Summary of the Agro-ecological and Socio-economic Context for the Cereal Systems Initiative for South Asia (CSISA)

Valerien Pede
International Rice Research Institute

Patrick S. Ward
International Food Policy Research Institute

David J. Spielman
International Food Policy Research Institute

Thelma Paris
International Rice Research Institute

October 2012

Contents

List of Abbreviations

BMGF	Bill and Melinda Gates Foundation
BRRI	Bangladesh Rice Research Institute
CA	Conservation Agriculture
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CSISA	Cereal Systems Initiative for South Asia
DSR	Direct Seeded Rice
DTR	Diurnal Temperature Range
FAO	Food and Agricultural Organization
ICRM	Integrated Crop Resource Management
IFPRI	International Food Policy Research Institute
IIASA	International Institute of Applied Systems Analysis
ILRI	International Livestock Research Institute
IGP	Indo-Gangetic Plains
LCU	Local Currency Units
LLL	Laser Land Leveler (or Leveling)
NGO	Non-Governmental Organization
OPV	Open-Pollinated Variety
PHB	Pioneer Hi-Bred
PPP	Purchasing Power Parity
RCT	Resource Conserving Technology
SSNM	Site-Specific Nutrient Management
UC	Union Council
UN	United Nations
USAID	United States Agency for International Development
VDC	Village Development Committees
ZT	Zero Tillage

Tables

Figures

Acknowledgements

This study was jointly funded by the Bill and Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID). The study was jointly conducted by socio-economists from IRRI, CIMMYT, ILRI, and IFPRI with the participation and support of Vijesh Krishna and Meera Bhatia (CIMMYT, India), Nils Teufel and Arindam Samaddar (ILRI, India), and many others. Technical assistance and suggestions were also received from the following: Samarendu Mohanty and David Raitzer (IRRI, Philippines); Andy McDonald (CIMMYT, Nepal); Ganeshamoorthy, Anurag Kumar, Raman Sharma, and Surabhi Mittal (CIMMYT, India); P.K. Joshi and Vartika Singh (IFPRI, India); Alamgir Chowdhury (Socioconsult Ltd., Dhaka, Bangladesh); Venkatesa Palanichamy (Tamil Nadu Agriculture University); Shweta Prasad (Banaras Hindu University, Varanasi, India); Joyce Luis, Justin McKinley, Cornelia Garcia, Ellanie Cabrera, Gina Zarsadias, Amelia Cueno, and Zenaida M. Huelgas (IRRI, Philippines); Prasun Kumar Das (KIIT University, Bhubaneswar, Odisha, India); and Rajshree Bedamatta (IIT, Guwahati, Assam, India). The invaluable assistance of all other people who participated in field work as team members to obtain reliable information from household surveys is greatly recognized. Furthermore, the technical guidance as well as comments provided by D.P. Sherchan (Nepal hub manager), B.R. Kamboj (Haryana hub manager), H.S. Sidhu (former Punjab hub manager), R.K Malik. (eastern Uttar Pradesh and Bihar hub manager), Natarajan Kumaran (Tamil Nadu hub manager), M.L. Jat, and M.S. Rao are highly appreciated.

Executive summary

The Cereal Systems Initiative for South Asia (CSISA) Baseline Household Survey was conducted in late-2010 and early-2011 across eight of the hub domains in which CSISA was operating during its initial phase. The household survey was designed to inform CSISA management as well as to establish a priori conditions (farming practices, farmer livelihoods, etc.) against which the social, economic, and livelihood impacts of CSISA will be evaluated. Pursuant to these objectives, a structured questionnaire was developed in a joint effort of socio-economists from different centers of the Consultative Group on International Agricultural Research (CGIAR), as well as agronomists and hub managers. In all, the baseline household survey collected data on 2,628 households across the CSISA hub domains of Haryana, Punjab, eastern Uttar Pradesh, Bihar and Tamil Nadu in India; Dinajpur and Gazipur in Bangladesh; and the Terai region of central Nepal.

The present report aims to summarize the characteristics of households that reside within the purview of these hub domains so as to better understand the context in which CSISA is operating and to strategically target activities, technologies, and practices into areas that are most suitable for them. Some of the salient findings and implications from this report are summarized as follows:

1. The CSISA coverage area is highly diverse in terms of climatological and agro-ecological conditions, cropping patterns, livestock management, land holdings, production practices, yields, and other variables. This reinforces the initiative's site- and context-specific approach to effecting change, but complicates the evaluation of impact across the entire coverage area.

2. CSISA targeting is generally reflective of the surrounding population in the hub domain. However, evidence of more explicit targeting (e.g., of women-headed households or other vulnerable groups) was found only in the Gazipur hub.

3. Whereas findings suggest that labor-saving technological change may be a priority in the northwestern hubs (Punjab, Haryana), productivity-enhancing technological change that intensifies production on small landholdings may be a priority for most other hubs.

4. Poverty and inequality measures indicate significant levels of vulnerability in the Nepal Terai, Bangladesh, eastern UP, and Bihar. This may indicate a need for some re-prioritization of CSISA work in favor of Nepal, provided that CSISA's technologies and approaches are appropriate to its needs.

5 The role of women in agriculture varies widely across the CSISA hub domains, and is determined largely by social status and social constructs. In general, women provide vital inputs into agricultural production, both in terms of labor as well as decision-making. The complexities of these issues suggest the need for more rigorous analysis regarding gender gaps in access to technical knowledge and information, inequalities in participation in key decision-making processes, as well as the impacts of the RCTs that are being promoted under CSISA. This may necessitate the collection of gender-disaggregated data for constraints analysis, technology prioritization among different household types, and careful consideration in the design, implementation and evaluation of impact assessments.

6 Familiarity with RCTs is most limited in Bihar and other eastern hub domains, suggesting the obvious potential for expanding CSISA activities in these areas. That said, sources of information on RCTs are quite domain-specific and vary significantly between CSISA, input retailers, and friends/neighbors.

7 There is evidence from the baseline survey to suggest that while non-adoption is largely driven by insufficient information about several RCTs, disadoption driven by poor yield performance and other factors is a non-trivial phenomenon in the CSISA domains.

1. Introduction

1.1. Overview of the Cereal Systems Initiative for South Asia (CSISA)

The Cereal Systems Initiative for South Asia (CSISA) was launched in 2009 with support from the Bill and Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID). CSISA is essentially a descendent of the Rice-Wheat Consortium (RWC), a joint initiative of the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT) designed to develop and deploy more efficient, productive and sustainable technologies for the diverse rice-wheat production systems of the Indo-Gangetic Plains (IGP) that ultimately improve food supply and improve the livelihoods of the poor in the region. CSISA builds on the RWC by bringing IRRI and CIMMYT together with the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI), and the WorldFish Center to accelerate sustainable intensification of cereal productivity growth in South Asia and to improve the poverty impacts of such growth.

CSISA's vision is to decrease hunger and malnutrition and to increase food and income security for resource-poor farm households in Bangladesh, India, Nepal and Pakistan through the accelerated development and inclusive deployment of new and improved crop varieties, sustainable technologies and management practices, and improved policies. CSISA activities are based on a "hub approach", which emphasizes the role of a central innovation and delivery center from which activities are directed. Hubs serve as unique platforms for integrating scientific research into on-farm trials with the help of partners from government and private sector organizations. The hubs are created to provide farmers with a complete range of quality inputs, objective technical guidance, easy crop financing, and direct output linkages for farmers. Hub scientists focus on a suite of technologies geared toward sustainable increases in cereal productivity and farm income. These technologies are made accessible to resource-poor farmers, providing a means by which they may potentially escape the trap of persistent poverty.

The hub approach also harnesses the potential for public-private partnerships for development and dissemination of technologies. In Phase I of CSISA, nine hubs were in operation, mostly in the IGP regions in India, Bangladesh, Nepal, and Pakistan. Of these nine hubs, five were located in India (Punjab, Haryana, Eastern Uttar Pradesh, Bihar, and Tamil Nadu), two in Bangladesh (Dinajpur in Rangpur Division and Gazipur in Dhaka Division), one in the Terai region of Nepal, and one in Pakistan (Faisalabad, Punjab).[1] The location of these hubs in the larger geographical context is shown in

[1] Tamil Nadu is the only hub that is not within the IGP. Because Tamil Nadu will not remain an active CSISA hub during the second phase of the initiative, we will not focus much attention on Tamil Nadu.

Figure 1.1.1. From these nine hubs, CSISA staff targeted villages and farmers to promote various activities in line with the initiative's broad objectives.

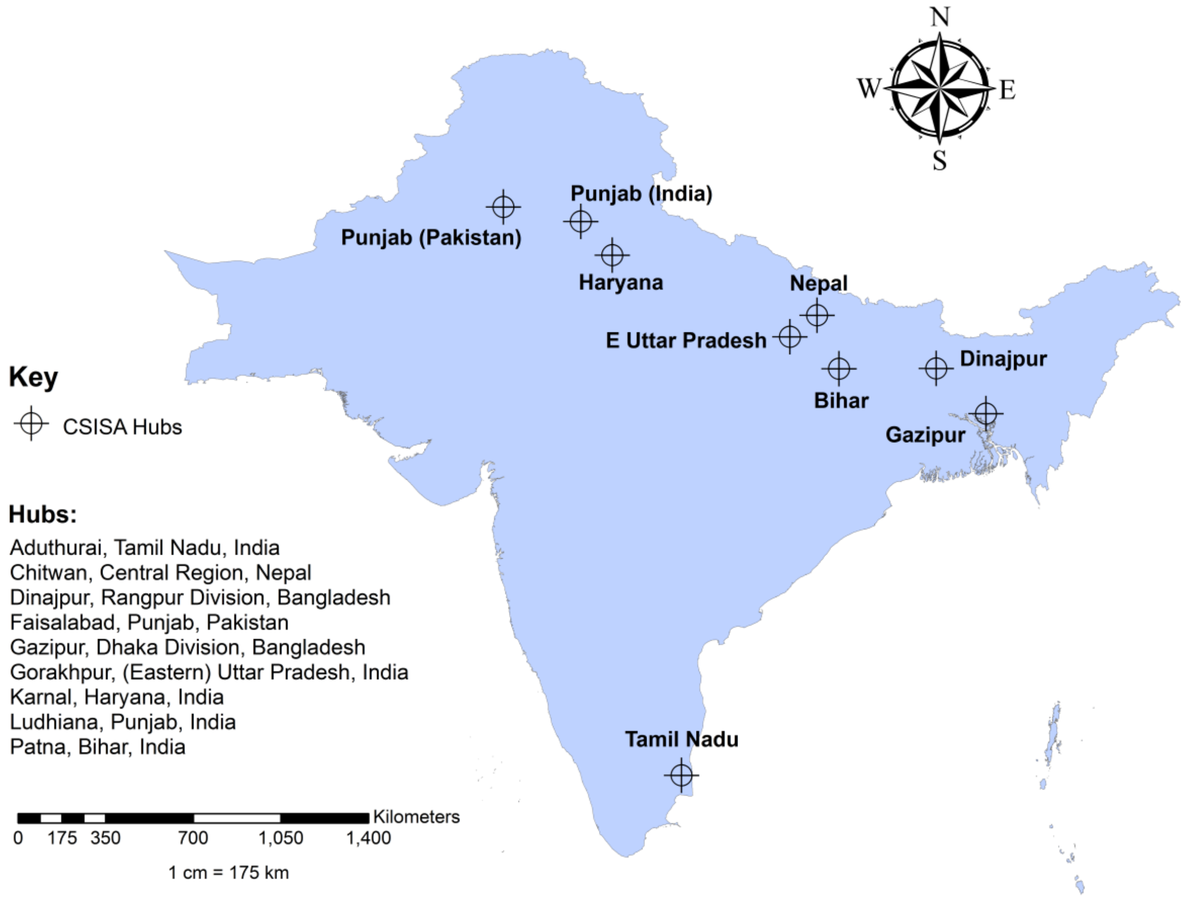

Figure 1.1.1 Cereal Systems Initiative for South Asia (CSISA) hub domains

The IGP are large floodplains of the Indus and Ganges-Brahmaputra river systems. The plains are among the most populous region on Earth, with almost 1 billion people residing in this 700,000 km^2 plain bounded on the north by the Himalayan Mountains. The IGP are some of the most fertile agricultural areas in the world: the Indian states of Punjab and Haryana and Pakistan's Punjab province formed the cornerstone of the successes of the Indian Green Revolution. These two Indian states account for 21 percent of India's food grains production but only 3 percent of its land area (Erenstein et al., 2007). Similarly, Pakistan's Punjab is a breadbasket for the entire country.

The dominant cropping system throughout the region is rice-wheat, though other cropping systems of varying degrees of importance also exist.[2] With respect to the associated yield potential, two broad categories of rice-wheat systems emerge (Ladha et al., 2000):

i. Favorable rice-wheat environment, characterizing districts with predominantly irrigated rice and wheat, found in the western part of the IGP (i.e., Indian Punjab, Haryana, and western Uttar Pradesh; Pakistan Punjab)
ii. Unfavorable rice-wheat environment, comprising districts with predominantly rainfed rice and wheat (either irrigated or rainfed), covering the eastern part of the IGP (i.e., eastern Uttar Pradesh, Bihar, and West Bengal in India, as well as Nepal and Bangladesh).

Many of the technologies that are being promoted as part of CSISA activities are resource-conserving technologies (RCTs), which enhance productivity while conserving scarce inputs such as land, labor, water, and fertilizer. Some of these technologies include improved seed varieties (e.g., hybrid rice, hybrid maize, and abiotic stress-tolerant rice) which provide a means of intensification when cultivable land area is a binding constraint. Other technologies include direct-seeded rice (DSR), zero-tillage for wheat (ZT), and laser land leveling (LLL), which require less labor than traditional rice transplanting, conventional tillage, or other non-mechanized forms of land leveling. ZT and LLL have additional benefits, such as reduced irrigation requirements (either through enhanced soil moisture in the case of ZT or through increased water-use efficiency in the case of LLL).

The appropriateness of these various technologies depends crucially on the context-specific resource endowments of the areas in which CSISA is active. As would be expected in an environment as diverse as South Asia, the resource endowments are widely varied. Part of the purpose of this report is to summarize the characteristics of households that reside within the purview of these hubs so as to better understand the context in which CSISA is operating and to strategically target activities, technologies, and practices into areas that are most suitable for them.

1.2 The CSISA baseline survey design

The ensemble of baseline surveys under CSISA socio-economic objective consists of three activities: (a) village survey or focus group discussions (b) village census and, (c) farmer/household survey. These surveys are designed to establish a priori conditions

[2] When specifying multi-crop systems throughout this report, the first crop referenced will be for the rainy season (also known as monsoon, *kharif,* or *aman*), while the second crop will be for the dry, winter season (also known as pre-monsoon, *rabi*, or *boro*).

(farming practices, farmer livelihood etc.), against which the social, economic, and livelihood impacts of the CSISA project will be evaluated. The village survey instrument was designed to collect general information about the villages/wards regarding cropping patterns, infrastructure facilities, population characteristics etc., which will be difficult to gather in a personal interview mode. The villages were selected, keeping the purpose of generating baseline information in mind. From the complete list of districts, where CSISA is currently active, we have selected 3 districts per each hub, after discussing with the hub-managers and national partners. The aim of this purposive district selection was firstly to capture the major cropping patterns cropping patterns prevailing in the respective hubs and secondly to consider the pattern of RCT diffusion. For example, Bathinda of Punjab was selected to capture the cotton-wheat cropping system unique to the district, while Amritsar was included for the wide diffusion of laser land levelers and other RCTs in the rice-wheat cropping system.

As the next step, a complete list of CSISA intervention villages, along with their respective sub-districts (blocks in India, village development committees (VDCs) in Nepal or union councils (UCs) in Bangladesh) in each of the selected districts was obtained from the four hub-managers. From this list, three CSISA-active sub-districts were randomly selected for each previously selected district. Subsequently, one CSISA intervention village (ward in Nepal) and one non-CSISA village were randomly selected. The selection of the non- CSISA villages was drawn from a complete list of villages obtained from public institutions. In India, the data was provided by the National Census Bureau while in Nepal and Bangladesh, the sub-district head offices provided the village lists. A total of 72 villages were covered in the survey, in 36 of which CSISA activities were started or on-going during the time of baseline survey. The sampling process, which would be the basis for the forthcoming farmer/household survey, is presented as Figure 1.1. A structured questionnaire was developed for the data collection in a joint effort of socio-economists from different CGIAR-centers associated in CSISA (CIMMYT, IRRI, ILRI and IFPRI), agronomists and hub managers. The questionnaire was pre-tested in Haryana and Bangladesh and modified before the actual survey was initiated. It is comprised of five principal sections: (i) general household characteristics, (ii) input utilization for crop production, (iii) experiences and adoption of crop production technologies, (iv) livestock production and residue management, and (v) socio-economic dimensions of the households (e.g., income sources and expenditures, access to and uses of credit, gender dimensions of household activities and decision-making, etc.). In other words, information on variables influenced by the CSISA project (e.g. details on current RCT adoption, cropping patterns, social indicators) and exogenous variables (e.g. land characteristics, prices of inputs and outputs, market access etc.) that could determine the project's performance were included in this instrument. In all, the baseline household survey collected data on 2,628 households across the CSISA hub domains.

1.1 Uses and limitations of the CSISA baseline survey

The baseline survey was designed primarily with CSISA management in mind, motivated by the need to provide an accurate characterization of diversity in production systems (i.e., cropping systems, input use, livestock management, and residue management) across the initiative's coverage area. Although efforts were made to structure the survey with a longer-term impact assessment in mind, the conditions under which the survey was designed and implemented made this difficult to achieve. Those challenges are as follows. [3]

First, it is difficult to conduct a baseline survey for a program with a wide variety of technological interventions and technology delivery modalities spread over a wide geographic domain, especially when both of these elements evolve throughout the course of the initiative. Ideally, the impact of each technology or modality would require its own specific survey with a sampling frame appropriate to the heterogeneity of the population in question and a questionnaire focused on the technology's particular costs and benefits or the modality's operating principles and partners.

Second, with continuous change in the geographic emphasis of CSISA, the construction of a reasonable midline or endline survey becomes challenging. This is important in light of the fact that CSISA's Phase II operations are prioritizing several existing hubs, expanding other newly established hubs, and transitioning out of still other hubs.

Third, if CSISA operations expand within each hub domain as planned, the original survey design of "treatment vs. control" becomes problematic. The loss of valid controls, combined with the possibility of unobservable network effects and spatial externalities, makes the concise attribution of impact to CSISA using a standard difference-in-differences methodology challenging.

Finally, because the baseline survey focused on providing management with actionable data and analysis, it does not contain economic data that can be used to reliably assess quantitative changes in food and income security among its participating smallholder farmers. For this, more complete data on household consumption and expenditure, wealth and assets, health and nutrition, and other indicators are needed. Surveys that collect these types of data are both time and resource-intensive and generally beyond the scope of interest within CSISA.

[3] An additional challenge arises from the questionable quality of data collected in the Punjab hub domain. While efforts are currently underway to correct errors and inconsistencies, these data were not available at the time of writing. As such, we will generally refrain from references to data from households from the Punjab hub domain.

Going forward, data and analysis from this baseline survey are meant to provide CSISA's management and its stakeholders with a detailed picture of the diversity found across the initiative's coverage area. It is likely that researchers looking to gauge the social and economic impact of CSISA with any amount of rigor will have to rely upon additional surveys and other sources of primary data that are more specifically targeted at a particular geographic domain and with a particular empirical emphasis. While these approaches may not provide a picture of CSISA's impact over the long run, they can be used by management, partners, stakeholders and donors to assess the value of individual CSISA components within specific geographies covered by the initiative.

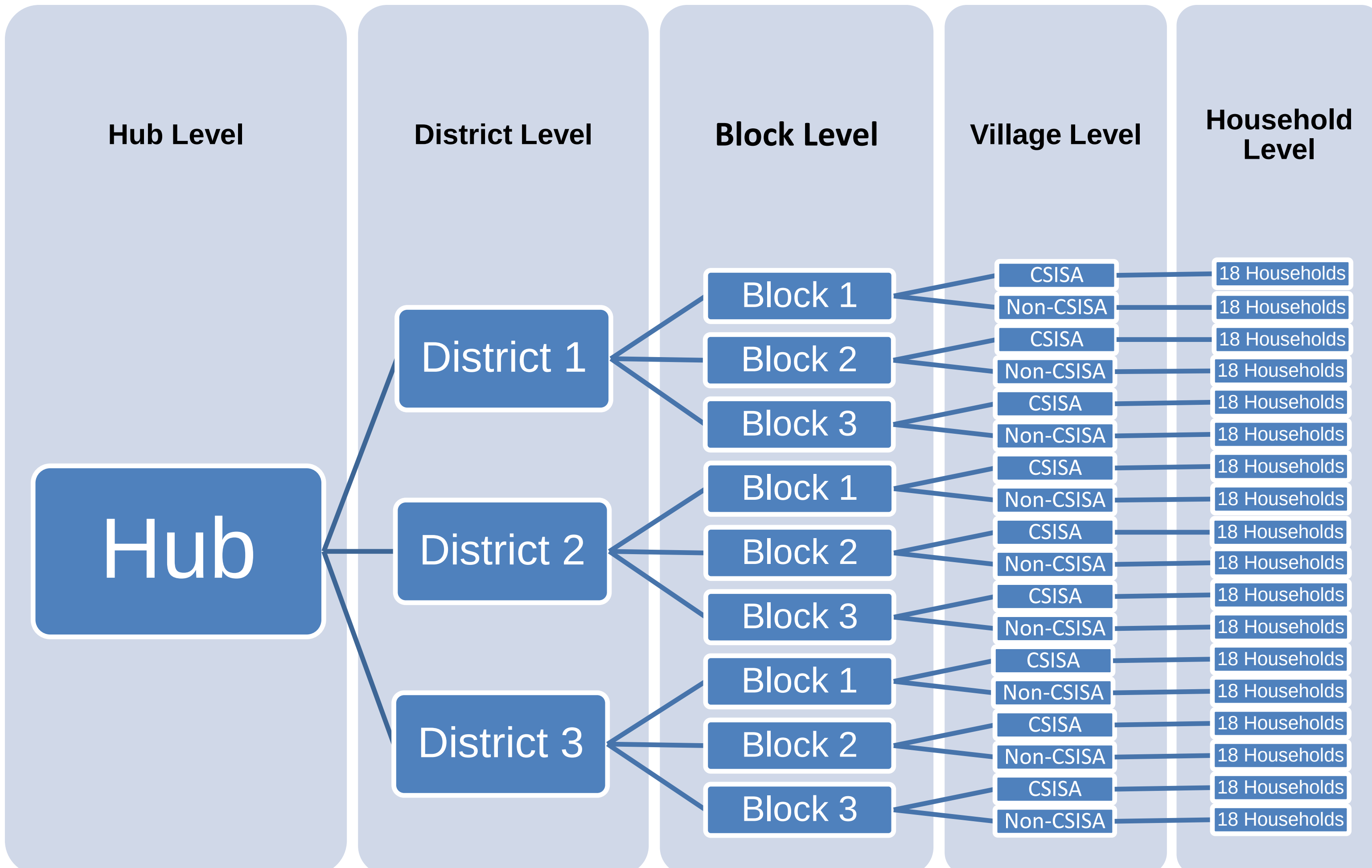

Figure 1.1 Sampling Scheme for CSISA baseline household survey

2. Heterogeneity of the CSISA domain

2.1. Agro-climatic heterogeneity

While most of the area included in CSISA can generally be identified as the IGP, this general classification fails to emphasize the great deal of ecological and climatological variation that exists within the IGP, especially when underlying soil characteristics and irrigation infrastructure are taken into account. The various hubs incorporated as innovation and delivery centers demonstrate a great deal of heterogeneity in these regards.

Agriculture in South Asia is characterized by seasonal rainfall patterns, which is largely a function of monsoon onset. The Southwest Monsoon, which arrives during the summer months and signifies the beginning of the *kharif* season, arrives in the southern tip and northeastern states of India at the beginning of June. By the end of the first week of June, the monsoon progresses north into Karnataka, Andhra Pradesh, West Bengal, and southern parts of Maharashtra (in India), and most of Bangladesh. By mid-June, most of central and north-central India will begin experiencing the monsoon rains, including Bihar, Eastern Uttar Pradesh, Odisha, Madhya Pradesh, and Gujarat. The monsoon reaches Delhi, western Uttar Pradesh, and parts of Haryana and Rajasthan around the beginning of July before finally reaching Punjab in mid-July. While the Southwest Monsoon reaches Tamil Nadu in early June, Tamil Nadu actually benefits more from the Northeast Monsoon which arrives during the winter months. It is during this latter monsoon that Tamil Nadu receives most of the rainfall needed for irrigation, and during which crops commonly associated with the *kharif* season (i.e., rice) are grown.

It is during the summer Southwest Monsoon period when areas in the IGP of India, Bangladesh, Nepal, and Pakistan receive most of their rainfall. For the CSISA hub domains, most receive 75 percent or more of their total annual rainfall during the monsoon season. Figure 2.1.1 shows the geographic distribution of rainfall across India, Bangladesh, Nepal and Pakistan. These are derived from historical observations, and thus represent climatological conditions rather than observed weather conditions for a particular year. While these figures represent monthly averages (in millimeters), they can also be viewed as indicative of total annual rainfall, at least in relative terms. Thus we see that, generally speaking, there is an increase in rainfall as one moves from west to east across the IGP. The Punjab and Haryana hub domains in western India receive the least amount of annual rainfall, with, on average, roughly 550 and 750 millimeters of rain per year, respectively. The hubs in Bangladesh each receive among the most rain on average. The Gazipur hub domain receives more than 2,000 mm of rain each year, while the Dinajpur hub domain receives slightly less than 1,900 mm of rain.

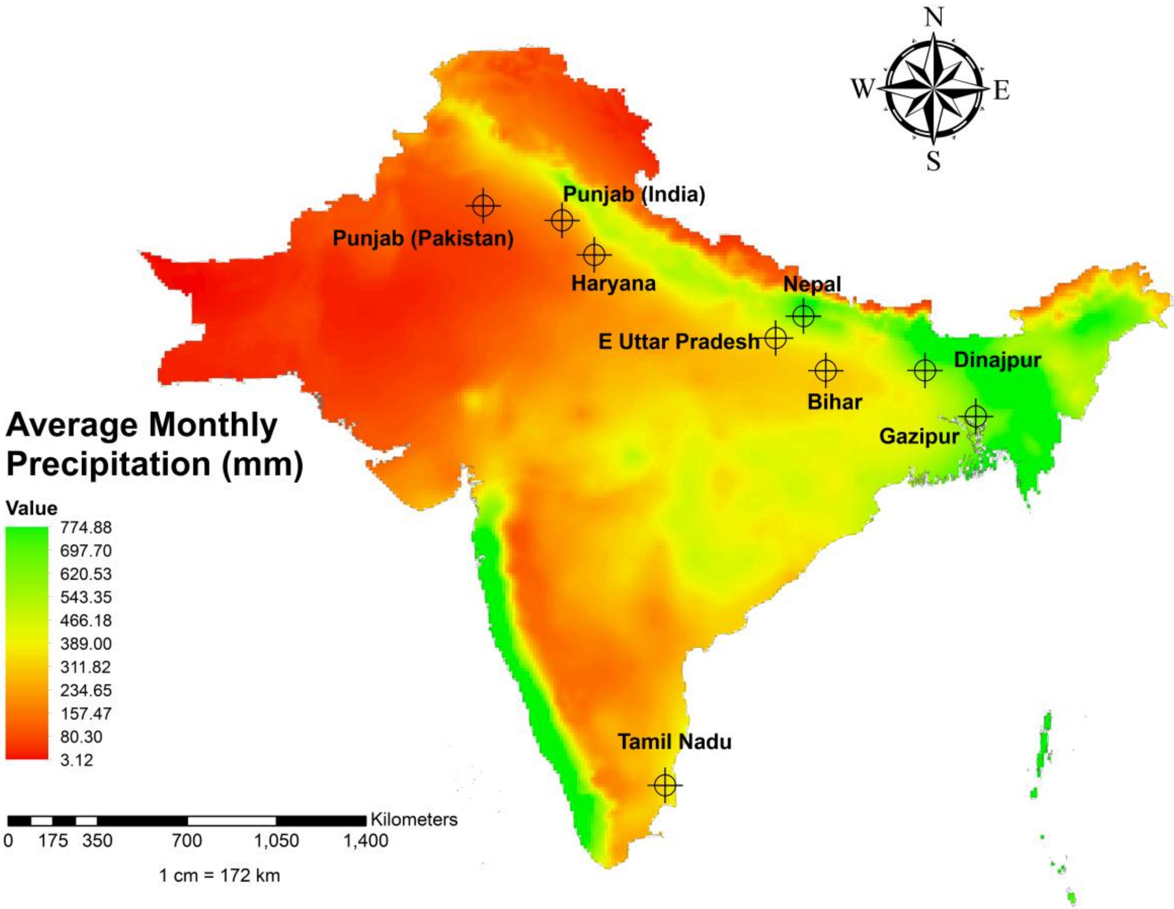

Figure 2.1.1 Average Monthly Precipitation (mm)

Source: Authors' rendering of data from New et al. (2002). Figures represent average annual temperature within an administrative unit.

Figure 2.1.2 illustrates annual average temperatures throughout India, Nepal and Bangladesh. As with rainfall data, these temperatures are drawn from a long time series, and represent long-term averages rather than observations from any particular year. Annual average temperatures across the different hub domains range from roughly 23°C (in the Terai region of Nepal) to over 28°C (in Tamil Nadu). While these temperatures may seem similar enough, taking annual averages somewhat masks the wide differential in climate conditions experienced in these different areas throughout the year. For example, the relatively low annual average temperatures in Haryana and Punjab mask the fact that these two areas have very hot summers, since these average temperatures are skewed by the rather cool winters. In Punjab, average temperatures dip down to the low teens in December, January and February, though they are near or above 30°C during May, June, July and August. As such, the Punjab hub domain has one of the largest variations between temperatures during the coldest month and temperatures during the warmest month. Many other hub domains have higher annual average temperatures, but the temperatures in these other domains do not have nearly the wide variation as temperatures in Punjab (see Table 2.1.1). In the Bangladeshi hub domains, winter temperatures are considerably warmer than temperatures in most other hub domains, though the summer temperatures are generally cooler, resulting in less variable temperatures throughout the year.

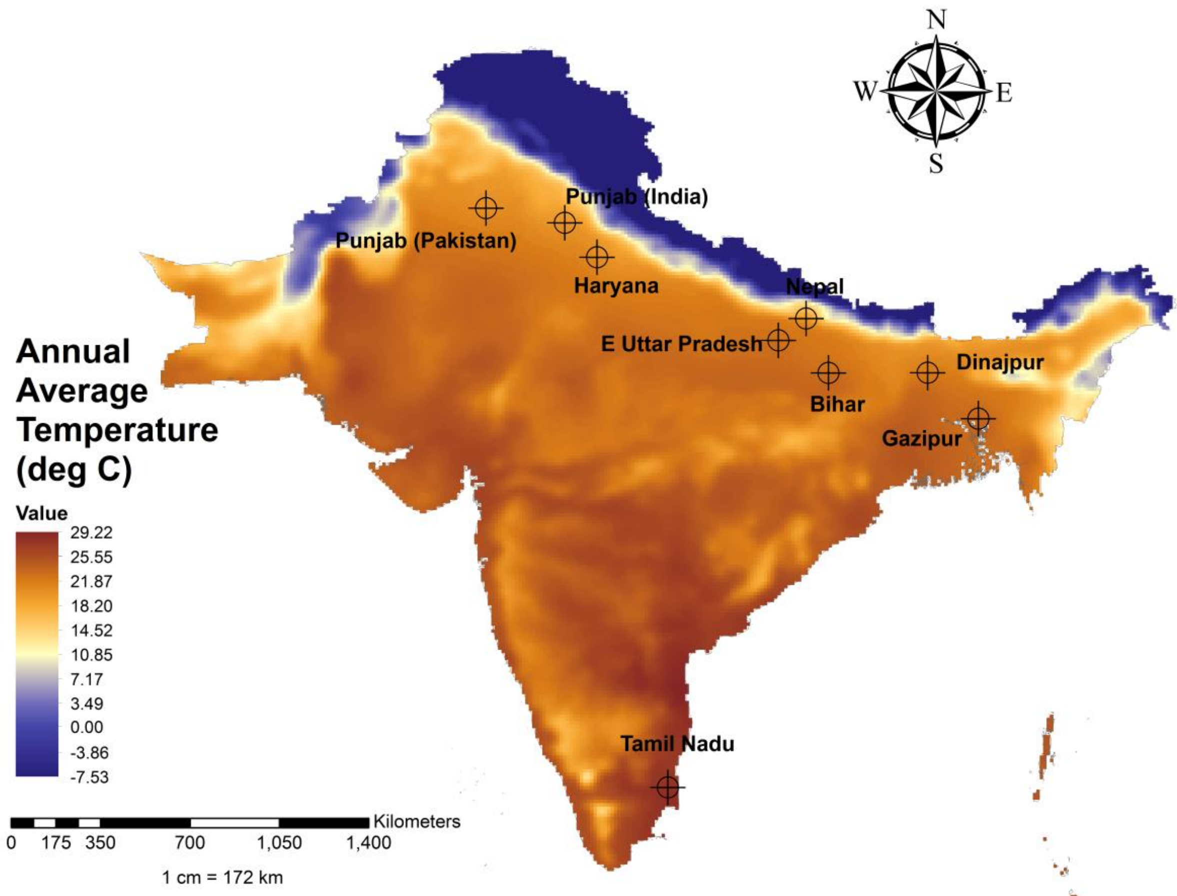

Figure 2.1.2 Annual average temperatures (°C)

Source: Authors' rendering of data from New et al. (2002). Figures represent average annual temperature within an administrative unit.

In terms of diurnal temperature range (DTR, the difference between the highest temperatures during the day and the lowest temperatures during the night), there is a clear pattern that distinguishes the IGP hub domains from Tamil Nadu (Figure 2.1.3). For the IGP hub domains, the DTR is generally highest in the winter months, and reaches its trough in August. At this time, daily temperatures (while warm) do not vary much between daytime highs and nighttime lows. One reason behind this trend is that this period largely coincides with the Southwest Monsoon. The extent of cloud cover during this period limits solar radiation and its ability to increase temperatures during daytime. In Tamil Nadu, on the other hand, the DTR stays relatively constant throughout the year, and reaches its peak about the time that the DTR begins to decline in the IGP.

Table 2.1.1 Average monthly temperatures (°C), by CSISA hub domain

	Bihar	Dinajpur	E Uttar Pradesh	Gazipur	Haryana	Nepal Terai	Punjab	Tamil Nadu
Jan	16.34	17.24	16.10	19.03	13.95	13.99	12.12	25.37
Feb	18.85	19.34	18.77	21.66	16.55	15.90	14.37	26.60
Mar	24.09	23.85	24.22	26.13	22.01	21.08	19.49	28.49
Apr	28.97	26.94	29.76	28.56	28.25	25.47	25.81	30.46
May	30.80	27.73	32.50	28.78	32.07	27.57	30.18	31.13
Jun	30.87	28.49	32.60	28.78	33.56	28.31	32.53	30.53
Jul	29.14	28.41	29.75	28.76	30.86	27.53	30.38	29.74
Aug	28.89	28.65	28.98	28.83	29.70	27.27	29.50	29.20
Sep	28.57	28.12	28.76	28.90	29.09	26.71	28.32	28.90
Oct	26.56	26.45	26.62	27.57	26.03	24.07	24.32	27.89
Nov	21.91	22.45	21.75	24.09	20.25	19.42	18.24	26.46
Dec	17.43	18.78	17.11	20.09	15.24	15.09	13.34	25.46
Annual Avg	25.20	24.70	25.58	25.93	24.80	22.70	23.22	28.35
Annual SD	5.32	4.24	5.87	3.75	6.93	5.38	7.37	2.00

Source: Authors' calculations based on data from New et al. (2002).

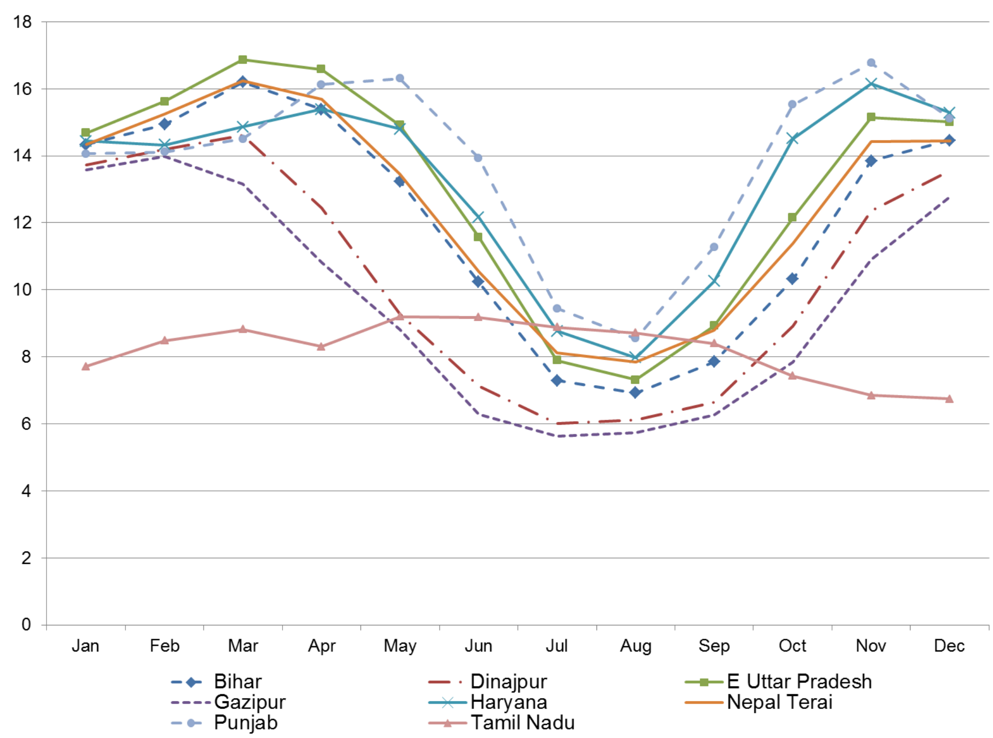

Figure 2.1.3 Average diurnal temperature range per month, by CSISA hub domain

Source: Authors, based on data from New et al. (2002).

DTR is largely determined by topographical and environmental features. High, desert areas typically have the largest DTRs, while lowland, tropical areas tend to have the narrowest DTRs. This is largely reflected among the CSISA hub domains. The Bangladeshi hub domains of Gazipur and Dinajpur have the two lowest DTRs among the hubs in the IGP, while the Haryana and Punjab hub domains have the two highest DTRs for much of the year. While DTR is not nearly as important of a determinant of agricultural productivity as other climatological variables like temperature and precipitation, a recent study has shown that increasing DTR may have a negative positive impact on rice yields in India and Bangladesh (Lobell, 2007).

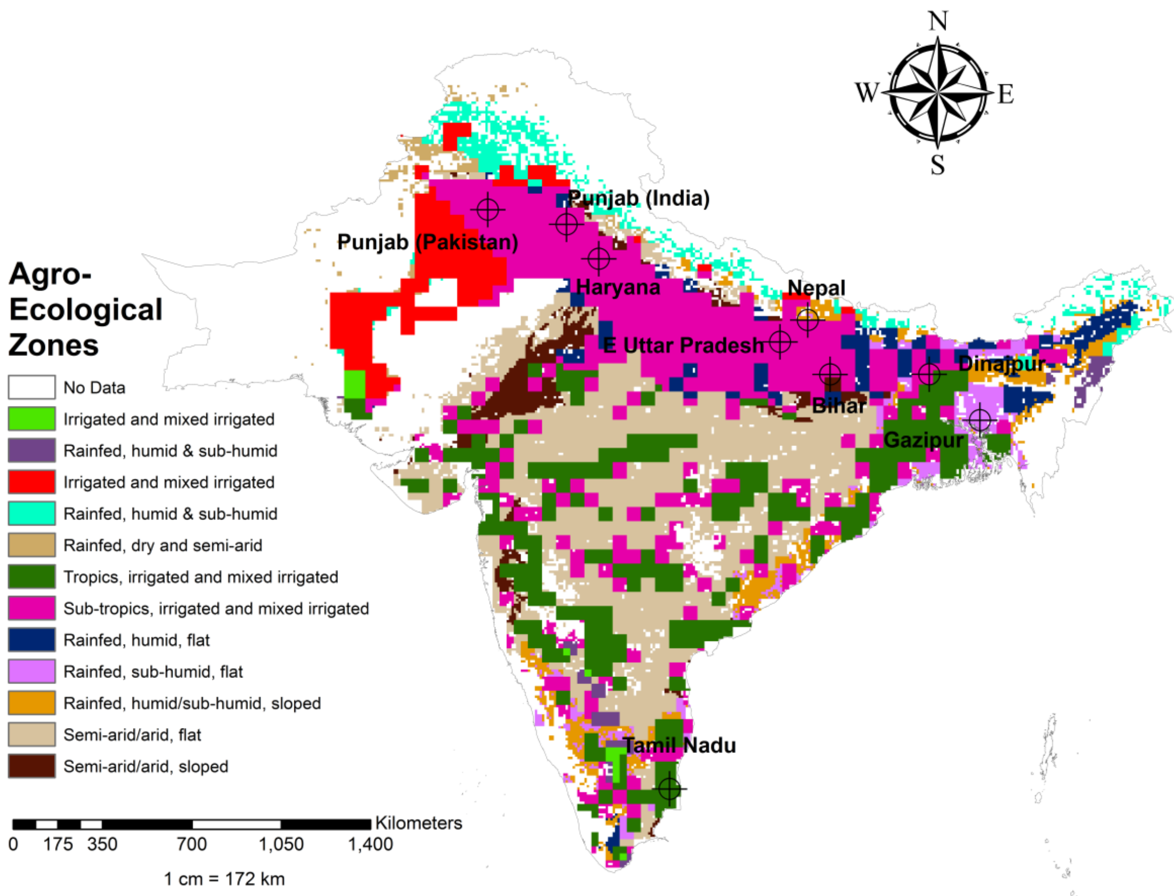

Figure 2.1.4 Agro-ecological zones

Source: Authors' rendering, based on data from Wood et al. (2000).

FAO/IIASA (1999) and Wood et al. (2000) classified gridded areas of the world by agro-ecological conditions, identifying a series of 17 zones differentiated based on climatic conditions, topography, environmental resource base, soil suitability and physical infrastructure, specifically the accessibility of irrigation.[4] Figure 2.1.4 illustrates the

[4] Excluding oceanic zones, there are 16 distinct agro-ecological zones identified in these studies.

spatial distribution of these agro-ecological zones across India, Bangladesh, Nepal and Pakistan. Most of the hub domains (Haryana, eastern Uttar Pradesh, and both Indian and Pakistani Punjab), exist within a sub-tropical, irrigated and mixed irrigated agro-ecological zone. The Nepal Terai hub domain is primarily classified as rainfed, humid and sub-humid, though there is also some classified as rainfed, sub-humid and flat. In Bangladesh, there is significant distinction between the villages in the Dinajpur hub domain and the Gazipur hub domain. In the Dinajpur hub domain, most villages are within sub-tropical, irrigated and mixed irrigated zones, while in the Gazipur hub domain, most villages lie within a rainfed, sub-humid and flat zone.

2.2 Major cropping patterns in CSISA domain

The cropping pattern in all hubs under study is primarily dominated by rice and wheat. But in some hubs like Bihar and eastern Uttar Pradesh, maize stands as the third largest crop after rice and wheat. Maize production is negligible in Haryana and Punjab.

Rice stand out as the prominent crop in the *kharif* (rainy) season and wheat during the *rabi* season. However, there are other non-cereal crops (e.g., cotton, sugarcane, jute, pulses, mustard and vegetables) that are grown in significant areas across the hubs. The vast majority of the cultivated lands in most of the hubs are rice-based, ranging from 73 percent to 95 percent. The exceptions are the Bihar and Punjab hub domains, in which only 44 percent and 66 percent of cultivable lands, respectively, were used for growing rice. The remaining cultivable areas are devoted to wheat, maize, or non-cereal crops like cotton, sugarcane, vegetables, root crops, linseed, pulses, jute and groundnut. The rice-wheat rotation is most predominant in Haryana (79 percent coverage), Punjab (66 percent coverage) and eastern Uttar Pradesh (56 percent coverage).

Crop diversity is high in Nepal Terai and Dinajpur compared with other hubs. In these regions, millets, pulses, fiber crops and oilseeds co-exist with cereals. The variation in crop rotations observed in the study areas indicate a higher cropping diversity in the eastern plains compared to the western IGP. In the Nepal Terai hub, nearly all cultivable land is under rice during the *kharif* season, with about 80 percent of the land is under inbred varieties and about 17 percent of land under hybrid varieties. During the rabi season, wheat is cultivated on half of the cultivable acreage by 84 percent of households, and maize represents only 9 percent of the cultivable land with 20 percent of household involved in its production. Some non-cereal crops are produced in the rabi season as well. During the third season, land is usually kept in fallow or used to produce maize or some non-cereal crops.

In Bihar the majority of farmers follow the rice-wheat cropping system. However, there are certain district-specific cropping patterns that were also identified. In the eastern Uttar Pradesh hub, a majority of the farm households also follow the rice-wheat cropping system. The CSISA baseline survey shows that some medium and large farmers also grow potatoes and sugarcane. The vegetable-based cropping system and banana-based cropping system are also popular in some pockets.

The cropping pattern in the Bangladesh hub is determined by the three seasons: boro (rabi), aman (kharif), and aus (summer). Rice is cultivated during all three seasons, while wheat and maize are cultivated on a limited scale. In the Gazipur hub domain, the major cropping patterns are rice-rice and non-cereal crops, rice-rice-rice and wheat/maize-non-cereal crops. The major crop rotations followed in the Gazipur hub are rice-rice, rice-rice-rice, rice-rice jute, vegetable-vegetable-vegetable, maize-jute and others. In the Dinajpur hub domain, the major cropping patterns are: rice-rice, rice-wheat, rice/fallow-maize and potato/maize-rice. Rice is the dominant crop in *kharif,* with 84 percent of farmers cultivating, and OPVs are more common than hybrid rice (Prabhakaran et al., 2012).

2.3 Agricultural production

Crop productivity and input use

We turn our attention to characterizing agricultural systems in the different hub domains. To introduce additional dimensions of heterogeneity, we classify farmers based on total land holdings. For this classification, farmers in each of the hub domains are divided into tertiles representing small, medium and large farmers. Dividing the samples into these sub-segments allow for insight into where interventions could potentially have the most significant impacts in terms of yields, cost savings, and eventually improved livelihoods. In this section we consider the baseline situation in terms of yields and usage of key agricultural inputs such as land, labor, and other inputs.

Yields

Most of CSISA's activities involve the promotion of technologies that not only conserve scarce (and hence valuable) resources but also boost yields. To gauge the aggregate effectiveness of the technologies that CSISA promotes across the hub domains in which they are active, it is valuable to appreciate the yield situation for important cereal crops prior to CSISA interventions. Table 2.3.1 summarizes the average productivity level for rice, wheat and maize across hubs during the survey period. The average productivity level is given for each farm size group of farmers and also overall at the hub level.

Among the different hub domains, rice yields are highest in the Tamil Nadu hub domain, with nearly 20 quintals/acre. The lowest rice yields are found in the Bihar hub domain, which suffers from exposure to both tails of rainfall extremes and has a poorly developed irrigation infrastructure. Rice yields are significantly higher in the eastern Uttar Pradesh hub domain, even though it shares many of the same agro-climatic conditions as Bihar. In terms of wheat yields, the highest yields are found in the eastern Uttar Pradesh hub domain, yielding on average 12.4 quintals/acre, while the lowest wheat yields are found in the Gazipur hub domain. For maize, it is Dinajpur that records the highest yield at 28 quintals/acre and Nepal Terai the lowest at 8 quintals/acre.

It is widely observed that larger farmers have higher yields than either small or medium farmers. This is a fairly consistent observation across all hub domains and for various crops. Several explanations are possible. Large farmers have better access to credit and inputs than small farmers and they often have higher preference for risk. It could also be that larger farms are able to take advantage of economies of scale, which affects the calculus by which farmers make decisions about optimal input use. What is interesting, however, is that the survey data show that there are many instances in which smaller farmers achieve higher yields than medium farmers. This, too, is a phenomenon that is observed in different hubs and for different crops. Given that these small and medium farmers likely face similar constraints and have the same set of feasible input combinations, this may reflect the frequently observed inverse farm size-productivity relationship. This relationship may not continue to large famers, since larger farmers may be choosing inputs from a completely different set of feasible alternatives. Other explanations pertain to the risk aversion of small farmers that creates the incentive to manage their farms more intensively.

Table 2.3.1 Cereal productivity, by hub domain and farmer land holding classification

	Rice				Wheat				Maize			
	Small	**Med**	**Large**	**All**	**Small**	**Med**	**Large**	**All**	**Small**	**Med**	**Large**	**All**
Eastern Uttar Pradesh	15.3 (12.2)	13.9 (9.3)	16.2 (7.7)	15.4 (9.4)	12.9 (8.2)	11.8 (4.0)	12.2 (4.5)	12.4 (6.3)	18.3 (6.4)	19.2 (10.5)	16.4 (8.5)	17.5 (8.9)
Bihar	11.8 (8.6)	11.1 (5.7)	12.1 (5.8)	11.6 (6.6)	12.3 (4.2)	10.8 (4.3)	10.5 (4.5)	11.3 (4.4)	13.1 (9.8)	13.2 (9.5)	13.7 (8.7)	13.3 (9.1)
Tamil Nadu	18.1 (3.3)	19.5 (4.2)	22.8 (4.5)	19.9 (4.4)								
Gazipur	18.2 (4.2)	18.7 (4.2)	18.6 (4.7)	18.6 (4.4)	6.0 (2.8)	5.7 (1.2)	7.3 (2.1)	6.7 (2.0)	16.0 (0)	13.5 (3.8)	15.7 (5.2)	14.7 (3.7)
Dinajpur	13.4 (0.4)	13.5 (0.3)	13.4 (0.3)	(13.4) (0.2)	11.0 (0.4)	10.7 (0.4)	11.8 (0.4)	11.2 (0.2)	25.2 (2.9)	25.4 (2.1)	29.7 (1.3)	28.0 (1.1)
Nepal Terai	14.6 (0.3)	13.5 (0.3)	13.6 (0.4)	13.7 (0.2)	9.8 (0.6)	9.3 (0.4)	10.1 (0.8)	9.8 (0.4)	7.3 (0.6)	7.8 (0.5)	8.9 (1.3)	8.0 (0.5)

Note: The yield is expressed in quintal/acre. Standard deviations are in parentheses.

Land

Land is a vital factor in crop production. In the eastern Uttar Pradesh hub domain, the average land cultivated by farmers is 2.20 acres, which is less than the average area owned (2.30 acres).There are large variations in ownership and cultivation of land across farm sizes in eastern Uttar Pradesh. Large farmers own almost 10 times as much land (4.65 acres) as the small farmers. This difference arises due to the incidence of leased/shared land (average 14 percent). The average land cultivated by small farmers (0.42 acre) is also less than the land owned (0.48 acre) because, somewhat surprisingly, some of these small farmers lease out land.

In Bihar, the overall average ownership holding was 3.25 acres and the average area of land cultivated was 3.35 acres. All households' farmers in the Bihar hub participate in leasing and sharing arrangements. The proportion of land leased in is highest among small farmer households (16.6 percent) followed by the medium farmer households (11.58 percent). On the whole, almost 12 percent of the sample households in Bihar leased-in land for cultivation. Land leased-out is highest among large farmer households (3 percent) and land shared-in and shared-out is highest among the medium farmer households (7 percent and 2 percent respectively). However, sharing-in of agricultural land for cultivation among small farmer households is only slightly lower than that of the medium farmer households, demonstrating that both these farmer groups are largely dependent upon sharing and leasing arrangements for crop cultivation.

In the Gazipur hub domain the average land area owned and cultivated is 1.06 acres and 1.17 acres respectively. The average is slightly higher for the Dinajpur hub (land area owned and cultivated is 1.17 acres and 1.49 acres respectively). On average, the area of land owned as well as cultivated is higher in the Indian hubs than in Bangladesh.

The topic of land holdings is explored in greater detail below to shed light of their social and economic relevance to households in the hub domains.

Labor

Labor also represents an important factor in crop production. Labor commonly available the hub areas derives from family and hired sources. Using detailed information for survey respondents' largest plot, we compute the total person-days required per acre for the production of rice, wheat and maize for each hub (Table 2.3.2). In the eastern Uttar Pradesh hub, about 69 person-days are use in the cultivation of *kharif* rice, of which 58 percent is family labor and 49 percent is female labor. The cultivation of wheat in the *rabi* season in that hub requires 47 person-days per acre, of which 59 percent is hired labor and 32 percent are women. The total man-days required for rice cultivation in *kharif* is much less in Bihar than eastern Uttar Pradesh (26.2 person-days/acre). However, it appears that small farmers in Bihar use more labor (55 person-days/acre) which is mainly composed of family labor. The use of labor in wheat cultivation in Bihar is also less than in eastern Uttar Pradesh (about 23 person-days/acre). In the Gazipur and Dinajpur hubs, the labor requirement is higher for *boro* rice cultivation than *aman* (61 vs 45 person-days/acre and 68 vs 58 person-days/acre, respectively). In the In the Nepal Terai hub a total of 71 person-days/acre is used for rice cultivation, of which more than half is female.

Table 2.3.2 Labor inputs: Person-days used in cultivation, by hub- and farm-size classification

	Rice				Wheat			
	Small	**Med**	**Large**	**All**	**Small**	**Med**	**Large**	**All**
Eastern Uttar Pradesh	43.1 (38.0)	70.3 (59.4)	104.1 (66.4)	68.9 (59.5)	7.5 (11.5)	30.1 (44.5)	89.5 (109.8)	46.6 (81.7)
Bihar	55.1 (43.1)	19.6 (13.5)	11.1 (8.4)	26.2 (30.5)	4.7 (5.5)	14.2 (23.9)	45.7 (73.9)	23.2 (50.4)
Tamil Nadu	22.5 (38.1)	43.1 (43.4)	64.3 (24.8)	41.1 (40.6)				-
Gazipur	86.6 (63.7)	49.3 (31.6)	39.8 (28.8)	57.7 (48.1)	95.5 (65.7)	62.6 (43.0)	47.7 (38.5)	67.6 (53.5)
Dinajpur	42.4 (1.9)	45.9 (2.1)	46.7 (2.6)	44.8 (1.2)	19.0 (0.7)	20.6 (1.0)	20.6 (0.9)	20.0 (0.5)
Nepal Terai	77.6 (2.6)	67.2 (2.0)	64.8 (2.0)	70.9 (1.3)	37.0 (1.7)	27.9 (1.5)	27.7 (1.1)	31.0 (0.9)

Note: Labor use is reported in man-days. Standard deviations are in parentheses. For the Indian hubs, rice is for kharif season and wheat for rabi. For the Bangladesh hubs, rice is for aman season and wheat for boro season.

Fertilizers and other inputs

The use of fertilizer and other inputs also varies across hubs and within farmers groups in the same hub area (Table 2.3.3). In the eastern Uttar Pradesh hub, the average seed rate is 19.57 kg/acre for rice cultivation. Chemical fertilizer composition in *kharif* rice is 4 kg of nitrogen, 101 kg of phosphorus, 124 kg of potash, and 11 kg of soil pH amendments. In addition, 5.39 quintals/acre of farmyard manure are used. A small quantity of herbicides (858 mL/acre) and fungicides (572 mL/acre) is used in *kharif* rice cultivation. With regards to wheat, the average seed rate is 54 kg per acre, and about 49 quintals/acre of farmyard manure is used. The chemical fertilizer composition of wheat per acre is as follows, 23 kg of nitrogen, 11 kg of phosphorus, 12 kg of potash, and 9 kg of soil pH amendments. A limited amount of herbicides (556 mL/acre) and fungicides (163 mL/acre) is used.

Table 2.3.3 Use of other inputs in rice and wheat production, by hub and farm size classification

	Rice				Wheat			
	Small	**Med**	**Large**	**All**	**Small**	**Med**	**Large**	**All**
Eastern Uttar Pradesh								
Seed Rate	11.7	19.4	25.3	19.6	51.7	53.4	57.1	54.3
	(35.9)	(43.0)	(53.9)	(46.3)	(16.7)	(14.6)	(14.8)	(15.5)
FYM use	1.2	7.2	6.7	5.4	53.3	47.1	46.6	48.7
	(4.9)	(13.4)	(10.6)	(10.6)	(11.6)	(17.8)	(25.8)	(20.2)
Machine Labour	1838.0	1772.9	2479.3	2083.0	1876.6	1724.5	1760.3	1795.1
	(663.5)	(746.9)	(5026.3)	(3281.0)	(925.1)	(648.4)	(637.3)	(767.7)
Bihar								
Seed Rate	6.3	4.6	6.4	5.8	63.0	60.6	56.9	59.9
	(3.2)	(3.5)	(3.4)	(3.5)	(17.7)	(12.3)	(13.4)	(14.6)
FYM use	0.1	0.3	0.5	0.4	53.4	55.3	49.7	52.7
	(0.0)	(0.3)	(1.6)	(1.2)	(18.5)	(13.0)	(10.1)	(13.5)
Machine Labour	1850.9	1887.3	1698.2	1805.7	1653.8	1838.8	1784.0	1752.8
	(522.2)	(646.2)	(612.9)	(604.5)	(818.4)	(670.3)	(702.5)	(739.2)
Tamil Nadu								
Seed Rate	5.5	10.4	19.9	11.1				-
	(8.9)	(9.9)	(2.9)	(10.0)				
FYM use	13.3	23.0	50.0	27.5				
	(23.2)	(27.2)	(29.4)	(30.4)				
Machine Labour	2074.7	2369.4	2689.7	2348.7				
	(696.8)	(703.6)	(1301.8)	(931.1)				
Gazipur								
Seed Rate	10.3	7.4	7.7	8.5	39.3	53.4	38.6	42.1
	(15.7)	(1.3)	(1.6)	(9.1)	(15.1)	(6.6)	(17.5)	(15.7)
FYM use	3.4	3.0	3.3	3.3	28.6	51.5	35.4	38.6
	(1.0)	*(0.8)*	*(0.7)*	*(0.8)*	*(0.0)*	*(8.1)*	*(18.6)*	*(16.6)*
Machine Labour	1545.7	1467.5	1549.8	1522.0	1682.3	2097.3	1843.3	1802.8
	(276.3)	(271.5)	(233.8)	(262.7)	(271.9)	(330.2)	(628.9)	(354.8)
Dinajpur								
Seed Rate	21.1	20.5	20.8	20.8	59.1	59.3	61.9	60.1
	(0.5)	(0.5)	(0.5)	(0.3)	(0.5)	(1.1)	(1.0)	(0.5)
FYM use	7.1	8.1	10.7	8.6	5.8	8.0	10.4	8.1
	(1.0)	(0.8)	(0.8)	(0.5)	(0.8)	(0.9)	(0.8)	(0.5)
Machine Labour	1814.2	1679.8	1746.9	1750.0	1910.8	1665.8	1758.3	1789.9
	(84.9)	(101.1)	(107.5)	(55.7)	(89.2)	(89.7)	(91.7)	(52.7)
Nepal Terai								
Seed Rate	20.9	21.4	19.7	20.6	56.4	52.7	56.7	55.3
	(2.1)	(0.9)	(1.6)	(0.9)	(2.1)	(1.8)	(1.6)	(1.1)
FYM use	15.8	18.3	18.4	17.5	17.8	13.8	15.3	15.5
	(1.2)	(1.3)	(1.5)	(0.8)	(2.2)	(1.8)	(1.8)	(1.1)
Machine Labour	3206.9	3637.7	4452.1	3794.2	2164.2	2066.4	1982.5	2073.2
	(282.2)	(631.4)	(707.1)	(333.8)	(113.7)	(88.2)	(117.8)	(61.8)

Note: The seed rate is in kg/acre, the Farm Yard Manure (FYM) is in quintal/acre and the machine labor use in Rs/acre. Standard deviations are in parentheses. For the Indian hubs, rice is for kharif season and wheat for rabi. For the Bangladesh hubs, rice is for aman season and wheat for boro season.

In the Bihar hub domain, the average seed rate for rice cultivation in *kharif* is significantly lower than eastern Uttar Pradesh (5.75 kg/acre). The usage of chemical fertilizer composition in *kharif* rice is 26 kg of nitrogen, 26 kg of phosphorous, 107 kg of potash and 34 kg of zinc. Overall, the use of fertilizers is higher among small farmers than medium and large farmers. As far as wheat cultivation is concerned, the average seed rate is higher than in eastern Uttar Pradesh (59.9 kg/acre) and the use of FYM is higher as well (49.7 quintal/acre). The chemical fertilizer usage for wheat cultivation per acre of land is as follows: 24 kg of nitrogen, 97 kg of phosphorous, 41 kg of potash and 482 kg of soil PH amendments used. On average, the usage of herbicides is 555 ml/acre and that of fungicides 653 ml/acre.

Irrigation

All farmer households show heavy dependence on tube wells for irrigation except those in Tamil Nadu (Figure 2.3.1). In Eastern Uttar Pradesh, except a few pockets, *kharif* crops are fully irrigated and *rabi* crops are also grown under irrigated conditions. The major source of irrigation in eastern Uttar Pradesh was the diesel tube well. In general, the kharif crop depends primarily on rainfall for irrigation with supplemental use of tube wells when needed. The rabi crop is grown using irrigation water drawn from tube wells. The ownership pattern of diesel tube well is clearly skewed towards the large (48.62 percent) and medium farmers (27.37 percent).

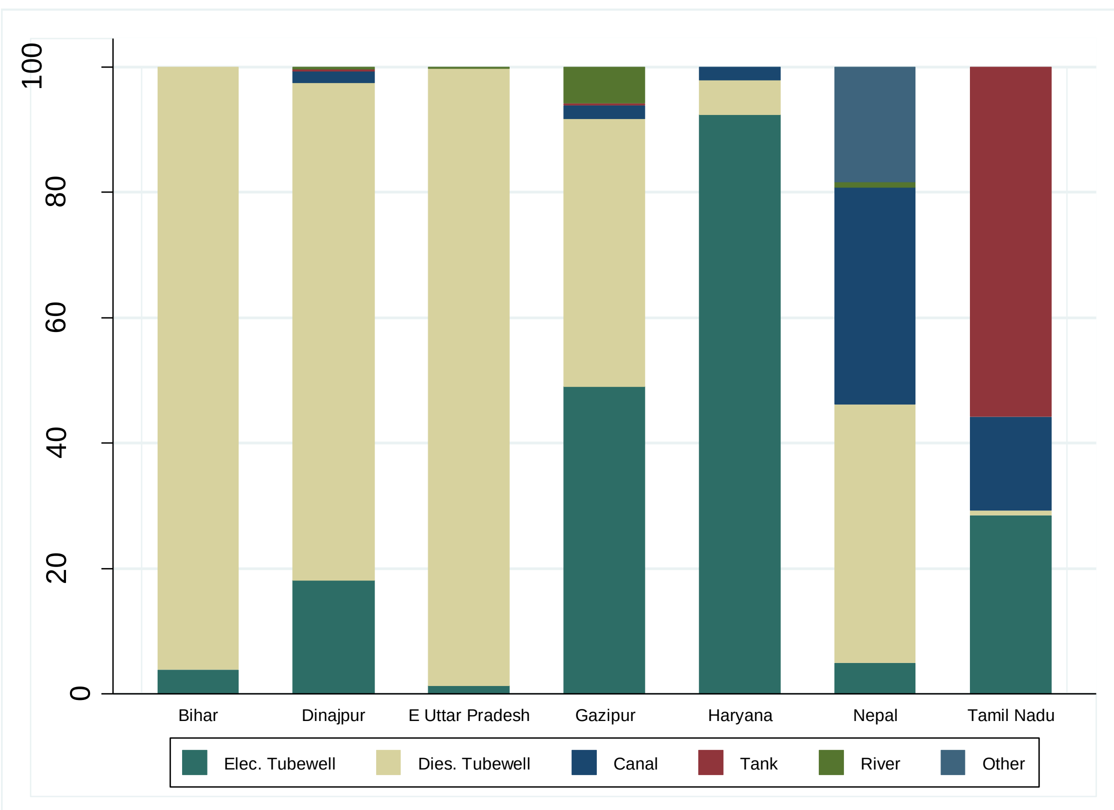

Figure 2.3 Sources of irrigation

Costs incurred for irrigation showed that although lower proportions of farmers bought electric diesel in eastern Uttar Pradesh, the unit cost of using electricity was higher than that of purchasing diesel. The skewness in meeting irrigation costs in eastern Uttar Pradesh is apparent in that while a typical small farmer household incurred a cost of Rs 105.61 per month, while medium farmers spend Rs. 145.92 per month and large farmers spend Rs. 234.84 per month. A similar picture emerges in the case of Bihar where diesel tube well turned out to be the major source of irrigation. Ownership of diesel tube wells is higher among large farmers (51.1 percent) than medium (30.56 percent) and small farmers (13.56 percent). For Bihar the overall costs of purchasing water from tube wells and the costs incurred are more or less similar across all farmer categories. The average amount spent (across all categories) is Rs 74.14 per hour.

Cultivation in the Gazipur hub is also conducted largely under irrigated conditions. Although multiple sources of irrigation are available to farmer households in the Gazipur hub, they depend heavily on tube wells, both owned and purchased. A higher proportion of large farmers own tube wells (13.31 percent) compared with small (2.46 percent) and medium (2.73 percent) farmers. In terms of proportion of farmer households having access to irrigation water, canal and tank irrigation are clearly the minor sources. In Bangladesh, the costs incurred by purchasing irrigation water through use of tube wells, are the highest across the study area. The cost incurred per land unit (*acre*) shows that in Gazipur the costs are higher for a medium farmer household (Tk 5506.65 per acre), followed by a small farmer (Tk 4873.56 per acre) and a large farmer (Tk 4672.43 per acre). Unlike the case in Tamil Nadu, there arise substantial costs for irrigation sourced from canals for small (Tk 2288 per acre) and medium farmers (Tk 2002 per acre) and through tank irrigation for large farmers (Tk 286 per acre). Nevertheless the unit costs of irrigation are higher for farmers using tube wells.

2.3.1 Livestock

A large majority of the households in the hubs under study depend upon livestock activities. The livestock activities are important with the cereal production in all hubs. This section provides livestock information in the hubs with regards to milk productivity, marketing through supply and demand, use of crop residue for feeding livestock, animal health and breeding cost.

A large variability is noticed in the livestock productivity across hubs. The productivity also varies whether it is local cattle or crossbred. For instance, the highest average productivity for local cattle is observed in Tamil Nadu at 7.4 liters per day and the lowest is 2.2 liters per day in the Gazipur hub. In general the productivity of crossbred is much higher than the local. The highest average productivity for crossbred cattle is observed in Bihar followed by Uttar Pradesh, and the lowest productivity is again found in the Gazipur hub. Across all hubs and for both local and crossbred cattle, it is often the case that large farmers have higher milk productivity than medium and small farmers.

In terms of residue use for feeding of livestock, the most common feed for dairy animal in the study area are rice, wheat, maize straw and concentrates. Small farmers depend primarily on cereal straw for feeding their livestock rather than concentrates or other types of feed. Some of the major livestock health expenditures are: insemination costs of dairy animals, costs incurred on private veterinary doctors, stock assistants, and user fees of government health clinics.

During the baseline survey, information was also collected on milk market linkages in the hub domains. In eastern Uttar Pradesh, the milk market is largely informal in nature and there were few formal sector linkages for meeting demand and supply of milk. Small and medium farmers in eastern Uttar Pradesh sold milk directly to consumers. Although a sizeable proportion of large farmers also sold milk directly to the consumers, their share of this informal sector activity was lower compared to the small and medium farmers. The milk market is also largely informal in the Gazipur hub and all three categories of farmers adhere to this system. However, in the Dinajpur, Bihar and Nepal Terai, the formal marketing system predominates.

3 Heterogeneity in household composition, demographic structure and socio-economic context

Since most of the technologies that are being promoted under CSISA are resource-conserving, their promotion must generally be specific to the underlying conditions of the various hub domains, and the appropriateness of a technology in a particular context is dependent upon the relative abundance or scarcity of agricultural inputs like land and labor. For this reason, understanding the physical and socio-economic endowments of the households residing in each of these hub domains is important. In this section, we review some of the key aspects that contextualize the CSISA hub domains.

3.1 Household Demographic Characteristics

While the principal objectives of CSISA are measurable impacts in terms of improved livelihoods and food security, the underlying differences in household demographics and socioeconomics must be taken into consideration since these factors are important determinants of the appropriateness of a given technology or development approach.

Indeed, the delivery of new agricultural technologies is very much a site-specific exercise which must consider the underlying social, institutional, and economic endowments of the farmers who are being targeted.

Within the broad CSISA context, there are wide differentials in terms of household composition and demographics. Table 3.1.1 reports a summary of demographic statistics across the 8 hubs that were active during Phase I and covered in the baseline survey.

From the baseline survey sample, almost all household heads are male, and are generally in their upper forties or low fifties in age. Only in Nepal do female-headed households represent more than 10 percent of the population. But even in female-headed households, it is rare to find the absence of adult male members who are able to economically contribute to the household (there are only seven female-headed households without an adult male in the entire sample). Equally as rare is to find male-headed households without an adult female present (only six in the entire sample). And there are no households in the sample that are headed by children in the absence of adult members.

Household heads are generally younger in the Dinajpur hub domain than in other areas, at roughly 44 years of age, with household heads in Tamil Nadu, Gazipur, and Bihar older than in other areas (50 years). In the remaining hub domains, the household head is generally in his or her upper forties, with the average age over the whole sample at just under 49 years old.

Some interesting figures are revealed when we consider household head education levels. The most educated household heads in our sample are found in Bihar, with an average of 8.3 years of formal education.[5] This is a surprising result, especially given Bihar's relatively low development indicators. Indeed, Bihar ranks last out of the 35 states and union territories in India in terms of a composite (primary and upper primary level) Educational Development Index,[6] well below Tamil Nadu (5th overall), Punjab (7th overall), and Haryana (11th overall). In this regard we must consider the baseline survey sample not at all representative of the larger state or national picture.[7] The least educated household heads are from the Dinajpur hub domain, with just over 6 years of education. This is less than the reported educational attainment of household heads

[5] Due to data limitations, we are unable to quantify the education levels of household heads in Eastern Uttar Pradesh and Gazipur.

[6] Source: Lok Sabha Unstarred Question No. 2213, dated on 10/03/2010 and Ministry of Human Resource Development, Government of India. Accessed on IndiaStat website (http://www.indiastat.com) on 13 August 2012.

[7] Part of the explanation for this could lie in the sampling scheme. The survey was targeted toward those households that owned land. In Bihar, there remains a relatively large number of landless households who nonetheless are engaged in agriculture. These households would be omitted from the sample. So it is possible that the baseline survey sample is collecting data on an upper class of households in Bihar.

from Nepal, which has a lower national education index score than either India or Bangladesh.[8]

Table 3.1.1 Summary of key household demographic characteristics

	Bihar	Dinajpur	E Uttar Pradesh	Gazipur	Haryana	Nepal Terai	Tamil Nadu
Household Head Age (years)	50.09 (13.72)	43.92 (11.78)	50.34 (13.64)	50.09 (14.29)	47.77 (12.93)	47.76 (12.94)	50.37 (7.63)
Household Head Education (years)	8.31 (5.98)	6.08 (3.79)			8.26 (4.23)	6.48 (5.01)	6.62 (6.01)
Female Headed (=1)	0.01 (0.09)	0.02 (0.14)	0.02 (0.15)	0.04 (0.20)	0.003 (0.06)	0.13 (0.33)	0.03 (0.16)
Household Size (# Persons)	7.35 (4.70)	4.53 (1.86)	8.16 (4.59)	4.50 (0.94)	6.83 (4.08)	6.69 (3.52)	5.01 (1.83)
Dependency Ratio	0.61 (0.53)	0.61 (0.53)	0.66 (0.59)	0.56 (0.50)	0.38 (0.38)	0.67 (0.65)	0.35 (0.38)

Note: Table reports sample means within each hub, with sample standard deviations reported in parentheses. The dependency ratio is calculated as the proportion of young (below age 15) to the working age population (those over age 15).

Households in Bangladesh (both Dinajpur and Gazipur) are generally smaller, with roughly 4.5 household members in each of these two hubs. This contrasts rather remarkably with the two Indian hubs closest to Bangladesh (Bihar and eastern Uttar Pradesh), which have, on average, 7.35 and 8.16 household members, respectively.

There is a great deal of similarity when these household sizes are decomposed into economically active and inactive subsegments. To examine this, we compute dependency ratios. Due to data limitations, we are unable to compute dependency ratios according to their most common definition, which includes elderly (those over age 65) and young (those under age 15) as dependent household members, while those aged 15-64 are deemed as productive and economically active members. Nevertheless, we can assume that even elderly people make some contribution to the household economy, even if it is only in the production of household commodities or in tasks less physically demanding than would be done by younger family members.

The dependency ratios between eastern Uttar Pradesh and Bihar, on the one hand, and Dinajpur and Gazipur, on the other, are actually quite similar, at roughly 0.6. This figure suggests that for every 5 working age household members, there are roughly 3 dependents. These dependents are consuming from the household’s stock of wealth

[8] Source: International Human Development Indicators, Education index (expected and mean years of schooling). Accessed at http://www.hdrstats.undp.org on 13 August 2012.

and assets, but because they are not economically productive, they are not contributing to this stock. While Dinajpur and Gazipur may have smaller average household sizes, the similarity in dependency ratios with Bihar and eastern Uttar Pradesh suggests that households may be as economically constrained in the Bangladeshi hubs as those in the Indian hubs to which they are being compared. The dependency ratio in Dinajpur could partly reflect the younger demographic structure among households in that hub domain, since the household heads are significantly younger there than in any of the other hub areas. Since the household heads are younger, it should also be generally observed that offspring will also be younger and therefore less able to contribute to the household economy.

In all hub domains, the highest dependency ratio is 0.67 (Nepal), which suggests that for every three working-age household members in Nepal, there are two dependents. Taken in tandem with the relatively high proportion of female-headed households, these figures suggest that there is a relatively large segment of the sample that could be classified as being members of vulnerable groups. In fact, for female-headed households in Nepal, the dependency ratio is significantly higher than the sub-sample average, with nearly 0.9 dependents for every economically active adult household member. The dependency ratio is much lower in Haryana (0.38), which suggests a much larger share of economically active household members in these hubs compared to the other hubs.

Since the value of a baseline survey is often primarily in its ability to foster baseline-endline comparisons (e.g., impact evaluations), it is important to be able to identify the program intervention as a causal factor driving outcomes observed as of the endline. This is why the CSISA baseline survey was conducted in both intervention and non-intervention villages throughout the hub domains: observed differences in key indicator variables in CSISA intervention villages can eventually be compared against these same key indicator variables from the non-intervention villages (assuming the characterizations of intervention and non-intervention remain for all villages). But in order to draw causal interpretations, it is important that the causal mechanism be adequately identified, which generally implies that the only avenue through which the different observed outcomes can come about is through the intervention.

An ideal background against which to conduct such impact evaluations is that of random assignment of the intervention. This may not be feasible in many settings, so the second best option is to observe recipients of a particular intervention who are essentially indistinguishable from those not receiving the intervention. If this is the case, then it is *as if* the two samples were randomly drawn from among the underlying population. If this selection was truly random, then the characteristics of intervention villages should be roughly the same as the characteristics of the non-intervention villages, which would then imply that the intervention villages would be roughly representative of the totality of the hub domain, and any observed outcomes for a particular indicator could be attributed to the intervention. Using simple statistical methods, we can test whether the villages selected as intervention villages are similar to other villages in the hub domains randomly selected for inclusion in the baseline survey.

Tests of this nature take the form of two-sample *t*-tests. For such a test, let the null hypothesis be that the sample mean for a particular metric among CSISA intervention villages within a particular hub is the same as the sample mean among non-intervention villages within the same hub. Table **3.1.2** reports the sample means and standard deviations for the above referenced household characteristics, broken out by both hub and intervention designation (CSISA versus non-CSISA).

Table 3.1.2 Comparison of household characteristics between CSISA intervention and non-intervention households

		Household Head Age (yrs)	Household Head Education (yrs)	Female-Headed (=1)	Household Size (persons)	Dependency Ratio
Bihar	CSISA	50.94 (0.97)	8.56 (0.45)	0.01 (0.01)	7.22 (0.35)	0.59 (0.04)
	Non-CSISA	49.24 (1.07)	8.06 (0.44)	0.02 (0.01)	7.49 (0.35)	0.63 (0.04)
Dinajpur	CSISA	43.28 (0.94)	6.36 (0.36)	0.02 (0.01)	4.63 (0.14)	0.59 (0.04)
	Non-CSISA	44.56 (0.90)	5.77 (0.33)	0.02 (0.01)	4.43 (0.16)	0.64 (0.04)
E Uttar Pradesh	CSISA	49.86 (1.05)		0.01 (0.01)	8.14 (0.34)	0.68 (0.05)
	Non-CSISA	50.82 (1.09)		0.03 (0.01)	8.17 (0.38)	0.64 (0.05)
Gazipur	CSISA	49.53 (1.11)		0.01 (0.01)	4.43 (0.15)	0.55 (0.04)
	Non-CSISA	50.65 (1.13)		0.07** (0.02)	4.57 (0.17)	0.57 (0.04)
Haryana	CSISA	49.30 (1.02)	8.42 (0.35)	0.01 (0.01	6.88 (0.35)	0.33 (0.03)
	Non-CSISA	46.25** (1.00)	8.11 (0.32)	NA	6.77 (0.29)	0.42** (0.03)
Nepal Terai	CSISA	48.61 (1.06)	6.69 (0.41)	0.14 (0.03)	6.92 (0.32)	0.68 (0.05)
	Non-CSISA	46.97 (0.98)	6.29 (0.38)	0.11 (0.02)	6.48 (0.24)	0.67 (0.05)
Tamil Nadu	CSISA	50.85 (0.62)	6.67 (0.51)	0.04 (0.02)	5.15 (0.15)	0.32 (0.03)
	Non-CSISA	49.90 (0.58)	6.58 (0.43)	0.01* (0.01)	4.88 (0.13)	0.38* (0.03)

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level. Sample standard deviations in parentheses. Significance markers are derived from a t-test of group means and indicated statistically significant differences between sample means between CSISA intervention villages and non-intervention villages for the indicator considered. The null hypothesis being tested is that the means between the two sub-populations are equal.

For almost all characteristics in each of the hubs, there is not a statistically significant difference between the samples drawn from CSISA intervention villages and non-intervention villages. This is suggestive that, for the most part, at least in terms of these household demographic and compositional factors, the villages that have been identified for strategic intervention by CSISA hub managers are representative of the larger domains surrounding the hub. There are some exceptions to this general observation. For example, villages in the Haryana hub domain that are beneficiaries of CSISA interventions have significantly older household heads (49.30 years versus 46.25 years) and lower dependency ratios (0.33 versus 0.42) than the villages classified as non-CSISA.[9] Similarly, villages in the Gazipur hub domain that are beneficiaries of CSISA interventions have a significantly higher proportion of female-headed households than those villages that do not benefit from CSISA interventions (0.07 versus 0.01).

3.2 Household Socioeconomic Characteristics

Household Head Occupations

We next consider the households' socioeconomic contexts. To begin, we consider the occupation of household heads. Many household heads have both a primary and a secondary occupation, and since both occupations can generate income for the household, we will report on both. We have taken open-ended responses to primary and secondary occupations and classified them as falling into one of seven occupational categories: agricultural self-employment, agricultural labor, non-agricultural labor, business (essentially non-agricultural self-employment), services, housewife, and other. Agricultural self-employment and wage employment are determined based on the location of employment. For example, if the occupation is categorized as agricultural, and the place of occupation is listed as the respondent's farm, then the respondent is counted as agricultural self-employed. If the occupation is agriculture, but the place of employment is in the village, district, state, or domestic or foreign country, then the respondent is counted as agricultural labor. Table 3.2.1 reports respondents' primary and secondary occupations of the pooled sample. Agriculture is clearly the most dominant category of employment, with nearly 77 percent of all respondents indicating agriculture (in some fashion) as their primary occupation. Of the 23 percent not primarily engaged in agriculture, nearly 70 percent list agriculture as their secondary occupation. Other occupations are important as well. Over 6.5 percent of the sample reports non-

[9] As previously suggested, these two factors are closely related. Older household heads tend to have older children, and there is threshold age (15 year) where children switch from being counted as dependents and begin being counted as economically active household members. Household heads aged 49 would generally be assumed to have more 15+ year old children than a household head aged younger than 15.

agricultural labor as a primary occupation, and an additional 12.14 percent report non-agricultural labor as a secondary occupation.

Table 3.2.1 Primary and secondary occupations

	Primary Occupation		Secondary Occupation	
	# Respondents	**%**	**# Respondents**	**%**
Agricultural Self-Employed	682	26.10	209	7.95
Agricultural Labor	1,317	50.40	445	16.93
Non-Agricultural Labor	170	6.51	319	12.14
Business	196	7.50	114	4.34
Service	203	7.77	35	1.33
Housewife	23	0.88	0	0.00
Other	22	0.84	23	0.88
No Secondary Occupation			1,483	56.43

Table 3.2.2 reports cross tabulations of primary and secondary occupations, which allows for analysis of complete employment. Even among those who list some form of agriculture as their primary occupation, a nontrivial portion list a form of agriculture as their secondary occupation as well. For example, there are 200 individuals (7.7 percent of the total sample or 15.2 percent of those engaged in agricultural labor as a primary occupation) who list agricultural labor as both their primary and secondary occupations, which may reflect separate seasonal sources of wage employment (e.g., the primary occupation might be agricultural wage labor during *kharif* or *aman* season, while the secondary occupation could be agricultural wage labor during the *rabi* or *boro* season), or possibly engagement in two distinct aspects of the agricultural sector (e.g., crop and livestock production). Of these 200 individuals, 28 percent specialize in farming as a primary occupation and raising livestock as a secondary occupation.

Many household heads who specialize in agricultural production as a primary occupation apparently attempt to supplement agricultural income with non-farm income, as seen from the 426 individuals primarily engaged in either agricultural self-employment or agricultural labor who have a secondary occupation categorized as either non-agricultural labor or business. One possible reason for this is the desire of risk-averse households to diversify income sources to reduce the variability in total household consumption. Given the high volatility of agricultural incomes, it has widely been observed that households may choose to take on additional employment as a means of smoothing household income and de-coupling household consumption from a single, volatile income source.

Table 3.2.2 Cross-tabulation of primary and secondary occupations

Primary Occupation	Secondary Occupation						
	Agricultural Self-Employed	Agricultural Labor	Non-Agricultural Labor	Business	Services	Other	No Secondary Occupation
Agricultural Self-Employed	13	1	118	13	7	3	527
Agricultural Labor	1	200	196	99	27	20	774
Non-Agricultural Labor	60	68	0	1	0	0	41
Business	45	95	5	0	1	0	50
Services	88	64	0	1	0	0	50
Housewife	0	4	0	0	0	0	19
Other	2	13	0	0	0	0	7

Note: Figures represent the number of household head respondents listing each combination of primary and secondary occupation.

Table 3.2.3 reports the primary occupation of household heads by CSISA hub. This table helps to illustrate some of the important differences that arise between CSISA hub domains, especially as it pertains to an important socioeconomic dimension such as occupation or employment.

Table 3.2.3 Primary occupation, by CSISA hub (percent)

	Bihar	Dinajpur	E Utter Pradesh	Gazipur	Haryana	Nepal Terai	Tamil Nadu
Agricultural Self-Employed	29.44	0.31	0.00	70.37	4.94	49.85	46.60
Agricultural Labor	38.33	61.73	84.57	0.93	88.89	2.17	47.84
Non-Agricultural Labor	15.00	9.57	5.56	5.56	0.00	13.00	0.62
Business	7.50	21.60	2.78	12.35	1.23	9.29	2.78
Services	8.33	6.17	6.48	6.79	4.63	25.70	1.85
Housewife	0.56	0.62	0.00	3.09	0.00	0.00	0.00
Other	0.83	0.00	0.62	0.93	0.31	0.00	0.31

Note: Figures represent the percentage of respondent household heads listing each occupation as primary occupation.

Household land holdings and cultivated area

As alluded to in the introduction to this section, a household's land endowment can be an important determinant in whether a particular agricultural technology is appropriate. While land endowment is most appropriately reflected by ownership of land, taking into consideration area leased or shared in or out provides a better sense for farmers' access to land for productive purposes. Figure 3.2.1 provides a visual summary of the average cultivated land area across the various hubs, both in terms of total acreage as well as in per household member terms. Comparing total cultivated area across the eight hub domains, we can see there is clearly a great deal of heterogeneity. Land holdings are typically larger in the Indian hub domains, especially those in the western IGP. Households in Haryana tend to cultivate significantly larger areas (on average, more than 8 acres per household) than their counterparts in the other hubs, particularly the two hubs in Bangladesh, where households cultivate less than 2 acres on average.

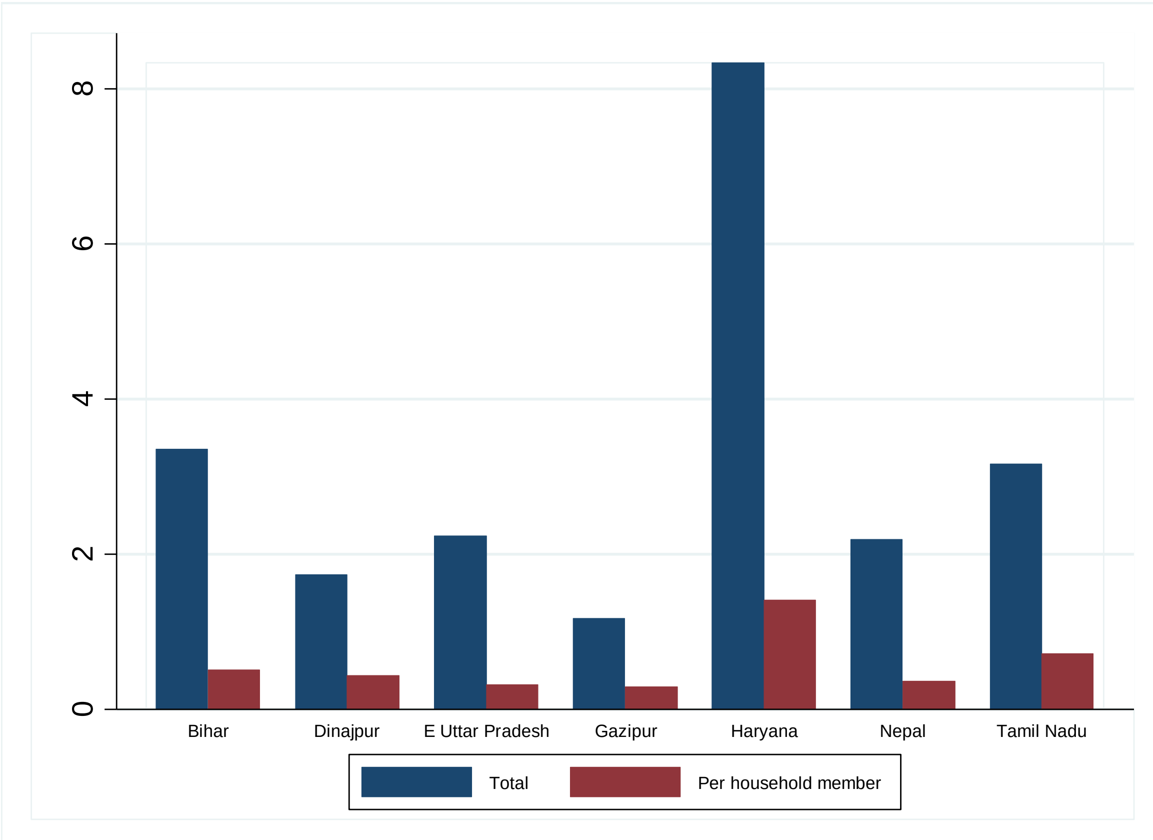

Figure 3.2.1 Area of land cultivated (total and per household member), by hub

Analysis of the per capita area of land cultivated provides some of a clearer picture of the relative abundance and scarcity of land and labor. This metric is akin to a land/labor ratio, though we acknowledge that not every household member included in the denominator of this ratio is active in cultivating the area included in the numerator. For higher land/labor ratios, households are relatively more abundant in land and relatively scarce in labor, while the converse holds if households have lower land/labor ratios. Analyzing these figures also provide clues as to how constrained households are in their access to land, since a given area of land must be used to feed every member of the household. This is especially true if households are subsistence farmers, consuming most of their production with little or no marketed surplus. By this metric, Haryana stands out again, with well over 1 acre of cultivated land per household member. With such abundant land in these hub domains, the promotion of land-saving technologies may be less urgent than the increased development and delivery of important labor-saving technologies. The remaining hubs have low land/labor ratios, ranging from 0.72 in Tamil Nadu to roughly 0.3 in the Eastern Uttar Pradesh and Gazipur domains. For these latter two hub domains, as well as the Dinajpur and Bihar domains (with 0.43 and 0.5 acres per household member, respectively), technologies that increase the productivity of land may be identified as especially important, since it would be beneficial for these smallholder farmers to have access to technologies that would increase the amount of output obtained from these relatively small areas of land.

Household assets and resource base

Household asset holdings are a critical element in determining household wealth, poverty, and vulnerability. Not only can assets serve as a store of capital (i.e., that can be liquidated during lean periods to supplement depressed incomes), they can also serve productive purposes, just like traditional definitions of industrial capital.

There are several broad classifications assets or capital that can be considered based on the CSISA baseline survey. We begin by considering a very specific form of physical capital: housing capital. These assets, which include such things as roofing and flooring materials, water and sanitation access, and household utilities, capture the robustness or development of household infrastructure. Table 3.2.4 summarizes some of these assets by hub domain. These figures are based on (mostly) binary (0/1) responses in the CSISA baseline survey. For example, for thatched roofs, household responses are coded as a 1 if a household has a thatched roof, and are coded as 0 otherwise. Because of this simple coding, the reported figures represent proportions of the samples within each of the hub domains that own or have access to each of these various forms of housing capital. The only exception to this general rule is for number of rooms in dwelling; this figure reports the average number of rooms a household has in its dwelling.

Several of these responses demonstrate wide differences in the level of development across these hub domains. For example, only 11 percent of households in the Nepal Terai hub domain have access to piped drinking water, suggesting that the remaining 89 percent must get their drinking water from other sources, most likely wells or streams that leave these households significantly more exposed to water-borne diseases. Similarly, only 25 percent of households in eastern Uttar Pradesh and 49 percent of households in Bihar have latrines, implying that the remaining portions of the population in these hub domains have to use other, more primitive toilet facilities. Access to clean sources of cooking fuel is also an important development indicator. In the Haryana hub domain, for example, 85 percent of households have access to piped gas connections (most likely liquefied petroleum gas, LPG), a much cleaner cooking alternative than kerosene, charcoal, wood, dung, or many other forms of primitive indoor cooking fuels that have been widely associated with illnesses arising from inhalation of indoor air pollutants.

Table 3.2.4 Housing assets, by CSISA hub domain

	Bihar	Dinajpur	E Uttar Pradesh	Gazipur	Haryana	Nepal	Tamil Nadu
Thatched roof (%)	0.69 (0.46)	0.60 (0.49)	0.58 (0.49)	0.003 (0.06)	0.16 (0.37)	0.39 (0.49)	0.69 (0.47)
Concrete floor	0.48 (0.50)	0.40 (0.49)	0.71 (0.45)	0.10 (0.30)	0.87 (0.34)	0.65 (0.48)	0.38 (0.49)
Number of rooms in dwelling	3.59 (2.60)	3.15 (1.29)	3.64 (2.55)	2.22 (1.13)	4.09 (1.99)	3.91 (1.61)	2.45 (1.08)
Piped water	0.81 (0.39)	1.00 (0.00)	0.29 (0.45)	0.00 (0.00)	0.91 (0.29)	0.11 (0.32)	0.44 (0.50)
Cooking gas connection	0.22 (0.41)	0.00 (0.00)	0.18 (0.38)	0.00 (0.00)	0.85 (0.36)	0.40 (0.49)	0.89 (0.31)
Open well	0.08 (0.27)	0.01 (0.08)	0.05 (0.22)	0.77 (0.42)	0.02 (0.14)	0.22 (0.41)	0.17 (0.37)
Latrine	0.49 (0.50)	0.89 (0.32)	0.25 (0.44)	0.95 (0.21)	0.95 (0.22)	0.63 (0.48)	0.43 (0.50)
Electricity	0.37 (0.48)	0.38 (0.49)	0.38 (0.49)	0.86 (0.46)	1.00 (0.06)	0.87 (0.35)	1.00 (0.00
Television	0.25 (0.43)	0.36 (0.48)	0.26 (0.44)	0.43 (0.50)	0.97 (0.18)	0.67 (0.47)	1.00 (0.00)
Mobile Phone	0.97 (0.16)	0.51 (0.50)	1.00 (0.00)	1.00 (0.00)	0.93 (0.26)	0.98 (0.13)	1.00 (0.00)

Note: With the exception of number of rooms, the reported figures represent sample proportions owning each of the listed assets. For number of rooms, the reported figure represents the sample mean. Standard deviations are reported in parentheses.

Animal assets are another important form of capital, and can serve as both productive capital as well as a store of wealth. Table 3.2.5 summarizes household holdings of livestock and ruminants across the CSISA hub domains, revealing a great deal of variation in holdings of animal assets across the different domains. The eastern Uttar Pradesh hub domain stands out as being particularly deprived in terms of animal assets. On average, households own less than one specimen of each of the animal species considered. The Haryana hub domain is particularly dependent upon large livestock, with over four buffalo and almost two cattle (including both bulls and cows, which may serve as dairy cows) on average per household, while ownership of poultry and the other considered ruminants are negligible. In the Gazipur and Nepal Terai hub domains, there are large average poultry holdings, though the very large standard deviations suggest that these sample means are skewed by a few extremely large holdings. For example, in the Nepal Terai hub domain, there are several commercial poultry operations included in the sample, some with over 1,000 chickens. Over 75 percent of the households in the Nepal Terai hub domain are without chickens, but these few large operations raise the sample mean to the second largest out of all the hub domains. There is a similar situation within the Gazipur hub domain, though more than 86 percent of households in this latter domain own poultry to some degree.

Table 3.2.5 Household livestock and ruminant holdings, by CSISA hub domain

	Bihar	Dinajpur	E Uttar Pradesh	Gazipur	Haryana	Nepal	Tamil Nadu
Buffalo	0.61 (1.41)	0.43 (0.30)	0.84 (1.27)	NA	4.39 (4.31)	1.21 (1.34)	0.06 (0.58)
Cattle	2.05 (2.03)	2.54 (2.41)	0.65 (1.15)	2.45 (2.22	1.89 (2.39)	0.78 (1.27)	1.88 (3.69)
Goats	0.11 (0.54)	1.62 (2.17)	0.38 (1.33)	0.67 (1.69)	NA	3.09 (3.22)	1.34 (2.55)
Sheep	NA	NA	0.003 (0.06)	0.06 (0.60)	NA	0.01 (0.11)	0.05 (0.50)
Poultry	0.02 (0.32)	6.20 (8.88)	0.03 (0.37)	35.04 (187.09)	NA	31.08 (229.223)	3.23 (4.20)

Note: Reported figures represent sample means. Sample standard deviations are in parentheses. ‘NA’s indicate there were no households in a given hub domain owning a particular type of animal.

We can also consider household ownership of assets that can be used in agricultural production, e.g., mechanized agricultural implements such as tractors, irrigation pumps, threshers, etc. Table 3.2.6 summarizes ownership of these machines by CSISA hub domain. Ownership of mechanized inputs is generally relatively sparse throughout the different hub domains, especially for large implements such as 4-wheel tractors. Apparently the most widely owned mechanical input among households in the CSISA hub domains is a diesel pump for tube-well irrigation. Nearly half of all households in the Haryana hub domain own a diesel pump, while nearly one in three households in each of the Bihar, Dinajpur, and Eastern Uttar Pradesh hub domains own one.

Table 3.2.6 Household ownership of mechanized agricultural implements, by CSISA hub domain

	Bihar	Dinajpur	E Utter Pradesh	Gazipur	Haryana	Nepal	Tamil Nadu
2-wheel tractor	1.1%	2.5%	0.0%	1.4%	0.0%	0.6%	1.3%
4-wheel tractor	2.2%	0.0%	2.2%	0.0%	43.8%	3.4%	0.6%
Diesel generator					3.4%	0.0%	
Diesel pump	29.4%	33.6%	29.3%	5.2%	46.6%	19.6%	0.6%
Disc harrow	0.3%	0.0%	2.2%		41.8%	1.2%	0.0%
Electric submersible pump	0.6%	0.9%	0.9%	0.0%	72.8%	3.1%	20.6%
Knapsack sprayer	10.3%		9.0%	5.1%	81.6%	13.9%	2.3%
Monoblock pump	0.0%	0.0%			86.3%	0.0%	0.6%
Power thresher	2.5%	2.1%	6.2%	55.4%	3.9%	1.2%	3.2%
Rotavator	0.3%	0.0%	0.3%		5.3%	0.3%	2.7%
Seed drill	0.3%			0.4%	9.8%	0.3%	
Tine cultivator	6.4%	0.0%	4.2%		43.0%	3.1%	0.3%

Note: Reported figures represent the percentage of the sample populations that own at least one unit of these mechanized implements.

3.3 Household consumption, poverty and inequality

We next turn our attention to consumption and poverty. To generate internationally-comparable figures for consumption and poverty measures, we first must convert the reported consumption expenditures from local currencies (i.e., Indian or Nepalese rupees or Bangladeshi takas) into international dollars.[10] This is accomplished using purchasing power parity (PPP) conversion factors obtained from the United Nations (UN) Millennium Development Goals Database.[11] First, the reported average monthly household expenditures (in local currency units, LCUs) are converted to expenditures per person by simply dividing the reported expenditure amounts by the household size. Next, these per person figures are adjusted for inflation and converted to real 2005

[10] The total household consumption figures represent aggregations of categorical monthly household expenditures for food, fuel and electricity, clothing and footwear, household items, travel, education, medical and health care, ceremonies, and all other expenditures.
[11] Source: UN Millennium Development Goals Database, United Nations Statistics Division. Accessed online at http://data.un.org. Last updated 29 August 2011.

LCUs using country-wide consumer price index data obtained from the World Bank's World Development Indicators.[12] Since the household survey interviews were conducted at various points in time throughout 2010 and 2011, the price index used to deflate the reported expenditure figures to 2005 LCUs will vary based on the timing of the survey interview, even with villages.[13] These inflation-adjusted expenditure figures were converted to international dollars by using the aforementioned PPP conversion factors. For 2005, the PPP conversion factors were 25.49 for Bangladesh, 15.60 for India, and 26.47 for Nepal. These conversions convert inflation-adjusted local currencies into figures that capture differences in real exchange rates between countries, following the Law of One Price. Average monthly per capita expenditures for various expenditure categories are reported in Table 3.3.1.

Table 3.3.1 Household expenditures per person, by CSISA hub domain

	Bihar	Dinajpur	E Utter Pradesh	Gazipur	Haryana	Nepal Terai	Tamil Nadu
Food	23.64	26.95	17.43	27.60	20.18	18.49	14.52
	(22.29)	(8.97)	(12.93)	(8.40)	(16.36)	(15.60)	(5.68)
Fuel	5.19	3.41	2.69	2.39	10.45	1.89	2.31
	(3.73)	(1.77)	(5.13)	(1.14)	(10.40)	(5.93)	(2.01)
Clothing	4.41	2.37	3.62	2.74	10.17	4.01	4.03
	(3.38)	(1.21)	(5.92)	(1.82)	(9.20)	(3.55)	(3.10)
Household Items	0.61	1.11	0.34	0.88	4.10	1.45	1.49
	(0.71)	(0.61)	(0.83)	(2.35)	(5.01)	(1.36)	(1.27)
Travel	3.61	2.28	3.22	0.35	6.90	2.72	3.21
	(5.28)	(2.01)	(5.73)	(0.91)	(7.29)	(4.86)	(2.55)
Education	11.13	2.57	6.30	3.90	15.41	7.03	8.05
	(16.80)	(3.11)	(14.0)	(5.25)	(21.89)	(9.26)	(8.12)
Medical	4.80	1.27	5.24	2.10	8.53	4.00	5.23
	(4.58)	(0.94)	(7.17)	(3.69)	(17.25)	(4.25)	(4.82)
Ceremonies	4.16	1.59	22.31	3.75	13.03	3.79	2.98
	(5.69)	(1.18)	(62.49)	(4.90)	(81.27)	(6.25)	(4.01)
Communication	1.55	1.20	1.08	1.91	2.30	2.60	2.85
	(1.67)	(1.62)	(1.13)	(1.39)	(1.96)	(2.29)	(1.68)
Total Expenditures	55.03 (39.08)	42.76 (14.69)	60.82 (76.83)	43.77 (17.06)	90.49 (99.25)	45.21 (28.57)	43.05 (21.61)

Note: Reported figures represent average monthly household expenditures per capita (PPP-adjusted international dollars) disaggregated by expenditure category. Standard deviations are in parentheses.

The final row in this table provides estimates of the average level of per capita expenditures in each of the hubs. Since consumption in developing countries is often precariously linked with incomes, and due to myriad complications with income data, per capita expenditures are often used as a proxy for income. Thus, comparing and

[12] World Development Indicators: http://databank.worldbank.org.

[13] Most surveys were conducted during the second half of 2010 or first quarter of 2011, reflecting income most generally from the 2010 agricultural season. However, for households surveyed in early 2011, the reported expenditures likely reflect 2011 prices rather than 2010 prices. Therefore, we have made an approximation to the price level faced by these households by averaging the 2010 and 2011 price indices.

ranking the total spending levels in each of these hubs allows us to infer rankings among the hubs in terms of total income. Clearly, from summing these columns, we can see that mean expenditures (and hence incomes) are significantly higher in the Haryana domain, while they are lowest in Dinajpur, Gazipur, Nepal Terai, and Tamil Nadu, which have roughly the same average expenditure levels per person per day.

It is also instructive to consider not just the absolute levels of consumption expenditures, but also the proportionate shares of spending in each of the referenced categories. This is illustrated in Figure 3.3.1, which plots the distribution of total household per capita spending in each of the CSISA hub domains by each of these expenditure categories.

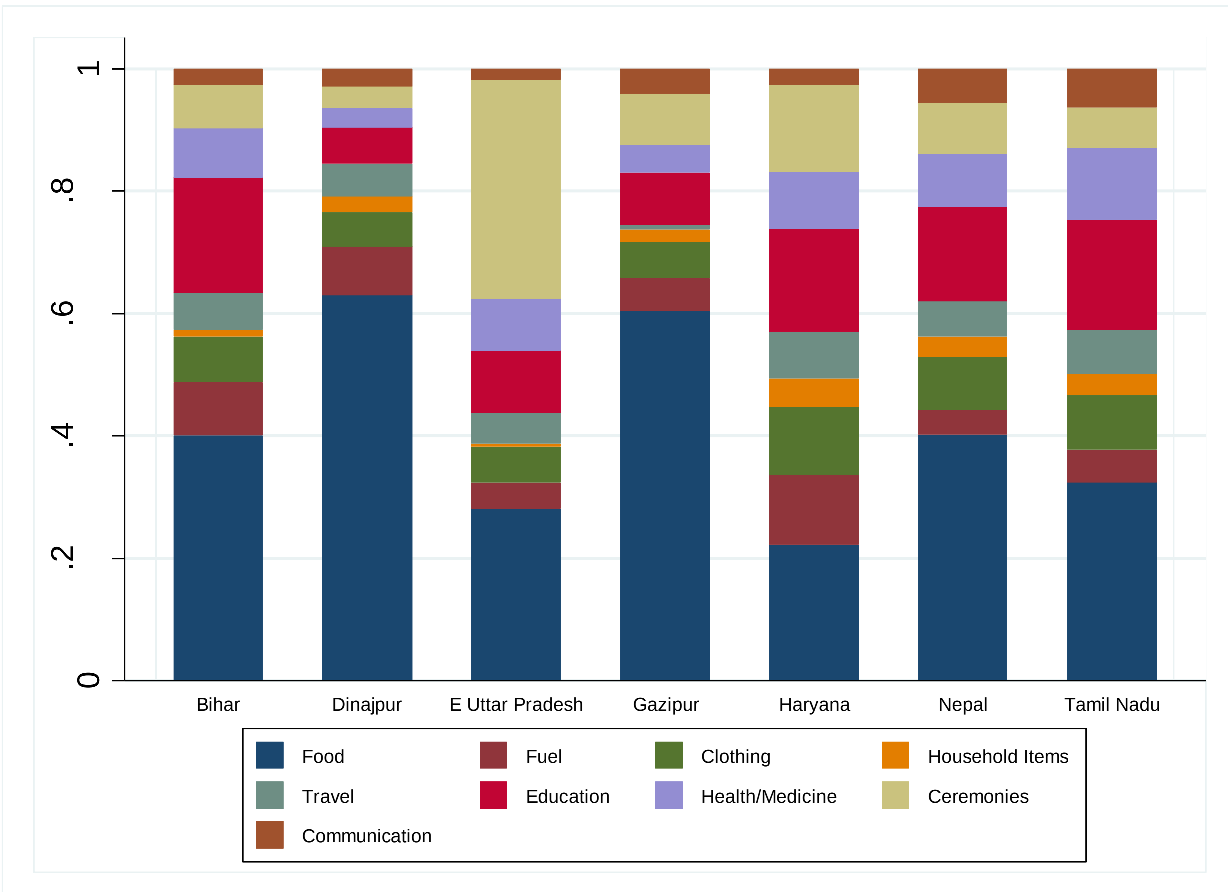

Figure 3.3.1 Average expenditure shares, by CSISA hub domain

To examine patterns of poverty among households in the CSISA hub domains, we first have to choose a threshold level of per capita income (expenditures) below which a household is deemed to be poor (a poverty line). The World Bank has traditionally used

$1.00 per day and $2.00 per day as common poverty lines for international comparisons, meant to define extreme poverty and moderate poverty, respectively.[14] In our analysis of poverty, we will focus on those considered to be in extreme poverty. Once the poverty line has been defined, we must define our measurement of poverty. For this, we will use the class of poverty measures defined by Foster, Greer and Thorbecke (1984). We compute poverty headcount ratios and poverty gaps for the eight CSISA hub domains and report these estimates in Figure 3.3.2.[15]

Based on these calculations, the Nepal Terai hub domain has both the highest poverty headcount ratio as well as the largest poverty gap. Within the Nepal Terai hub domain, we estimate that nearly 60 percent of the population has incomes below the poverty line. Additionally, we estimate a poverty gap of 22 percent, suggesting that every non-poor person in the country would need to transfer wealth equivalent to 22 percent of the poverty line in order to eliminate poverty within the Nepal Terai hub domain. The Dinajpur and eastern Uttar Pradesh hub domains each have poverty headcount ratios near 50 percent, though the poverty gap is significantly higher in eastern Uttar Pradesh than it is around Dinajpur, suggested that the many of the poor in the Dinajpur hub domain have per capita incomes only just below the poverty line, such that it would not require significant cash transfers to raise them out of poverty. In eastern Uttar Pradesh, the poverty gap is only slightly less than that of the Nepal Terai hub domain, so while the headcount ratio is smaller (59 percent compared to 50 percent), there is a greater depth of poverty among many of the poor in eastern Uttar Pradesh.

While the figures in Table 3.3.1 clearly allow us to examine the differences in absolute household spending across the different hubs, the wide standard deviations in these figures reveal the vast differences in spending even within hub domains. In several cases, the standard deviations are larger than the estimated mean expenditure levels, implying relatively large coefficients of variation in several of these expenditure categories in various hubs. Since the dispersion of expenditures (and hence incomes) is indicative of inequality, these figures suggest significant levels of inequality. One problem with using standard deviations (or variances) to draw inferences on inequality is that these measures violate the axiom of scale independence, which is one of the key axioms for well-defined measures of income inequality.[16] We can turn to more formal metrics of inequality which satisfy the axioms of anonymity, scale invariance, population

[14] The $1.00 per day poverty line used to define “extreme poverty” was first established by the World Bank in 1990, and was later adjusted to $1.08 per day. Starting in 2005, the World Bank began using a re-calibrated poverty line based on $1.25 per day in PPP terms based on 2005 prices. This change reflects the fact that previous poverty lines failed to consider differences in quality, and therefore overrestimated the purchasing power of a unit of local currency.

[15] The poverty gap is the average income shortfall below the poverty line, computed as a proportion of the poverty line. It measures the amount of money that would be required from every individual in a society to raise eliminate poverty through perfectly targeted cash transfers.

[16] The property of scale invariance implies that inequality is homogeneous of degree zero in income.

independence, and the Pigou-Dalton principle of transfers. One such measure is the Gini coefficient.

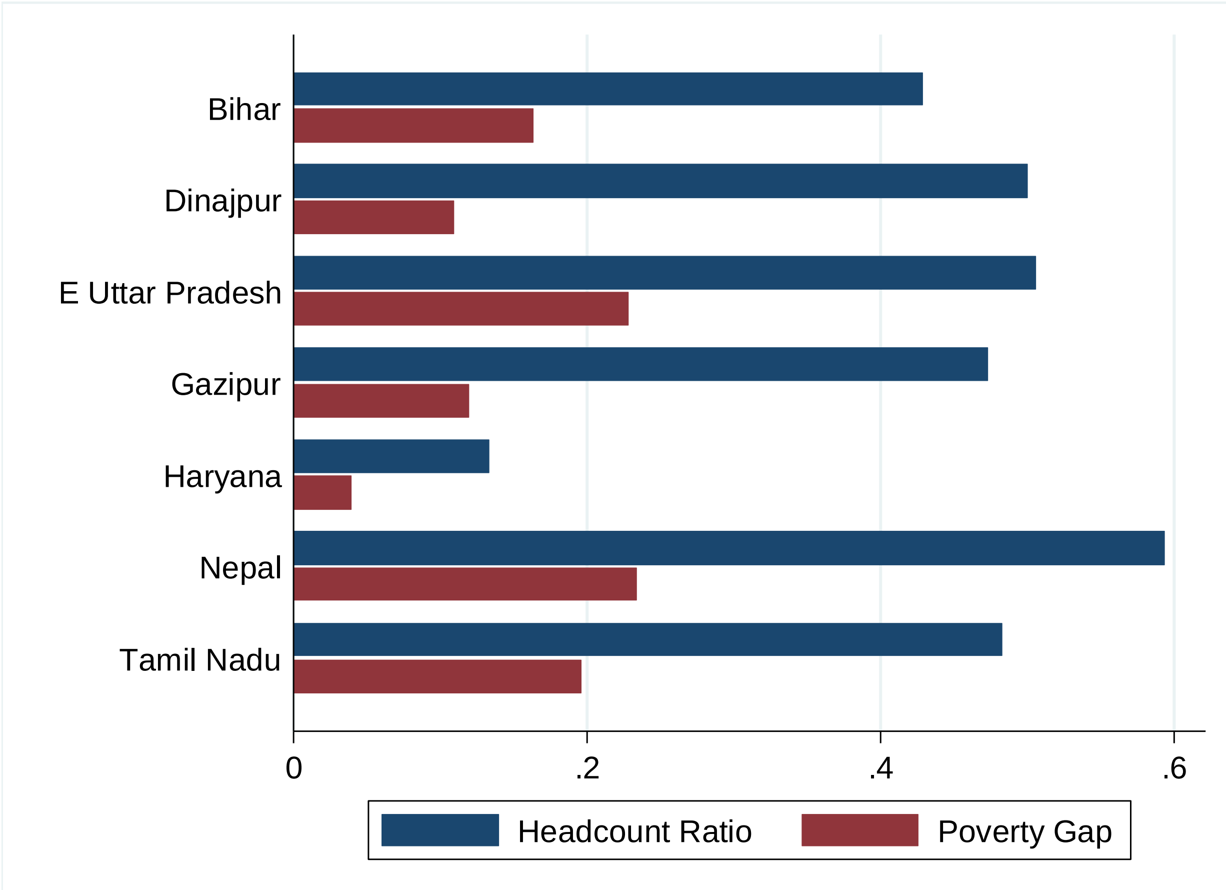

Figure 3.3.2 Poverty headcount ratios and poverty gaps, by CSISA hub domain

Higher Gini coefficients signify a higher degree of income inequality within the population. The Gini coefficients for the eight CSISA hubs are reported in Table 3.3.2. Income inequality is often depicted graphically through the use of Lorenz curves. These curves illustrate the distribution of income among the members of a given population. The vertical axis plots the proportion of total income, while the horizontal axis plots the proportion of the total population. An example of Lorenz curves illustrating income inequality among the CSISA hub domains is shown in Figure 3.3.3. In this figure, the solid black line (a 45°) represents perfect income equality. Deviations from perfect equality (i.e., curves that bow away concave to the 45° line) represent varying degrees of inequality, with further deviations indicative of a greater degree of inequality. From both the Gini coefficients and the Lorenz curves, we estimate that the two hub domains in Bangladesh have the lowest degree of income inequality among the eight CSISA hubs, while eastern Uttar Pradesh, Haryana, Bihar, and Punjab are among the highest in terms of income inequality. Inequality is an important indicator of patterns of participation in overall economic development. High levels of income inequality suggest that the poorer segments of society are not benefiting from economic development, while the gains are accruing to a small population segment with a disproportionate control over society's capital.

Table 3.3.2 Gini coefficients, by CSISA hub domain

	Gini Coefficient
Bihar	0.38
Dinajpur	0.22
Eastern Uttar Pradesh	0.45
Gazipur	0.25
Haryana	0.47
Nepal Terai	0.31
Tamil Nadu	0.27

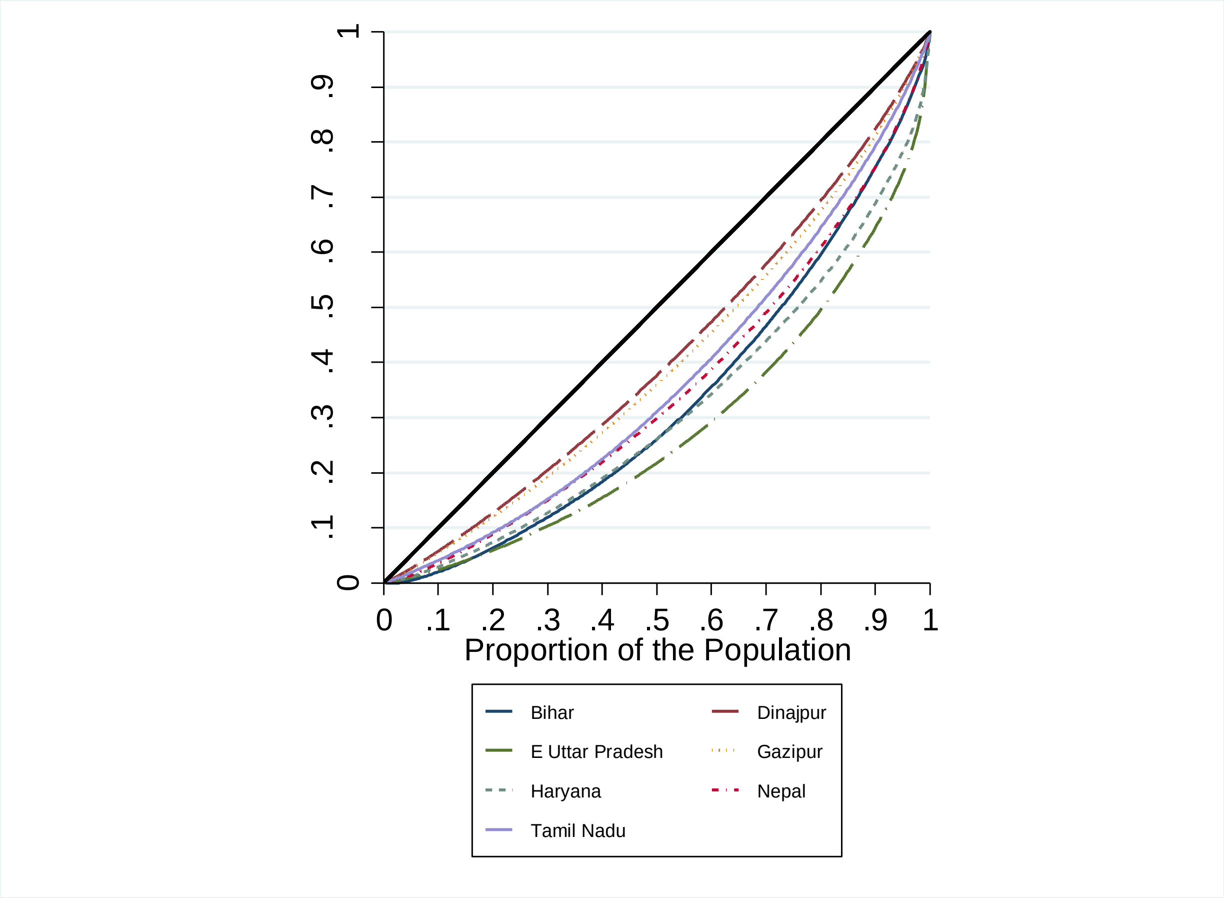

Figure 3.3.3 Lorenz curves for income inequality, by CSISA hub domain

3.4 Sources and uses of credit

Credit often plays an important role in agricultural production, as it largely facilitates the purchase of necessary farm inputs. In many developing countries, credit constraints can be pose significant challenges for households in escaping cycles of poverty and malnutrition. It is important to understand the functioning of credit systems in these areas, including the sources and uses of credit, the constraints to accessing credit, and how credit is used.

Credit comes from many different sources, including commercial banks, cooperative societies, friends, family and other farmers, informal money lenders, and non-governmental organizations (NGOs). Table 3.4.1 reports the sources of credit among those households who had accessed credit during the 2009-10 agricultural year. In some cases, the columns exceed 100 percent because households access credit from more than one source. This is particularly true in the Dinajpur hub domain, where the average household receiving credit accesses credit from more than two different sources. Moneylending NGOs are particularly active in the Dinajpur hub domain, as the average household accessing credit receives credit from two different NGOs. In the Gazipur hub, almost 80 percent of households accessing credit receive it from NGOs. NGOs are not active in lending money throughout any of the Indian hub domains, and are only marginally active in the Nepal Terai hub domain.

Table 3.4.1 Sources of credit, by CSISA hub domain (% of households accessing credit)

Credit Sources	Bihar	Dinajpur	E Uttar Pradesh	Gazipur	Haryana	Nepal	Tamil Nadu
Commercial Banks	58.0	21.1	46.9	17.2	57.7	76.6	2.2
Cooperatives	47.9	0.6	1.1	1.0	58.5	19.5	10.8
Friends/Family/Other Farmers	0.0	0.0	18.4	0.0	0.0	18.2	1.2
Money Lenders	4.2	0.0	34.1	14.7	63.5	0.0	1.2
NGOs	0.0	201.2	0.0	79.9	0.0	2.6	0.0

Note: These figures represent the percentage of households who access credit by the different credit sources listed. Not all households access credit; such households are not considered in this table.

Not every household accesses credit. Roughly 67 percent of households in Bihar, 50 percent of households in Dinajpur, 45 percent of households in eastern Uttar Pradesh, 37 percent of households in Gazipur, 20 percent of households in Haryana, 73 percent of households in Nepal, and 85 percent of households in Tamil Nadu do not access credit. Interestingly, however, most of these households do not face credit constraints; in the CSISA hub domains, almost everyone that wants credit can get credit. Across all of the CSISA hubs, only about 6 percent of households do not utilize credit because they were unable to access it. The vast majority of these households (almost 67 percent) do not access credit because they are able to manage without credit. The remaining 27 percent have some moral or psychological aversion to the very notion of credit.

There are significant differences in the interest rates charged by these different credit sources. The baseline survey data suggest the lowest average interest rates are charged by cooperative societies, with an average rate of 8.11 percent per annum. The highest average interest rates were charged by informal money lenders (23 percent per annum) and NGOs (26 percent per annum).

Credit is used for various activities, including crop cultivation, managing livestock, as well as for meeting household and other unanticipated expenses (Table 3.4.2). Most households used credit in several cropping activities. In Bihar, for example, nearly 90 percent of households that have taken advantage of available credit have used credit in relation to wheat production. But there are also 77 percent of households that have used credit for rice production and 69 percent of households that have used credit for maize production. Clearly there are a large number of households that have used credit for more than one purpose. In fact, almost half of the households from Bihar that have used credit claim to have used credit for rice, wheat, and maize cultivation.

Table 3.4.2 Agricultural uses of accessed credit, by hub domain (% of households)

	Bihar	Dinajpur	E Uttar Pradesh	Gazipur	Haryana	Nepal	Tamil Nadu
Rice	77.3	17.5	79.3	48	94.6	37.7	44.3
Wheat	89.9	2.0	89.9	0.0	90.9	23.4	82.5
Maize	68.9	0.4	12.8	0.9	0.4	11.7	3.3
Livestock	5.9	0.7	2.8	4.9	46.1	14.3	62.7

Note: Figures represent the percentage of households who have accessed credit and used credit for the listed agricultural purposes.

3.5 Gender dimensions

Gender roles vary depending upon the production systems, degree of mechanization, market orientation, socio-economic status (caste/class) and presence of the male head of the household. In the irrigated hub sites in eastern Uttar Pradesh, Bihar and Tamil Nadu, land cultivation is mainly mechanized. However, the rest are done by male and female family and hired labor. Female labor contribution is highest in Tamil Nadu (64 percent), followed by eastern Uttar Pradesh (49 percent) and Bihar (40 percent). In Bangladesh, female labor participation in field activities is lower due to social restrictions. However, most of the activities in the homesteads and near their homesteads are done by women. Female labor participation is determined by social status. Women from the upper caste do not work on the fields. In eastern Uttar Pradesh, women contribute 32 percent and 44 percent, respectively to total labor inputs in wheat and maize production. They also participate in the production of other crops such as mustard, potato, pulses, oilseeds and sugarcane. Small and marginal farming households are highly dependent on their family members to complete crop operations required during the crop season. Women contribute significantly in transplanting, weeding, harvesting and manual threshing. Aside from providing labor in their family-owned fields, they also perform most of the post-harvest activities such as drying, winnowing, storing seeds, selected seeds for the next season, in some cases, parboiling, and processing paddy into other food products. Women from small and marginal farms comparatively spend more time in animal husbandry, collection of fuel and animal fodder than men. They clean the seeds, collect farm yard manure and apply them on the soils to improve soil fertility, graze the animals, prepare animal food, collect dry cow dung for household fuel and milk the cows. Women also take care of goats and poultry for additional income. Despite women's significant contributions in crop and livestock production and management, there are gender inequalities in access to education, land property rights, technical knowledge and information, and support services. However, in terms of agriculture-related decisions, women participate more in decisions related to animal management than in crop-related decisions.

4 Experiences and patterns of adoption and disadoption of resource conserving technologies

During the first phase of CSISA, several technologies were promoted to conserve scarce resources: direct-seeded rice (DSR), laser land leveling (LLL), hybrid rice, integrated crop resource management (ICRM), seed treatment, zero tillage (ZT), and the Turbo Happy Seeder. Additional technologies are similarly being promoted such as wide bed planting (maize and black gram), narrow bed planting (maize and pulses), maize intercropping, maize with complete residue, zero-till (maize, ground nut), surface seeding, unpuddled transplanted rice, punch planter, jab seeder, improved sprayer and spraying techniques, site-specific nutrient management (SSNM), and the Super Bag. Three of the key resource-conserving technologies (RCTs) deserve special attention due to their potential to enhance farm productivity and enhance farm profits: zero tillage, direct seeded rice, and laser land leveling.

In all, the CSISA baseline household survey collected data on a suite of fourteen different resource conserving and related technologies which were promoted in the different hub domains. While not all fourteen technologies were promoted in each of the eight hubs, there were some technologies that were more heavily emphasized across the initiative. In addition to the three key resource conserving technologies discussed above, hybrid rice and hybrid maize were also intensively promoted and have the potential to significantly increase farm productivity in these hub domains.

Zero tillage wheat (ZT)

ZT wheat is the most widely adopted CA-based RCT in the rice-wheat systems of IGP (Laxmi et al., 2007; Erenstein and Laxmi, 2008). Farmers in South Asia have started adopting ZT wheat cultivation during the late 1990s and this practice accelerated in the early 2000s, such that the estimated area under this technology is now nearly 1.8 million hectares (Erenstein, 2009a). Adoption of ZT was found to be significant in the rice-wheat systems of the northwest IGP, where, after the initial spread, the area under ZT wheat stabilized between 20-25 percent of total area (Erenstein, 2009b). At present, many of the ZT wheat farmers come under the category of partial adopters (Erenstein *et al*, 2007; Farooq *et al*, 2007). Farm size (operational holding) and land ownership were found to have strong positive association with its adoption in this belt (Erenstein and Farooq, 2009). The major advantages of ZT wheat are found to be earlier planting, control of obnoxious weeds, cost reduction and water savings. The yield-enhancing and cost-saving effects of ZT wheat have contributed significantly towards the farm income in selected villages of India (Erenstein and Laxmi, 2008).

Direct seeded rice (DSR)

DSR is a water- and labor-saving technology that serves as an alternative to transplanting rice seedlings into puddled fields. This technology has been found to be suitable for different production systems of South Asia (Gopal et al., 2010). By removing the requirement of puddling and transplanting of rice seedlings, the technology provides an option to resolve labor scarcity—a constraint of increasing importance in cereal production systems in the IGP. There are several variations on directly seeded rice: broadcasting, manual line sowing, using drum seeders, and using seed drills. Since much of the labor requirements for rice cultivation are during the transplanting stage, labor time can be reduced by up to 75 percent.

Laser land leveling (LLL)

Precision land leveling through the use of LLL is another intervention which complements the adoption of other RCTs in the uneven soil surfaces of IGP under flood irrigation. This technology aims to conserve irrigation water, which is highly relevant in the rice-wheat systems of the IGP. Laser assisted precision land leveling could potentially save an average of 10-15 percent water demanded annually in these systems (Gupta and Sayre, 2007; Jat et al., 2006). In addition to its effect on improving crop yields, the application of LLL can also increase water productivity and fertilizer use efficiency. Furthermore, leveled fields can reduce labor requirements for irrigation and other activities in the subsequent years.

Familiarity with technologies

Technology adoption represents the culmination of a process whereby farmers choose to shift production practices based on technologies that maximize expected profits (or, assuming some level of risk aversion on behalf of small farmers, expected utility of farm income). These expected levels of profit or farm income are conditioned by experiences with different technologies. Clearly households cannot adopt a particular technology if they are unaware of it. It is therefore important to understand familiarity with different technologies and the penetration of technologies into the consciousness of farmers in a particular community. Table 4.1 summarizes household familiarity with these three key resource conserving technologies, hybrid maize, and hybrid rice across the different hub domains. ZT wheat is considered to be the most widely adopted technology under the "conservation agriculture" umbrella, though there remain significant knowledge gaps regarding this technology. ZT wheat is most widely adopted in the Haryana hub domain, where over 36 percent of households in the sample have at one point or another adopted ZT wheat, while an additional 57 percent have seen ZT wheat in practice. All told, nearly 96 percent of households in the Haryana hub domain are familiar with ZT wheat. In the Bihar and Gazipur hub domains, less than 10 percent of households are familiar with the technology, but this is not particularly surprising, since ZT wheat has not been promoted in these areas until lately.

Familiarity with DSR is also largely constrained in the eastern Uttar Pradesh and Bihar hub domains. Given the heavy dependence upon rice cultivation in these areas, these data suggest significant potential for increased emphasis in promoting DSR as a means of reducing labor and irrigation costs associated with puddling and transplanting. In addition, while there are significant shares of households in the other hub domains that are somewhat familiar with DSR, there are generally few households that have adopted the technology. In the Haryana hub domain, for example, while 75 percent of households are familiar with DSR, only about 1 percent of households have ever adopted it. Almost 44 percent of households in the Gazipur hub domain have adopted DSR, but there remain almost 55 percent of households that have seen or heard about the technology but who have not adopted it.

In Haryana, almost all households are familiar with LLL, though only about one in three households have ever adopted the technology. There are significant numbers of households who have seen land be leveled by laser-assisted levelers, and presumably have also observed the cost savings and increased water and fertilizer efficiency, but for some reason they have not yet made the decision to adopt the technology themselves. Relatively speaking, LLL adoption in these two domains is very significant, since most households in the other hub domains are clueless when it comes to LLL.

Table 4.1 Familiarity with key resource conserving technologies and hybrid varieties, by hub domain

		Bihar	Dinajpur	Eastern Uttar Pradesh	Gazipur	Haryana	Nepal	Tamil Nadu
Zero Tillage	**Unfamiliar**	92.5	57.9	64.2	100.0	4.3	35.9	100.0
	Heard About	0.3	11.5	7.1	0.0	2.5	20.1	0.0
	Seen	2.8	29.1	24.7	0.0	57.1	34.4	0.0
	Adopted	4.4	1.5	4.0	0.0	36.1	9.6	0.0
Direct Seeded Rice	**Unfamiliar**	98.1	76.0	92.6	1.6	24.7	34.4	46.6
	Heard About	0.3	1.5	2.5	15.1	25.3	19.9	14.2
	Seen	0.6	21.0	4.3	39.5	48.8	25.2	9.0
	Adopted	1.1	1.5	0.6	43.8	1.2	20.5	30.2
Laser Land Leveling	**Unfamiliar**	98.1	97.6	83.7	100.0	0.6	99.4	93.2
	Heard About	0.8	0.9	1.5	0.0	2.8	0.3	6.8
	Seen	0.6	1.5	12.0	0.0	62.0	0.0	0.0
	Adopted	0.6	0.0	2.8	0.0	34.6	0.3	0.0
Hybrid Maize	**Unfamiliar**	46.4	0.3	50.4	80.8	49.6	23.3	70.7
	Heard About	0.0	19.4	4.9	3.4	16.4	23.6	19.1
	Seen	0.0	52.5	25.6	13.0	27.8	34.2	6.8
	Adopted	53.6	27.8	19.1	2.8	6.2	18.9	3.4
Hybrid Rice	**Unfamiliar**	46.4	0.3	46.3	1.6	3.6	16.7	74.1
	Heard About	0.0	19.4	7.7	15.4	1.9	26.3	24.4
	Seen	0.0	52.5	27.5	64.8	42.0	24.5	1.2
	Adopted	53.6	27.8	18.5	18.2	52.5	32.5	0.3

Note: Reported figures represent the percentage of the sample population reporting various levels of familiarity with the different technologies. The categories of familiarity represent mutually exclusive categories.

All in all, households in Bihar appear to be quite uninformed when it comes to these key resource conserving technologies. Only about 2 percent of households are familiar with DSR and LLL, and less than 8 percent are familiar with ZT wheat. This suggests that increased or more focused efforts to promote these valuable technologies could be undertaken in Bihar, an area which is widely considered to be among the poorest and most backward states in India.

While RCTs are not widely known in Bihar, farmers there do have a great deal of experience with hybrid crops, specifically hybrid rice and maize. More than half of the households in the sample have adopted each of these hybrids. Hybrid adoption is lower in the other hub domains, though a significant portion of farmers in some of the other hub domains have adopted hybrid varieties. More than half of the farmers surveyed in the Haryana hub domain have adopted hybrid rice, though only 6 percent of farmers have adopted hybrid maize.

Sources of information about new agricultural technologies

Farmers get information about technologies from various sources, including government extension agencies, private dealers, and social networks. Data from the CSISA baseline survey classifies the primary sources of information as CSISA staff; cooperative societies or farmers' associations; private dealers; exhibitions or melas; friends, neighbors or other farmers; government extension officers; mass media (including radio and print media); non-governmental organizations (NGOs); relatives or family members; or other sources. Table 4.2 summarizes farmers' primary sources of information about the key resource conserving technologies and hybrid varieties included in the CSISA portfolio.[17] Clearly, social networks are a powerful force in the transmission of information regarding different technologies. The most commonly cited sources of information about each of these technologies are friends, neighbors and other farmers, with well over 50 percent of respondents citing these sources as their primary source for each of the different technologies.

For ZT and DSR, CSISA extension efforts have been modestly successful in promoting the technologies, with the percentage of respondents citing CSISA as the primary information source in double digits for these two technologies. For DSR, the second most widely cited source of information (after friends, neighbors and other farmers) is relatives or family members. Combining these two groups into an aggregated grouping loosely labeled "social networks" would suggest that approximately 80 percent of farmers rely on social networks of some fashion to receive information about DSR. For the two hybrid varieties, private dealers represent an important source of information. Nearly 30 percent of qualifying farmers cited private dealers as their primary source of information about hybrid maize, while just over 25 percent of qualifying farmers cited private dealers as their primary source of information about hybrid rice. Since these dealers represent an important source of information about these improved varieties, strengthening the presence of private dealers' positioning could increase overall adoption of these varieties across the CSISA hub domains.

[17] The figures in this table draw upon responses for those households that claimed some level of familiarity with the different technologies.

The importance of each of these information sources will, of course, vary by CSISA hub domain. For example, CSISA extension efforts are more widely cited as the primary source of information for the three key resource conserving technologies in the Bihar, Dinajpur, and Eastern Uttar Pradesh hub domains than they are in the other hub domains. Similarly, while friends, neighbors and other farmers are the most frequently cited source of information on hybrid varieties in the pooled samples, they are far less frequently cited as the primary source of information in Bihar (only 12 percent and 8 percent of farmers cited these networks as the primary source of information for hybrid maize and hybrid rice, respectively), while private dealers are much more widely cited as the primary information source. In the Gazipur hub domain, relatives and family members represent a major source of information about DSR and hybrid varieties, being the most widely cited primary source of information for DSR and hybrid maize and the second most widely cited primary source of information for hybrid rice.

Table 4.2 Sources of information about key resource conserving technologies and hybrid varieties (percent)

	Zero tillage (%)	Direct seeded rice (%)	Laser land leveling (%)	Hybrid maize (%)	Hybrid rice (%)
CSISA	19.12	10.31	5.83	1.10	0.40
Cooperatives	4.95	0.00	6.10	1.65	2.72
Dealers	1.65	0.73	1.25	29.24	25.30
Exhibitions	2.09	0.18	6.66	0.08	0.12
Friends, neighbors or other farmers	55.05	57.21	68.38	54.22	58.17
Government extension	7.36	1.92	8.88	3.15	5.49
Media	5.71	1.64	0.83	1.42	0.87
NGOs	0.55	0.00	0.00	0.39	0.40
Others	0.11	5.47	0.42	0.24	0.06
Relatives or family members	3.41	22.54	1.66	8.51	6.47
N	910	1,096	721	1,269	1,731

Note: Figures represent the percentage of households who classify the various information sources as their primary source of information about a particular technology.

Reasons for not adopting technologies

For the households that have not adopted these technologies, even though they have heard about or seen these technologies in practice, it is helpful to understand the factors that have constrained or acted as a barrier to adoption. The survey questionnaire asks respondents for open-ended reasons why a technology is not currently being used. To analyze these open-ended responses, we have aggregated the responses into a series of 15 categories: capital constraints, damage by animals (e.g., nilgai or nil cows), dissatisfaction with the technology, information constraints, labor constraints, land constraints, low yield, more costly/less profitable, not popular (which is, itself perhaps a form of information constraint), increased pests/diseases/weeds, poor grain quality, poor (or questionable) seed quality, risk aversion, unsuitable technology for a particular ecology or cropping system, and other reasons. Table 4.3 summarizes the primary reasons given by households as to why a particular technology has not yet been adopted, though they have at least heard about the technology.[18]

Table 4.3 Reasons for non-adoption of key resource conserving technologies and hybrid varieties

Reason	Zero tillage (%)	Direct seeded rice (%)	Laser land leveling (%)	Hybrid maize (%)	Hybrid rice (%)
Capital constraints	11.69	5.6	48.7	5.6	7.3
Damage by bulls				16.2	
Dissatisfaction	5.19	0.2		0.2	
Information constraints	32.84	31.9	14.1	23.5	25.8
Labor constraints		0.2	1.9	1.0	0.8
Land constraints	5.19	2.8	7.7	14.9	10.7
Low yield	24.30	12.1	1.9	11.2	5.8
More costly/Less prof	1.30	0.3	10.9	6.2	15.7
Not popular	4.82	22.5	7.7	5.6	8.7
Others	7.61	6.8	2.6	3.8	2.5
Pests/Diseases/Weeds	2.04	6.5	0.6	1.5	5.6
Poor grain quality	0.74	0.3	1.9	1.6	8.1
Poor seed quality	0.37			0.6	5.4
Risk aversion	2.78	8.8		0.6	2.0
Unsuitable	1.11	2.2	1.9	7.5	1.7
N	539	605	156	678	892

Note: Reported figures represent the percentage of households that have either seen or heard of a technology but have not adopted a particular technology primarily for the reason listed.

Clearly information constraints remain a significant barrier to adoption, even though households may be familiar with a particular technology. Nearly one in three households that have heard about or seen ZT or DSR in practice have not adopted the ZT because of information constraints. Similarly, about one in four households that are familiar with hybrid varieties have chosen not to adopt. These information constraints involve a general lack of sufficient knowledge about the potential benefits or costs of a given technology, and this insufficient information makes it difficult for farmers to estimate expected profits, a task that is complicated even more if households demonstrate

[18] While there are almost certainly secondary and perhaps even tertiary reasons why farmers have not adopted a technology, we focus on the primary reason since it provides the most information about the most significant constraints.

ambiguity aversion, a general distaste of incomplete information about the distribution of the potential benefits of a technology useful for conditioning production decisions. For LLL, the primary constraint has do to with insufficient access to capital, namely unavailable machinery (or at least machinery not available not in a timely fashion). Farmers are also concerned about the additional cost of leveling land using laser-guided technology compared with traditional leveling practices or cultivating on unleveled land.

While information constraints hinder the adoption of hybrid varieties, there are other factors that also act as barriers. Land constraints are the primary barrier to adoption of hybrid maize and rice, reported by nearly 15 percent and 11 percent of respondents, respectively. For many of these farmers, their total land holdings are so small that they feel the additional productivity wrought by hybrids will not be enough to compensate for the more expensive seeds. Nearly 16 percent of households responded that they did not grow hybrid rice because hybrid rice was simply not profitable for them. About 80 percent of these found hybrid rice not to be profitable due to the higher seed costs and the higher expenditures on complementary inputs such as irrigation and fertilizer. The remaining 20 percent cited low output prices as limiting profitability. Current generations of hybrid rice have often been characterized as having poor cooking qualities, resulting in either sticky rice or rice that does not keep for an extended period of time after cooking. Several farmers implicitly highlighted this issue by cited poor grain quality as their primary reason for not adopting hybrid rice.

For households that have not adopted hybrid maize, over 16 percent cite damage by nilgai (blue cows, also known as nil cows). These wild creatures, which are ironically named since they are related more to antelope than to bovine, have a history of trampling crops, especially maize crops. While only respondents from Haryana claimed this as the primary constraint to adoption, these creatures exist throughout much of India and may thus be a constraint in other hub domains.[19]

[19] There have traditionally been protections to prevent the killing of wild animals, but there have recently been changes to legislation in Uttar Pradesh and Bihar which allow for the killing of nilgai, especially if they have been observed grazing or trampling one's crops. Whether this will circumvent this constraint to hybrid maize adoption remains to be seen. Because these antelope have been traditionally labeled a cow, and due to the reverence with which Hindu devotees feel toward cows, it is possible that they may be hesitant to kill nilgai. This legislation (and others like it) may be viewed as a negative externality arising from the increased adoption hybrid maize. Such losses in biological diversity may be assigned a value in future cost/benefit analyses for the promotion of hybrid maize.

Reasons for disadopting technologies

In addition to those households that are familiar with a technology but have not adopted it, there are also some households who have adopted and later abandoned or disadopted. As with non-adoption, there are reasons for disadoption, and understanding these reasons can be important for customizing CSISA's efforts in promoting these resource conserving technologies. The primary reasons for disadopting the key RCTs and hybrid maize and rice varieties are reported in Table 4.4. Care must be taken when analyzing these data, since there are generally small subsamples of farmers for which these responses are relevant. For example, there is only one farmer in the sample that had previously adopted LLL but has disadopted its use, suggesting that generalizations about his reasons for disadoption--the additional cost of using LLL as compared with conventional leveling—should not be made.

Table 4.4 Primary reasons for disadoption of RCTs and hybrid varieties (percent)

Reason	Zero tillage (no till) (%)	Direct seeded rice (%)	Laser land leveling (%)	Hybrid maize (%)	Hybrid rice (%)
Capital constraints				2.4	
Damage by bulls				22.0	
Information constraints	1.7	0.7		12.2	2.3
Labor constraints				2.4	1.2
Land constraints		0.7		14.6	5.8
Low yield	86.7	44.7		9.8	30.2
More costly/Less profitable			100.0	7.3	5.8
Not popular	3.3	48.9		7.3	4.7
Others	3.3	2.8		7.3	3.5
Pests/Diseases/Weeds	1.7				18.6
Poor grain quality		0.7		7.3	4.7
Poor seed quality				4.9	20.9
Risk aversion					2.3
Unsuitable	3.3	1.4		2.4	
N	60	141	1	41	86

Note: Reported figures represent the percentage of households that have ceased using a particular technology primarily for the reason listed.

For the other technologies, there are larger pools of farmers from which to glean information about causes and patterns of disadoption. For example, among the 60 farmers who have ceased using ZT technology, the vast majority (nearly 87 percent) have done so because of low yields (i.e., presumably lower than their experiences with conventional tillage). Among the 141 farmers who have disadopted DSR technology, roughly half claimed to have done so because DSR was simply not a popular practice in their area. All of these farmers were from the Gazipur hub domain, an area in which there is generally a high degree of familiarity of DSR. While there is wide familiarity with DSR, and significant degrees of adoption (nearly 44 percent of households have adopted it at one point or another), the practice is still not a popular practice, and this lack of popularity has compelled practicing farmers to change their practices. This suggests an important role for social networks and social norms in the technology adoption process. Low yields were also highlighted as an important cause for disadopting DSR, with nearly 45 percent of qualified respondents citing low yields as the primary reason for their disadoption.

As far as hybrid varieties are concerned, there are a great many reasons that farmers have cited as leading to their decision to cease using hybrids. For hybrid maize, 22 percent of the 41 farmers who have disadopted hybrid maize have done so because of the damage caused by nilgai. Given the higher cost of hybrid seed and complementary inputs, it is perhaps not surprising that farmers would choose to cultivate cheaper traditional varieties if there was a significant threat that there crop would be eaten or trampled by nilgai. For hybrid rice, roughly 30 percent of disadoption was due to low yield, though there were significant numbers of farmers who also cited poor seed quality and increased susceptibility to pests, diseases, and weeds as primary reasons for disadoption. Of those citing poor seed quality, nearly 95 percent where in the Haryana hub domain, while the remaining 5 percent were from the Gazipur hub domain. In both cases, poor seed quality can be attributed to (or at least attributed to the perception of) seed mixing, in which seed dealers mix new high quality hybrid seed with old or low quality seed. The result is a diluted supply of seed that does not produce the expected yield. Susceptibility to pests, diseases, and weeds is also a fault widely attributed to hybrid rice, and given limited supplies or knowledge about pesticides, this would generally be viewed as detrimental to yields. So while farmers might attribute their disadoption to hybrid rice's increased susceptibility to pests, diseases, and weeds or to poor seed quality, the fact that these primary concerns ultimately lead to lower yields suggests that efforts that raise hybrid rice productivity may eliminate some of the important barriers to hybrid rice adoption in South Asia.

5 Summary of main findings

The CSISA baseline survey provides an overview of the agro-ecological and socioeconomic diversity of the initiative's coverage area. Several salient findings from this exercise are as follows.

1 The CSISA coverage area is highly diverse in terms of climatological and agro-ecological conditions, cropping patterns, livestock management, land holdings, production practices, yields, and other variables. This reinforces the initiative's site-

and context-specific approach to effecting change, but complicates the evaluation of impact across the entire coverage area.

2 CSISA targeting is generally reflective of the surrounding population in the hub domain. However, evidence of more explicit targeting (e.g., of women-headed households or other vulnerable groups) was found only in the Gazipur hub.
3 Whereas findings suggest that labor-saving technological change may be a priority in the northwestern hubs (Punjab, Haryana), productivity-enhancing technological change that intensifies production on small landholdings may be a priority for most other hubs.
4 Poverty and inequality measures indicate significant levels of vulnerability in the Nepal Terai, Bangladesh, eastern Uttar Pradesh, and Bihar. This may indicate a need for some re-prioritization of CSISA work in favor of Nepal, provided that CSISA's technologies and approaches are appropriate to its needs.
5 The role of women in agriculture varies widely across the CSISA hub domains, and is determined largely by social status and social constructs. In general, women provide vital inputs into agricultural production, both in terms of labor as well as decision-making. The complexities of these issues suggest the need for more rigorous analysis regarding gender gaps in access to technical knowledge and information, inequalities in participation in key decision-making processes, as well as the impacts of the RCTs that are being promoted under CSISA. This may necessitate the collection of gender-disaggregated data for constraints analysis, technology prioritization among different household types, and careful consideration in the design, implementation and evaluation of impact assessments.
6 Familiarity with RCTs is most limited in Bihar and other eastern hub domains, suggesting the obvious potential for expanding CSISA activities in these areas. That said, sources of information on RCTs are quite domain-specific and vary significantly between CSISA, input retailers, and friends/neighbors.
7 There is evidence from the baseline survey to suggest that while non-adoption is largely driven by insufficient information about several RCTs, disadoption driven by poor yield performance and other factors is a non-trivial phenomenon in the CSISA domains.

Finally, attention should be given to the current and future use of the CSISA baseline survey data. The baseline survey was designed primarily with CSISA management in mind, motivated by the need to provide an accurate characterization of diversity in production systems (i.e., cropping systems, input use, livestock management, and residue management) across the initiative's coverage area. Although efforts were made to structure the survey with a longer-term impact assessment in mind, the conditions under which the survey was designed make this difficult to achieve. Going forward, data and analysis from this baseline survey are meant to provide CSISA's management and its stakeholders with a detailed picture of the vast diversity found across the initiative's coverage area in terms of agro-ecological conditions, production systems, and socioeconomic conditions. It is likely that researchers looking to gauge the social and economic impact of CSISA with any amount of rigor will have to rely upon additional surveys and other sources of primary data that are more specifically targeted at a particular geographic domain and with a particular empirical emphasis. While these approaches may not provide an overall picture of CSISA's impact over the long run, they can be used by management, partners, stakeholders and donors to assess the value of individual CSISA components—technologies, modalities—within specific geographies covered by the initiative.

References

CSISA (Cereal Systems Initiative for South Asia). 2012. Resource Constraints and Conservation Technologies in the Cereal Production Systems of South Asia. Cereal Systems Initiative for South Asia: Phase I Baseline Village Survey Report. Los Banos, Philippines: IRRI.

Erenstein, O. 2009a. Leaving the plow behind: Zero-tillage rice-wheat cultivation in the Indo-Gangetic Plains. In Spielman, D. and R. Pandya-Lorch (eds): Millions fed: Proven successes in agricultural development (Washington, D.C.: IFPRI).

Erenstein O. 2009b. Zero tillage in the rice-wheat systems of the Indo-Gangetic Plains: a review of impacts and sustainability implications. IFPRI Discussion Paper. Washington, D.C.: International Food Policy Research Institute. Available online at www.ifpri.org/sites/default/files/publications/ifpridp00916.pdf .

Erenstein, O. and U. Farooq. 2009. A Survey of Factors Associated with the Adoption of Zero Tillage Wheat in the Irrigated Plains of South Asia. *Experimental Agriculture* 45, 133-147.

Erenstein, O. and V. Laxmi. 2008. Zero Tillage Impacts in India's Rice-Wheat Systems: A review. *Soil & Tillage Research* 100, 1-14.

Erenstein, O., W. Thorpe, J. Singh, and A. Varma. 2007. Crop-livestock interaction and livelihoods in the Indo-Gangetic Plains, India: A regional synthesis. Crop-livestock Interactions Scoping Study - Synthesis. CIMMYT-ILRI-RWC, New Delhi, India.

FAO/IIASA. 2000. Global Agroecological Zoning. FAO Land and Water Digital Media Series #11.

Farooq, U., M. Sharif, and O. Erenstein. 2007. *Adoption and Impacts of Zero Tillage in the Rice-Wheat Zone of Irrigated Punjab, Pakistan*. Research Report. CIMMYT & RWC, New Delhi, India.

Foster, J., J. Greer and E. Thorbecke. 1984. A class of decomposable poverty measures. *Econometrica* 52(3), 761-766.

Gopal, R., R.K. Jat, R.K. Malik, V. Kumar, M.M. Alam, M.L. Jat, M.A. Mazid, Y.S. Saharawat, A. McDonald, and R. Gupta. 2010. Direct dry seeded rice production technology and weed management in rice based systems. Technical Bulleting. International Maize and Wheat Improvement Center, New Delhi, India.

Gupta, R. and K. Sayre. 2007. Conservation Agriculture in South Asia. *Journal of Agricultural Sciences* 145, 207-214.

Jat, M.L., P. Chandna, R.K. Gupta, S.K. Sharma, and M.A. Gill. 2006. *Laser Land Levelling: A Precursor Technology for Resource Conservation*. Rice-Wheat Consortium Technical Bulletin Series 7. New Delhi, India.

Ladha, J.K., K.S. Fischer, M. Hossain, P.R. Hobbs, and B. Hardy. 2000. Improving the productivity and sustainability of rice-wheat systems of the Indo-Gangetic Plains: A synthesis of NARS-IRRI partnership research. Discussion Paper No. 40, International Rice Research Institute.

Laxmi, V., O. Erenstein, and R.K. Gupta, R.K. 2007. Impact of Zero Tillage in India's Rice-Wheat Systems. Research Report. CIMMYT & RWC, New Delhi, India.

Lobell, D. 2007. Changes in diurnal temperature range and national cereal yields. *Agriculture and Forest Meteorology* 145(3-4), 229-238.

New, M.D., D. Lister, M. Hulme, and I. Makin. 2002. A high resolution data set of surface climate over global land areas. *Climate Research* 21.

Wood, S., K. Sebastian, and S. Scherr. 2000. *Pilot Analysis of Global Ecosystems: Agroecosystems*. International Food Policy Research Institute and World Resources Institute: Washington D.C.