NBR of aquaculture for various types of households in Bangladesh. The first column indicates the proportion of all households in that category. The next three columns show the average production ratio (s_{i0} in equation (1)), the average consumption ratio (q_{i0} in equation (1)), and the average net benefit ratio ($s_{i0} - q_{i0}$), respectively. The last three columns present the share of households in that category that are net sellers, autarkic (neither buying nor selling), or net buyers. The results are disaggregated by household location (rural or urban), administrative division, the sex of the household head, fishing practices, and income quintile.

Table 5.1 Net positions of households in aquaculture fish in Bangladesh

Household category	Percentage of all households	Production ratio	Consumption ratio	Net benefit ratio	Net seller	Autarky	Net buyer
		% of total income			% of households in each category		
Location							
Rural	80	2.51	3.90	-1.38	9.1	13.2	77.6
Urban	20	0.32	3.27	-2.96	1.2	10.4	88.4
Sex of head							
Male	91	2.21	3.80	-1.59	8.0	11.9	80.1
Female	9	0.61	3.48	-2.86	2.5	20.1	77.5
Regional							
Barisal	7	1.99	2.09	-0.10	9.7	34.5	55.8
Chittagong	23	1.77	4.37	-2.60	5.4	12.8	81.8
Dhaka	33	1.78	3.87	-2.09	6.9	8.6	84.6
Khulna	12	5.38	3.74	1.64	14.0	11.6	74.5
Rajshahi	25	1.18	3.54	-2.36	6.7	12.5	80.8
Occupation							
Fish farmer	23	9.06	4.94	4.12	32.9	9.2	57.9
Other	77	--	3.42	-3.42	--	13.7	86.3
Income quintile							
Poorest	20	1.52	3.15	-1.63	4.7	21.4	73.9
2nd	20	2.21	3.67	-1.45	8.1	15.1	76.8
3rd	20	2.35	4.16	-1.81	8.6	11.8	79.7
4th	20	2.61	4.10	-1.49	9.5	10.4	80.1
Richest	20	1.65	3.78	-2.13	6.7	4.6	88.6
National	100	2.07	3.77	-1.70	7.5	12.7	79.8

Source: Authors' calculation based on HIES 2000 (BBS 2001).

Starting with the national estimates (the last row of the table), aquaculture production accounts for 2.07 percent of income,¹³ while aquaculture consumption represents 3.77 percent of income, giving an NBR of -1.7 percent. This means that a 10 percent increase in aquaculture prices would result in a 0.17 percent decrease in income for Bangladeshi households. The last three columns of the last row indicate that about 80.0 percent of households are net buyers, 12.7 percent are autarkic, and about 7.5 percent are

¹³ Throughout this analysis, total household consumption expenditure is used as a proxy for income because income is subject to more measurement error.

net sellers. Putting it differently, only 7 percent of Bengali households are aquaculture farmers, and they supply aquaculture products to the rest of the population.

A couple of other results are worth highlighting. First, estimated NBRs are positive only for fish farmers and for households in the Khulna division, implying that these two groups will gain from an increase in aquaculture prices and lose from a decline in prices, at least in the short run. For fish farmers, a positive NBR is obvious. For Khulna, the largest fish-producing region in the country, a positive NBR means that the gains from a price increase to producers will outweigh the losses to consumers. Second, among the household categories with negative NBRs, the estimates vary, from as low as -3.42 for nonfarmers to as high as -0.10 percent in Barisal. This implies that the impacts of an increase (decrease) in aquaculture fish prices will be felt differently depending on the household categories. For instance, urban households would benefit more, on average, from a price decline than would rural households. However, the magnitude of welfare gain (loss) due to a decrease (increase) in fish prices is small. A doubling of fish prices would lead to only about a 3 percent decline in the welfare of urban households. The same argument goes for male-headed households.

Impacts of Aquaculture Growth on Income Distribution

To estimate the distributional impact of aquaculture growth, this paper uses the information on production and consumption from the 2000 HIES, as well as estimates for four parameters—the growth in aquaculture production, changes in consumer and producer prices, the price elasticity of demand for fish, and the supply responses for long-run estimates. A few points about the model calibration need to be clarified. First, available estimates of price elasticity of demand for aquaculture vary widely. The absolute values of recent estimates, presented in Dey, Alam, and Paraguas (2011), range from 0.10 for Indian carp to 0.94 for tilapia. For live fish, which include major aquaculture fish like pangasius, the absolute value of price elasticity is 0.75.¹⁴

Second, due to the limitations of using unit values from the HIES data, price changes between 2000 and 2010 are taken from DoF estimates. The Dhaka price is used, as it reflects changes in consumer prices, and the Khulna price is taken to reflect trends in producer prices. The logic behind this choice is simple: Dhaka is the largest metropolitan city, and Khulna is the largest producer of aquaculture fish. Third, the simulation was carried out on 2010 survey data, with 2000 as the reference round. This consideration is primarily driven by the fact that aquaculture experienced the fastest growth in this period, as discussed in the previous section. Finally, to calculate the long-run effects—that is, to account for both price and supply changes—the aquaculture production estimates published by the DoF are used.

Based on this background, we present two sets of results—one showing the impacts on income distribution and the other showing the impacts on poverty reduction. Table 5.2 presents the results of the impacts on income distribution. Similar to Table 5.1, results are disaggregated by location, gender of the household head, and income quintile. Both short- and long-run impacts of aquaculture growth have been analyzed. The short-run analysis is based on the assumption that there is no supply response or technical changes, so that household welfare is influenced only through price change. The long-run estimates account for household responses to price changes and technological change. In other words, these two types of estimates account for both price and quantity effects, which is more pertinent in the context of Bangladesh, as aquaculture fish prices consistently declined while production grew over the past several years.

¹⁴ Analyses have also been carried out with other elasticity assumptions, but the results remain very similar. These results are available from the authors upon request.

Table 5.2 Impacts of aquaculture growth on household's income

Household category	Baseline expenditure (Taka/capita/ year)	Short-run price effect	Long-run effect		
			Only price effect	Price and quantity effect on fishers	Price and quantity effect on all household
(% change in income)					
Location					
Rural	11,394	0.77	1.09	5.36	2.87
Urban	17,003	1.32	1.53	5.19	1.75
Sex of head					
Male	12,475	0.84	1.15	5.41	2.68
Female	13,186	1.40	1.64	3.99	2.07
Regional					
Barisal	11,380	0.05	0.26	3.70	1.88
Chittagong	12,685	1.23	1.56	6.13	2.87
Dhaka	13,886	1.02	1.32	5.80	2.57
Khulna	12,563	-0.28	0.13	7.45	3.69
Rajshahi	10,822	1.11	1.37	3.60	2.19
Occupation					
Fish farmer	12,418	-1.13	-0.54	5.36	5.36
Other	12,553	1.54	1.75	-	1.75
Income quintile					
Poorest	5,774	0.84	1.08	4.65	2.08
2nd	8,002	0.96	1.25	5.25	2.53
3rd	10,107	0.98	1.31	5.43	2.83
4th	13,382	0.76	1.11	5.72	3.06
Richest	25,339	0.85	1.16	5.56	2.73
National	12,519	0.88	1.18	5.36	2.65

Source: Authors' analysis based on HIES 2000 and 2010 rounds (BBS 2001; 2010).

Notes: The data are based on the following assumptions: 1. Consumer and producer prices decline by 45 and 36 percent, respectively. 2. Growth in production is 104 percent. 3. Demand and supply elasticity estimates are -0.6 and 0.5, respectively.

The estimates of the short-run impacts, presented in the third column of Table 5.2, suggest that price decline by itself has been welfare enhancing for all groups of households, except for Khulna and for fish-farming households. Starting at the national level, the short-run impacts (the third column in the last row) show an increase in real income by 1.0 percent. However, nonfish farmers, representing 77 percent of the Bangladeshi population, gain about 1.5 percent from the decline in aquaculture fish prices. Fish farmers lose because supply is assumed to be fixed in the short run; thus, a decline in prices reduces their revenues. Although very small in magnitudes, Khulna as a whole loses as well, which suggests that the reduction in revenue due to a fall in prices outweighs the gain by consumers in the division. This finding is consistent with the fact that Khulna is the largest producer of aquaculture fish.

In the long run, the welfare implications reverse for some household categories. Urban households benefit relatively more in the short run, though this trend reverses in the long run. The explanation for this trend reversal is simple: in the long run, rural households benefit from both an increase in production and a decrease in prices. The regional-level estimates are also consistent with a priori information about aquaculture in Bangladesh. For instance, in the short run, Khulna is negatively affected by a price decline (-0.18 percent), and Chittagong reaps the most benefits (1.56 percent). However, when production growth is factored in, Khulna becomes the biggest winner in terms of income gains. The same goes for fish farmers, as they gain the most in the long run. Overall, aquaculture growth contributed to about a 2.6 percent increase in income.

Impacts of Aquaculture Growth on Poverty

Between 2000 and 2010, production of aquaculture fish (excluding shrimp) has more than doubled, and the real prices of major varieties of aquaculture at the retail and farm-gate level declined by 45 percent and 36 percent, respectively. This section presents an analysis of how these changes are translated into poverty reduction. We begin by estimating the baseline poverty rate by household categories using 2000 HIES. The national poverty rate in 2000 was 48.8 percent; rural and urban poverty rates were 52.0 and 35.0 percent, respectively. So, the estimates are very close to the ones presented in World Bank (2013) and the government's figures based on the HIES data (BBS 2010).

The first set of simulations assesses how the poverty rates decline in the short run following a reduction in the real price of aquaculture products. Two points should be highlighted from these results. First, the magnitude of overall reduction in poverty due to price change is small: a 45 percent decline in the retail price leads to less than 1 percent (0.77 percent) decline in poverty. This finding is not surprising in that, on average, aquaculture products account for less than 4 percent of the household budget. Second, a decline in price does not reduce poverty rates among the bottom two quintiles of households. This does not mean that those households do not gain from price decline; rather, it means that the gains are not large enough to pull those households out of poverty. To some extent, these results are similar to those of Belton and Little (2011), who argued that aquaculture is unlikely to benefit the poorest through own production and increased consumption, though they may benefit through employment in the sector. Finally, poverty among fish-farming households increases by 0.56 percentage points in the short run, which implies that fish-farming households just above the poverty line could slip into poverty when only price decline is considered. However, this simulation does not account for productivity gains and the second-round effects specified in equation (2).

The long-run estimates are presented in the last three columns of Table 5.3. The first of these three columns reports the long-run effects of a decline in prices, taking into account household response; the second column shows the joint impact of price decline and productivity growth on fish-farming households only; and the final column presents the long-run impacts on all households. Four general conclusions can be drawn from these long-run results. First, the long-run poverty impacts are much larger than the short-run impacts. The impact of price decline on poverty in the long run is 1.08 percentage points, which is about 40 percent larger than the short-run impacts. Second, households in the third income quintile benefit the most. The magnitudes of poverty reduction are as high as 16.7 percent if only fish-farming households are considered; they are almost 10 percentage points if all households are considered. Third, among the other household categories, poverty reduction is greatest among fish-farming households (3.97 percent), followed by households in Khulna (3.24 percent) and Barisal (2.6 percent). However, the impacts are also substantial for other divisions. The final points to highlight are that overall impacts on households in the poorest two quintiles are modest (less than 0.4 percent) and that there is no change in the richest two quintiles.

Table 5.3 Impacts of aquaculture growth on poverty reduction

Household category	Baseline poverty rate (%)	Short-run price effect	Long-run effect		
			Price effects	Price and quantity effect on fishers	Price and quantity effect on all households
(percentage point change in poverty)					
Location					
Rural	52	-0.84	-1.15	-4.02	-2.35
Urban	35	-0.50	-0.81	-2.35	-0.89
Sex of head					
Male	49	-0.71	-1.04	-4.11	-2.08
Female	47	-1.71	-1.71	0.00	-1.71
Regional					
Barisal	53	-0.98	-1.15	-4.72	-2.60
Chittagong	45	-0.74	-1.20	-4.42	-2.01
Dhaka	46	-0.70	-0.99	-4.09	-1.80
Khulna	45	-0.47	-0.59	-4.59	-3.24
Rajshahi	57	-1.00	-1.31	-2.73	-1.71
Occupation					
Fish farmers	44	0.56	-0.03	-3.97	-3.97
Others	50	-1.21	-1.43	-	-1.49
Income quintile					
Poorest	100	0.00	0.00	-0.53	-0.11
2 nd	100	0.00	0.00	-1.63	-0.36
3 rd	44	-4.33	-5.88	-16.71	-9.83
4 th	0	0.27	0.27	0.00	0.00
Richest	0	0.21	0.21	0.00	0.00
National	49	-0.77	-1.08	-3.97	-2.06

Source: Authors' analysis based on HIES 2000 (BBS 2001).

Notes: This set of simulations is based on the following assumptions: 1. Consumer and producer prices decline by 45 and 36 percent, respectively. 2. Growth in production is 104 percent. 3. Demand and supply elasticity estimates are -0.6 and 0.5, respectively.

To summarize, the all-inclusive long-run results suggest that, at the aggregate level, the growth of aquaculture in Bangladesh between 2000 and 2010 was responsible for a 2.72 percent increase in real incomes and a 2.06 percent reduction in poverty. Official statistics show that overall poverty in the country declined from 48.9 percent to 31.5 percent during the same period, for a decrease of 17.4 percentage points. This implies that about 12 percent (2.06/17.4) of the overall reduction in poverty can be attributed to the growth in aquaculture during 2000–2010.

6. SUMMARY AND IMPLICATIONS

Defying many earlier predictions, global fish production has grown faster than the world's population in the past couple of decades. Aquaculture has been the biggest contributor to this growth, with its share in total fish production rising from about 16 percent in 1990 to more than 50 percent in 2012. This remarkable transformation has important implications for food security, poverty, and environment, especially for developing countries of Asia. This paper contributes to that literature by clarifying some conceptual issues and presenting the quantitative evidence on the income and poverty impacts of aquaculture growth in Bangladesh.

Conceptually, the aquaculture-poverty linkage literature closely resembles agricultural growth linkage literature. Evolved in the 1960s, the agricultural growth linkage literature demonstrated that, in addition to its direct benefits, agriculture generates multiplier effects through increased demand of nontradable goods outside of agriculture. The existing studies on aquaculture's linkage to poverty and income distribution appear to miss this impact channel, however, as they focus only on aquaculture and ignore links to other sectors. The existing empirical literature has two important gaps—problems of generalizability of results and the quantification of income and poverty impacts. Because most of the studies are based on nonrepresentative samples, their conclusions cannot be generalized, even though they offer useful insights into the process. Perhaps the most important gap in the literature is that previous studies did not estimate the degree to which aquaculture has contributed to income growth and poverty reduction. This paper addresses both of these gaps by estimating the income and poverty impacts using nationally representative household survey data from Bangladesh, a country that has been very successful in promoting aquaculture and reducing poverty since the early 2000s.

The results of this study suggest that the impacts of aquaculture growth on income distribution and poverty reduction in Bangladesh have been substantial, even though the impacts on households in the bottom income quintile have been modest. Estimates of aquaculture's contribution to income growth between 2000 and 2010 range from 0.88 percentage points in the short run (only price effects) to about 2.72 percentage points in the long run (price and quantity effects). The corresponding estimates for poverty reduction are 0.77 and 2.06 percentage points, respectively. Although these estimates seem small, they represent a substantial share of overall poverty reduction between 2000 and 2010. For instance, national headcount poverty rates declined from 48.9 percent in 2000 to 31.5 percent in 2010 (World Bank 2013). This implies that the growth in aquaculture has been responsible for almost 12 percent of the overall poverty reduction in Bangladesh during the first decade of the 21st century. Put differently, of the 18 million Bengalis who escaped poverty during 2000–2010, more than 2 million of them managed to do so because of aquaculture.

Although these are impressive numbers, this is only part of the story. More analysis is needed to better understand the true benefits and costs of promoting a “blue revolution” strategy. First, a general equilibrium analysis could incorporate additional impact channels, such as through wage rates, which would likely generate higher estimates for the daily wage worker who belongs to the bottom income quintile. Second, it would be useful to explore the nutritional impact of the expansion of aquaculture in Bangladesh through both changes in income and the reduced price of fish and other aquaculture products. Finally, the environmental impact of the “blue revolution” needs to be incorporated into the analysis, raising difficult questions regarding the quantification of costs.

REFERENCES

- Adelman, I., and C. Morris. 1973. *Economic Growth and Social Equity in Developing Countries*. Palo Alto, CA, US: Stanford University Press.
- Ahmed, M., and M. H. Lorica. 2002. "Improving Developing Country Food Security Through Aquaculture Development—Lessons from Asia." *Food Policy* 27: 125–141.
- BBS (Bangladesh Bureau of Statistics). 2001. *Household Income and Expenditure Survey 2000*. Dhaka: Ministry of Planning, Government of Bangladesh. <http://catalog.ihns.org/index.php/catalog/135>.
- . 2010. *Report of the Household Income and Expenditure Survey 2010*. Dhaka: Ministry of Planning, Government of Bangladesh. <http://catalog.ihns.org/index.php/catalog/2257>.
- Bangladesh, Ministry of Fisheries and Livestock. Various years. *Fisheries Statistical Year Book of Bangladesh*. Dhaka.
- Behrman, J. R., and A. B. Deolalikar. 1987. "Will Developing Country Nutrition Improve with Income? A Case Study for Rural India." *Journal of Political Economy* 95 (3): 492–507.
- . 1990. "The Intra-household Demand for Nutrients in Rural South India: Individual Estimates, Fixed Effects, and Permanent Income." *Journal of Human Resources* 25 (4): 665–696.
- Belton, B., M. M. Haque, and D. C. Little. 2012a. "Does Size Matter? Reassessing the Relationship Between Aquaculture and Poverty in Bangladesh." *Journal of Development Studies* 48 (7): 904–922.
- Belton, B., and D. C. Little. 2011. "Immanent and Interventionist Inland Asian Aquaculture Development and Its Outcomes." *Development Policy Review* 29 (4): 459–484.
- Bouis, H. E. 2000. "Commercial Vegetable and Polyculture Fish Production in Bangladesh: Their Impacts on Household Income and Dietary Quality." *Food and Nutrition Bulletin* 21 (4): 482–487.
- Bouis, H. E., and L. J. Haddad. 1992. "Are Estimates of Calorie–Income Elasticities Too High? A Recalibration of the Plausible Range." *Journal of Development Economics* 39: 333–364.
- Deaton, A. 1989. "Rice Prices and Income Distribution in Thailand: A Nonparametric Analysis." *Economic Journal* 99: 1–37.
- de Janvry, A., and E. Sadoulet. 2010. "Agricultural Growth and Poverty Reduction: Additional Evidence." *World Bank Research Observer* 25 (1): 1–20.
- Dey, M. M., M. F. Alam, and M. L. Bose. 2010. "Demand for Aquaculture: Perspectives from Bangladesh for Improved Planning." *Reviews of Aquaculture* 2: 16–32.
- Dey, M. M., M. F. Alam, and F. J. Paraguas. 2011. "A Multistage Budgeting Approach to the Analysis of Demand for Fish: An Application to Inland Areas of Bangladesh." *Marine Resource Economics* 26 (1): 35–58.
- Economist, The*. 2003. "Fish Farming: The Promise of a Blue Revolution." www.economist.com/node/1974103.
- FAO (Food and Agriculture Organization of the United Nations). 2014. *The State of World Fisheries and Aquaculture: Opportunities and Challenges*. Rome: FAO Fisheries and Aquaculture Department. www.fao.org/3/a-i3720e.pdf.
- . 2005. "National Aquaculture Sector Overview." Rome: FAO Fisheries and Aquaculture Department. www.fao.org/fishery/countrysector/naso_bangladesh/en.
- Hirschman, A. O. 1957. "Investment Policies and 'Dualism' in Underdeveloped Countries." *American Economic Review* 47 (5): 550–570.
- Ivanic, M., and W. Martin. 2008. "Implications of Higher Global Food Prices for Poverty in Low-Income Countries." *Agricultural Economics* 39: 405–416.
- Johnston, B. F., and J. W. Mellor. 1961. "The Role of Agriculture in Economic Development." *American Economic Review* 51 (4): 566–593.

- Mellor, J. W. and U. Lele, 1972. "Growth Linkages of New Agricultural Technology." *Indian Journal of Agricultural Economics* 18: 10–15.
- Minot, N., and R. Dewina. 2015. "Are We Overestimating the Impact of Higher Food Prices: Evidence from Ghana." *Agricultural Economics* 46 (4): 579–592.
- . 2013. *Impact of Food Price Changes on Household Welfare in Ghana*, Discussion Paper No. 01245, Washington DC: International Food Policy Research Institute,
- Minot, N., and F. Goletti. 1998. "Export Liberalization and Household Welfare: The Case of Rice in Vietnam." *American Journal of Agricultural Economics* 80 (4): 738–749.
- Naylor, R. L., R. J. Goldburg, J. H. Primavera, N. Kautsky, M. C. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. "Effect of Aquaculture on World Fish Supplies." *Nature* 405: 1017–1024.
- Pingali, P., 2001. "Environmental Consequences of Agricultural Commercialization in Asia." *Environment and Development Economics* 6: 483–502
- Roos, N., M. A. Wahab, C. Chamnan, and S. H. Thilsted. 2007. "The Role of Fish in Food-Based Strategies to Combat Vitamin A and Mineral Deficiencies in Developing Countries." *Journal of Nutrition* 37: 1106–1109.
- Sachs, J. D. 2007. "The Promise of the Blue Revolution: Aquaculture Can Maintain Living Standards While Averting the Ruin of the Oceans." *Scientific American*. www.scientificamerican.com/article/promise-of-the-blue-revolution-july-2007/?print=true
- Subramanian, S., and A. Deaton. 1996. "The Demand for Food and Calories." *Journal of Political Economy* 104 (1): 133–162.
- Toufique, K. A., and B. Belton. 2014. "Is Aquaculture Pro-Poor? Empirical Evidence of Impacts on Fish Consumption." *World Development* 64: 600–620.
- Wodon, Q., and H. Zaman. 2010. "Higher Food Prices in Sub-Saharan Africa: Poverty Impact and Policy Responses." *World Bank Research Observer* 25 (1): 157–176.
- World Bank. 2008. *The World Development Report 2008: Agriculture for Development*. Washington, DC.
- . 2013. *Bangladesh Poverty Assessment: Assessing a Decade of Progress in Reducing Poverty 2000–2010*. Washington, DC. <https://openknowledge.worldbank.org/bitstream/handle/10986/16622/785590NWP0Bang00Box0377348B0PUBLIC0.pdf?sequence=1>.

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