CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA IN BANGLADESH

END OF PROJECT REPORT

NOVEMBER 2015

CIMMYT

IRRI

WorldFish

CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA IN BANGLADESH

END OF PROJECT REPORT

OCTOBER 2010 – SEPTEMBER 2015

Submitted to
United States Agency for International Development (USAID)
Dhaka, Bangladesh

Submitted by
International Rice Research Institute (IRRI), International Maize and Wheat Improvement Center (CIMMYT), and WorldFish

NOVEMBER 2015

CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA IN BANGLADESH

END OF PROJECT REPORT 2015

Acknowledgments

This report is based on contributions from a large number of CSISA-BD staff. The chief of party would like to acknowledge the work done by CSISA-BD staff and the excellent contributions they have made to the preparation of this report.

Timothy Russell

Chief of Party, CSISA-BD

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ADO	agriculture/aquaculture development officer
AFP	axial flow pumps
AIN	agricultural input and nutrition
ART	adaptive research trials
AWD	alternate wetting and drying
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BDS	Bangladesh Development Society
BDT	Bangladeshi taka
BINA	Bangladesh Institute of Nuclear Agriculture
BMS	Bihango Mohila Sangstha
BMT	Bangladesh management team
BRRI	Bangladesh Rice Research Institute
BRAC	Bangladesh Rural Advancement Committee
CA	conservation agriculture
CAF	commercial aquaculture farming
CBO	community-based organization
CDC	collapsible dryer case
CIMMYT	International Maize and Wheat Improvement Center
CoP	chief of party
CSISA-BD	Cereal Systems Initiative for South Asia in Bangladesh
CSISA-MI	Cereal Systems Initiative for South Asia Mechanization and Irrigation
DAE	Department of Agricultural Extension
DoF	Department of Fisheries
DQA	data quality assessment
DSR	direct-seeded rice
EU	European Union
EV	exchange visit
FFD	farmers' field day
FOG	Financial Operations Guideline
FtF	Feed the Future
FY	financial year
GIS	geographic information system
GJUS	Grameen Jano Unnayan Sangstha
HAC	hub administrative coordinator
HDO	horticulture development officer
HH	household
HYV	high-yielding varieties
ICT	information communication technology
iDE	International Development Enterprises
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute

ILRI	International Livestock Research Institute
IR	intermediate results
IRRI	International Rice Research Institute
ISWA	Integrated Social Welfare Association
IWD	International Women's Day
JCF	Jagoroni Chakra Foundation
LE	linkage event
LoA	letters of agreement
LSP	local service provider
MAS	Mechanization of Agriculture System
M&E	monitoring and evaluation
MYAP	Multiyear Action Plan
NDVI	normalized difference vegetation index
NGO	nongovernment organization
OSP	orange sweet potato
PFT	participatory farmer trials
PMEP	Project Monitoring and Evaluation Plan
PNGO	partner nongovernment organization
PVC	polyvinyl chloride
PVS	participatory varietal selection
QPM	quality protein maize
RFLDC	Regional Fisheries and Livestock Development Component
SACO	Social Advancement Community Organization
SDC	Society Development Committee
SMSPA	Small and Marginal Seed Producers Associations
SOP	standard operating procedures
SRSPDS	Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh
ST	strip tillage
STRV	stress-tolerant rice variety
SWSPAB	Southwest Seed Producers Association of Bangladesh
T. aman	transplanted aman rice
TMSS	Thengamara Mohila Sabuj Sangha
ToT	training of trainers
UDP	urea deep placement
USAID	United States Agency for International Development
USG	United States government
WF	WorldFish

Agri-businesses experiencing increased engagement of women

EXECUTIVE SUMMARY

The Cereal Systems Initiative for South Asia in Bangladesh (CSISA-BD) project was a five-year USAID-funded project starting in October 2010 and ending in September 2015. The project had a core budget of US$24,398.375, to which was added $5,000,000 to finance the 18-month Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh (SRSPDS) and $12,926,998 to finance the five-year CIMMYT-managed CSISA Mechanization and Irrigation project (CSISA-MI).

The project worked out of six focal areas (hubs), four of which were located in the Feed the Future zone of influence in southwest Bangladesh and two in northern Bangladesh. It aimed to test and disseminate new cereal system-based technologies anticipated to raise family income by at least US$350. It was expected that 60,000 farming families would adopt this technology directly through training and demonstrations and that a further 300,000 farmers would adopt it indirectly through participation in field days and through farmer-to-farmer knowledge exchange.

Survey data collected from both CSISA farmers (in 2015) and Baseline farmers (in 2012) were utilized to evaluate the impact of the project. The key attributable indicator is the difference (CSISA − Baseline) in mean income per household, for all income derived from crops (rice, maize, wheat, mustard, sunflower, fish, prawns, and shrimp) promoted by CSISA-BD. On average, the project increased household income by **US$ 464.** Similarly, but somewhat less, a separate income differential was estimated to be **$320** for a subset of the baseline farmers who were resampled concurrently with the CSISA farmers in 2015. This "Endline" income difference is smaller due to the fact that many Baseline farmers have also adopted technologies during the project period, which means there has been some positive indirect impact on income, as well.

Positive CSISA-Baseline income differentials were also observed for each of 4 farm size categories: *Marginal and Landless* (< 0.21 ha; **$278**), *Small* (0.21-1.0 ha; **$245**), *Medium* (1.01-3.0 ha; **$854**), and *Large* (> 3.0 ha; **$4,246**). These differences represent another indication of CSISA-BD's success in terms of delivering higher incomes for farmers adopting project-promoted crops, varieties, other technologies, and/or best management practices. The much greater size of the differential observed for *Large* farms, as compared to the other categories, likely results from the ability of larger-scale farmers to better leverage the technology and information to which they were introduced by CSISA. Income differentials between CSISA farmers and selected indirect farmers (chosen to represent a tighter attribution to the project) are statistically insignificant for all but the *Small* farm category, in which the differential is 11% higher for CSISA farmers. Thus, other farmers beyond just the direct project beneficiaries were increasing their household incomes as a result of CSISA-BD and, in effect, at the same levels on average.

Project-derived improvements in crop gross margin values underpin the observed increases in income. CSISA-Baseline gross margin differentials for the key cereal crops are $54 ha^{-1} for Aman rice, $72 ha^{-1} for Boro rice, $37 ha^{-1} for wheat, and $107 ha^{-1} for maize; for aquaculture crops the differential are $1,287 ha^{-1} for fish, $1,267 ha^{-1} for prawns, and -$322 ha^{-1} for shrimp. Clearly aquaculture is extremely important to increasing farm incomes for those households that own or lease a pond. Note that all of these values are based on production in Year 5 (FY 2014-15), with the exception of some aquaculture crops which were yet to be harvested. Moreover, most of the CSISA-Baseline gross margin differentials for Year 4 are worse than the Year 5 values, although most of the Year 3 differentials are much better. This highlights the year-to year vicissitudes of agricultural and aquaculture production, which is affected by a combination of weather, prices, political unrest, government policies (e.g. subsidies), international economic price trends, etc.

The observed gains in gross margins and incomes were achieved by farmers via a combination of cost savings, productivity increases, and better prices received (partly due to improved marketing) as a result of applying things they learned from engaging with CSISA-BD. Project activities included a program of demonstrations, trials, and training for more than 106,000 farmers, as well as the implementation of farmer field days in which approximately 130,700 farmers participated. In addition, 999,517 farmers received seed through the SRSPDS project (spun off from CSISA-BD) that included new varieties of rice tolerant to soil salinity, flood submergence and drought, and the latest high-yielding varieties. The CSISA-MI project (another spin-off) facilitated investment by the private sector of approximately $1,041,000 in the import and sale of new planting, harvesting and irrigation equipment. In support of the private sector, CSISA-MI also provided training and links to these machinery suppliers for 511 small-scale businesses (Local Service Providers) who bought the machines and earned income from providing planting, harvesting and irrigation services to 22,012 farmers.

The project conducted 2,456 trials and 37,773 demonstrations. Data from these trials and demonstrations showed the following.

Rice production

The mean grain yield from trials and demonstrations shows that farmers applying recommended practices obtained a yield that was 88% higher than the national average yield for aman rice and 37% higher than the national average yield for boro rice

The biggest yield increases are achieved when farmers with low grain yield adopt recommended practices, indicating that targeting farmers with low resources and low crop yield would have the most impact.

Just changing to a new variety can increase grain yield by 8.3% for aman rice.

For every day the age of boro rice seedlings increases from 15 to 25 days, farmers lose 200 kg/ha in grain yield and, for every day farmers delay transplanting boro rice from 1 January, they lose 39 kg/day. As a result, a farmer transplanting on 31 January instead of 1 January would have a crop with a grain yield potential that is 17% less than a crop planted on 1 January.

On moderately saline soils, changing variety from the salinity-sensitive variety BRRI dhan28 to a saline-tolerant variety such as Bina Dhan10 or BRRI Hybrid3 and sowing seed on 25 November rather than on 5 December results in a 40% grain yield increase.

Micro-dosing tall local high-value rice varieties in a tidal flood environment with 20 kg N/ha using urea super granules (USG) increased grain yield by 0.5 t/ha and gave a cost-benefit ratio of 1:2 to 1:5.

Drilling prilled urea into rice gave a similar grain yield as USG. As prilled urea is more readily available than USG, using a manually operated fertilizer drill for deep-placing urea would appear to be a more practical way of applying urea than USG.

The alternate wetting and drying (AWD) irrigation system improves grain yield by 7.5% and reduces the number of irrigations required by 20% but can be applied only if farmers and pump owners can agree on new ways of paying for water.

The grain yield of rice planted on land not puddled is less than in puddled plots, but using only one power tiller pass and planting with a rice transplanter produced higher grain yield for less cost than puddled rice. The grain yield of wheat following rice grown without puddling is 10% higher than in wheat following puddled rice.

Rice transplanters can plant 1 hectare in 10 person-hours whereas it takes 137 person-hours to plant a hectare by hand. However, the labor required for raising seedlings for rice transplanters is double that of seedlings raised for manual rice transplanting. Considering the cost of hiring a transplanter in addition to the higher seedling-raising costs, the cost of transplanting with a machine is similar to that of transplanting by hand. For the farmer, though, the advantages of using a rice transplanter are that the time taken to transplant is much less, convenience exists with the hiring of a machine rather than using labor, and a 9% to 10% yield increase is seen in all trials in which transplanters have been compared with manual transplanting.

In the aman season of 2015, 221 farmers used rice transplanters they hired with support from CSISA-BD to plant 35 ha of rice.

On land not flooded in the aman season, little difference in yield between new varieties such as the submergence-tolerant BRRI dhan52 and the medium-duration BRRI dhan49 and old varieties such as BR11 and Gutiswarma could be observed. However, on land subject to temporary flooding, BRRI dhan52 on average gave a 20% higher yield than BR11. BRRI dhan52 cultivation is highly recommended for lower-lying land subject to monsoon-season flooding.

The yield of short-duration varieties (less than 110 days from sowing) is 10% less than that of long-duration (145 days from sowing) BRRI dhan52. As they are harvested some 30 days earlier than long-duration varieties, rabi-season crops can be planted earlier, thus improving rabi-season crop yield and in many cases allowing the cultivation of a third crop.

Aromatic BRRI dhan34 (Chinigura) has a yield that is 55% less than that of BRRI dhan52, but, because of the higher value of BRRI dhan34, the profit from growing BRRI dhan34 was double that of BRRI dhan52. Similarly, in the boro season, although the basmati-type BRRI dhan50 has a yield that is 10% lower than that of the best standard boro varieties, its higher market price gives a profit that is 28% higher than that of standard boro varieties.

The best boro self-pollinated variety (BRRI dhan29) will yield as well as the best hybrid (Hira2) but newly released varieties such as BRRI dhan58 and -60 failed to yield more than BRRI dhan29 released more than 20 years ago.

On the very fertile fish ghers in Khulna, the best self-pollinated varieties (Bina Dhan10) will yield as well as the best hybrids (BRRI Hybrid3) and, as they have good grain quality, they give a higher profit. On nonsaline ghers, BRRI dhan58 was the highest yielding variety while on saline ghers Bina Dhan10 was the highest yielding variety. Bina Dhan10 will produce a 4 t/ha crop on soil as saline as 10 dS/m, is popular with farmers, and is therefore highly recommended for cultivation on saline soils.

From 9,149 demonstrations conducted to show farmers that by planting short-duration aman rice varieties they could plant a mustard crop between an aman and boro rice crop, it was shown that farmers could gain an extra $441 to $589/ha. Replacing boro rice with lentil followed by mungbean would give farmers an extra $877/ha over growing the traditional aman rice followed by boro rice.

On the saline soils of coastal Kulna and Barisal, replacing locally grown long-duration aman rice varieties and a low-productivity dry-season “fallow” with a high-yielding, saline-tolerant, short-duration aman rice and sunflower in the dry season will increase farm income by 400%. Dibble-planting hybrid sunflower directly into rice stubble to enable November planting proved to be the most productive system. Switching to a sesame-based system increased income by 68%. Sunflower production was promoted through 2,112 demonstrations. The cost of the seed and difficulty producing high-quality oil remain the main constraints to expanding sunflower production.

Maize and wheat

Maize and wheat production on sandy soil chars has expanded rapidly in Mymensingh and Barisal with a maize grain yield of 8.1 t/ha and wheat yield of 3.7 t/ha. Survey data indicate that, following the project intervention, 4,200 farmers are growing maize or wheat on Mymensingh chars.

Intercropping maize with short-duration vegetables such as amaranthus and peas doubles maize gross margins.

Nitrogen fertilizer rates on wheat should be decreased to 67 kg/ha from 100 kg/ha when wheat is sown after 15 December. This will ensure that farmers make a profit from late-sown wheat.

All maize hybrids tested over three years and sites in both southern and northern Bangladesh responded similarly to different yield-determining environments, indicating that southern Bangladesh is just as suitable for maize production as northern Bangladesh.

New BARI wheat varieties BARI Gom28 and -29 yield more than older varieties in demonstrations and trials by 5%. Faridpur and Mymensingh appeared to be better wheat-producing areas than other hubs and strip till planting was preferred by farmers over bed planting and broadcast sowing.

Aquaculture

Some 27,495 farmers were trained in aquaculture production.

Ten simple aquaculture practices increase pond production by 236% and gross margin by 204%. The technology includes producing vegetables and orange-fleshed sweet potato on pond banks (dikes). Of the production from demonstration ponds, it was found from farmer-maintained record books that 21% of fish, 47% of high-nutrient-content indigenous mola fish, and 41% of vegetables produced are consumed at home.

Production in commercial ponds showed a 2- to 5-fold increase and reduced the time from stocking to harvest after the introduction of tilapia, Shingi, and Thai Pangas and the use of high feed rates.

Gher aquaculture systems were made two to five times more productive by introducing virus-free prawn and shrimp larvae, shrimp and prawn nursery establishment in a corner of the gher, two cycles a year of tilapia production instead of prawn in response to changing export market demand, double-cycle shrimp production, shrimp-fish mixed culture, efficient use of dikes with vegetables, and an adaptive production calendar.

Switching from rice–fish gher systems to tilapia-carp systems increased income by 131%.

The productivity of shady ponds managed by women can be increased by 454% by the introduction of good feeding practices and stocking with a mix of fast-growing tilapia and Koi fish, high-value Shingi, and carp for home consumption.

Twenty-seven hatchery owners were trained in improved fish breeding practices.

Sunflower cake can substitute for fish meal as a feed for prawns and tilapia without reducing productivity.

Removal of sludge from the bottom of ponds doubled the profit of fish production by reducing fish mortality.

Mechanization

By concentrating on power tiller-operated machinery, reapers, and axil flow pumps, CSISA-MI linked 511 trained local service providers with dealers from three major machinery import dealers. With the machines purchased, these LSPs provided 22,012 farmers with planting, harvesting, and irrigation services to grow 5,726 ha of crops.

Crucial to this program has been the 202 linkage events in which farmers, LSPs, microfinance institutions, and dealers meet to learn about the opportunities from buying services and purchasing equipment.

A voucher scheme offering a 75% discount for the first buyers of machines helped stimulate sales. Other ways of promoting the machines included the use of videos, games, quizzes, gifts, and referral coupons.

The private sector has been promoting its machines through billboards, video road shows, and cable TV advertisements.

Remote-sensing and GIS tools identify the area of land in Barisal Division that could be easily irrigated with surface water using low-lift axial flow pumps.

RFL started to manufacture axial flow pumps in Bangladesh.

CSISA-MI was able to help the Bangladesh Agricultural Development Corporation (BADC) rehabilitate 50 km of canals in Barisal Division by excavating the canals and building sluice gates by facilitating access to $1.5 million of funding from USAID. These renovated canals will bring access for thousands of farmers to supplies of surface water for dry-season crop irrigation.

Seeds

The project, through the Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh (SRSPDS) project, helped 999,517 farmers gain access through demonstrations and seed distribution programs to seeds of salinity, submergence, drought, and new high-yielding varieties.

Through support and training from this program, 333 small seed companies based in southwest Bangladesh were able to more than double their seed sales.

Through farmer training, 272 tons of quality wheat seed were produced by CSISA-BD farmers for use by themselves or for sale to other farmers. Much of this seed was of varieties only recently released by BARI and not yet readily available for purchase through normal retail outlets.

Women and agricultural development

Making use of pond banks (dikes) for the production of vegetables and orange-fleshed sweet potato provides an income of $34 from just a 10-$m^2$ plot in 3 months from sowing. A typical 1,000-m^2 pond would have 240 m^2 of banks on which vegetables could be grown, suggesting that farmers could generate vegetables worth $836 from a relatively small pond. As these ponds are largely managed by women, this is income and nutritious food that could be used by women. To encourage the use of these pond dikes for vegetable production, 4,904 women were given vegetable production and child nutrition training. Training material, including recommendations for vegetable production on dikes, was prepared. Mini-packs (5- to 10-g packs) of vegetable seeds marketed by the Lal Teer Seeds Company were sold to pond owners to facilitate the planting of vegetables on the small plots available on pond dikes. Research was done to determine the best combination of vegetables to be grown on the dikes.

Incorporating business and aquaculture technical training adds value to gender empowerment training and makes it easier to understand.

Training women in seed production and storage improves the viability and quality of rice and wheat seeds.

Business training and linkage events for women entrepreneurs help women expand existing businesses and embrace new business opportunities.

Four young women obtained loans after intensive training to buy laptops so that they could provide community members with Internet-based services such as agricultural advice.

As a result of project interventions there has been considerable adoption and marketing of high value “basmati” type rice varieties

1. INTRODUCTION

1.1 Background

The report will begin with a description of the project history, project objectives, activities planned to achieve these objectives, project achievements against FtF indicators, and project implementation strategy. This will be followed by a description of technology validated by the project that it considers to be ready for large-scale dissemination to farmers in Bangladesh, the scale of adoption of these new technologies, and the impact this has had on farmers' income.

Origins of the project

The **Cereal Systems Initiative for South Asia in Bangladesh** (CSISA-BD) project was developed out of the Cereal Systems Initiative for South Asia (CSISA), which itself had its origins in the IRRI/CIMMYT-implemented Rice/Wheat Project. CSISA, which is now coming to the end of a second phase and will soon enter a third phase, worked mainly in India and Nepal but also had a small program in Bangladesh and was funded by USAID-Washington and the Bill & Melinda Gates Foundation. Two projects were developed out of CSISA-BD: **Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh** (SRSPDS) and the **CSISA Mechanization and Irrigation** (CSISA-MI) project (Fig. 1).

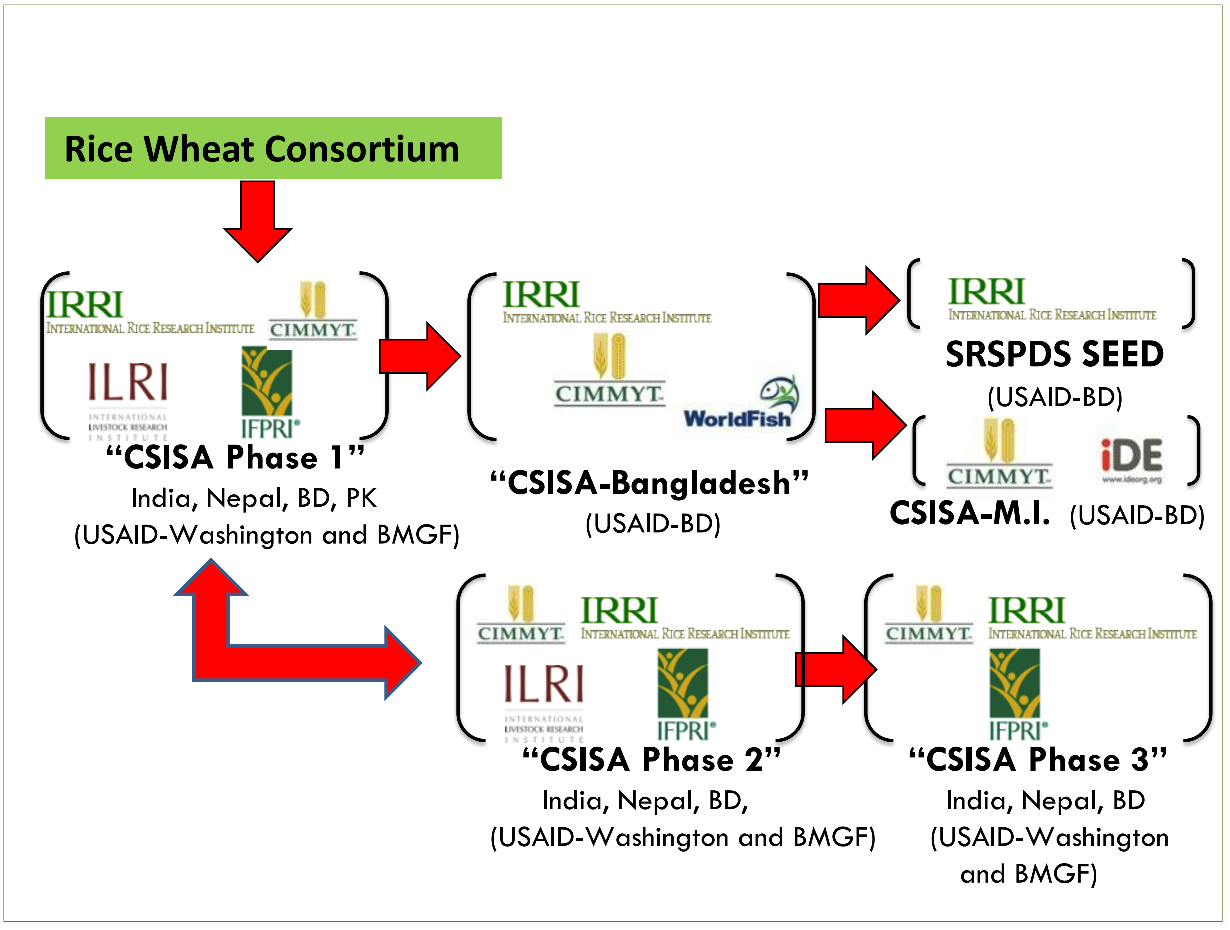

Fig. 1. The relationship between CSISA-BD and CSISA-Phase 2.

The CSISA-BD project was implemented as a partnership among three CGIAR centers: IRRI, CIMMYT, and WorldFish. It was funded by USAID's Feed the Future (FtF) initiative, with an initial grant of US$24,398,375 for a five-year project starting on 1 October 2010. An additional grant of $5,000,000 was provided to finance the 18-month IRRI-managed SRSPDS project, followed by $12,926,998 to finance the five-year CIMMYT-managed CSISA-MI project. The SRSPDS project facilitated the production and dissemination of rice varieties that are tolerant of soil salinity, submergence, or drought to almost a million farmers. This project ended in December 2013. CSISA-MI facilitates the dissemination of crop mechanization technology through partnerships with private-sector machinery suppliers. This project will end in 2018. The work of these two projects is described later in this report.

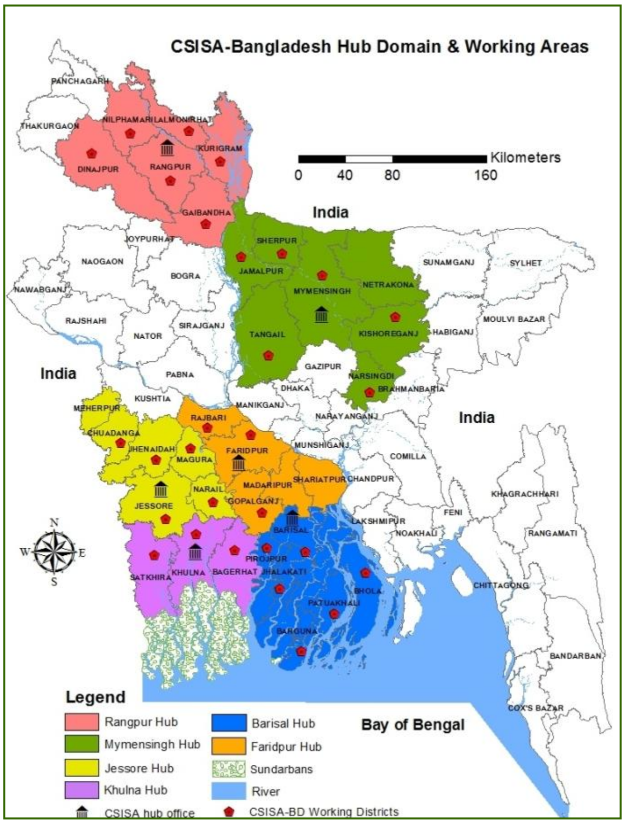

Fig. 2. Map showing location of project hubs and districts.

Project location

The project worked in 29 districts from six program activity centers or "hubs." Two of these hubs were located in northern Bangladesh, where the CSISA Phase 1 project had worked, and the remaining four were in the FiF zone of influence in southwest Bangladesh. See Figure 2 for the location of the hubs and Figure 3 for a description of the hub agricultural characteristics.

1.2 Project Objectives and Target

The project aimed to test and disseminate new cereal system-based technologies anticipated to raise family income by at least $350 if adopted. The target was that 60,000 farming families would adopt this technology directly through training and demonstrations and that another 300,000 farmers would adopt it indirectly through participation in field days and farmer-to-farmer knowledge sharing.

The specific objectives of CSISA-BD as stated in the project proposal follow:

1. *Widespread delivery, participatory fine-tuning, and adoption of improved varieties, production technologies, and natural resource management for cereal and fish systems in order to improve productivity, income, and resilience to risk;*
2. *Adaptive research trials to test, validate, and refine newly developed agronomic practices for cereals and aquaculture practices for fish;*
3. *Capacity building for researchers, extension workers, and service providers from public, private, and NGO sectors to enable the rapid dissemination and adoption of improved technologies and management approaches;*
4. *Socioeconomic and farming systems analysis for technology targeting, and the deployment and improvement of market linkages and livelihood systems for inclusive agricultural growth and sustainable poverty reduction; and*

5. *The development of innovative information delivery mechanisms, including robust decision support tools that integrate producer information, market prices, weather, and risk in formats that are simple to use and accessible by all agricultural stakeholders.*

Northwest: *six districts in greater Rangpur*

A major cereal-growing area with extensive use of high-yielding varieties (HYVs), fertilizer, and pesticide. Cropping intensity surpassing 200% and systems with two rice crops are common. The area is prone to breaks in the monsoon season, making drought a potential problem. The area is a major producer of winter-season (boro) irrigated rice and dry-season maize. Excessive use of groundwater for boro-season rice production has seriously depleted groundwater reserves. There are also extensive areas of riverine flood plain that are prone to flash flooding (short-duration flooding of 2 weeks and less).

North-Central*: six districts in greater Mymensingh*

In parts, this area has a high cereal production potential with extensive use of HYVs, fertilizer, and pesticide. Cropping intensity surpassing 200% and systems with two rice crops are the most common cropping systems used. This is a major fish pond culture area. There are also extensive areas of riverine flood plain that are prone to flash flooding (short-duration flooding of 2 weeks and less) with sandy soils. These riverine areas are not suitable for rice production but are quite suitable for wheat and maize production.

Central Southwest: *six districts in greater Jessore*

This is an area with high potential for cereals with extensive use of HYVs, fertilizer, pesticide, fish pond culture, and horticultural crops. Cropping intensity surpasses 200% and cropping systems can be very diverse though systems with two rice crops are the most common. The northern districts of Chuadanga and Jenaidah are major maize-growing areas.

Southwest coastal Bangladesh: *three districts in greater Khulna*

Of this area, 60% is prone to high dry-season soil and water salinity, low adoption of HYVs caused by monsoon-season flooding, low use of inputs such as fertilizer and pesticide, comparatively low cropping intensity (150% or less), and both brackish-water and freshwater aquaculture-based farming systems, which dominate approximately 60% of the land use. The area is susceptible to cyclone damage.

South-Central Coastal Bangladesh: *six districts in greater Barisal*

The southern part is prone to dry-season soil and water salinity, and the northern and eastern parts are subject to monsoon flooding and tidal inundation. Both result in low adoption of HYVs, low use of inputs such as fertilizer and pesticide, and comparatively low cropping intensity (less than 150%). The area of southwestern Bangladesh is most pro ne to cyclone damage.

Central: *three districts in greater Faridpur*

This area has high potential for cereals with extensive use of HYVs, fertilizer, pesticide, and fish pond culture. Large areas of Gopagunj District are subject to seasonal flooding, making the land best suited for monsoon-season fish culture followed by dry-season boro rice. The sandy soils make this area best suited for wheat and onion production in the dry season and jute cultivation in the premonsoon season.

Fig. 3. Hub characteristics.

In 2013, a project monitoring and evaluation (M&E) plan was developed that incorporated a new results framework (Fig. 4). This results framework formed the basis for project activities and clearly emphasized raising farm income through increased agricultural and aquacultural productivity brought about by the adoption of new varieties, production technology, seeds, and agricultural machinery services. These new varieties and technologies were to be developed from agricultural research and would be adopted through awareness-raising activities involving training, demonstrations, field days, and mass media presentations.

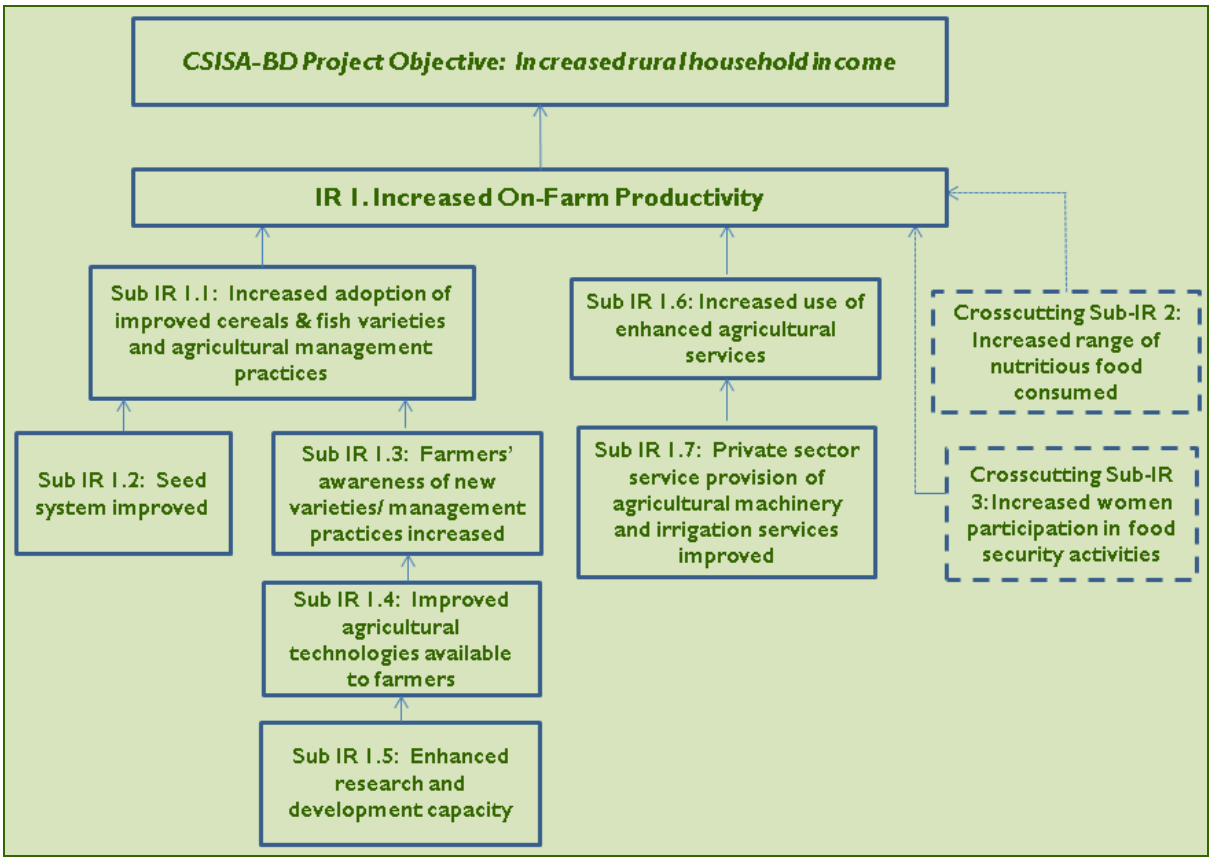

Fig. 4. CSISA-BD results framework.

As a general rule, IRRI was responsible for implementing activities related to rice production, CIMMYT for wheat and maize production, and WorldFish for aquaculture and pond-bank vegetable production. There was, however, considerable blurring of these divisions as each CGIAR center worked closely with the others in this partnership to implement trials and demonstrations in the context of complex farming systems.

1.3 Project Management

The project was managed through a national-level management team led by a project chief of party who had a coordinating as well as managerial role. This national team consisted of project coordinators for the IRRI, CIMMYT, and WorldFish work and support staff consisting of socioeconomists, M&E managers and specialists, and training, communications, and gender specialists. IRRI employed accounting and administration staff at the national and hub level to manage financial and administrative issues. The project was guided administratively by a project operations manual and a Financial Operations Guideline (FOG). Fortnightly meetings at the national level of the management team and monthly meetings of the hub team were the main vehicles used for coordinating the project.

At the hub level, the project activities were implemented by a team consisting of hub managers, agriculture/aquaculture development officers (ADOs), and partner NGOs. One of the hub managers was appointed by the hub team for one year as the hub administrative coordinator (HAC), with responsibility for the administration of the hub. The hub structure is presented in Figure 5.

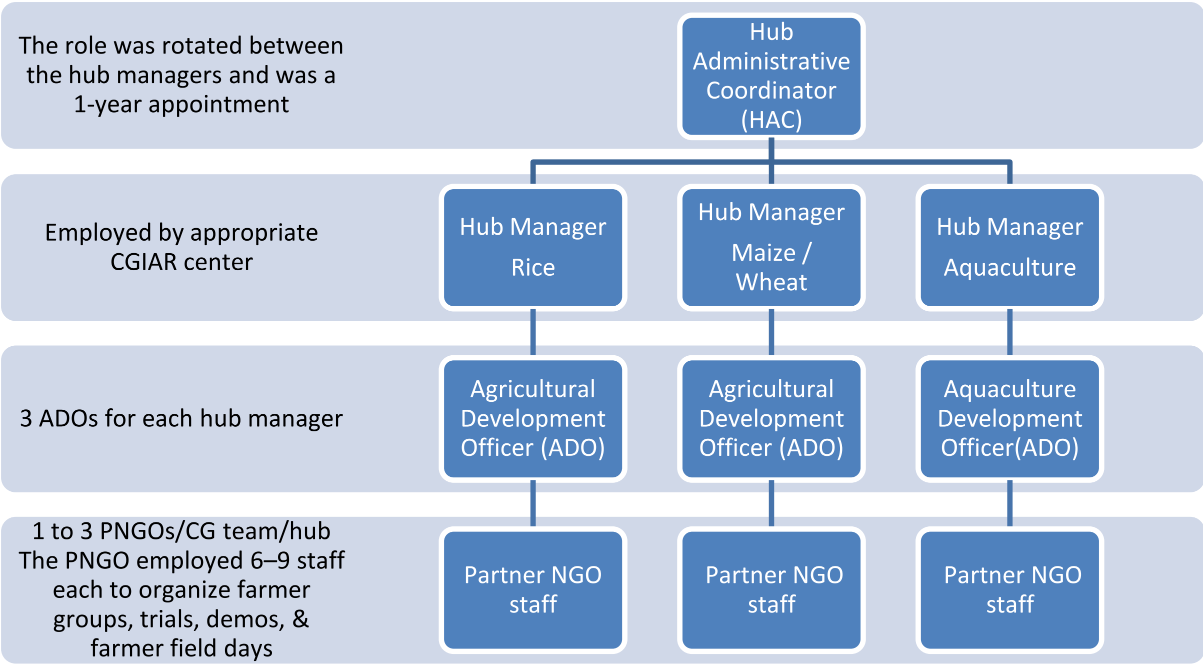

Fig. 5. Hub operating structure.

1.4 Project Implementers and Partners

By working through partners, the project was able to implement the project without having to recruit a large number of staff and, at the same time, through training and provision of equipment, increase the capacity of partner organizations to continue the work of the project after the project ended.

The project was implemented in collaboration with the following three types of partners.

National agricultural research and extension system (NARES) partners

The Department of Agricultural Extension (DAE) helped the project identify areas where the project should work. In many cases, these were areas where the DAE was not working. The DAE district and block-level staff then participated in ToT training of project partner staff and in farmer training. They were also invited to participate in farmer field days and exchange visits. Annually, hubs had stakeholder meetings at which the results of project work were presented to project stakeholders, including senior hub-level DAE staff.

National agricultural research institutes (namely, BRRI, BARI, and BFRI) directly managed research programs financed by the project and also participated in field days and stakeholder workshops.

Partner NGOS

Partner NGOS (PNGOs) were contracted by the project to provide field staff who could organize training events, demonstrations, and trials with farmers. They were tasked with collecting the basic M&E data required by the project such as farmer attendance at training events or farmer participation in trial and demonstration programs. They also helped ADOs collect data from demonstration and trial plots.

Private sector

Machinery local service providers (LSPs) and seed growers were the most commonly engaged members of the private sector. Millers were involved in rice milling training, input dealers such as

Petrochem in maize seed supply, and large machinery companies such as ACI, RFL, and Metal in machinery sales to machinery LSPs.

Excluding support to the private sector, the project provided contracts and support to the NARES and PNGO sectors worth $3,251,376. In addition, the project acquired funding worth $110,000 from the CSISA-II project to support a competitive research grants scheme.

1.5 Project Implementation Strategy

The project followed a classic project cycle implementation strategy starting with farmer focus group discussions conducted at the start of the project in early 2011, followed by project planning, staff and partner training, farmer training and demonstration, farmer participatory trials, impact evaluation studies, and project activity planning.

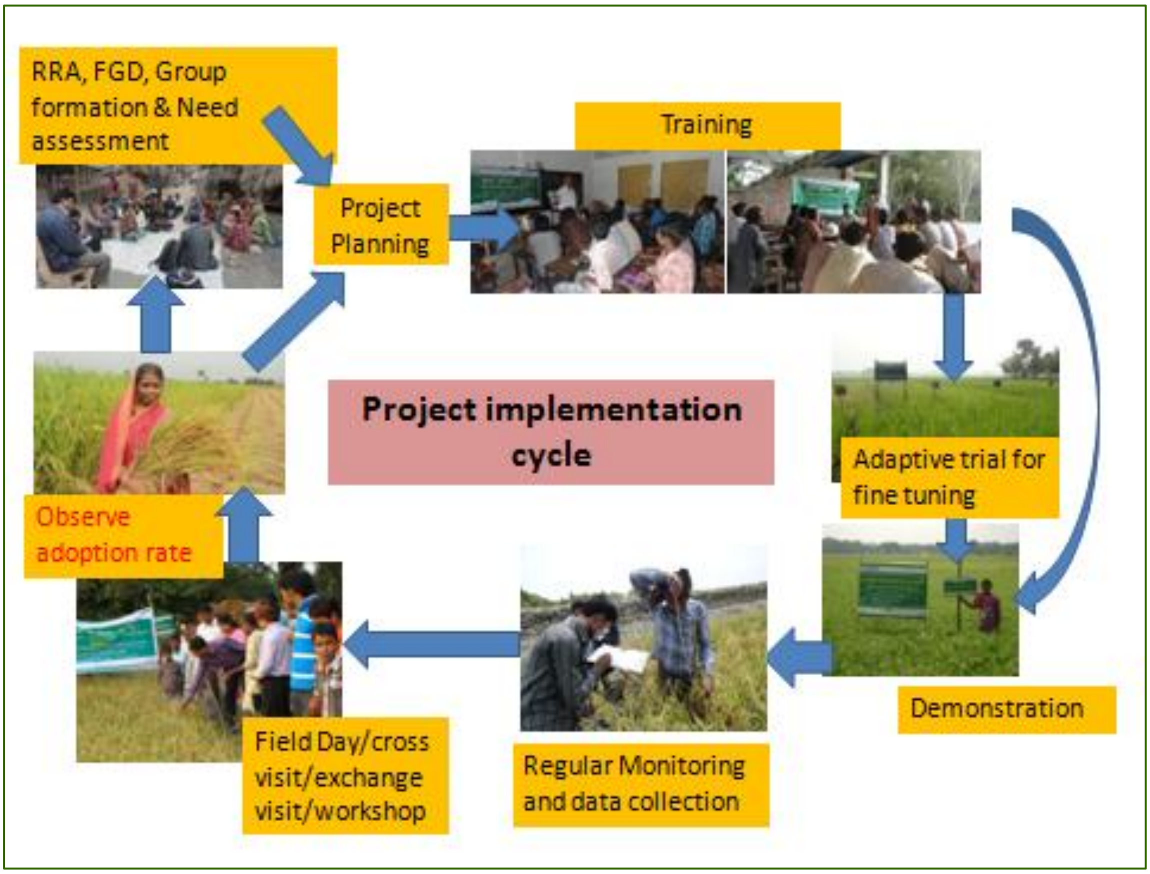

Fig. 6. Project implementation cycle.

The CSISA Village concept

It was recognized that many technologies could not be successfully implemented if other technologies promoted by another CGIAR center were not adopted by the same farmer. For instance, maize or wheat cultivation could not be successfully carried out if aman-season rice varieties were not changed to short-duration varieties so that maize and wheat could be planted during their optimal planting time in November. Similarly, aquaculture generates income that can be used by the family to invest in new crops such as maize. Linking fish farmers to maize technology would allow them to develop not just one new high-income-generating technology but two. At the village level, the project aimed to have all project CGIAR partners working in the same village and, when possible, with the same farmers. This was not always possible due to the geography of the location. For instance, in areas subject to flooding where rice-fish farming dominated, wheat and maize could not be grown. Conversely, in some of the intense cropping areas, farmers were heavily engaged in crop production and, because much of the land was not subject to flooding, farmers with ponds or interested in aquaculture were rare and in these areas WorldFish did not work. Rice cultivation was often the common denominator, with the result that IRRI was the most frequent partner with other CGIAR centers in a village.

Only 5% of the farmers worked with all three CG centers but 25% of the farmers received support from two or more CG centers and all three CG centers worked together in 29% of the villages. These villages became known as **CSISA Villages**.

1.6 Mid-Term Evaluation

In March 2014, the project hired Dexis Consulting Group to conduct an external review of the project. The team of three international specialists spent 40 days in the country conducting a series of farmers' meetings and hub-level and national stakeholder consultation meetings. Their principal findings follow:

1. The project is making excellent progress in achieving appropriate development of agricultural technology and/or management practices. Preliminary estimates provided by a Technology Adoption Survey show a very high uptake by both direct and indirect participants. Therefore, we recommend that USAID/Bangladesh consider continued funding for the current project to avoid any uncertainties and premature cutting back of field activities in the near future.
2. Many of the add-on/scale-up options require strengthening private-sector participation in order to create the necessary value chains before the project encourages farmers to make risky decisions or before the project expands to more remote areas or areas with more marginalized farmers. We recommend setting up a "Seed Unit" to help, as well as contracting with specialized local firms/NGOs/consultants to help with market development as needed for maize and sunflower in particular.
3. In Section 6.5, we made technological recommendations that require either expansion or testing. For seeds, we recommended creating a Seed Unit to help with specific problems in seed supply. For the work in *gher* systems, we recommend one more year of work to determine whether it is worth larger efforts in the new areas near the Rangpur and Mymensingh hubs. For cage culture, we recommend continuing ARTs to determine where this should receive more project inputs. For ARTs, we recommend expanding work on fertilizer practices since farmers identified this as a major project benefit.
4. During both the National Stakeholders Workshop and the Hub Stakeholder Workshop, participants mentioned the need to merge some of the CSISA-BD research programs with

those of the institutes. Such a process could allow for sharing of costs, and joint credit for research and joint publications. It would also allow for more research that focused on hub needs and would continue even after the CSISA-BD project closes. We anticipate that this linkage would help the institutes expand the supply of breeder seed varieties that farmers desire. A project-based Seed Unit could help with this.

5. As part of the process of gradually merging project approaches and activities into GoB extension services (agriculture and fisheries), we recommend the project initiate agreements with some donor-funded projects and NGOs working with DOA and DOF extension units. These partnerships would then try to provide CSISA-BD content to deliver more results to farmers in the FtF zones. To help ensure more private-sector participation, we recommend the project hire a business manager who can help farmers' organizations develop business links with buyers. This would involve increasing the number and quality of farmers' organizations (similar to what CIMMYT has done). A business manager and better business linkages would lead to more private-sector involvement in input supply, finance, farmer training, and value chain improvements through better marketing channels and improved processing.
6. The current project structure with CSISA-BD CG partners working together is sound; we recommend maintaining this structure and the current distribution of hubs. The current project structure was robust enough to allow continuation of normal operations despite the extensive time lost due to political disruptions.

1.7 End-of-Project Field Days and Workshops

A consultation process began during the final six months of the project to present the results of the project to the main stakeholders and partners and to determine what they considered were the main impacts of the project and how it could have been improved.

This followed a three-stage process:

1. Stakeholder farmer field days

Farmers' field days (FFDs) were organized in March and April in every hub for representatives of key stakeholders from within the hub zone of influence (Fig. 7). The objective of these FFDs was to ensure that our stakeholder partners were aware of the main technologies the project was promoting and could meet farmers who had adopted these technologies. Through this, it is anticipated that successful technology will be included in the programs of our main partners such as the Department of Agricultural Extension (DAE).

Fig. 7. Farmers' field day.

2. Hub-level stakeholder workshops

Workshops were held in all six hubs to present the results of the project in each hub and to obtain feedback from our main hub partners. In total, 615 people attended these workshops, of which 74 were farmers, 243 were from DAE and DOF, 139 were from NARES and universities, 84 were from PNGOs, and 24 were from the media.

Technologies and varieties thought to be useful follow.

New rice varieties

- ✓ Demonstrating aromatic rice and stress-tolerant varieties

Crop intensification: early-maturing monsoon-season rice

- ✓ Rice-mustard-rice cropping system
- ✓ Rice-mustard/onion/wheat/maize/sunflower
- ✓ Rice-mustard/lentil/mungbean/wheat-aus/jute
- ✓ Maize intercropping with leafy vegetables

Aquaculture

- ✓ Integrated rice-fish culture + dike vegetable culture
- ✓ Carp-Shingi, carp-tilapia polyculture + dike vegetable culture
- ✓ Homestead pond carp with mola + dike vegetable culture
- ✓ Golda-carp polyculture + dike vegetable culture

Conservation agriculture

- ✓ Strip tillage and bed planting for maize and wheat
- ✓ Power tiller-operated seeder
- ✓ Rice transplanter, reaper, power thresher, axial flow pump

Less valuable technologies follow:

- AWD (little water saving but more weeding)
- Reaper for wheat (collecting the harvested crop required more labor than hand-harvested wheat)
- Boro cultivation in zero tillage after mustard harvest
- Four-crop cropping pattern (soil and labor stress)
- Carp-Shingi polyculture, pen culture
- *Rice Crop Manager*

Stakeholders suggested that there should be

- Involvement of mainstream extension agencies, academia, and research at planning stage
- Increased coordination, monitoring, and capacity building
- Location-specific technology in relation to soil, water, and market
- More training, demonstrations, field days, and exchange visits
- More machinery adoption trials, more involvement of private sector and LSPs
- Research on diversified use of new crops, fish and saline gher sludge, fruits on dikes
- Maximum use of gher dikes; promoting fish breeding nucleus
- More use of ICT (smartphone, projector, laptop)

In a future project, there should be

- Use made of yield and profitability results in future design
- Stakeholder consultations at the beginning to design technology interventions
- Links deepened with universities and NARES in field research, case studies, thesis program

- Private-sector engagement beyond value chain development (e.g., breeding research, mechanic services)
- Support to local market development (e.g., Faria/Bepari and LSPs as potential market actors)
- Processing and branding of products (e.g., Cheera, muri, SIS fish processing and vegetable cookies)
- NGO training needs alignment with entrepreneurship and business skill development

3. National-level workshop

A workshop was held on 15 September 2015, at which summaries were presented of

- The findings from the hub-level workshops presented by Dr. Sattar Mandal.
- Rice, wheat, maize, aquaculture, and mechanization technology.
- The impact of the project in terms of the number of farmers adopting new technology and the impact this had on farm income.

The general consensus was that this was a useful event for presenting a summary of the project results to the 106 participants but that a longer workshop that presented the results of the project in more detail would have been appreciated.

New methods of wheat production are widely adopted

2 SUMMARY OF FtF INDICATOR REPORT

4.5-4 Gross margin per unit of land, kilogram, or animal of selected products (crops/animals/fisheries and selected varieties by country)

As the project came to a close, measuring its impact in terms of technology adoption and income became an important activity. A set of surveys that measured the adoption of CSISA-BD-promoted technology by farmers was conducted. In October 2013, the project surveyed a sample of farmers who received training and conducted demonstrations or trials in 2012. In 2014, the project surveyed 2013 farmers and farmers who the 2012 farmers reported to have adopted technology promoted by the project but who had not received training or conducted trials or demonstrations. In 2015, the project surveyed a sample of 2012, 2013, and 2014 farmers and a sample of farmers who participated in the project baseline survey conducted in 2012.

By the end of FY5, the project had already surpassed its original targets. Technology packages that allow farmers to increase income through using land normally left fallow in the dry season to grow at least one more crop had been developed and progress with disseminating them to farmers had advanced. As a result of this work, the 2015 surveys showed that project-trained farmers increased the gross margin they obtained from rice production by US$295/ha, from maize production by $751/ha, from wheat by $185/ha, from pond fish production by $3,357/ha, and from gher shrimp production by $1,055/ha.

4.5.2-2 Number of hectares under improved technologies or management practices as a result of USG assistance

By the end of FY5, the project counted the total area under improved technologies through two activities: adaptive research trials (ARTs) and demonstrations (Table 1).

The project uses demonstrations in a participatory way to promote farmer awareness of improved seed/cropping technologies, crop and fish varieties/species, machinery, and agricultural/aquacultural management practices. Demonstrations also play an important role by putting technologies into farmers' fields so that people can see how these improved technologies can directly benefit them.

Table 1. Area (ha) under improved technology or management practices as a result of USG assistance.

Activities under indicator	CSISA-BD				Activity totals (CSISA-BD/ excluding SRSPDS)		CSISA-MI		SRSPDS (FtF zone)
	FtF zone hubs		N hubs		FZ + N. hubs		FtF zone hubs		
	Males	Females	Males	Females	Males	Females	Males	Females	
Subtotals in year 5	**481**	**42**	**235**	**30**	**716**	**72**	**5,587**	**138**	
CSISA-BD project total area in year 5	**523**		**265**		**788**		**5,725**		
Subtotals in year 4	**1,060**	**85**	**594**	**54**	**1,654**	**139**	**3,502**	**82**	
CSISA-BD project total area in year 4	**1,145**		**648**		**1,793**		**3,584**		
Subtotals in year 3	**1,232**	**108**	**698**	**54**	**806**	**162**			**46,436**
CSISA-BD project total area in year 3	**1,340**		**753**		**968**				**46,436**
Subtotals in year 2	**441**	**38**	**592**	**27**	**1,033**	**65**			**139,645**

CSISA-BD project total area in year 2	**479**		**619**		**1,098**				**139,645**
Subtotals in year 1	**10**	**1**	**6**	**2**	**16**	**3**			
CSISA-BD project total area in year 1	**11**		**8**		**19**				
Subtotals up to year 5	**3,224**	**274**	**2,125**	**167**	**4,225**	**441**	**9,089**	**220**	**186,081**
CSISA-BD project total area	**3,584**		**2,467**		**4,926**		**9,309**		**186,081**

The area calculated is based on the area of demonstration and trial plots planted by the three CGIAR centers. The data provided are therefore purely output data. Data on the actual area of land under new technology disseminated by the project were collected through the annual "technology adoption and impact" survey conducted in FY5. Table 2 gives the results from the adoption and impact survey in year 5.

Table 2: Number of hectares under improved technologies or management practices as a result of USG assistance.

Amount of area (ha) with applied technologies	**2014 farmers**			**2013 farmers**		
	FtF zone	**Non-FtF zone**	**CSISA-BD**	**FtF zone**	**Non-FtF zone**	**CSISA-BD**
Crop genetics	**1,065**	**516**	**1,581**	**3,112**	**1,471**	**4,583**
Cultural practices	**14,051**	**6,180**	**20,231**	**17,457**	**7,766**	**25,223**
Soil-related	**4,664**	**2,065**	**6,729**	**7,706**	**3,425**	**11,131**
Irrigation	**477**	**377**	**853**	**783**	**401**	**1,184**
Water management	**1,299**	**576**	**1,874**	**2,354**	**634**	**2,988**
Mechanization	**1,239**	**277**	**1,515**	**1,946**	**724**	**2,670**
Others	**125**	**84**	**209**	**110**	**87**	**197**
Total w/one or more improved technology	**22,920**	**10,074**	**32,993**	**33,467**	**14,509**	**47,976**
Males	**20,783**	**8,424**	**29,207**	**29,646**	**12,333**	**41,980**
Females	**2,137**	**1,650**	**3,786**	**3,821**	**2,176**	**5,996**
Total	**22,920**	**10,074**	**32,993**	**33,467**	**14,509**	**47,976**

Table 2 shows that, after receiving training and demonstration support from the project, the area under improved technologies in year 3 was 47,976 hectares and in year 4 was 32,993 hectares (22,920 hectares covered by male farmers and 10,074 hectares covered by female farmers). The lower number for technology adoption and area under new technology in year 4 compared with year 3 is because crops and fish ponds planted or stocked in year 4 were harvested before the technology adoption survey was conducted in mid-year of FY5.

4.5.2-5 Number of farmers and others who have applied new technologies or management practices as a result of USG assistance

Participants under this indicator include farmers who have applied CSISA-BD-supported technologies and agricultural management practices for two activities: demonstrations and adaptive research trials. In total, 49,949 producers participated in demonstrations and trials on applying new technologies up to this reporting period: 30,075 producers from the FtF zone and 19,874 producers from the non-FtF zone. Table 3 shows the distribution of participating producers applying new technologies and practices according to each project component and/or area, and by gender.

Table 3. USG-supported producers applying new technology through demonstrations and trials.

Activities under indicator	FtF zone hubs		N hubs		Activity totals (FZ + N hubs)		SRSPDS (FtF zone)
	Males	Females	Males	Females	Males	Females	
CSISA-BD component total in year 5	4,780	617	3,353	441	8,133	1,058	
CSISA-BD project total area in year 5	5,397		3,794		9,191		
CSISA-BD component total in year 4	8,626	819	4,561	418	13,187	1,237	
CSISA-BD project total area in year 4	9,445		4,979		14,424		
CSISA-BD component total in year 3	9,382	1,192	5,563	762	14,945	1,954	326,272
CSISA-BD project total area in year 3	10,574		6,325		16,899		326,272
CSISA-BD component total in year2	3,928	657	4,344	387	8,272	1,044	673,245
CSISA-BD project total area in year2	4,585		4,731		9,316		673,245
CSISA-BD component total in year1	49	25	26	19	75	44	
CSISA-BD project total area in year1	74		45		119		
CSISA-BD component total	26,765	3,310	17,847	2,027	44,612	5,337	999,517
CSISA-BD project total	30,075		19,874		49,949		999,517

Data from the survey conducted in the third quarter of FY5 on the number of farmers who applied new technology appear in Table 4.

Table 4. Number of farmers and others that applied new technologies or management practices as a result of USG assistance.

Number of farmers that applied technologies	2014 farmers			2013 farmers		
	FtF zone	Non-FtF zone	CSISA-BD	FtF zone	Non-FtF zone	CSISA-BD
Crop genetics	3,906	1,903	5,809	6,800	2,869	9,669
Cultural practices	11,096	4,519	15,614	12,411	4,647	17,058
Soil-related	7,213	3,304	10,517	9,705	3,136	12,841
Irrigation	1,392	1,587	2,979	2,872	1,244	4,116
Water management	2,352	912	3,264	2,784	1,504	4,289
Mechanization	2,379	810	3,189	3,800	1,108	4,909
Others	3,782	1,044	4,826	2,920	784	3,704
Total w/one or more improved technology	32,120	14,079	46,198	41,292	15,292	56,586
Males	10,977	4,041	15,018	12,882	4,598	17,479
Females	1,171	942	2,113	1,096	420	1,517
Total	12,148	4,983	17,131	13,978	5,018	18,996

These surveys revealed that, of a total of 27,455 farmers trained in year 4 on new technologies, 17,131 (62%) were using these technologies in 2015. More impressively, of the year 3 farmers, it was found that, out of 25,253 farmers trained in the use of new technology, 18,996 (75%) continued to use this technology in 2015. Of these farmers, 74% are males and 26% are females. Many farmers adopted more than one technology. If all these new technology adoptions are summed, then 46,198 technology adoptions were made by year 4 farmers and 56,586 by year 3 farmers.

4.5.2-7 Number of individuals who have received USG-supported short-term agricultural sector productivity or food security training

CSISA-BD has provided direct training support to 17,826 farmers in year 5, with around 26% being females (see Table 5, line 1). New technology was adopted by 27,795 farmers after seeing it at farmer field days, 277 farmers adopted after an exposure visit, and 10,589 adopted through meetings and a result-sharing workshop on new varieties and technologies.

In addition, CSISA-BD has provided capacity-building support to 226 individuals, including GO staff and partner NGOs and private-sector individuals, as part of its commitment to developing the agricultural sector of Bangladesh in this reporting period (FY5).

Under CSISA-MI, a total of 693 farmers received short-term support and 1,500 GoB, NGO, and private-sector personnel received capacity-building support. Among them, 2,001 are males and 192 are females.

Table 5. Activity-wise breakdown of USG-supported short-term training.

Activities under indicator	FTF zone hubs				Northern hubs				Total			
									CSISA-BD		CSISA-MI	SRSPDS
	Direct		Indirect		Direct		Indirect		Direct	Indirect	Direct	Direct
Gender	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**				
Direct farmers	*8,646*	*3,489*			*4,469*	*1,222*			*17,826*		***693***	
Farmer field day			*14,479*	*7,483*			*3,633*	*2,200*		*27,795*		
Cross visits (farmers)			*243*	*23*			*11*	*0*		*277*		
Workshops (farmers)			*3,195*	*3,014*			2,745	1,635		*10,589*		
Capacity building (GoB)	*15*	*0*			*17*	*2*			*34*		***128***	
Capacity building (private sec.)	*23*	*4*							*27*		***1,285***	
Capacity building (NGOs)	*94*	*1*			*65*	*5*			*165*		*87*	
Subtotals in Yr5 (M/F)	*8,778*	*3,494*	*17,917*	*10,520*	*4,551*	*1,229*	*6,389*	*3,835*	***56,713***		***2,193***	
Subtotals (M + F) in Yr5	*12,272*		28,437		*5,780*		10,224					
Subtotals in Yr4 (M/F)	*18,669*		*23,084*		*8,641*		*9,224*		***59,618***		***5,840***	
Project total in Yr4	***41,753***				***17,865***							
Subtotals (M + F) in Yr3	***25,131***		***25,926***		***8,327***		***10,086***		***69,470***			***1,312,935***
Project total in Yr3	***51,057***				***18,413***							
Subtotals (M + F) in Yr2	***14,882***		***13,562***		***6,703***		***10,150***		***45,297***			

Project total in Yr2	***28,444***		***16,853***				
Project total in year 1					***5,939***		
Subtotals (M + F)	***70,954***	***91,009***	***29,451***	***39,684***	***237.037***	***10,226***	***1,312,935***
Project total	***161,963***		***69,135***				

By the end of year 5, 106,344 direct farmers had received support on short-term training and 130,693 farmers and individuals participated in project events such as farmer field days. In total, project coverage through training and other events was 237,037.

4.5.2-13 Number of rural households benefiting directly from USG interventions

In year 5, a total of 26,528 households directly benefited from the project activities. Of this figure, 13,839 (from southern and northern hubs) are new HHs while 12,689 are continuing HHs. Among those new households, 9,132 represented the FtF zone (southern zone) and 4,707 households represented the northern zone.[1]

Table 6. Total household coverage.

	FtF zone hubs	*N hubs*	*Activity totals (FZ + N hubs)*
New households	***63,502***	***26,850***	***90,352***
Continuing households	***24,651***	***8,472***	***33,123***
Total CSISA-BD	***88,153***	***35,322***	***123,475***

Over 5 years, the project directly supported 90,352 new farming households, of which 63,502 were through southern hubs and 26,850 were through northern hubs (Table 6).

4.5.2-37 Number of MSMEs, including farmers, receiving business development services from USG-assisted sources

Up to this reporting period, a total of 605 MSMEs received business development service from the CSISA-MI project, of which 511 are micro-enterprises, 91 are small enterprises, and only 3 are medium enterprises. In the CSISA-MI project, local service providers (LSPs) are treated as a small enterprise and they provided services to farmers in 46 upazillas. Among those, only one LSP is a female. A dealer is treated as a medium enterprise. By the end of the CSISA-BD project, CSISA-MI

[1] CSISA-BD acknowledges the potential for double-counting households; however, and for the time being, referential and experiential feedback from the hubs has indicated that this is, at present, a minor discrepancy, as the vast majority of households have 1-farmer/1-household participation within the project. At the same time, it has been duly acknowledged that there are instances of multiple household members participating in the project, and hence double-counting of households, by hub staff as well. CSISA-BD is currently reviewing its documentation system for field-level data collection and data entry/capture. The M&E team is also working to develop an overall and encompassing strategy for a results-based M&E system that better addresses the new organization of FtF indicators, and that can take into full account indicator definitions and the several additional levels of data disaggregation.

was working directly with 45 dealers in 32 upazillas. Three importers, ACI, RFL, and Metal, were working with the CSISA-MI project and importing agro-machinery.

CUSTOM Indicator 1. Value of private-sector investment in agricultural machinery and equipment resulting from project interventions

Up to this reporting period, importers, dealers, and LSPs invested $1,040,965 in water conveyance equipment (mainly axial flow pumps), power tiller-attached planters, reapers, and threshing machines (Table 7).

Table 7. Service-wise investment by importers, dealers, and LSPs.

Item	Investment made (US$)
Water conveyance equipment	*409,030*
Machine land preparation and planting	*359,930*
Machine harvesting and postharvest operations	*272,006*
Total	*1,040,965*

CUSTOM Indicator 2. Number of farmers using improved agricultural services

By the end of CSISA-BD, 22,012 farmers had received services from LSPs, of which 21,362 were males and 650 were females (Table 8). Of these, 9,502 purchased water pumping services, 6,696 mechanized planting services, and 5,814 mechanized harvesting and threshing services.

Table 8. Service-wise farmers' coverage by gender.

Service	*Investment made (US$)*	*Notes*
Water conveyance	*9,502*	*Male farmers: 9,371* *Female farmers: 131*
Mechanized land preparation and planting	*6,696*	*Male farmers: 6,300* *Female farmers: 396*
Mechanized harvesting and postharvest operations	*5,814*	*Males: 5,691* *Females: 123*
Total	*22,012*	*Males: 21,362* *Females: 650*

SUCCESS STORY

Woman seed entrepreneur growing BRRI dhan50

Expanding Women-Managed Businesses. The story of Nasrin Nahar: A woman seed entrepreneur growing BRRI dhan50 (Banglamati)

"First time, I was afraid and felt shy how high-class society of workshop will accept me but I was praised and honored as a woman entrepreneur and encouraged to strengthen my seed business and go ahead."

Nasrin Nahar roguing her seed plots with her contract grower

Nasrin working in her office

"I want to see my Utsab Seed Farm as a national institution in Bangladesh as an encouragement for other women. I dream that woman agriculturists and other women will work and be involved in my institution. I shall not be alive but Utsab Seed Farm will be sustained in the long run with many women."

Nasrin Nahar started her seed business, Utsab Seed Farm, Jessore, in 2006. Initially, she produced 7 to 10 tons annually of seed of popular varieties such as BRRI dhan28 and BR11 through seven contract growers. Since then, her business has expanded and now she produces seed of six varieties through 26 contract growers.

In 2009, she obtained 20 kg of the fine-grained basmati-type BRRI dhan50 from BRRI plant breeders. She produced 20 tons of seed but could sell only 1 ton. In 2011, she joined the Small and Medium Seed Producers Association (SMSPA) in Jessore and through it began to work with CSISA-BD. Through participation in farmer field days and rice production training, she observed that "Farmers are obtaining a higher price for BRRI dhan50 than other varieties and millers are getting more experience of milling it." She could see the potential for marketing BRRI dhan50. In 2014, she produced 12 tons of BRRI dhan28 certified seed and sold 8 tons but 4 tons remained unsold. She also produced 8 tons of BRRI dhan50 certified seed but, unlike the BRRI dhan28 seed, she was able to sell all of this seed.

In 2013, she participated in the CSISA-BD-organized Women's Entrepreneurship Workshop held in Khulna, where she made useful links with other seed companies, supermarkets, and banks. One link led to her being able to obtain bank loans to finance an expansion of her seed business. She said of the workshop: "First time, I was afraid and felt shy how high-class society of workshop will accept me but I was praised and honored as a woman entrepreneur and encouraged to strengthen my seed business and go ahead.

"Programs that focus on woman entrepreneurs can help them expand by linking them with finance institutions and markets," she added. "Women's Agricultural Fairs that display products produced by women such as packaged and branded seeds, puffed rice, flattened rice, pop rice, and other products would be of considerable help with expanding their businesses." Another approach she suggests is to conduct exchange visits and develop contract grower schemes and machinery hire service business with women.

Adoption of Modern aquaculture technologies increase production

3 RESULTS AND ACHIEVEMENTS

This section presents information gathered during the project on the likely rise in production that farmers could achieve if they adopted new rice, wheat, maize, and aquaculture technology and then shows data from surveys that reveal the number of farmers who adopted this technology and the impact this had on family income.

The project conducted 2,456 trials, 37,773 demonstrations, and 2,828 farmer field days and trained 87,315 farmers. In addition, the SRSPDS seed project provided seeds of stress-tolerant and high-yielding rice varieties to 999,517 farmers through demonstrations and trained 17,032 farmers. The CSISA-MI project provided 3,705 machinery demonstrations and trained 5,458 producers, 2,431 private-sector individuals, and 144 GoB staff members.

This large investment in demonstrations and training resulted in significant adoption of new crops such as maize, new varieties such as short-season aman rice varieties, and new crop and fish production technology such as pond aquaculture technology. This technology was adopted by the 116,000 farmers directly participating in the project and helped the 430,141 indirect beneficiaries who adopted CSISA-BD technology by copying from CSISA-BD farmers. All this resulted in gains in income from increased gross margins of $122 for rice, –$49 for wheat, $132 for maize, $1,331 for fish, and $164 for prawns.

The trials and demonstrations provided data from which the benefits from adopting new technology could be calculated and the best technology for dissemination to farmers could be identified. The next section presents the results from these trials and demonstrations and lessons learned from the dissemination of this technology to farmers.

3.1 Key Successful Technologies

On-farm productivity will be increased by disseminating proven technology to as many farmers as possible. Two major concerns are addressed through the program: increased productivity of crop and aquaculture systems and increased intensity of cropping and aquaculture systems.

Increased crop and aquaculture productivity: This is achieved through training and demonstrations that show farmers the best methods for raising crops and fish, developing systems that allow farmers to obtain good seed of the best varieties, and testing and introducing new crop and fish varieties.

Increased cropping intensity: This involves increasing the number of crops grown where crops could not previously be grown or, in the case of aquaculture, having more fish production cycles each year. In most cases, a key perquisite for increased cropping intensity is the introduction of early-maturing aman-season rice varieties. This allows dry-season crops to be planted earlier. This not only increases crop yield but also allows crops to be grown in the gap between the aman and boro rice crops or to grow two, instead of only one, rabi crops. It can also allow crops to escape rising soil and water salinity or late dry-season drought and high temperatures. Cropping intensity can also be increased through the introduction of rice varieties that can grow on land frequently flooded during the monsoon and mechanized planting and harvesting that allow for faster turnaround between crops.

3.1.1 Agriculture (rice)

Over the life of the project, 35,876 demonstrations and 1,494 trials were conducted with farmers. The data collected from these trials and demonstrations showed the potential for grain yield and income improvement that could be achieved if the varieties and technology tested in the trials or displayed in the demonstrations could be adopted by farmers. The data reveal three main ways in which production and income from rice-based cropping systems could be improved: by changing management practices, variety, and cropping system.

Increasing rice yield through changing crop management practices

Data from 3,598 aman-season and 2,466 boro-season rice trials and demonstrations conducted between 2011 and 2015 in which farmers followed the crop production practices recommended by project staff revealed the large gap between the grain yield farmers could attain and what is being attained nationally. The gap is largest in the aman season at 88% higher than the 2012-13 national average (Fig. 8). In the boro season, the gap is 37% higher than the 2012-13 national average (4.49 t/ha).

Aman-season data **Boro-season data**

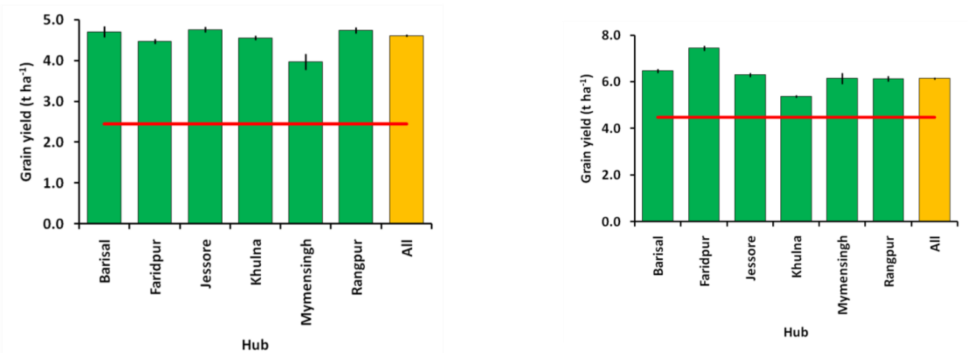

Fig. 8. Grain yield (t/ha) of T. aman and boro rice across all trials and demonstrations conducted during 2011-15 in six hubs of the CSISA-BD project area of Bangladesh. Vertical bars are 95% confidence intervals. The yellow column designates the mean from all six hubs. The horizontal line is the 2013 national average yield.

Trials comparing rice growing using a package of recommended practices with farmers' practices were conducted in 2012 and 2013 in the project called Good Agronomic Practices (GAP). The recommended practices included the use of purchased seed of a modern high-yielding variety, young seedlings, transplanting on time and at the correct spacing, and growing using the recommended fertilizer rate. Grain yield increased by 10.2% in the aman season and by 9.9% in the boro season compared with yield in the farmers' practices (Fig. 9). The response was greatest on the lowest-yielding farmers' plots, indicating that those farmers who now do not obtain a high yield would gain more from adopting good rice crop production practices than those with higher grain yield who are probably already applying these good practices.

Aman season **Boro season**

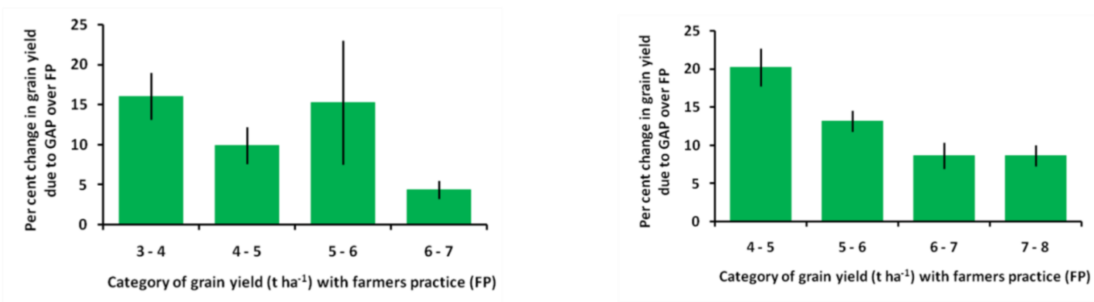

Fig. 9. Relative change in grain yield of rice due to good agronomic practices (GAP) compared with farmers' practices (FP) across four categories of farmers' yield in five hubs of the CSISA-BD project area of Bangladesh during aman and boro seasons. The vertical bar on each column indicates standard error.

A trial conducted in the aman season of 2014 indicated what might be the key factors affecting aman rice grain yield. In this trial, the main factors thought to be determining yield were compared separately and in combination (best-bet practices) with the farmers' practices at each trial site. The factors were changing variety, planting young seedlings grown from purchased seed (SSPP), applying fertilizer at the correct rate and in the recommended way, following good weed control practices, and irrigating when needed (Fig. 10). The "best-bet" package of good agronomic practices was then compared with this agronomic package applied using machine-planted rice. The results showed that just changing variety alone would increase grain yield by 8.3% while the best-bet package increased grain yield by 15.5%.

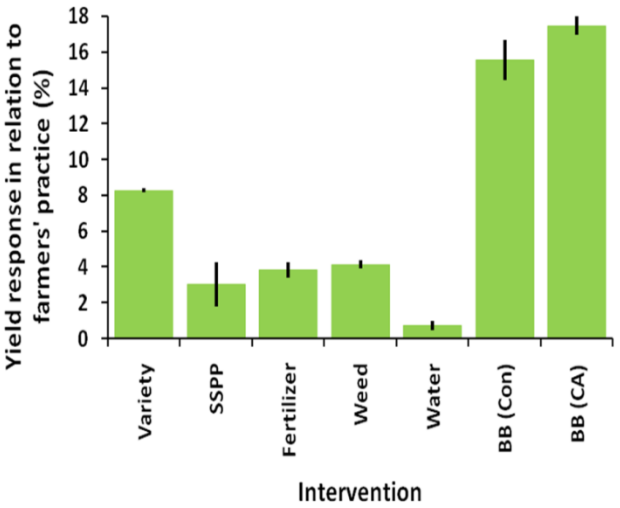

Fig. 10. Decomposed yield gap, relative to farmers' practices, of T. aman rice in 2014 cropping season across the six CSISA-BD hubs. The yield gap has been separated into six yield-determining factors. "SSPP" denotes quality seed and appropriate plant population, "BB" denotes best bet, "Con" denotes conventional practice, and "CA" denotes

Seedling age and time of transplanting also appear to be critical factors. Analysis of data from 1,522 data points from boro rice trials and demonstrations conducted during the life of the project clearly shows a sharp decline in grain yield from 15-day-old seedlings to 35-day-old seedlings. Critically for every day from 15- to 25-day-old seedlings, yield dropped by 200 kg/ha/day (Fig. 11).

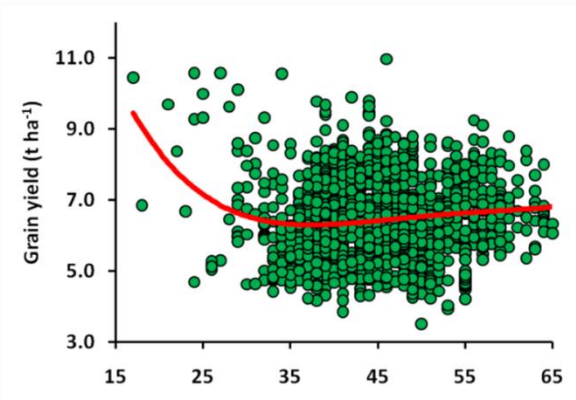

Fig. 11. Yield effect for seedling age.

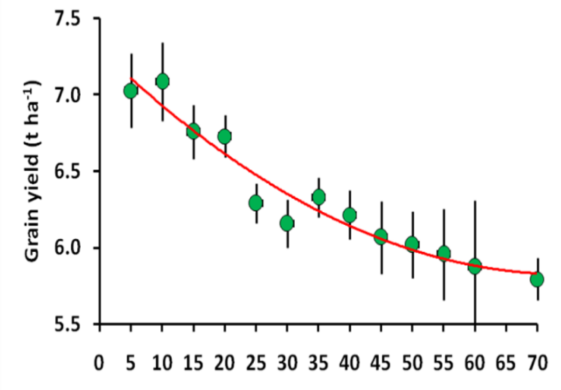

Fig. 12. Yield effect for time of transplanting.

The time of transplanting for boro rice is also critical. Analysis of data[2] from 1,530 data points from boro rice trials and demonstrations shows a yield loss of 39 kg/ha for each day transplanting is delayed after 1 January (Fig. 12). Delaying transplanting to the end of January would therefore result in a yield loss of 1,210 kg/ha or approximately 17% of a 7-ton rice crop.

---

[2] In the datasets, the transplanting time of the rice ranged between 1 January and 12 March. The dates were converted into "Julian Days" and summarized at 5-day intervals. The average and 95% confidence interval were calculated for each interval. Finally, a regression equation was developed using the 13 summarized data points.

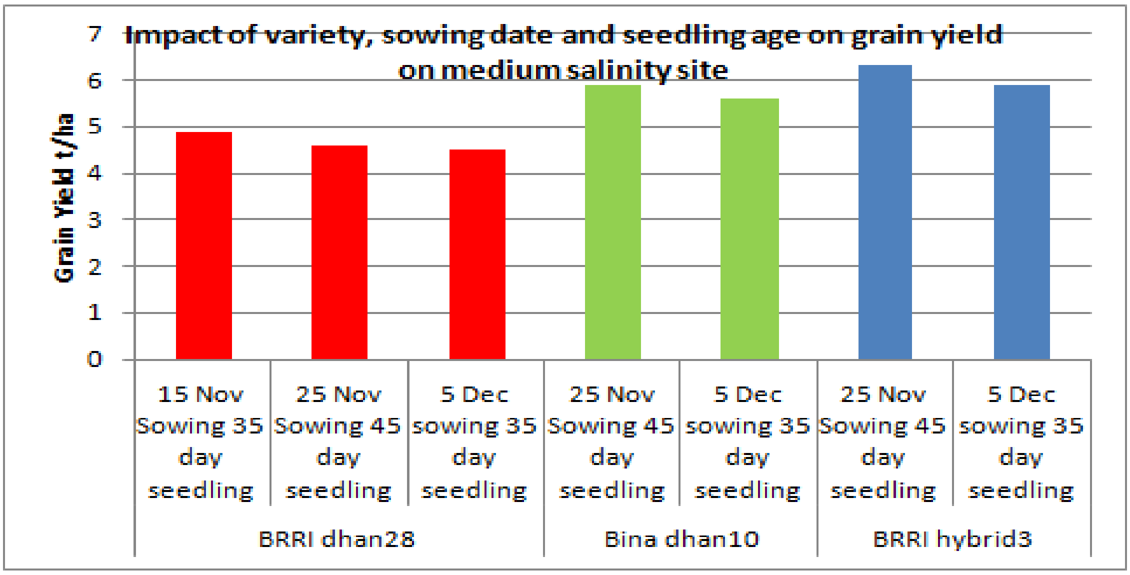

Fig. 13. Yield effect by variety and seedling age.

On moderately saline soils, changing variety to a saline-tolerant variety had a much bigger impact on yield (37% increase) than transplanting early (7% increase). Changing from using salinity-susceptible BRRI dhan28 sown on 5 December to using salinity-tolerant BRRI Hybrid3 sown on 25 November raised grain yield by 40% (Fig. 13).

Increasing rice yield through changing fertilizer management practices

Trials conducted between 2012 and 2014 to see whether following fertilizer recommendations generated from the BRRI recommendation booklet or the IRRI *Rice Crop Manager* (RCM) web-based software both showed that the often-cited view that farmers use less fertilizer than that recommended and that this accounts for poor aman-season rice crop yield was not always true. In fact, there was little difference in grain yield between the farmers' practice and the recommended fertilizer rates and this was despite farmers using less urea and in most cases more phosphate and potassium fertilizer than recommended (Fig. 14). RCM consistently recommended lower P and K fertilizer than the BRRI recommendation and the farmers' practice and this appeared to result in a lower grain yield.

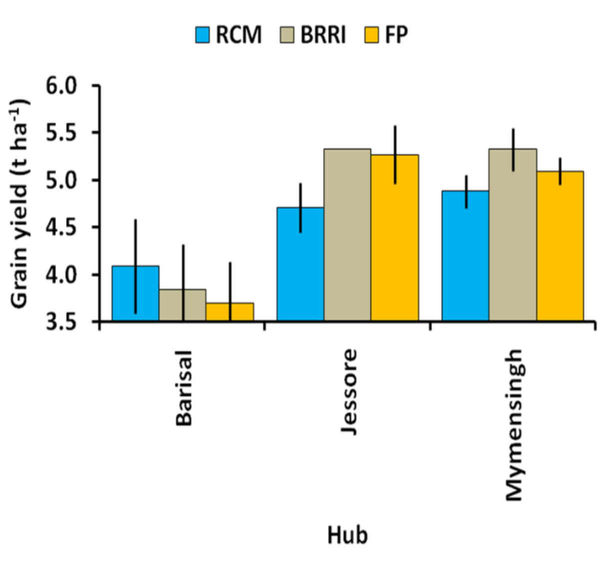

Fig. 14. Yield effect by RCM, BRRI, and FP.

It has been know since the 1970s that applying urea to the anaerobic subsoil in water-saturated puddled rice soils would reduce volatilization of the nitrogen in urea, resulting in a 30% savings in urea compared with broadcast-applied urea. It was also found that, when urea was formulated as large tablet-sized granules (urea super granules, USG), the release of urea was slow, allowing for more efficient absorption of the nitrogen by crops and the possibility of making a single application instead of two or three split applications. The cost, though, of placing USG by hand into the soil was higher than the value of the urea saved. In Bangladesh, this was exacerbated by the low value of rice and subsidies on urea that artificially reduced its cost. The project conducted 35,867 demonstrations on the use of USG but failed to observe substantial adoption of the technology. Two variations on the use of this technology have shown some promise.

On low-lying land that becomes flooded in the aman season by up to 40 or 50 cm, cultivation of short-statured high-yielding varieties is not possible. In Barisal District, where this is a common problem, farmers plant tall local varieties that are able to extend their stems fast enough to escape the rising flood waters. As this water is constantly moving in and out of the paddies with the change of the tide, applying urea as a topdressing is very difficult. It was found, though, that micro-dosing with approximately 20 kg of nitrogen per hectare as deep-placed USG would increase the grain yield of these local varieties by approximately 0.5 t/ha and, because of their high value, this practice would give a cost-benefit ratio of 1:2 to 1:5.

Another experiment (see Table 9) conducted in collaboration with BRRI showed that normal prilled urea placed in the subsoil by a simple manually operated drill was as effective as applying USG. As prilled urea is much more freely available than USG, this system is very attractive.

Table 9. Urea application method-wise yield and cost.

Urea application method	Grain yield (t/ha)	Labor use (hours/ha)	Urea cost ($/ha)
Broadcast (3 splits)	4.7	3.9	59
USG applicator	4.8	3.8	42
Prilled urea applicator	4.9	3.8	44

Increasing rice yield through changing irrigation management practices

Applying water-saving technology using the alternate wetting and drying (AWD) system significantly increased grain yield by 7.5% (Fig. 15). In this system, irrigation water is applied only when groundwater levels drop below 15 cm from the soil surface. Using this system, farmers typically have to irrigate five or six times less out of the total of 25 to 30 irrigations, thus saving on both water and costs. Application of this technology, however, is constrained by the way pump owners charge water users. Normally, farmers pay a set percentage of their crop, often 25%, for water to produce the crop. Under this system, saving water would benefit only the pump owner. The project was able to show that this system could be changed to one in which farmers paid pump owners for water used rather than a set seasonal fee. In demonstrations in which whole blocks of farmers used this system, both farmers and pump owners benefited. Farmers saved money and pump owners were able to sell the surplus water to other farmers. To do this, though, required the services of a skilled extension worker who had the capacity to mediate between farmers and pump owners. These skills are not readily available.

Fig. 15. Irrigation management.

Increasing rice yield through changing land preparation and crop planting practices

The normal way of preparing land for rice production is to “puddle” soils so that an impervious hard pan is created. This prevents rainfall or irrigation water from passing through the soil and allows rice to be grown in standing water. This controls weeds and retains soil nutrients close to crop roots. To create the hard pan and puddle the soil requires repeated passes of a power tiller or oxen-drawn plow and this is expensive. Further, crops following rice in a crop rotation do not grow well on soils in which root growth is hampered by the hard pan and soils do not drain well after heavy rain. CSISA-BD conducted a number of trials at all hubs in 2013 and 2014 to determine whether puddling was really necessary and whether alternative ways of establishing rice were possible. The results showed that zero tillage (transplanting into uncultivated wet soil) gave both a lower grain yield and, despite much lower tillage costs, much lower profit. This was largely because the cost of transplanting into soil by hand into land that had not been cultivated was much more time-consuming and because weed control was very poor. A single pass of a power tiller improved weed control but hand transplanting into a hard soil surface was still difficult. However, when a rice transplanter was used on plots that had been cultivated with a single pass of a power tiller, grain yield increased by 11% compared with that from conventionally puddled and manually transplanted rice.

Another approach is not to transplant rice but to sow it directly. A series of trials conducted at the BARI regional research station in Jessore showed that this not only produced an increase in rice grain yield and production profit but also benefited the other two crops in the rotation under test, wheat and mungbean. This minimal tillage package was therefore more productive and profitable than the normal puddled aman followed by boro rice system. The optimal sowing date for a medium-duration aman rice variety directly sown was the last week of May when the chances of heavy rain that would flood rice fields, preventing germination, were minimal. These interesting trial results came too late for inclusion in the CSISA-BD program but some demonstrations of using DSR for establishing aus rice in 2015 were very successfully established, indicating that this might be the best way of establishing this crop.

Mechanized transplanting into puddled aman and boro rice has been shown to be both profitable and popular with farmers. Two trials were conducted in Jessore hub on the mechanization of rice planting (Table 10). One compared direct-seeded rice with conventional transplanting and another compared the use of a mechanical rice transplanter with manual transplanting.

Table 10. Comparative grain yield in different rice mechanization treatments.

Transplanter trial treatments	Grain yield (t/ha)	Dry-seeding treatments	Grain yield (t/ha)
Mechanical transplanting	5.1	Dry seeding after tilling	4.2
Line transplanting by hand	4.6	Dry seeding without tillage	4.0
Transplanting by hand, not in rows	4.5	Transplanting by hand, not in rows	4.7

Farmers preferred transplanting with a rice transplanter (Fig. 16). The principal problem with dry seeding was that the planter did not deliver the seed in a uniform manner, resulting in gaps and missing rows. This was followed in the 2015 aman season with a program conducted in collaboration with the Department of Agricultural Extension (DAE) and the private company Syngenta. Farmers hired transplanting services from LSPs operating walk-behind, four-row rice transplanters borrowed from the project and the DAE. Farmers and LSPs were taught how to raise seedlings either in trays or on plastic sheeting (mat method) and assisted with planning the timing of sowing and transplanting for each farmer in the group. Farmers elected the variety they wished to grow and planting date was matched with their growth duration. Long-duration varieties such as Gutiswarma and BRRI

Fig. 16. Seedbed for rice transplanter.

dhan52 were sown first, medium-maturing varieties such as the aromatic BRRI dhan34 or BRRI dhan49 were planted next, and short-duration varieties such as BRRI dhan57 were planted last. The total area planted was 35 hectares, of which 28 ha were planted in Jessore, 5.5 ha in Khulna, 1 ha in Faridpur, and 1 ha in Barisal. Farmers normally paid BDT 1,500/bigha ($144/ha) for the transplanting services. The farmers willingly paid this fee as the transplanter saved considerably on time if not cost and the crop gave a higher grain yield (see also Table 11). The main problem is the complexity involved in raising the seedlings and the cost of purchasing the transplanter. This cost (approximately $5,000 each) is beyond the means of most farmers and power tiller-owning LSP and therefore innovative finance and hire schemes will have to be developed if rice transplanters are to become readily available.

In 2015, BRRI, with support from CSISA, conducted trials that compared manual transplanting with machine transplanting of boro rice in Rangpur and Jhenaidah districts. As seen in the Jessore 2014 trials (Fig. 17), machine-transplanted rice gave a 9% to 10% yield increase but the higher seed-raising costs for rice transplanters canceled out the gains made from lower transplanting costs. The result was that the production costs were similar but, because the grain yield from the transplanter plots was higher, the profit from using a rice transplanter was higher. For many farmers, the advantage of a rice transplanter is the reduced time taken for planting the crop. A typical 1-acre field can be transplanted with a machine in just over an hour compared with 2 days with three to four laborers for a manually transplanted field.

Table 11. Mean grain yield, labor use, and costs for manual transplanting compared with machine-transplanted rice in on-farm trials conducted in Rangpur and Jhenaidah districts in the 2015 boro season.

	Manual transplanting	Machine transplanting
Grain yield (t/ha)	**4.5**	**5.1**
Labor use (hours/ha) for seedling raising	46	74
Labor use (hours/ha) for transplanting	137	10
Total labor use	**183**	**84**
Costs (BDT/ha) of seedling raising	3,618	5,059
Costs (BDT/ha) of transplanting	6,973	4,455
Total costs (BDT/ha)	**10,591**	**9,514**

Fig. 17. Transplanter working in Jessore hub.

Increasing rice yield through variety change

Aman varieties for favorable and submergence-prone rice production environments

On land that was submerged for part of the growing season, data from trials and demonstrations indicated that newly released medium to long-season varieties such as BRRI dhan52 will yield more than varieties such as BR11 released in the 1980s (Fig. 18). Where the plots were not submerged, there was little difference between the grain yield of the more recently released varieties and the older varieties. The medium-maturing BRRI dhan49 will, however, provide almost the same grain yield in 135 days on land not prone to submergence as the longer duration BR11 and BRRI dhan52 will yield in 145 days. This allows farmers to plant dry-season crops earlier than would be possible if they planted long-duration varieties. As will be shown later in this report, early planting of dry-season crops greatly increases grain yield and reduces the risk of crop damage due to late dry-season soil salinity problems and early monsoon rains.

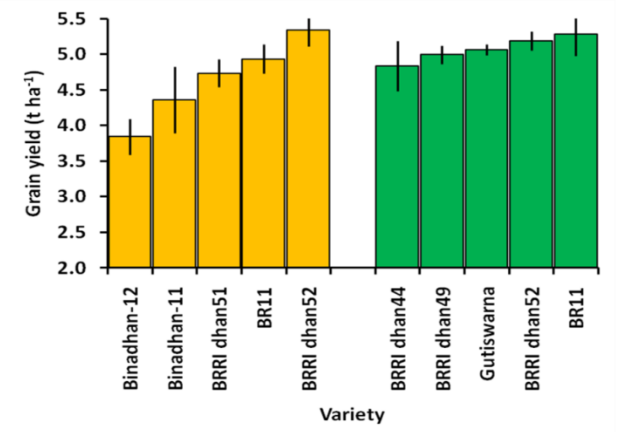

Fig. 18. Performance of rice varieties in the submergence (yellow bars) and favorable (green bars) ecosystems during T. aman season in six hubs. Vertical bars are 95% confidence intervals.

Aman short-duration varieties

Aman varieties that mature in 110 days or less from seeding would allow farmers to harvest aman rice in late October and plant rabi crops in early November. Early planting of crops such as wheat, maize, mustard, and lentil is known to significantly increase grain yield and allow for earlier and more optimal planting time for succeeding crops such as boro rice or mungbean. CSISA-BD conducted 20,277 cropping system demonstrations in which the cultivation of short-duration aman varieties was a key component of these new systems. These demonstrations invariably showed that this system was more profitable than systems based on long-duration aman varieties. In several cases, the yield of short-duration varieties was compared with that of long-duration varieties. Data showed that there was a 10% yield penalty for adopting the best short-duration aman variety (Bina dhan7) compared with the best long-duration aman variety (BRRI dhan52) (Fig. 19).

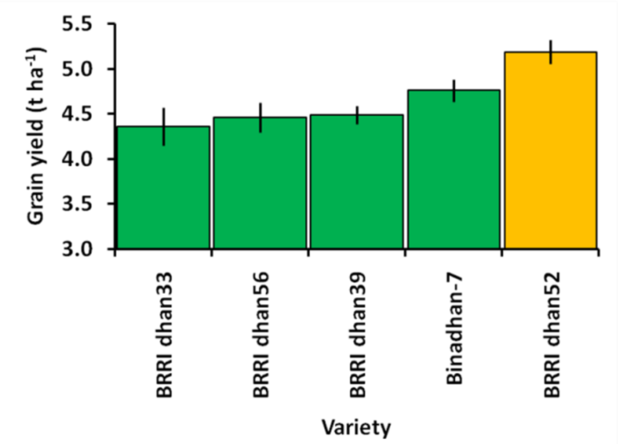

Fig. 19. Performance of four short-duration rice varieties (green bars) compared with a long-duration variety (yellow bar) during T. aman season in six hubs. Vertical bars are 95% confidence intervals.

Selecting varieties for premium quality: aromatic aman rice

Aromatic varieties of rice have a farm-gate price that is just over double that of high-yielding modern varieties such as BRRI dhan52 but a grain yield that is one-half to two-thirds of that of these varieties. Having a lower yield potential means that less fertilizer needs to be applied and so the combination of lower input costs and higher value results in higher profits for farmers growing these varieties. The lower input costs make growing these varieties particularly attractive to poorer farmers. In the 2014 aman season, trials were conducted in all the hubs to compare locally grown aromatic varieties such as Kalijira with selected or bred aromatic varieties such as BRRI dhan34 and with long-season varieties with high yield potential that are not aromatic such as BRRI dhan52. The results confirmed that BRRI dhan52 would yield 55% more than the best aromatic variety, BRRI dhan34, but, because of the higher value of BRRI dhan34, the profit from growing BRRI dhan34 was double that of BRRI dhan52 (Fig. 20). BRRI dhan34 gave a 9% higher grain yield than Kalijira, indicating that, with careful selection and production of quality seed, Kalijira, a highly prized variety well adapted to southern Bangladesh, could be developed into an aromatic comparable with BRRI dhan34.

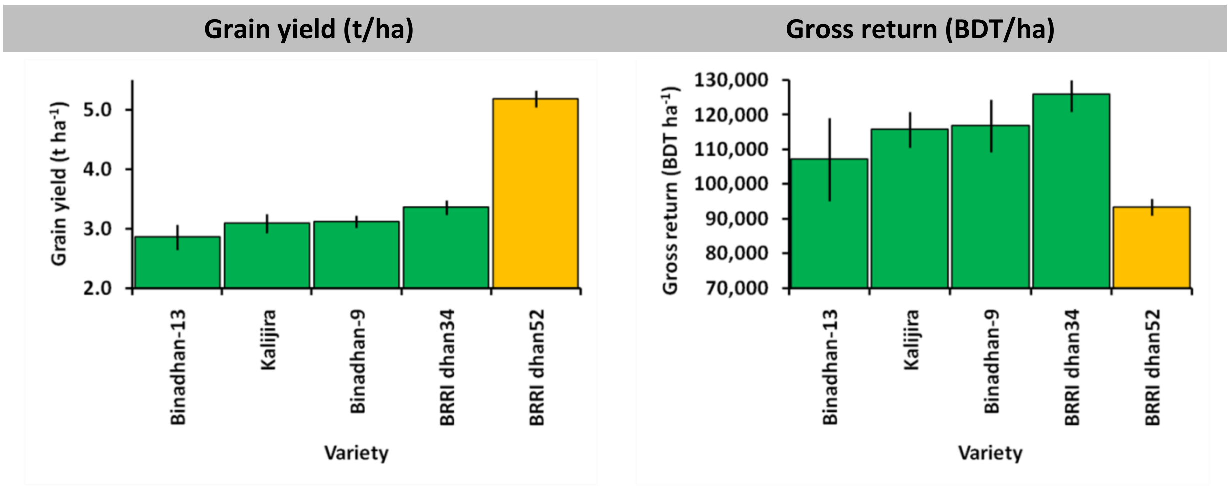

Fig. 20. Grain yield and gross return from four aromatic rice varieties (green bars) compared with a nonaromatic check variety (yellow bar) during T. aman season in the six hubs of the CSISA-BD project area of Bangladesh. Vertical bars are 95% confidence intervals.

Boro varieties for favorable rice production environments

In the 2014-15 boro season, a variety trial that compared the most widely grown boro varieties (BRRI dhan28 and 29) with some recently released varieties (BRRI dhan58, 60, and 64) and a selection of hybrids showed that the best self-pollinated variety (BRRI dhan29) will yield as well as the best hybrids (Hira2) but that the newly released varieties fail to show any advantage over the older varieties (BRRI dhan28 and 29) (Fig. 21).

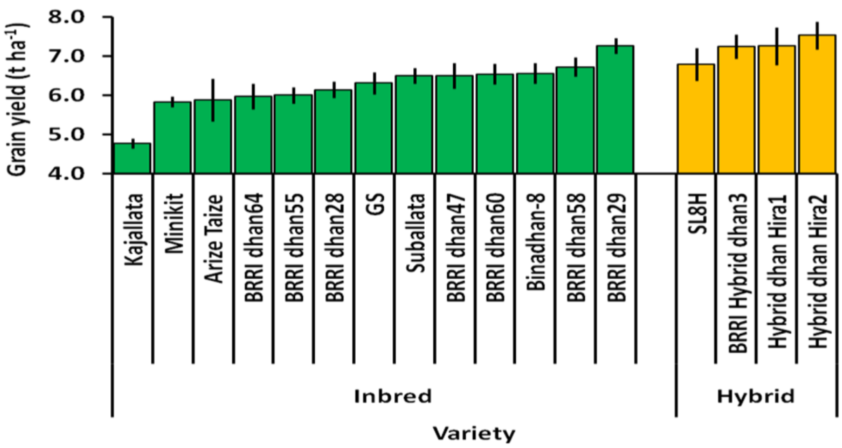

Fig. 21. Performance of boro rice varieties, inbred and hybrid, under favorable ecosystems in the six hubs of the CSISA-BD project area of Bangladesh.

Tolerance of salinity in fish ghers

The *gher* system is commonly used by farmers in the Khulna region to use land flooded in the monsoon to produce fish, prawns, and shrimp. The gher consists of a large pond in which fish, prawns, or shrimp are grown in the monsoon and rice in the dry season. Some of the ghers are saline and some not saline. Most farmers use hybrid rice on ghers as they tolerate some salinity and

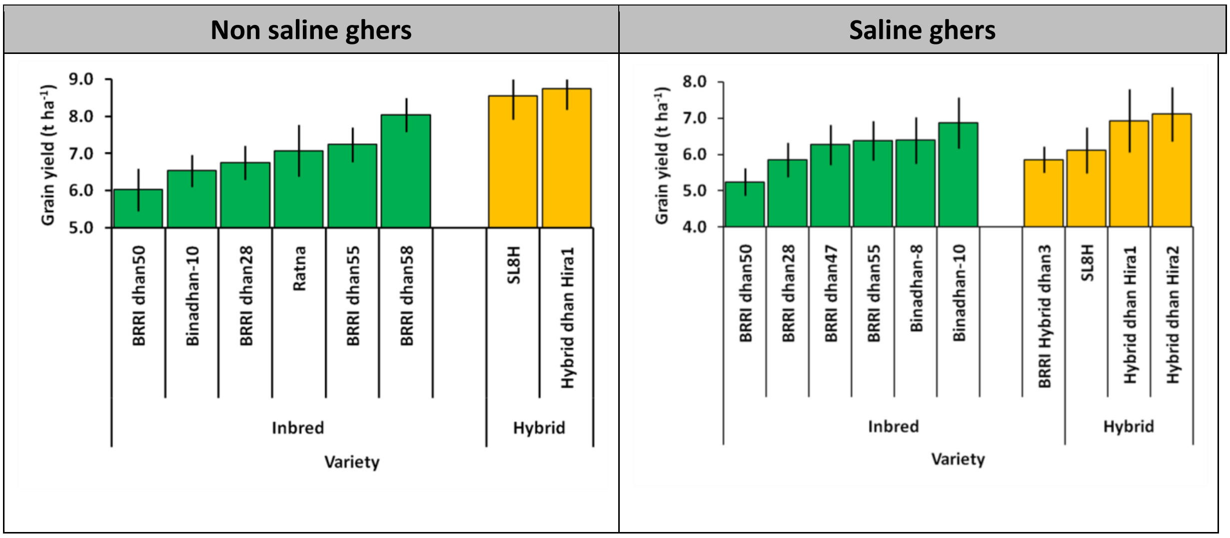

Fig. 22. Performance of boro rice varieties, inbreds (green bars) and hybrids (yellow bars), in nonsaline and saline ghers in Khulna hub.

produce well on the fish and feed residue that makes these gher soils very fertile. The hybrids, however, tend to have poor grain quality whereas self-pollinated varieties tend to have poor salinity tolerance but high grain quality. Self-pollinated varieties have recently been released that show good tolerance of salinity and have good grain quality. Trials comparing hybrids with self-pollinated varieties were conducted in the 2013-14 and 2014-15 boro seasons (Fig. 22).

On both saline and nonsaline ghers, the best self-pollinated varieties will yield as well as the best hybrids. Soil salinity data collected from the same trials showed that there is a limit to salinity tolerance and that the best self-pollinated saline-tolerant variety (Bina dhan10) may have more tolerance than hybrids of salinity above 10 dS/m but, at that level, grain yield drops to below 4 t/ha, the economic threshold for boro rice production (Fig. 23).

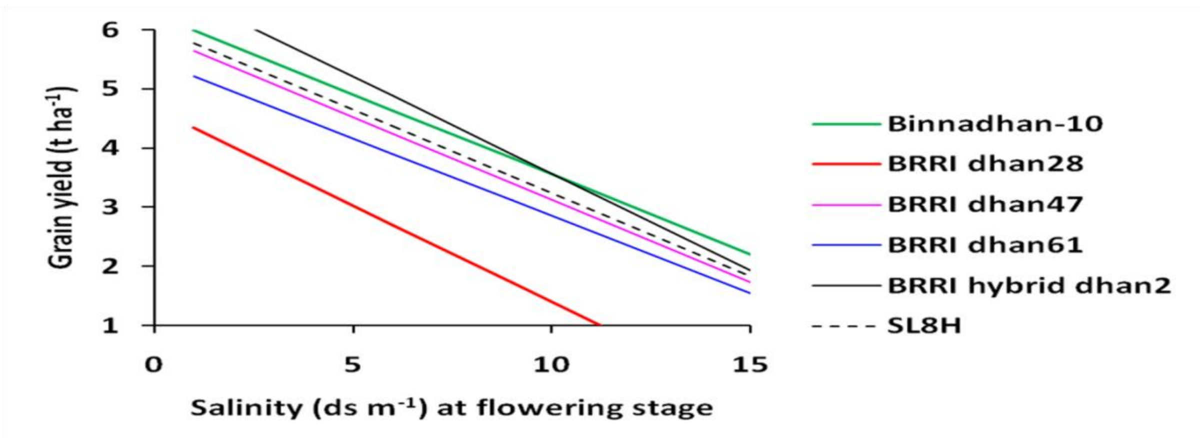

Fig. 23. Response of six boro rice varieties to four levels of salinity at flowering period in Khulna hub of the CSISA-BD project area of Bangladesh.

Basmati varieties compared with standard boro varieties

Farmers obtain a premium price of 15% to 30% more than the price offered for standard medium fine-grained varieties such as BRRI dhan28 and for the fine-grained aromatic basmati variety BRRI dhan50. Mean yield data from trials and demonstrations in which BRRI dhan50 was included were compared with data from a range of boro rice varieties included in the same trials and demonstrations.

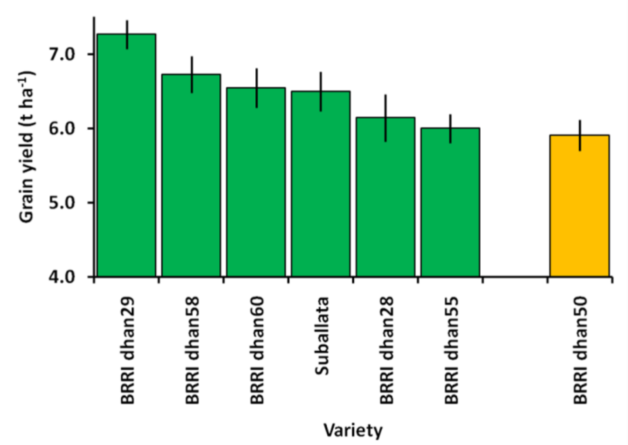

Fig. 24. Performance of the premium-quality rice BRRI dhan50 (yellow bar) compared with that of non-premium-quality varieties (green bars), during boro season in the five hubs of the CSISA-BD project area of Bangladesh.

The grain yield of BRRI dhan50 was 18% lower than that of BRRI dhan29, the best boro variety, but similar to that of other standard boro varieties such as BRRI dhan28 and BRRI dhan55 (Fig. 24). Despite this, because of its much higher price, BRRI dhan50 gave a gross margin that was 28% higher than that of BRRI dhan29.

The main market for fine-grained basmati-type rice is for long-grained bright white rice with some aroma. Parboiling of rice produces a dull-colored rice with little aroma. Many millers, however, do not have the equipment required to mill fine-grained rice that is not parboiled. This has made marketing the crop difficult. To some extent, this problem has been solved by some millers who have developed, with assistance from CSISA-BD, techniques that allow them to use their existing machines to mill BRRI dhan50. These milling processes, though, require more steps than those required for milling parboiled bold-grained rice and the amount of broken rice produced from milling BRRI dhan50 is still high. Improvement in milling equipment and techniques is required if small-scale "village" mills will be able to mill BRRI dhan50 profitably. Even so, the market for BRRI dhan50 (Banglamati) is growing rapidly and, partly due to the work CSISA-BD has done, the area under BRRI dhan50 in Jessore hub districts has risen from 11,000 ha to 44,000 ha since 2011.

Increasing Income through cropping system diversification

Increasing income by adding another crop to an existing system is possible if farmers adopt short-duration aman rice varieties and varieties or crops well adapted to growing on land with limited access to dry-season irrigation or with salinity problems. These systems were demonstrated in 20,277 demonstrations by CSISA-BD. As a measure of the success of this approach, 33% of the farmers working with the project had adopted a second or third crop and 33% had adopted short-duration aman varieties.

Oil seed mustard in rice-rice cropping systems

It is estimated that 51% of the cropped land in Bangladesh is planted to a two rice crops a year system: aman rice followed by boro rice. The cropping system diagram in Figure 25 shows how replacing long-duration aman varieties with short-duration varieties increases the period between the aman rice harvest and the transplanting of boro rice from 60 to 90 days. This is just sufficient to allow mustard varieties with high yield potential such as BARI Sharisha 14 and 15 to be grown between these crops.

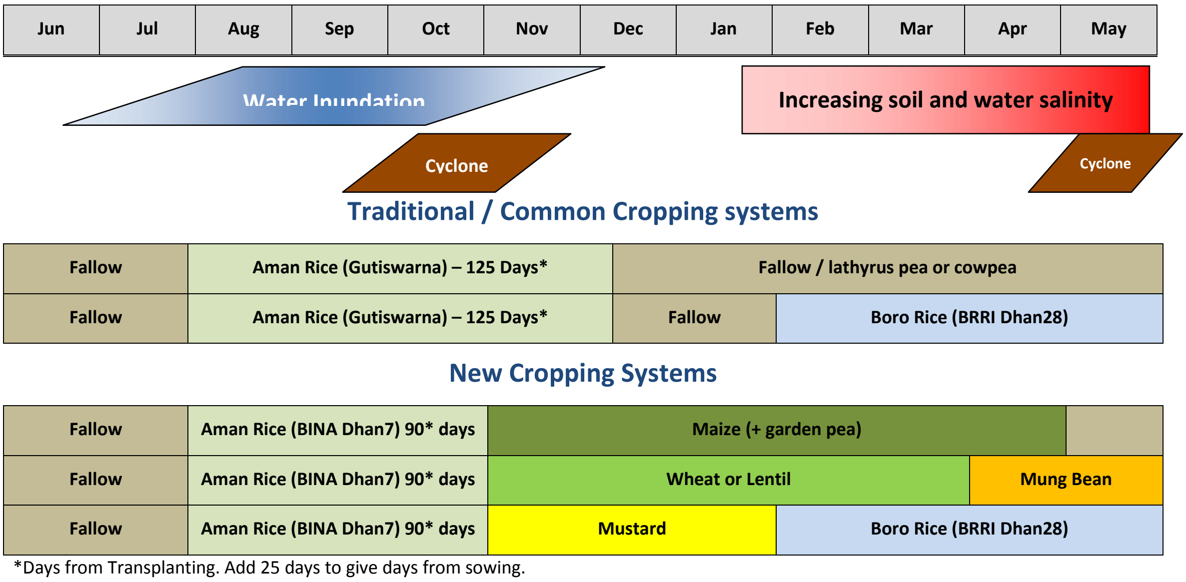

Fig. 25. Diagram showing traditional and new cropping systems.

The project conducted a total of 9,149 demonstrations of rice-mustard-rice systems, resulting in 33% of the farmers adopting this system. Data from the 2013-14 aman, rabi, and boro seasons showed that gross margins for farmers practicing a rice-mustard-rice system were from $441 to $589/ha greater than of those practicing a rice-rice cropping system (Fig. 26). Much of the mustard produced in these demonstrations was crushed to produce oil for home consumption, thus increasing the amount of this high-energy food in diets. This is of particular value for children, who often do not have sufficient high-energy foods in their diets.

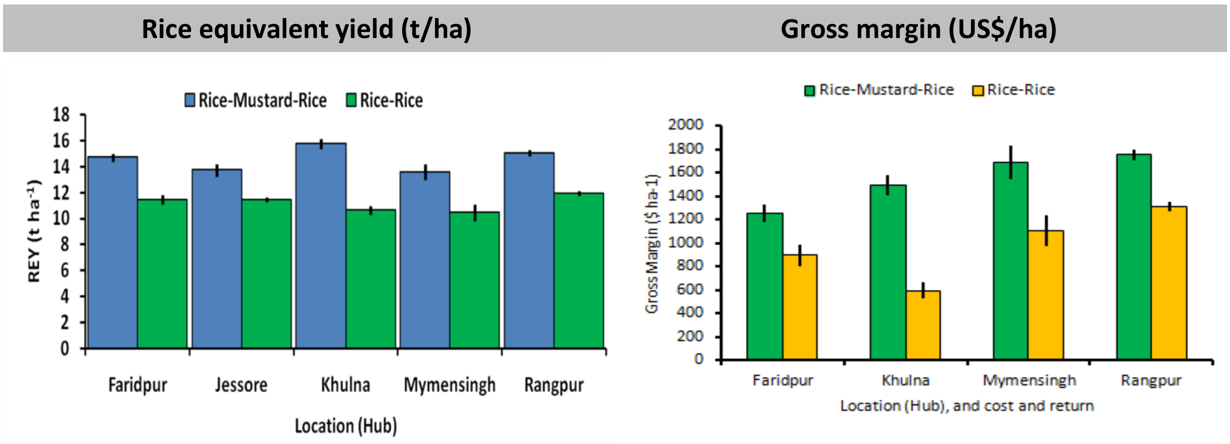

Fig. 26. Increasing incomes by replacing boro rice with grain legume crops.

In areas having a limited supply of dry-season irrigation water, growing grain legume crops or a combination of mustard followed by mung can be a very profitable way of using this land. An example of this can be shown from demonstrations in Jessore, where farmers replaced long-duration aman rice variety BR11 or Gutiswarma with short-duration BINA dhan7 and planted lentil followed by mungbean instead of boro rice. The cost of growing this system was $199/ha less and produced a gross margin that was $877/ha more than that of a rice-rice system (Fig. 27).

PTOS-planted mungbean	Total variable costs/gross return/gross margin

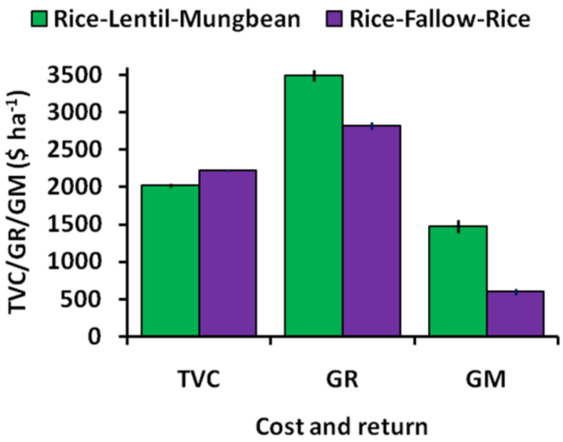

Fig. 27. Increasing Incomes by using dry-season fallow.

Sunflower and saline soils

In coastal Bangladesh, where soil and groundwater salinity is high in the dry season, producing crops that are not tolerant of salinity such as mustard is not possible. On moderately saline soils, sesame can be grown but the grain yield is low and the crop is frequently damaged by early monsoon rains. The project experimented with sunflower as a salt-tolerant alternative to mustard and sesame and as a crop that could use land left fallow in the dry season because of soil salinity. Between the 2011-12 and 2014-15 seasons, CSISA-BD developed low-cost planting methods such as dibbling that allowed farmers to plant into wet soils soon after the aman rice harvest and avoid rising salinity in March and April. Trials established the optimal planting date, plant spacing, and fertilizer rates and identified the sunflower hybrid Hysun 33 as the best-performing sunflower hybrid. In this period, the project conducted 2,112 demonstrations and established sunflower as a commercial crop. Data collected from some of these demonstrations conclusively showed that farmers obtained an income that was 400% higher by adopting a high-yielding modern aman rice variety followed by sunflower compared with the current system of a local variety flowed by a dry-season "fallow" (Fig. 28).

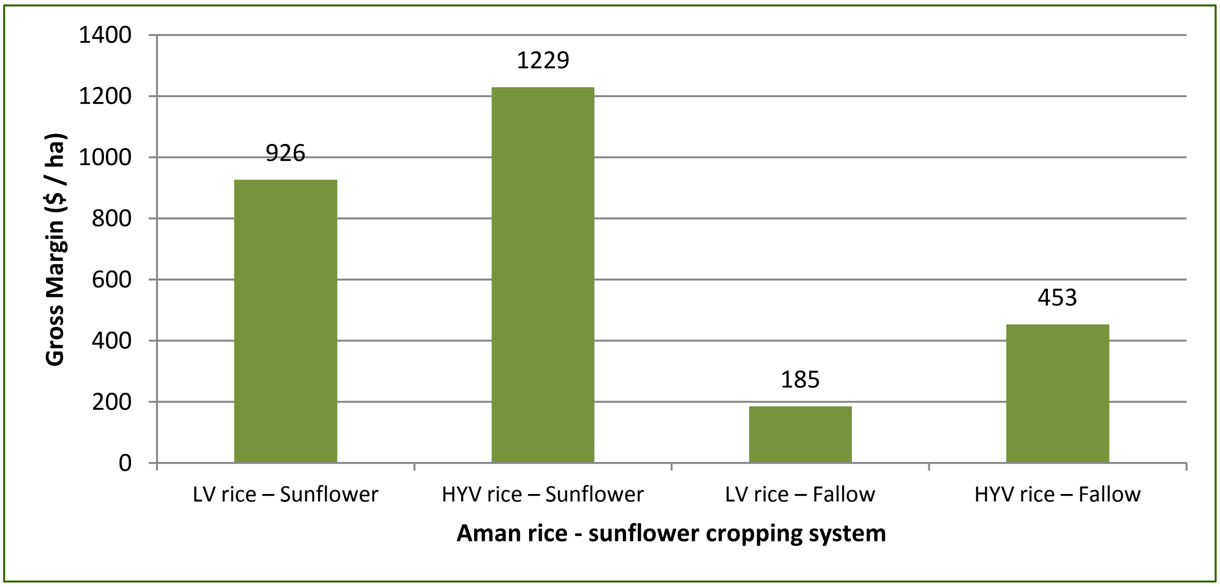

Fig. 28. Gross margin of sunflower with an aman rice variety.

Two methods of planting sunflower were used in demonstrations: dibbling seed directly into rice stubble without cultivation and sowing into land cultivated after at least two passes with a power tiller. Grain yield from 150 demonstrations in which the crop was dibble planted and 90 demonstrations in which it was planted after power-tiller land preparation was almost the same but, because of the higher cost of land preparation when a power tiller is used, the gross margin from dibbled plots was 19% higher than that from tilled plots (Fig. 29).

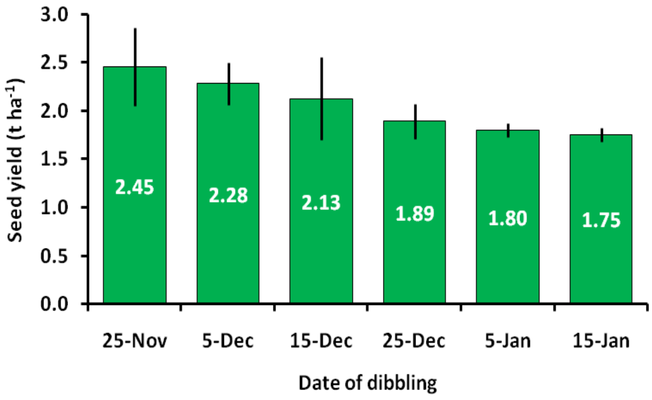

Fig. 29. Grain yield of sunflower at six times of dibbling in Khulna hub during 2013-14 and 2014-15. Vertical bars are 95% confidence intervals.

Delaying planting reduces grain yield by 14 kg for each day planting is delayed (Fig. 30). This means that a crop planted on 25 December would produce a crop worth $200/ha less than a crop sown on 25 November.

Delayed planting exposes sunflower to rising heat, drought, risk of damage by early monsoon rains, and salinity. Soil salinity at seeding is positively correlated with soil salinity at harvest and high soil salinity at planting results in much reduced yield at harvest.

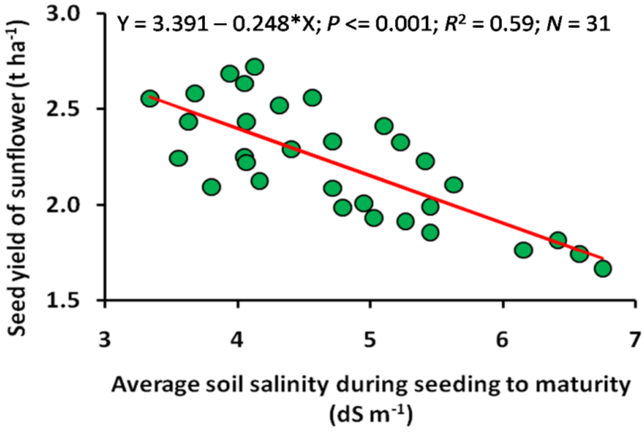

Fig. 30. Sunflower seed yield with soil salinity.

Sesame on saline soils

Sesame also has some tolerance of salinity and for this reason is grown by farmers as a catch crop after the aman rice harvest. Demonstrations conducted in Khulna showed that planting sesame after a high-yielding aman variety increased gross margins for farmers by only $68/ha compared with the $1,044 gained when sunflower was grown after a high-yielding aman variety that replaced the local variety.

3.1.2 Agriculture (wheat and maize)

Conversion of fallow charlands to green croplands in Mymensingh hub

CSISA-CIMMYT staff in Mymensingh hub used secondary information, as well as field visits and FGDs, to identify approximately 75 almost-fallow charland areas where only one crop (mostly blackgram) was being grown. Since the gross margin of blackgram is very low (less than $130/ha), ample potential existed for increasing income by getting farmers to adopt new technologies and alternative crops, especially maize and wheat. Therefore, in consultation with farmers, government and NGO personnel, and private-sector representatives, suitable technologies were identified for inclusion in on-farm demonstrations in these chars beginning in 2011-12. These demonstrations featured new wheat varieties for grain and seed, sole and intercropped hybrid maize, jute as a third crop, conservation agriculture (CA), resource-conserving machinery, and best-bet management practices.

In 2011-12, 674 charland farmers were trained, with at least 500 growing maize and/or wheat for the first time. In the following year (Project Year 3), these continued growing maize/wheat on a total of 124 ha and achieved mean yields of 7.48 t/ha (for maize) and 4.06 t/ha (for wheat), both of which were above the respective national averages. More importantly, these farmers obtained (on average) $206 and $111 in net revenue per household from maize and wheat, respectively. Figure 31 shows the expansion of maize and wheat following the initial year (2011-12) when CSISA-BD began its intervention on the charland.

Fig. 31. Initial intervention by CSISA-BD (left); the same location in subsequent years (right).

This provides an indication, for the period 2012-13 to 2014-15, of the impact of CSISA on the intensification of charland in Mymensingh hub. From survey data, it is estimated that more than 4,200 farmers (both direct and indirect) began cultivating either maize or wheat on nearly 1,100 hectares of charland. The weighted average yields across these three production years is an impressive 8.10 t/ha for maize and a very respectable 3.70 t/ha for wheat. Average net revenues are $263 and $73 per household for maize and wheat, respectively.

Note that the number of farmers and total area are lower-bound projections and are likely to be understated by a fair amount, for three reasons. First, the surveys (because of random sample selection) do not always include every village in which the project worked. Second, the values in Table 12 for direct beneficiaries are aggregated from data collected from cohorts (e.g., farmers trained in Project Year 2), and do not include follow-up data from successive years for a given cohort. Third, since data on indirect (nonbeneficiary) farmers for the charland areas are very limited, the extrapolation of scale-out adoption was done using conservative assumptions. Furthermore, these estimates mainly project indirect adoption in the same villages in which CSISA-BD worked; they account for little, if any, wider scale adoption that exists.

Table 12. Adoption of maize/wheat as new crops by Mymensingh charland farmers (2012-15).

Variable	CSISA-BD (direct beneficiaries)			Indirect	All farmers
	Maize (M)	Wheat (W)	M + W	M + W	M + W
Total no. of farmers	736	926	1,662	2,569	4,231
Total area under M/W	183	253	436	657	1,093
Ave. yield (t/ha)	8.10	3.70	n/a	n/d	–
Ave. net revenue ($/HH)	263	73	336*	n/d	–
Ave. gross margin ($/ha)	1,104	353	1,457*	n/d	–

** If an average farmer grew both maize and wheat each on 0.25-ha plots during the rabi season.*

In addition to maize and wheat as new crops, CSISA-BD introduced the intercropping of leafy vegetables (e.g., red amaranth, spinach, coriander) with maize. Not only can farmers double their gross margin with maize intercropping, this sustainable intensification strategy reduces weeds and irrigation while also increasing household nutritional security and women's involvement in agriculture. In many villages, farmers prefer intercropping instead of sole maize. In many other villages, farmers have intensified cropping by adopting jute cultivation after growing early maize or wheat.

The project also demonstrated CA machinery that sows seed while reducing tillage intensity, and showed how reapers and maize shellers have incredible efficiency with respect to labor and costs compared with conventional practices. New BARI wheat varieties were promoted intensively in demonstrations and adaptive on-farm trials, and farmers were trained on wheat seed production and preservation to help improve the supply of these varieties. Linkage events such as cross visits, field days, etc., brought together farmers, NGOs, private-sector actors, and government officers in order to improve marketing opportunities as well as facilitate faster dissemination of technologies. Some farmers have developed businesses by becoming maize seed and input dealers, and others are now machinery service providers. Large income increases from CSISA-CIMMYT interventions have motivated charland farmers to adopt the new technologies and management practices described above. Some villages are now fully covered by new technologies (those that received interventions in the early years of CSISA-BD) and others are partially covered, but still need two or three more years to achieve wider scale-out.

Improved wheat management in southern Bangladesh

Rising wheat demand in South Asia necessitates crop intensification to meet food security needs. Increased grain output can be achieved by bridging yield gaps on currently farmed land or by expanding cultivation to new land, although the latter entails environmental trade-offs and offers limited potential as most of South Asia's arable land is already cropped. Alternatively, opportunities for boosting production may exist where farmers can transition from single to double cropping and forgo dry-season fallows, which are estimated at 240,000 to 800,000 ha in southern Bangladesh, and establish a crop such as wheat following monsoon-season rice.

From 2011 to 2013, CSISA-BD worked with 64 farmers who grew wheat for the first time on formerly fallow land in eight production environments in Khulna and Satkhira districts. Through on-farm trials, yield response was examined for three genotypes, Bari Gom 25 and Bari Gom 27 (with salinity- and heat-tolerance traits) and Bari Gom 21 (local check), across a gradient of sowing dates grouped as "early" (sown before 15 December) and "late" (after 15 December). Additionally, the following fertilizer rates were tested: 0, 100, and 133 kg nitrogen (N)/ha for early-sowing groups, and 0, 67, and 100 kg N/ha for late-sowing groups.

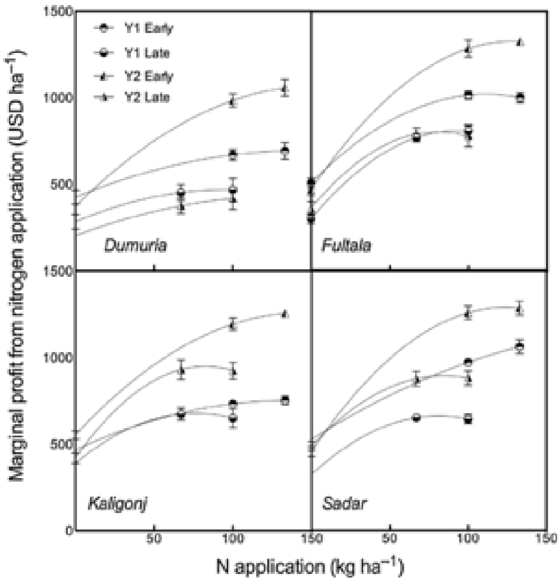

Fig. 32. Marginal profit from nitrogen under early and late planting.

Across environments and genotypes, yield ranged from 2.11 to 4.77 t/ha (mean: 3.90 t/ha) under early sowing and from 0.83 to 4.27 t/ha (mean: 2.74 t/ha) under late sowing. Despite putative stress-tolerance traits in two of the three entries, no genotypic yield differences were found under early sowing, although small differences (<0.19 t/ha) were observed with late sowing. Wheat performance varied with environment: the lowest yields were found where early sowing was delayed and soil salinity was elevated. Small but significant yield differences (0.22 t/ha) were found between 100 and 133 kg N/ha for the early-sowing group, though no difference was found between 67 and 100 kg N/ha for the late-sowing group.

The marginal economic value of N application followed similar trends, indicating that rates of at most 100 and 67 kg N/ha are favorable for sowing before or after 15 December (Fig. 32). This clearly indicates that national recommendations for nitrogen fertilization of wheat can and should be decreased by 33% (to 67 kg N/ha) without any decrease in yield or profitability for late-sowing farmers in Khulna and Satkhira. Results confirm that farmers interested in graduating from single aman (monsoon) rice to double cropping can successfully grow wheat by replacing dry-season fallows in Bangladesh's coastal environments, with potentially large contributions to national cereal production and food security.

Hybrid maize participatory adaptive trials: southern Bangladesh and Mymensingh charland

In early 2011, scientists from three CGIAR centers, representing different disciplines, conducted an exploratory visit to understand the biophysical and socioeconomic environment of the project locations in the south (Barisal, Khulna, and Jessore). The possibility of promoting maize was clearly identified as a highly potential intervention, which was also confirmed by the several focus group discussions and interactions with research and development professionals. Since maize was a relatively new crop to most farmers in these areas, a multi-location PVS trial on maize was designed to understand the suitability/adaptability of hybrids in southern Bangladesh.

Initiated in the 2011-12 rabi season, the PVS consisted of three BARI Maize Hybrid (BHM) varieties, four commercial hybrids, and a local hybrid (Table 13). Based on the trial results and farmers' preferences from 2011 to 2012, a few of these hybrids were further evaluated in the following year together with new varieties obtained from CIMMYT headquarters (Mexico) and the CIMMYT office in Zimbabwe. Thus, in 2012-13, eight hybrids were tested on four farms in each of three hub locations (Khulna, Mymensingh, and Barisal). One of the varieties tested was BARI Hybrid Maize 9 (BHM 9), two were commercial hybrids (999 Super and NK 40), and five were quality protein maize (QPM) varieties: three yellow-grained varieties from Mexico (Mex) and two white-grained varieties from Zimbabwe (Zim). The rationale for working with QPM was to promote maize with enhanced nutritional capacity for poultry and fish feed, as well as for human consumption (particularly white-grained maize), specifically because of its lysine and tryptophan content. QPM contains twice the amount of lysine and tryptophan as normal maize varieties, and these two essential amino acids are vital for children and pregnant women, and are also good for monogastric animals (e.g., pigs, poultry). Finally, three Pioneer varieties (P3502, P3491, P3396) were added to the 2013-14 evaluation. Grain yield results appear in Table 13.

Table 13. Performance of maize hybrids tested in participatory adaptive trials (2011-14).

2011-12[†]		2012-13[†]		2013-14[†]	
Hybrids	**Yield (t/ha)**	**Hybrids**	**Yield (t/ha)**	**Hybrids**	**Yield (t/ha)**
BHM 9	8.3	BHM 9	7.32	BHM 9	6.85
NK40	10.1	NK 40	7.94	NK40	7.52
BHM 3	7.5	999 Super	8.24	999 Super	7.45
BHM 5	8.0	Mex 1	7.89	Mex 1	7.55
Pinacle	9.5	Zim 1	7.29	Zim 1	6.61
CP 808	10.1	Mex 2	7.14	Elite	7.72
Local[††]	9.6	Mex 3	7.35	P3502	7.75

900M	10.0	Zim 2	6.72	P3491	7.26
				P3396	7.84
F-test (var.)	*P* = 0.001		*P* = 0.001		*P* = 0.001
LSD	0.704		0.421		0.318
CV (%)	12.3		6.9		5.3
Mean	9.14		7.49		7.39

† Locations: Faridpur, Khulna, Mymensingh, and Jessore (2012); Mymensingh, Khulna, and Barisal (2013); Faridpur, Khulna, and Barisal (2014); four replications (farms) in each location.

†† Each location used a locally popular hybrid variety (e.g., Miracle) to serve as a control.

In 2011-12, NK 40 (10.1 t/ha), CP808 (10.1 t/ha), and 900M (10 t/ha) were the top-performing hybrids in terms of yield, with a statistically significant (*P* = 0.001) difference in mean yield over the BARI hybrids. In the following year (2012-13), 999 Super (8.24 t/ha), NK 40 (7.94 t/ha), and Mex 1 (7.89 t/ha) were the highest-yielding varieties, irrespective of location. In terms of variety × location, 999 Super was the highest-yielding variety in Mymensingh (9.83 t/ha) and Mex 1 (7.43 t/ha) was the highest in Khulna. In terms of location, Mymensingh had the overall highest yield (9.17 t/ha), followed by Barisal (6.92 t/ha). All hybrids matured between 138 days (Zim 2) and 142 days (BHM 9) after sowing (data not presented).

In 2013-14, the number of hybrids evaluated varied by hub (six in Faridpur, seven in Khulna, and nine in Barisal). The first six hybrids shown in Table 13 were common to these three locations, and were selected based on their performance in previous years. Of the nine hybrids assessed, two were QPM maize (one yellow-grained and one white-grained) tested on four farms each across the hubs. Varietal yield differences were statistically significant (*P* = 0.001) irrespective of location, with yield ranging between 6.61 (Zim 1) and 7.84 t/ha (Pioneer P3396). Additional analysis (not shown) indicated an effect of location on yield performance, with the varieties evaluated in Faridpur hub yielding the highest (9.07 t/ha) compared with Barisal (6.54 t/ha) and Khulna (6.55 t/ha). Interaction effects between the hybrids and location were also found to be statistically significant, indicating that the performance of the tested hybrids across different locations was not consistent (results not shown).

A separate trial set was examined in Mymensingh hub (four farmers' fields) in 2013-14, consisting of six hybrids (Titan, Pioneer 30D97, Hira 101, Fortune, Elite, and Miracle). Statistical analysis for grain yield was performed in order to test whether there was genotypic difference. In Mymensingh, the mean grain yield (12.7 t/ha) was higher than in other locations in the south. Of these six, Elite (14.27 t/ha) was observed to be the highest yielding, followed by Titan (13.57 t/ha) and then Miracle (13.22 t/ha), although the differences were statistically insignificant among these three hybrids.

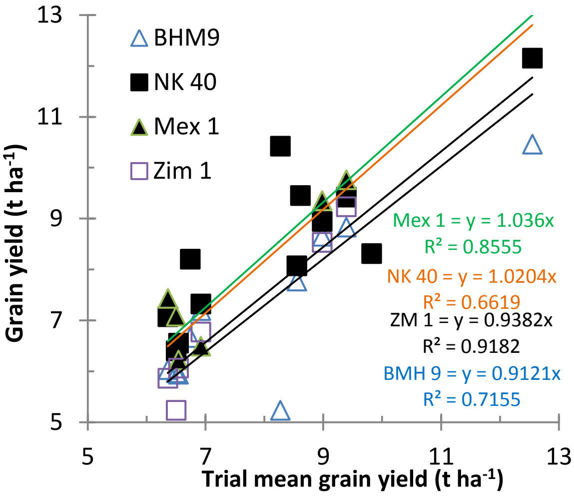

Fig. 33. Grain yields of four hybrids vs the mean grain yield of all hybrids tested in on-farm PVS trials during 2012-14.

Genotype by environment (G × E) interactions for selected hybrids are explored in Figure 33 by regressing their mean grain yield against the mean of all hybrids tested in CSISA-BD maize PVS trials from 2012 to 2014. The mean of all hybrids tested from 2012 to 2014 is referred to as the Environmental Index (the *x* axis in Fig. 33). The regression coefficients of each of the four hybrids performed well, as indicated by the R^2 values being well above 0.6, and each followed a similar trend under all environments tested (i.e., both good and poor). This suggests that southern Bangladesh is indeed a suitable area for cultivating maize. Hence, CSISA's efforts to promote maize for system intensification in the south are supported by PVS data, and these results were provided to stakeholders (including seed traders) in different locations so as to promote the right hybrids for a given location.

Evaluation of new wheat genotypes under different tillage methods, 2014-15

Proper crop residue management combined with different minimum tillage systems (e.g., raised beds or strip tillage) is the key component of new farming practices that can increase the profitability of smallholder farmers in Bangladesh. This is the essence of conservation agriculture (CA), a sustainable crop management practice being tested and promoted by CSISA-BD.

In 2014-15, a multi-location trial was established to evaluate new wheat varieties under different tillage systems in order to assess the biophysical and socioeconomic variability resulting from such interaction of technologies. Six wheat genotypes (Bari Gom 26, Bari Gom 27, Bari Gom 28, Bari Gom 29, Bari Gom 30, and BAW 1170) were examined under three tillage methods (traditional = TT, bed planting = BP, strip tillage = ST) in four locations (Rangpur, WRC Dinajpur, Jamalpur, and Faridpur), replicated three times in each location (one farm served as one replication). Both qualitative (farmers' perceptions) and quantitative data were collected.

Farmers preferred strip-tilled wheat, followed by bed planting, irrespective of location. Combined analysis of grain yield showed a significant varietal effect (P = 0.001), which is not surprising. Irrespective of tillage methods, newly released wheat varieties (BARI Gom 28, 29, and 30) produced significantly higher grain yield (4.24 to 4.33 t/ha) than BAW 1170 (3.87 t/ha), a pipeline genotype that matures significantly earlier (data not shown). Neither tillage methods nor tillage × variety interaction produced significant effects (Table 14), indicating that the wheat varieties tested yielded the same (on average) across different tillage methods. Location and location × variety both had a significant effect on grain yield. This indicates that some locations are better than others, and that genotypic performance is not consistent but rather varies by location. In this case, the Faridpur and Mymensingh locations were superior in terms of yield.

Table 14. Wheat genotype grain yield (t/ha) under different tillage systems across locations (2014-15).

Genotype	Tillage methods			Mean
	TT	BP	ST	
BARI Gom 26	3.94	4.21	4.19	4.11 b
BARI Gom 27	3.89	4.01	3.96	3.96 c
BARI Gom 28	4.04	4.27	4.41	4.24 a
BARI Gom 29	4.20	4.41	4.37	4.33 a
BARI Gom 30	4.08	4.48	4.42	4.33 a
BAW 1170	3.71	3.90	4.01	3.87 c
Mean	3.98	4.22	4.23	4.14

Note: $LSD_{0.05}$: variety = 0.109; location = 0.101, interaction (V × L) = 0.218 (interaction data not presented). Grain yield followed by the same letter is similar statistically.

Farmers preferred BARI Gom30 for high yield and BAW 1170 for its earlier maturation, which was approximately 7 days earlier than the other varieties (average across locations). Farmers preferred both bed-planted and strip-tilled wheat, irrespective of varieties, compared with conventional tillage methods. This suggests that, although the results were not statistically significant for tillage methods, there was good agreement between farmers' perceptions based on field observations and harvested grain yield. These interpretations are based on one year of data; thus, there is a need for repeating this experiment for at least another year to verify these results.

SUCCESS STORY

Intercropping vegetables with maize improves women's lives

Through CSISA-BD, CIMMYT has introduced new production technologies in maize to women farmers in Jessore.

Photo: CIMMYT JESSORE

"Monowara was awarded the Begum Rokeya Medal and recognized as the best entrepreneur in 2013 by Hunger Free World, Bangladesh."

Dr. Abdul Momin, CSISA-CIMMYT Cropping Systems Agronomist, Jessore

Monowara Begum is a farmer in Mostabapur Village in Jhenaidah District. Like others in her village, her family struggled to make a living from producing only one rice crop a year. However, in 2013, the Cereal Systems Initiative for South Asia (CS ISA-BD) project funded by USAID started working in her area to introduce maize cultivation using conservation agriculture methods—and the life of Monowara, as well as the lives of other farmers in the area, changed for good.

In October 2013, Monowara participated in a one-day training session on intercropping different economic crops with maize. After this training, she and her husband wanted to learn more and they participated in several training activities on best management practices for maize/wheat cultivation. Her son also participated in CIMMYT training on farming with machinery for local service providers. Since then, she has been actively involved in growing maize and vegetables, and also participated in several agriculture and women's fairs. She was the pioneer in growing hybrid maize in the area, with more than 33 decimals of land (which she leased) under cultivation. She harvested 1,380 kg of maize with a value of BDT 23,805 (the cost was around BDT 7,500).

Because of her enthusiasm, Monowara was chosen to be the leader of a women's group in her village, formed with help from CIMMYT: the Golup Mohila Samity (Rose Women's Society). Women from this group started producing maize with garden pea and bush bean as intercrops on only 5 decimals of land each, which has earned each woman a return of BDT 15,000 (US$188) from 175 kg of garden pea and 200 kg of maize. With the accumulation of this money from all members, Monowara helped her group to buy a power tiller. In addition, after CIMMYT provided this group with a seeder for promotional demo seeding, on which the group seeded more than 2 ha of land (earning BDT 4,600), the group decided to buy a seeder, for which they have made a down payment, and the rest will be paid from the revenues earned from seeding/tilling farmers' lands as a service provider.

Monowara and her group now produce vegetables using organic compost in their homestead gardens and sell them in a local market. She is a successful entrepreneur and dreams of being able to continue supporting her village members to reach for a better life and happiness.

3.1.3 Aquaculture

Aquaculture is expanding faster than any other area of agriculture in Bangladesh. Nevertheless, there is still huge untapped potential to make even greater contributions to food and nutrition security and to increase and diversify the incomes of poor rural households. WorldFish endeavors under CSISA-BD therefore centered around major outcomes that are also related to USAID intermediate results and the overall project goals: (i) increased farming household income, food, and nutrition security; and (ii) increased livelihood alternatives. To attain these outcomes, interventions are primarily aimed at disseminating improved varieties and technologies for farm producers. The aim is to improve on-farm productivity of prawn and shrimp in ghers (enclosed rice fields with high dikes), commercial and homestead pond systems with vegetables grown on the dikes and homestead area. WorldFish also works to develop technology and promote culture of nutrient-rich small fish such as “mola” with traditional carp polyculture and vegetables, including orange sweet potato. Establishment of participatory farmers’ trials (PFTs) and adaptive research trials (ARTs) along with need-based training and regular technical assistance have been proven the most effective approach to enhancing adoption and fine-tuning the new technologies and varieties. This allows farmers to build knowledge, learn in hand and enhance skill, build trust, and develop confidence on the technology. Thus, farmers feel encouraged to adopt and gain confidence in their investment. During the five-year period, CSISA-BD disseminated improved aquaculture technologies with horticulture to 27,495 direct project beneficiary farming households, of which 9,672 were women farmers, and 1,107 PFTs were established with 383.33 ha in six hubs. In principle, a PFT is established in a village where a group of 25 farmers receives training on a particular technology. In the true sense, a PFT is established to use as a field learning center for the community members. Comparatively young and enthusiastic farmers who are supportive of neighbors are selected as PFT farmers (lead farmers). This PFT offers to the community members season-long involvement and active learning of every step of the technology around the production season. The learning is further enhanced during coaching sessions and refresher training in the following year to discuss, analyze, and solve the progress, outcomes, and issues. An organized stakeholders’ linkage meeting after the end of the production of PFTs to share the results and experiences also enhances dissemination and adoption of the successful technologies and varieties. The next section describes the results of PFTs and adaptive research from Year 1 to Year 5.

Pond-based aquaculture

A pond is the mainstay of aquaculture in Bangladesh, which contributes about 86% of total aquaculture production, and 58% of culture area is being used (DoF 2012). Traditionally, each and every house has at least one pond at the village level in Bangladesh and pond culture is commonly practiced in nearly every district of the country. Estimates suggest that 4.27 million households in Bangladesh own a pond and these account for 29.5% of Bangladeshi aquaculture (Belton and Azad 2012). Although pond culture was only homestead based until the mid-1990s, it became a commercial enterprise due to technological innovation. In addition, fish production is a more profitable practice than many other forms of agriculture. In order to meet the domestic fish demand for the growing population, the government of Bangladesh and different NGOs have taken different initiatives to increase fish production through pond aquaculture. These initiatives contributed positively to the expansion of aquaculture area and productivity. On the other hand, because of an overall high profitability in fish farming compared with rice, farmers are more interested in culture fish in some parts of Bangladesh. In 2010, WorldFish established an initiative for increasing pond-fish productivity and income through the CSISA-BD project for both homestead-based and commercial pond aquaculture.

Homestead-based pond aquaculture and horticulture

A large number of rural households have homestead area that includes ponds and ditches. These ponds may vary from 5 to 20 decimals in area and they are traditionally farmed by the owners or sometimes remain fallow due to poor knowledge about improved aquaculture management. Homestead aquaculture basically means that these typically fallow ponds are brought under fish farming as an enterprise. These ponds actually have potential to rear small indigenous fish such as mola, darkina, etc., along with carp and tilapia. As part of the CSISA-BD objective, WorldFish has been working with "homestead aquaculture-horticulture technology" to improve the nutritional status and income of small and marginal farmers by increasing the production of fish and vegetables. Because homestead-based activities are considered best suited for the women of rural Bangladesh and most of them lack alternative livelihood options and productive activities, CSISA-BD and WorldFish initiated homestead pond aquaculture and horticulture by engaging the women of the participating families. The poor farmers use their limited homestead land and pond dikes to cultivate vegetables and produce fish for consumption and income by selling additional produce. These farmers require mainly appropriate culture technology and quality inputs (seed, feed, etc.) and linkage with the stakeholders and market to boost their production and income. From 2010 to 2015, CSISA-BD and WorldFish trained 4,904 women farmers and established 129 PFTs for increasing productivity, consumption, and income.

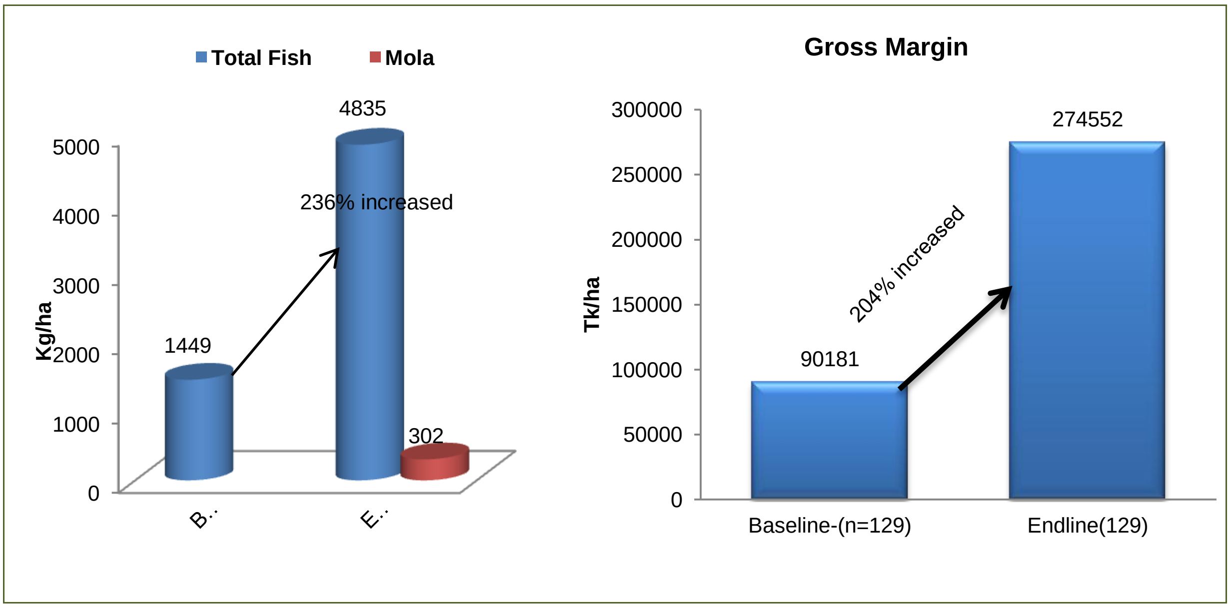

Fig. 34. Homestead pond aquaculture: productivity and gross margin.

Results from the 129 PFTs (Fig. 34) show that the fish productivity of homestead pond aquaculture increased by 236% in the endline compared with the baseline. Average total fish production was 1,449 kg/ha in the baseline and this increased to 4,835 kg/ha in the endline. Besides total fish production, small indigenous fish production (mola) was also adopted by the project households and mola productivity was 302 kg/ha in the endline (and zero in the baseline). Mola is an important small indigenous nutritious fish that is very rich in vitamin A, iron, zinc, and other micronutrients. It is easy to culture and harvest and it has self-regenerating capacity within pond culture.

In addition to fish culture, vitamin-A-rich orange sweet potato (OSP) and different other vegetables were promoted to cultivate on the dike homestead area. This also has influence on family consumption and additional income. According to information from the 129 farming households, per household average pond size is 13.49 decimals, pond dike area 3.50 decimals, and OSP area 0.65 decimal. Based on the results of 129 PFTs (Fig. 35), average production of fish was 261 kg per household whereas mola was 15 kg per household. Households also produced 181 kg of vegetables from the pond dike and 48 kg of OSP as well. From the homestead production, 21% of total fish, 47% of mola fish, 41% of vegetables, and 54% of OSP were used for family consumption (average family size is 4.82).

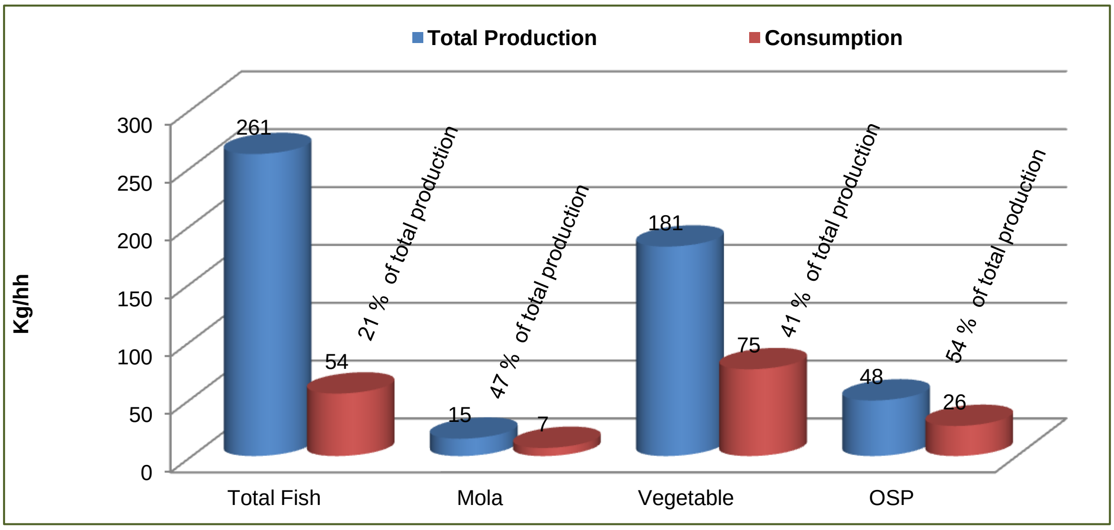

Fig. 35. Production and consumption of fish, vegetables, and OSP per household.

Commercial aquaculture in ponds

Commercial aquaculture started a few decades ago in Bangladesh. It has two main characteristics: first, the use of modern technologies and quality inputs (seed, feed, etc.), which means stocking more fingerlings per square meter, feeding with commercially produced feed, and using other inputs in appropriate and scientific ways; second, the farmer's main purpose of commercial aquaculture is to sell the product in the market with the highest possible margin. Generally, a pond or gher is used for commercial aquaculture. Aquaculture in Bangladesh is dominated by the polyculture system in which more than one species of fish is raised at the same time in a grow-out system such as a pond. Carp fish polyculture is the oldest system and is still widely practiced in Bangladesh. In the carp polyculture system, farmers commonly use six to seven carp species, including Indian major carp such as Catla (*Catla catla*), Ruhu (*Labeo rohita*), Mrigal (*Cirrhina mrigala*), etc., with some exotic, especially Chinese, carp species such as Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idella*), Common carp (*Cyprinuscarpio*), etc., and other minor carp species that include Thai sorputi (*Barbonymus gonionotus*), Bata (*Labeo bata*), etc. Traditional carp polyculture takes at least seven months to get a return, which seems to be longer than other forms of aquaculture practices. Farmers were struggling to harness full production potential because of the seasonal nature of the ponds; hence, the lower water depth and low temperature during some part of the culture period from December to March. As a result, fish production did not reach its full potential due to the lack of suitable species combinations, especially with fast-growing species. Considering the context, CSISA-BD and WorldFish introduced fast-growing Genetically Improved Farmed Tilapia (GIFT), Shingi (*Heteropneustes fossilis*), and Thai pangas (*Pangasius sutchi*) into the carp polyculture system, thus aiming to diversify and achieve returns within a short duration.

From 2010 to 2015, CSISA-BD and WorldFish trained 13,989 farmers; nearly 19% participated directly in the project-imparted training during the last five years. The project established participatory trials with farmers to test and fine-tune the technology and as a result boost the confidence of farmers about the improved and new polyculture system. We compared the results of the improved technologies disseminated during the last three years, including improved carp polyculture with tilapia in ponds (n = 277), improved carp polyculture with Shingi (n = 46), and improved farming of Thai pangas with tilapia (n = 80). In these three culture systems, fish production increased 2- to 5-fold compared with the baseline. Results from the PFTs (Fig. 36) show that, after using improved technology, the production of carp polyculture increased 94% when including tilapia (in the endline compared with the baseline). There was a 108% increase for carp-Shingi polyculture and a robust increase was observed from pangas-tilapia polyculture (350% in the endline compared with the baseline).

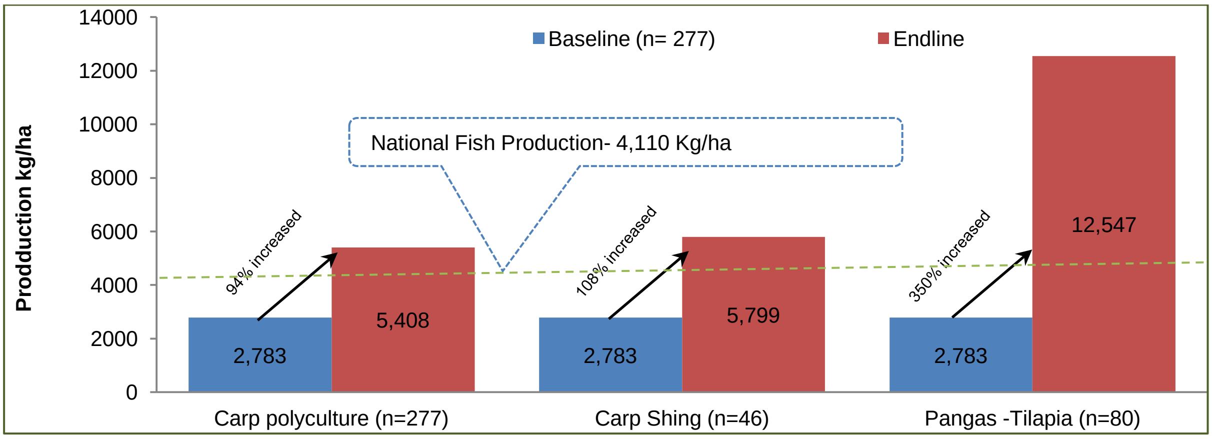

Fig. 36. Productivity: commercial pond aquaculture technology.

According to Figure 37, the gross margin was highest for carp-Shingi polyculture, was slightly lower for pangas-tilapia, and was lowest for overall carp polyculture. But, the benefit-cost ratio (BCR) of carp polyculture was the highest (2.41), was slightly lower (2.17) for carp-Shingi, and was lowest (1.92) for pangas-tilapia polyculture.

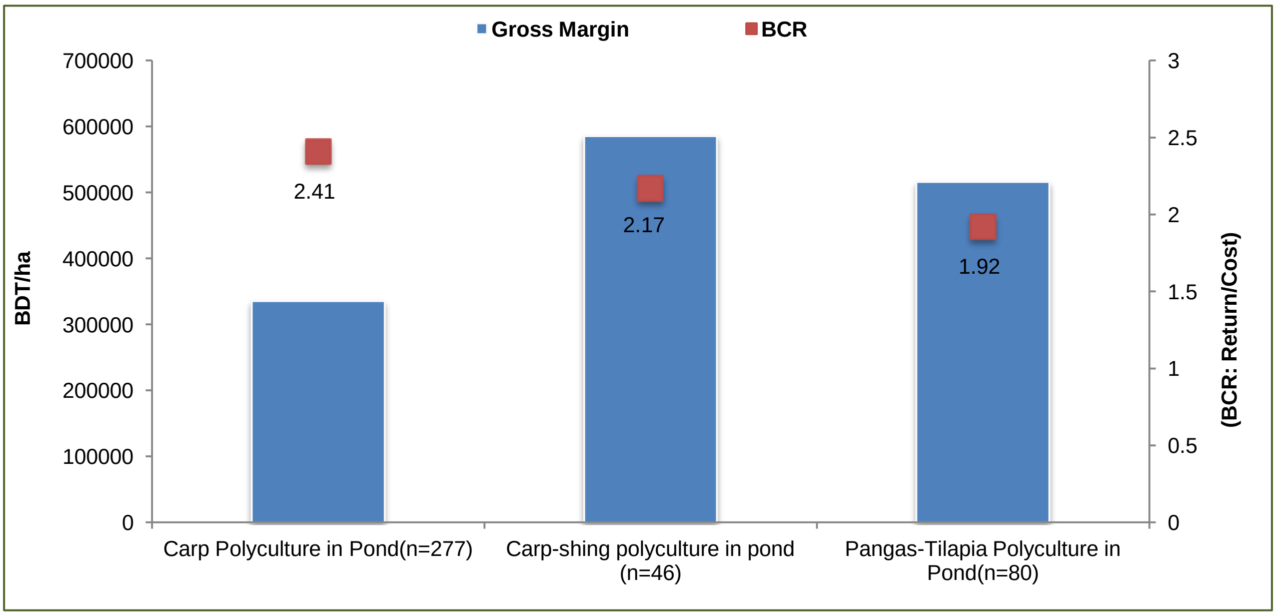

Fig. 37. Gross margin vs benefit-cost ratio: commercial pond aquaculture technology.

Gher (rice-aquaculture-horticulture)-based system

Gher farming technology is developed by farmers to overcome severe food shortages occurring from the degradation of farmland caused by polder development in the 1960s. Farmers of the coastal districts grow black tiger shrimp (*Penaeus monodon*) during February-July after aman rice cultivation. In some areas, especially in the deep low ghers, shrimp farming is characterized by only a single crop. On the other hand, in freshwater ghers, giant prawn (*Macrobrachium rosenbergii*) is grown together with fish and vegetables during April to December following boro rice production. It has emerged as a unique source of income, food security, and livelihood for the people living in the coastal region. The lack of farmers' technical knowledge, access to extension services and financial support, opportunity for research and technology development, policy support, and institutional linkages are considered as the most important constraints that restrict the expected improvement of the sector. To help farmers use the full potential of the gher system, CSISA-BD undertook various interventions focusing on research in development: (a) widespread dissemination of improved aquaculture technologies for increasing production and income; (b) testing and fine-tuning technologies suitable for existing farm situations and to address the effects of climate change; and (c) reducing investment risk through the addition of an extra crop and minimizing disease occurrences. Major interventions to improve farming practices and productivity include culture of disease-free and quality postlarvae (PL) of shrimp and prawn, fish fingerlings, shrimp and prawn nursery establishment in a corner of the gher, two-cycle tilapia as an alternative to prawn in response to export market challenges, double-cycle shrimp production, shrimp-fish mixed culture, efficient use of dikes with vegetables, and an adaptive production calendar (Table 15). A total of 5,484 farmers (with nearly 26% women) participated directly in the project-imparted training during the last five years in the freshwater gher system.

Table 15. Rice–[golda + fish]-vegetables: production calendar of gher system.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Boro rice												
Nursery												
Healthier postlarvae rearing in nursery												
Grow-out gher preparation												
Juvenile stocking in grow-out gher												

Freshwater gher system

In prawn-based freshwater gher farming, prawn and fish production increased by 103% compared with the baseline but, in tilapia fish-based farming in ghers, two-cycle tilapia and carp fish production increased by 359% at the endline compared with the baseline (Fig. 38). The highest fish production increase was found in two-cycle tilapia fish-based farming in ghers and it was 1,839 kg/ha in the baseline when farmers practiced one-cycle tilapia and that increased to 8,434 kg/ha. Besides fish, prawn, and rice production, the farmers cultivated a good amount (2,732–2,783 kg/ha) of vegetables from the dike of the gher. For all the cases, rice production was 5.5 to 6.5 t/ha. It is evident from Figure 38 that traditional rice-fish farming practiced by the farmers of the northwestern part of Bangladesh does not really realize the full potential from the same type of low-lying rice fields. Transformation of the gher-based farming system practiced by the farmers of southwestern to northwestern Bangladesh can increase the productivity and income of the farming households.

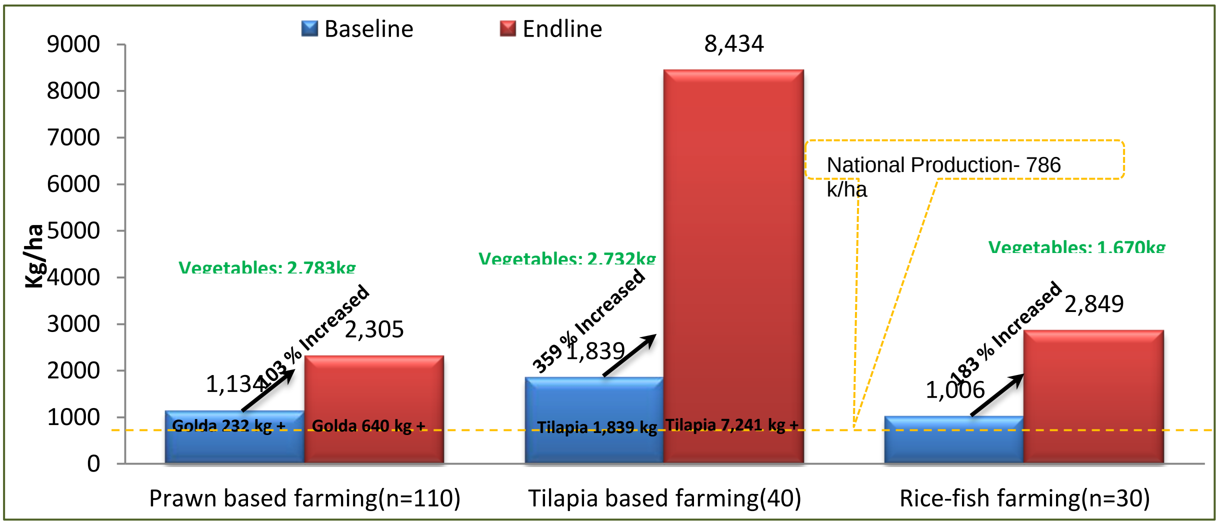

Fig. 38. Productivity: freshwater gher farming.

Figure 39 shows that gross margins increased by 257% for prawn-based gher farming, including prawn/golda and carp, by 368% for two-cycle tilapia-based gher farming, and by 251% for rice-fish farming. At the endline, GM was highest (BDT 400,818/ha) for two-cycle tilapia-based gher farming, and was almost the same (BDT 394,248/ha) for prawn-based gher farming. However, the gross margin was lowest (BDT 172,908/ha) for fish-rice farming from northern districts. The benefit-cost ratio (BCR) was highest (2.76) for prawn and carp-based gher farming, followed by 2.26 for rice-fish farming and 1.94 for tilapia-based gher farming, whereas the highest amount of gross margin was achieved by two-cycle tilapia-based gher farming.

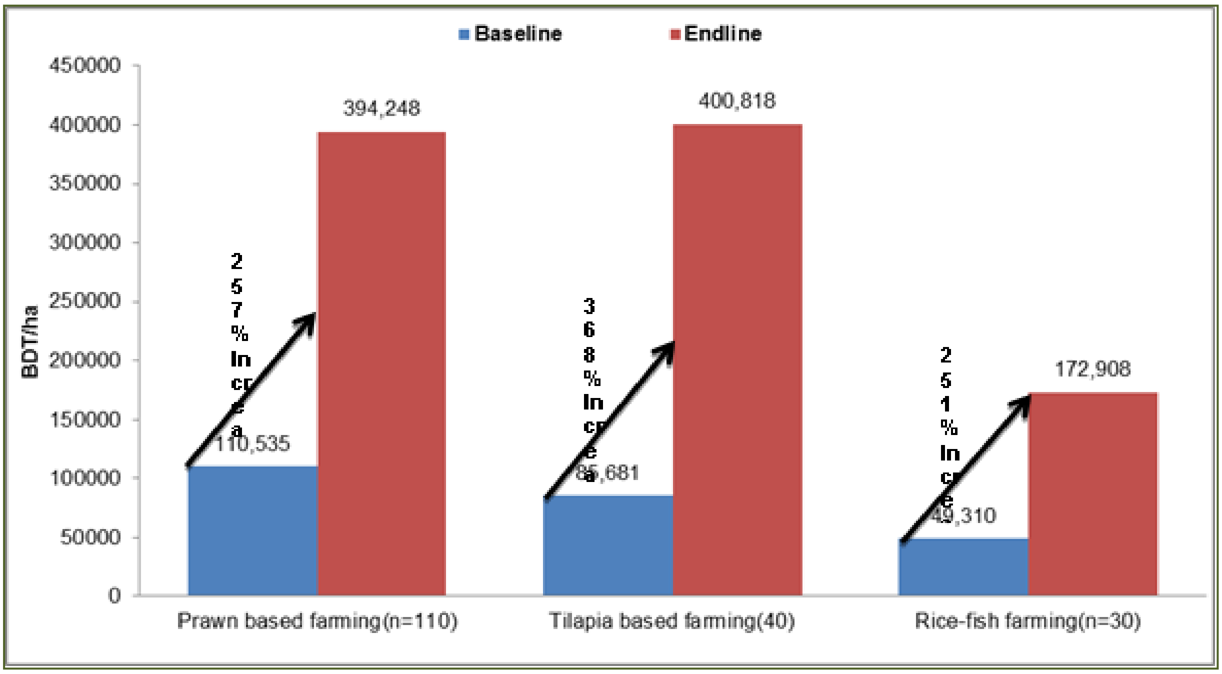

Fig. 39. Gross margin: freshwater gher farming.

Rice-fish farming is a dominant practice in northwestern Bangladesh in low-lying areas. Fish production increased by 183% compared with baseline production. The ecology of the rice fields in the region is quite diverse, but can be divided primarily into three systems of rice-fish integration for better income and livelihoods: concurrent (rice-fish simultaneously), alternate (rice in the boro season and then fish alone in the aman season), and rice-fish-rice (boro rice-fish nursery in the gap for about two months-aman rice) based on their farming and socioeconomic context. Generally, farmers practice this alternate rice-fish following boro rice (February-April) and then fish alone (March-October) in some of the areas of Rangpur.

Brackish-water gher system

In order to sustainably improve farming efficiency from the brackish-water gher, the project interventions included the introduction of a double-cycle shrimp crop and alternate fish culture in the wet season, promoting PCR-tested disease-free postlarvae (PL), developing a corner nursery for rearing healthy juveniles, and improving feeding practice through the dissemination of a comprehensive technology package. A total of 2,215 farmers (nearly 30% women) participated directly in the project-imparted training during the last five years. Lessons learned in the training were also complemented by establishing 88 demonstrations covering 20.90 ha. The project also supported linkage with value chain actors for quality inputs and technical assistance locally.

As a result of the project interventions, farmers brought about significant improvement in farming practices. Results from the 41 PFTs (Fig. 40) show that total fish production increased to 1,088 kg/ha in brackish-water shrimp ghers in the endline (it was 619 kg/ha in the baseline). So, this was a 76% increase in the endline compared with the baseline. Especially, the productivity of shrimp increased to 723 kg/ha (it was only 259 kg/ha in the baseline). So, the increase was 179% in the endline compared with the baseline.

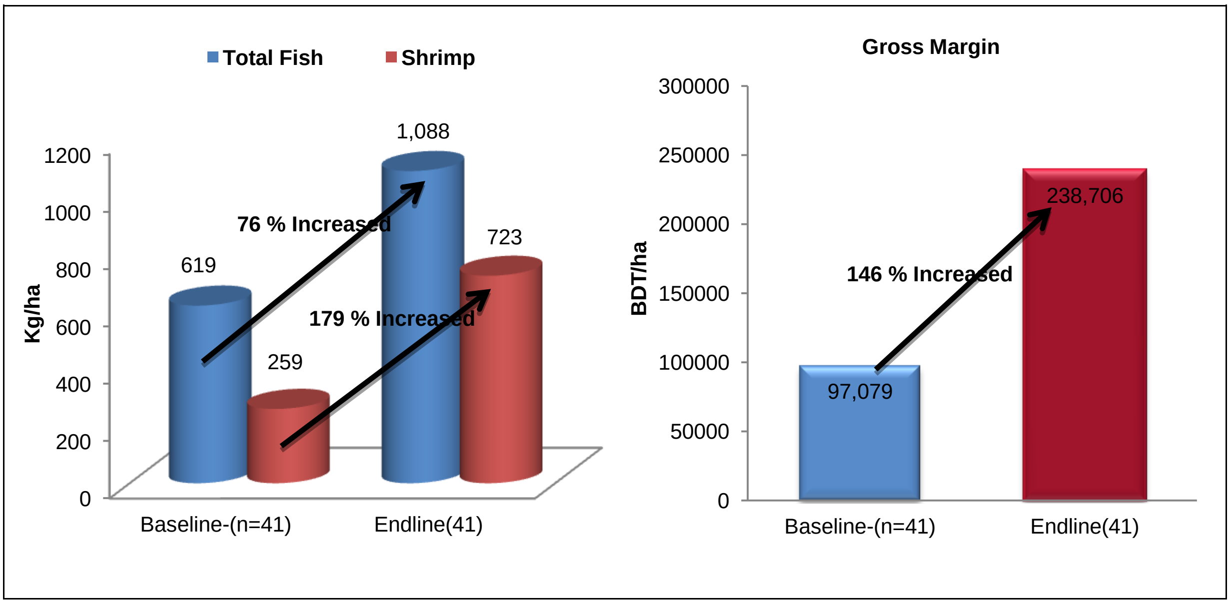

Fig. 40. Brackish-water shrimp farming.

The gross margin of overall brackish-water gher farming was BDT 238,706/ha in the endline but it was only BDT 97,079/ha in the baseline. So, the growth of the gross margin was 146% in the endline compared with the baseline.

Participatory adaptive research trials

Shaded pond aquaculture technology

The CSISA project aligned with the CGIAR Research Program on Aquatic Agricultural Systems, led by WorldFish, designed a program to increase productivity from those small shaded ponds by conducting research with women. The approach is based on a method in which farmers and scientists work together to not only solve problems but also develop the capacity and confidence of farmers.

Fig. 41. Sampling catfish and climbing perch showing good performance along with tilapia in a shaded pond trial, Barisal.

This process is thought to empower the overall community and allow sharing of knowledge in a more convincing way with a diverse audience within the community.

The primary aim of this research was to develop low input-based management practices to increase fish production in shaded ponds without interfering with the use of pond water for other household purposes. The overall aim was to improve household nutrition by increasing fish consumption, especially by identifying suitable fish species composition, and to increase women's decision-making capacity for homestead farming. The major findings are presented in brief.

A large number of ponds are either shaded by valuable fruits and timber trees or are full with water for only part of the year. Technology to help owners of these ponds to improve their pond productivity has not been fully developed. Therefore, to develop a better set of technology, WorldFish, through a number of different programs, including through CSISA-BD, began research at eight sites in saline and freshwater agro-ecological zones. At each site, a total of 12 ponds (shaded located close to homestead areas) are selected under three treatments. The three treatments are designed based on the different stocking ratio of different species of fish. Of the fish species, tilapia (mixed sex) are common for all the treatments; the other species are shade-living fish such as koi, Shingi, magur, silver carp, catla, and mirror carp (Table 16).

Table 16. Selected fish species in different treatments.

Category	Treatment 1	Treatment 2	Treatment 3
Regular uptake	Tilapia (GIFT)	Tilapia (GIFT)	Tilapia (GIFT)
High-value	Shingi: *Heteropneustes fossilis* (2)	Magur: *Clarias batrachus* (15)	Prawn/golda: *Macrobrachium rosenbergii* (5)
Fast-growing	Koi: *Anabas testudineus* (50)	Koi: *Anabas testudineus* (50)	*Barbonymus gonionotus* (10)
Cultural preference	Carpio: *Cyprinus carpio* (1)	Silver carp: *Hypophthalmichthys molitrix* (2)	Catla: *Catla catla* (2); Rui: *Labeo rohita* (2)

Note:

- Three similar treatments were followed in both freshwater and saline zones.
- Numbers in parentheses indicate the stocking density per decimal.

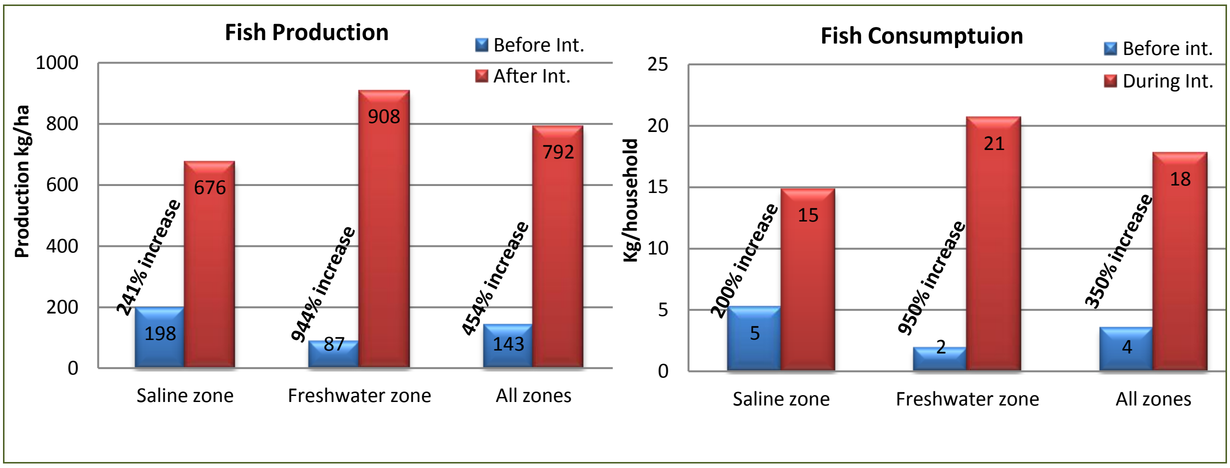

Fig. 42. Fish production and consumption from the shaded ponds.

According to Figure 42, both production and consumption increased 454% and 350%, respectively, after or during the intervention compared with pre-intervention. In both the saline and freshwater zone, production (241% and 944%, respectively) and consumption (200% and 950%, respectively) increased, but the freshwater zone had higher production as well as consumption.

Fish production increased to 676 kg/ha in the saline zone after the intervention compared with 198 kg/ha before the intervention. It increased to 908 kg/ha in the freshwater zone after the intervention compared with 87 kg/ha before the intervention. Similarly, consumption per household increased to 15 kg/household in the saline zone during the intervention compared with 5 kg/household before the intervention. Consumption increased to 21 kg/household in the freshwater zone during the intervention compared with 2 kg/household before intervention.

Fish seed quality improvement initiatives

Aquaculture production has increased significantly in recent years because of the adoption of various improved aquaculture technologies. This increase is affected by several constraints: genetic deterioration, inbreeding, interspecies hybridization, and poor broodstock management in the hatcheries. The stock deterioration has shown a negative impact on the growth in grow-out systems. It is observed in recent times that most existing carp and tilapia hatcheries are currently affected by this kind of genetic deterioration. However, stocks will continue to deteriorate until proper principles of genetic management are applied and implemented in the hatcheries. The hatcheries are producing sufficient numbers of fish seeds but the seeds produced in hatcheries, in most cases, are reported to be of poor quality. Fish seed accounts for approximately 30% of production costs; thus, the use of poor-quality seed in aquaculture production systems resulted in low and ineffective growth, leading to poor economic returns for farmers.

To overcome this problem, the CSISA-BD aquaculture program has trained 27 hatchery owners to implement a breeding process called cohort breeding nucleus. In this process, the genetic stock of fish species, especially tilapia, can be improved by using a simple cohort-based rotational breeding technique. In this breeding scheme, the best selected male broodstock of each cohort is mated with the female broodstock of the other cohort in each generation. During the first generation and every odd generation, for performing rotational mating, males from the cohort in pond/hapa-1 will be shifted to mate with females of the cohort in pond/hapa-2, while males from the cohort in pond/hapa-2 will go to the cohort in pond/hapa-3, and so on (Fig. 43). For the second generation and every even generation, rotational mating should be conducted following Figure 44. The males from the cohort in pond/hapa-1 will move to mate with the females of the cohort in pond/hapa-3, while the males of the cohort in pond/hapa-2 will go to the cohort in pond/hapa-4, and so on.

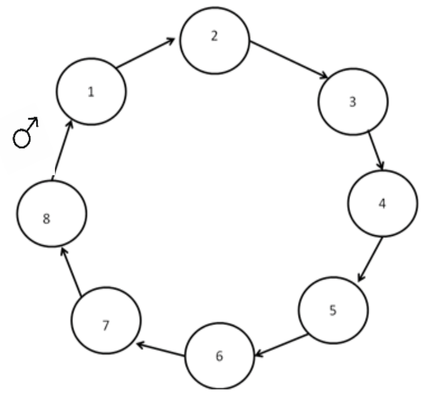

Fig. 43. Rotation of males for generations 1, 3, 5, and so on.

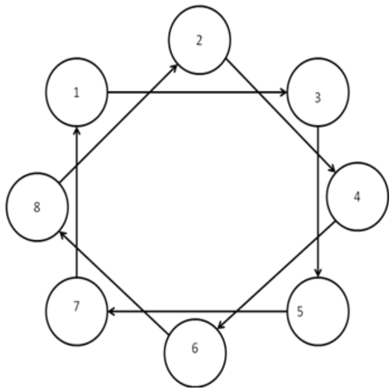

Fig. 44. Rotation of males for generations 2, 4, 6, and so on.

There is little chance of stock deterioration due to outbreeding and, in every generation, a certain degree of additive genetic gain is possible. As a result, a tilapia hatchery operator can follow the simple protocol of rotational breeding on the farm to obtain genetically improved broodstock generation after generation for quality seed production (Fig. 45).

Fig. 45. Tilapia brood production at Nova Hatchery.

Development of freshwater prawn and tilapia feed using sunflower cake as replacement of fishmeal and other plant-based protein

Prawn and tilapia feed has been identified as the largest expenditure item that hinders the promotion of semi-intensive farming in the freshwater gher system of southwestern Bangladesh. Feed accounts for 50–60% of total operation expenses. The high price of company-made feed with unsure quality really confuses poor and marginal farmers for making decisions whether to go for semi-intensive farming or continue traditional farming. During our work in CSISA-BD, responding to the farmers' requests and interests, WorldFish conducted participatory adaptive research in Khulna and Jessore to develop quality prawn and tilapia feed, respectively, by using locally available ingredients, mainly including sunflower cake with justified price.

The research was designed for two-phase implementation. The first phase (April-November 2014) of the research primarily focused on finding out the optimum inclusion rate of sunflower cake as an alternative protein source by replacing the most costly ingredient (fish meal and other plant-based protein). Sunflower cake was chosen because it is relatively cheap, it has good protein content, and it is expanding in the region. Four feeds, including one control for prawn (with around 30% crude protein content) and tilapia (with around 26% crude protein content), were formulated separately with different compositions of ingredients to conduct the first round of research. Three trial feeds were formulated by the inclusion of 30%, 40%, and 50% sunflower cake to the control feed. Fish meal, soybean cake, and mustard oil cake were replaced proportionately to keep the crude protein level the same for all four diets. An initial study showed that prawn-formulated feed treated as Feed-4, in which a lesser share of fish meal (13%) and a large share of sunflower cake (50%) were used, had a comparatively better performance. Feed-4 achieved a better food conversion ratio (FCR) of 1:3.41 compared with FCR 1:3.72, FCR 1:3.57, and FCR 1:3.66 for Feed-1, -2, and -3, respectively (Fig. 46). The cost per kg of prawn production declined by 27.38%, 18.36%, and 16.12% for Feed-4, -3, and -2, respectively, compared with the control feed. For tilapia feed, Feed-3 (9.50% fish meal and 40% sunflower cake) demonstrated better FCR 1:1.37 than Feed-1 (1:1.68), Feed-4 (1:1.49), and Feed-2 (1:1.47). The cost per kg of tilapia production declined by 23.05%, 17.28%, and 15.66% for Feed-3, -4, and 2, respectively, compared with control feed.

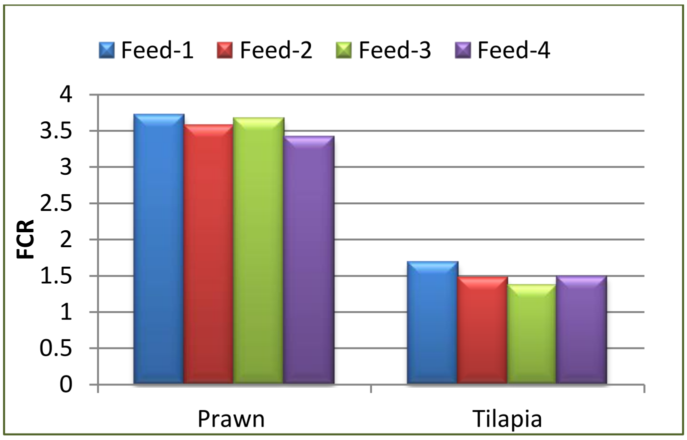

Fig. 46. Food conversion ration (FCR) in different feed in prawn and tilapia.

Fig. 47. Prawn feed experiment.

The second-phase trials were conducted during June-October 2015 for testing the efficiency of the best-performing feed found in the previous trial (Feed-4 for prawn and Feed-3 for tilapia), with two company feeds widely preferred in the area. For both cases, the experiments were designed with three treatments: two company feeds and one CSISA-BD-formulated feed with three replications for each. Prior to the experiments, two commonly used manufactured feeds for prawn and two for tilapia were selected using participatory rural appraisal tools, key informant interviews, and focus group discussions. Following protocols similar to those of the first round of research, prawn juveniles and tilapia fingerlings were stocked in the gher. Prawn and tilapia were harvested, after feeding them with the feeds for 100 days.

Complete data analysis has not been done yet but preliminary results showed no significant differences among the performances of those feeds. CSISA-BD-formulated feed had an FCR close to that of the two company-manufactured feeds

Effect of pond-bottom sludge removal on fish production

Commercial aquaculture depends strongly on pelleted feed. But, the underused feedstuffs and feces of the fish have long been cited as a major contributor to sludge generation on intensified commercial *Pangasius*-tilapia-carp farms. This sludge accumulation resulted in water pollution and a high feed conversion ratio that affects the production of harvestable biomass. Farmers are forced to apply drugs and chemicals indiscriminately to protect the fish from mortality, which eventually leads to economic loss for the commercial farms. To overcome the problems CSISA-BD Jessore hub designed an adaptive research trial on the “Effect of pond-bottom sludge removal on fish production.”

The objectives of the study were to (i) observe the effect of sludge removal on fish mortality and fish production, (ii) examine the effect of sludge removal on water quality, and (iii) evaluate farm economics. This study was established in Goalbari Village under Monirampur upazilla of Jessore District (23°10′07″ N, 89°12′47″ E), Bangladesh, for a period of 10 months from June 2014 to March p2015 with 10 farmers' ponds. The study had two treatments (T1: pond-removed sludge using a pond sludge removal pump (PSRP), T2: pond not removed sludge using PSRP), with five replicates (Fig. 48). Data collection has continued, including water and soil quality parameters. Water quality (temperature) was recorded fortnightly and other water quality parameters such as pH, dissolved oxygen (DO), and un-ionized ammonia were recorded before and after one day of sludge removal. Pond record books were provided to the farmers to document all relevant information. Some outcomes follow.

Table 17. Comparative production and profitability of control and trial ponds.

Item	Control (sludge not removed)	Trial (sludge removed)
Production (kg/ha)	18,132	27,165
Net profit (BDT/ha)	233,651	570,332
Mortality (%)	10	4
FCR	1.90	1.65

Figure 48: Sludge removal experiment

Table 17 shows that productivity was about 50% higher in trial ponds (27,165 kg/ha) than in control ponds (18,132 kg/ha). Profitability was 144% higher in trial ponds than in control ponds. Net profit was BDT 570,332/ha from the trial ponds and BDT 233,651/ha from the control ponds. Mortality was also lower (4%) in trial ponds than in control ponds (10%). So, pond sludge removal is very effective in increasing fish productivity and profitability, and in keeping pond water quality in a healthy state.

Introduction of fast-growing sex-reversed all-male tilapia with carp polyculture in pond systems enhanced production and income and reduced risk

Aquaculture in Bangladesh is dominated by the polyculture system in which more than one species of carp fish are raised at the same time in a grow-out system such as a pond. In the carp polyculture system, farmers commonly use six to seven carp species, including Indian major carp such as Catla (*Catla catla*), Ruhu (*Labeo rohita*), Mrigal (*Cirrhina mrigala*), etc., with some exotic carp such as Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idella*), Common carp (*Cyprinus carpio*), etc., and other minor carp species that include Thai sorputi (*Barbonymus gonionotus*), Bata (*Cyprinus bata*), etc. Traditional carp polyculture takes at least seven months to obtain returns, which seems to be longer than other forms of aquaculture practices. Farmers were struggling to harness the full production potential because of the seasonal nature of the ponds; hence, the lower water depth and cool weather in the culture period from December to March. As a result, fish production does not reach its full potential because of the lack of suitable species combinations, especially with fast-growing species. Considering the context, CSISA-BD and WorldFish introduced fast-growing mono-sex tilapia into the carp polyculture system, aiming to achieve returns within a short duration of 4 months.

Stocking density was adjusted with traditional carp polyculture up to 56–80 fry/fingerlings per decimal and species combinations such as tilapia (20–25), Catla (4–8), Silver carp (10–15), Ruhu (10–15), Mrigal (6–8), Grass carp (2–3), and Common carp (4–6).

The project established participatory trials with farmers to test and fine-tune the technology and boost the confidence of the farmers who were not confident about the new polyculture system.

After around 4 months (100–120 days), the farmers harvested tilapia, keeping the major carp in the pond and stocking tilapia further as a second crop. After these results, there has been a shifting from the conventional system of carp polyculture to carp-mono-sex tilapia polyculture adopted by many neighboring farmers. In this type of polyculture, in a year, two crops of tilapia and one crop of carp can be harvested and farmers can achieve an extra production from tilapia of 2.2 t/ha in a year with income of $316/ha.

We compared the results of the improved technologies disseminated during the last three years, including improved carp polyculture in ponds (CP; n = 50), improved carp polyculture with mono-sex tilapia (CMT; n = 40), and improved farming of mono-sex tilapia (MT; n = 20). The return on investment (ROI) was highest for MT (91%), was medium (86%) for CMT, and was lowest (62%) for CP (Fig. 49). Although MT was found to be better, most farmers favored CMT because of its potential profit coming from diversified crop and time, and hence lesser risk. Although MT is the most profitable, it requires high investment and management techniques and poses a high risk to investment. On the other hand, CMT has less profit than MT but it requires comparatively less investment and less risk. Moreover, CP is a less profitable enterprise and it requires less input and financial investment.

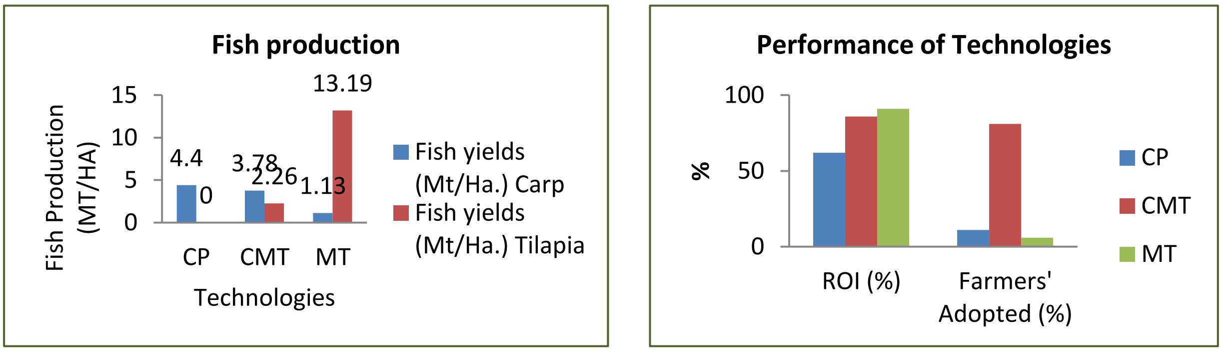

Fig. 49. Fish productivity, return on investment (ROI), and farmers' adoption of different technologies.

3.1.4 Mechanization

CSISA-MI (Cereal Systems Initiative for South Asia-Mechanization and Irrigation) is an International Maize and Wheat Improvement Center (CIMMYT)-led initiative that is partnering with International Development Enterprises (iDE) in Bangladesh. The program is using an innovative private-sector engagement model that is helping to unlock the potential productivity of the FtF (Feed the Future) region in Bangladesh through commercial mechanized agricultural activities.

CSISA-MI activities began in July 2013 and were developed from the learnings and as part of CSISA-BD (USAID-funded *Cereal Systems Initiative for South Asia* program in Bangladesh). The project will continue up to 30 September 2018 and it aims to transform agriculture in southern Bangladesh through the use of newly introduced irrigation pumps, tillage/seed drills, and harvest equipment appropriate for Bangladeshi farmers. CSISA-MI focuses on the commercialization of this and other agricultural machinery in the FtF zone.

While CSISA-BD worked to increase cropping intensification through technology testing, deployment of new crop varieties, demonstrations, direct training of farmers, and support for output markets, CSISA-MI goes beyond these to focus on the identification of scale-appropriate machines and, most importantly, the development of upstream market interventions involving machinery manufacturers, importers, dealers, and local service providers facilitating efforts to reach farmers at scale. Integration of these two pursuits results in synergy, rather than duplication, between the CSISA-BD and CSISA-MI projects.

Fig. 50. Harvesting of rice by multi-crop reaper machine.

Working with the government, particularly BARI and DAE, and a range of private-sector actors, the program seeks to intensify agriculture using surface-water irrigation, by introducing efficient and resource-conserving agricultural machinery, including pumps for irrigation, aquaculture, and drainage, land preparation and planting equipment, and harvesters and postharvest machinery, and primarily by developing local service providers (LSPs) to scale-out key agricultural machinery services in the FtF zone.

Fig. 51. Marketing material of RFL.

Our approach is built on an innovative private-sector engagement model that will develop self-sustaining value chains that will continue to deploy equipment on a continued basis after the close of the project. Our ultimate goal is to reach the "tipping point" of 15–20% of the total potential beneficiary LSPs and farmer population in the FtF zone, after which spontaneous private-sector-led and LSP and farmer uptake is expected to take place on a sustainable basis without further direct project intervention.

To drive the adoption of more precise and resource-conserving agriculture, CSISA-MI promotes three keystone technologies: the fuel-saving high-volume axial flow pump (AFP) for surface-water irrigation, the power tiller operated seeder (PTOS) that can be used for line-sowing and conservation agriculture, and the reaper to overcome labor bottlenecks at harvest and speed up the time between harvest and the planting of the next crop. These machines help boost yields by maximizing the productive use of soil moisture, fertilizer, and seed, while saving farmers' time, labor, and money. Through public-private partnerships with machinery manufacturers and importers, such as Advanced Chemical Industries (ACI), Metal Industries, Chittagong Builders, and the Rangpur Foundry Limited (RFL) Group, CSISA-MI is working to commercialize and catalyze the wide availability of these machines for LSPs in the FtF zone (Fig. 51).

CSISA-MI conducted six weeks of field research by employing human-centered design (HCD), a qualitative research methodology to understand the needs, wants, and constraints of various stakeholders along the agricultural value chain in southern Bangladesh. By conducting HCD deep dive research in the field, the research team uncovered rich insights that provided guidance to the project on improvements for the technology interventions, business model innovations, innovative and effective promotion strategies, and public and private partnership development for the support of commercial technology uptake in the project area.

During FY15, CSISA-MI developed 282 LSPs, which brings the total number to 511 LSPs that are supporting the farmers using project-targeted technology. During FY15, CSISA-MI's direct interventions led to 5,726 hectares of land being brought under different targeted agricultural machinery and irrigation services. During the period, the project supported wheat production on 1,086 hectares of land and supported 3,358 farmers. Similarly, the project supported maize production on around 100 hectares of land and supported 200 farmers. CSISA-MI is working to track copycat enterprises in the project areas. Through this process, the project tracked sales of around 660 machines for land preparation, mostly in Faridpur and Jessore regions. The project conducted a survey among 257 service providers that provided land preparation services to the farmers. The survey revealed that the land coverage by 660 service providers would be 4,200 hectares, which has been taken as indirect coverage of the project. Thus, the total land coverage under mechanization would be around 10,000 hectares over the last one year.


Fig. 52. Axial flow pumps stacked in a local depot.

Out of the direct 5,726 hectares, 2,183 hectares were irrigated by LSPs using fuel-efficient axial flow pumps supplied primarily through purchases made from one of CSISA-MI's private-sector partners, Rangpur Foundry Limited (RFL) (Fig. 52). Crucially, RFL and LSPs invested $81,000 of their own funds to spread AFP services to farmers.

Some 1,919 hectares of land were cultivated by using PTOS in a suite of crops including rice, maize, wheat, jute, vegetable crops (onion and garlic), and lentils, among others, while improving crop profitability. In order to make this happen, CSISA-MI's private-sector partners invested $107,000 of their own funds to expand use of the equipment. An additional 1,624 hectares of wheat and rice were harvested using multi-crop reapers through local service provision and the action of our private-sector partners ACI and Metal, which demonstrated and advertised to farmers and potential LSP clients.

Through forward linkage "business expansion" meetings at which LSPs were introduced to farmers' groups so that LSPs could describe their mechanized services, farmers could ask questions and business opportunities could be negotiated between the LSPs that wished to sell services and the farmers who wished to buy services (Fig. 53). Thus, market creation and linkage for the LSPs have been practiced. In addition, CSISA-MI initiated Service Demand Creation and Sales Planning Meetings (SDCSPMs), a forum in which key members of a community are brought together to learn about target technologies, understand the business case for the machines, and identify both those who are interested in buying the machines (LSPs) and those who are interested in buying services from the LSPs. These SDCSPMS engage potential customers, community leaders, microfinance institute (MFI) representatives (such as JCF, RRF, and TMSS), and private-sector representatives from partner companies (such as ACI, Metal, and RFL). So far, 202 SDCSPMs were conducted in the project area and, through these, more than 800 potential LSPs were identified.

To accelerate the use and sales of targeted agricultural machinery, CSISA-MI introduced a special voucher program to drive greater uptake of the technologies. To do this, the project worked with its private-sector partner RFL to offer a 75% discount voucher to farmers participating in key agricultural development projects implemented by the government of Bangladesh (GoB). Two DAE projects (IAPP and NATP) were targeted for this effort.

A total of 13,000 farmers in the FtF benefited from the project's activities through interventions implemented by the project and private-sector partners. An interactive campaign that included baul songs, games, quizzes, and promotional videos was conducted in 12 upazillas of three districts to motivate the potential buyers of the machines. Promotional gifts were shared and referral coupons were distributed among interested PTOS buyers. Leaflets, stickers, and flyers were also used. Through these activities, nearly 15,000 people were reached and exposed to the PTOS.

Fig. 53. Meeting with local service providers.

Unfortunately, because of political unrest, especially series of strikes and blockades, many of CSISA-MI's planned field activities were hampered. But, despite these problems, reasonable progress was made.

A key measure of CSISA-MI's success is the willing investment of ACI, Metal, Chittagong Builders, and RFL in the machinery technologies supported by the project. All are receiving technical support from CSISA-MI to import and market agricultural machines. These private-sector companies are generating demand for the machinery technologies through promotional activities such as video road shows, billboards, local newspaper and cable advertisements, and other marketing materials. A number of practical demonstrations in local markets (haat-bazar) and the dissemination of other communication items to enhance awareness and to motivate potential clients have been carried out.

Fig. 54. Practical session of AFP operations training.

Science-based interventions are part of CSISA-MI's work. Within the project, CIMMYT scientists are conducting research to develop appropriate irrigation and nitrogen regimes for maize and other cereal crops grown in the FtF region. Research is ongoing in using remote sensing and GIS to identify the appropriate environments and soils on which bed planters and PTOS can be used, and where AFPs can be employed to bring dry-season fallow and poorly productive land into intensified cropping. CSISA-MI private-sector partner RFL has been working with the project to fabricate prototypes for a domestically produced axial flow pump). Metal (Pvt.) Ltd., another CSISA-MI private-sector partner, decided that it also wanted to enter the market of domestic production and sales of AFPs. These efforts are combined with applied econometric analyses to identify the factors that influence LSPs' investment in agricultural machinery, and to uncover the predominant structure of irrigation water pricing in southern Bangladesh to develop improved business models to facilitate affordable surface-water irrigation. Additional research considers the trade-offs between crop residue use for livestock vs conservation agriculture, and in partnership with Wageningen University, CSISA-MI is supporting one PhD and one MS student using advanced crop and farming systems design models to propose solutions to these pressing concerns. In addition, the project is continuing research to improve the performance of the bed planter and domestic production of AFPs (Fig. 54).

To orient stakeholders on the use of different agricultural machinery being promoted by the project, CSISA-MI conducted training for a total of 2,193 participants (2,001 males and 192 females) during the reporting period. The training participants included LSPs, mechanics, private-sector actors, and farmers.

In order to facilitate rapid adoption and usage of surface-water conveyance equipment, including AFPs, in the FtF zone, CSISA-MI works through market channels. This commercialization approach is based on “Markets for the Poor,” or M4P theory, and has a two-tier focus: (1) opening the market for water conveyance services by creating a space for the water pumping equipment, and (2) expanding business opportunities for LSPs to farmers. LSPs are in turn both customers for pump purchases and service providers for farmers.

Critically, CSISA-MI works to layer interventions with other action to allow farmers to intensify dry-season cropping, including input provision, training on best-bet irrigation management and agronomy, and access to credit. The latter is particularly critical.

As part of developing targeted financial services to support the supply chain for agricultural mechanization products, CSISA-MI signed MoUs with the microfinance institutes Jagaroni Chakra Foundation (JCF), TMSS, and Rural Reconstruction Foundation (RRF) to ensure that LSPs have access to small-scale and low-interest loans for the purchase of reaper machines.

CSISA-MI’s interventions are intended to foster adoption of the technologies and associated business models supported by the project. As the AFP technology allows LSPs to adapt to changes in the agricultural environment (increasing salinity of groundwater, increasing costs of manual labor, increasing fuel prices, etc.), an increase in demand for surface-water use services will lead to an increase in business for LSPs, and an increase in sales of pumps for our private-sector partners. This mechanism is the key to the sustainability of the project interventions.

Fig. 55. BADC canal dredging work.

CSISA-MI works in close collaboration with a number of private-sector and government institutions. CSISA-MI also aims at improving the capacity of the public and private sector to ensure stronger science-led interventions, value chains for agricultural machinery and pumping equipment, and better services to farmers. As such, CSISA-MI strengthens relationships at the national and field level with the relevant government institutes and other partner organizations.

CSISA-MI is also working with the Bangladesh Agricultural Development Corporation (BADC) that received $1.5 million from USAID and with the amount they excavated 50 km of canal systems, and installed sluice gates in strategic locations to facilitate surface-water irrigation in Barisal District (Fig. 55).

CSISA-MI has also been coordinating activities with the extension staff of the Department of Agriculture Extension. CSISA-MI has oriented DAE staff on the use of surface-water irrigation and advanced agricultural machinery. In addition, CSISA-MI continues to collaborate with the Bangladesh Agricultural Research Institute (BARI) to test and refine two-wheel tractor-based agricultural machinery and irrigation pumps. Importantly, CSISA-MI is facilitating the testing of new domestically produced AFP prototypes at BARI for quality control assurance and developing the capacity of RFL in producing the pump locally.

SUCCESS STORY

CSISA-BD/CSISA-MI Behind Improved Knowledge and Income

CSISA-BD and CSISA-MI provide training on new wheat technologies using machines that improve the livelihoods of farmers and LSPs in Faridpur.

Photo: CSISA-BD personnel

"I am very grateful to CSISA-BD for the knowledge and guidance provided in working with CA machinery and for helping me to become a better LSP."

–Yunus Sardar, CSISA LSP located in Faridpur hub

Yunus Sardar, a farmer and a local service provider (LSP), lives in Bara Bazar Village in Rajbari District. This locality has a shortage of two-wheel tractors (2WT or "power tiller") to meet the demand for land preparation. The 2WT owners first plow their own land and then service the land of others. Often, the 2WT owners hire an operator under a daily-basis system for machine operation.

Yunus is 45 years old, with primary-level education, and is landless. He used to work as a power tiller operator earning $4 to $5 per day. With this wage, he was not able to make as much money as the LSPs/2WT owners. All of the time, he used to think about how he could become a 2WT owner, but by early 2014 he was jobless. His luck changed, however, when he participated in a CSISA-BD training event on line-sown pulses using CA machinery. Because he showed great interest and skill when practicing with the bed planter machine, CSISA-BD staff selected him for LSP training.

In October 2014, CSISA-MI conducted training on CA machinery attachments for 2WTs that Yunus attended, based in large part on his earlier display of skill and enthusiasm with respect to machine operation. It was there where he learned more about the large scope and ample opportunities for LSP businesses, which only increased his desire to purchase a 2WT. He finishes this success story in his own words:

"During rabi 2014, I purchased one 2WT at a 25% subsidized price from the agricultural machinery project launched by DAE. Now, I can earn $13 to $19 per day in comparison to the $4–5 per day that I used to get before. CSISA-BD helped me a lot to improve my knowledge and because of this I am now able to earn more money, which has changed my livelihood. I am very grateful to CSISA-BD for the knowledge and guidance provided in working with CA machinery and for helping me to become a better LSP."

3.1.5 Seed

The Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh (SRSPDS) project began in October 2011 and, after two no-cost extensions, was completed in December 2013.

Within a year of project inception, it was realized that farmers urgently needed rice varieties that had tolerance of salinity, submergence, and drought to help them reduce losses incurred during monsoon-season floods and droughts and to help them use land prone to salinity in both the monsoon season and, more importantly, the dry season. These varieties were available but the rate at which they were becoming available to farmers through normal commercial and government-sponsored demonstration processes was very slow. It was therefore decided to establish a project that would distribute seed packs of these new rice varieties to as many farmers as possible in salinity- and flood-prone areas of southwest Bangladesh and, in doing this, strengthen the capacity of small and medium-sized seed producers and government institutions to produce seed.

1. The project met its targets, and was able to disseminate seeds of HYVs and HY-STRVs to 999,517 farm households covering 215,000 ha of rice area through its direct interventions. Of these, 176,080 received seed of salinity-tolerant rice varieties and 171,723 received seed of submergence-tolerant varieties. The remaining seed distributed was mainly of short-duration monsoon-season rice varieties and the latest boro-season varieties.
2. The project worked closely with the three seed associations representing 333 seed companies, of which 33 are managed by women (Fig. 56). The associations were also provided with technical advice and promotional materials; ensured the supply of breeder seed of the new varieties by linking them with BRRI, BINA, and other research institutions; and given help in capacity building of their seed growers. Seed production by these associations increased from 935 tons to 2,300 tons in the 1.5 years the project worked with them.
3. For the first time, large seed companies such as Lal Teer, Energypack, and ACI were encouraged to undertake seed production programs for STRVs such as BINA 8, BINA 10, and BRRI dhan51 and 52.

Fig. 56. Packing seeds at a small company owned by a woman.

The project organized a workshop in Dhaka to facilitate increased collaboration in the seed sector between India and Bangladesh.

Increased production and supply of quality wheat seed

Annually, 60–65% of wheat seed in Bangladesh is either self-produced by farmers or obtained from other farmers. Thus, it is obvious that wheat productivity can be increased simply by training farmers on best practices for producing quality seed as well as by introducing them to new and improved varieties via demonstrations. As relatively limited amounts of newer (BARI Gom 25, 26, 27, 28) and newly released (BARI Gom 29, 30) stress-tolerant wheat varieties are available in the market, farmer-to-farmer transactions play an important role in their dissemination. Therefore, since 2012-13, two key activities undertaken by CSISA-BD/CIMMYT have been training on quality wheat seed production and conducting marketing workshops to link trained farmers to seed markets.

In collaboration with BARI and DAE, a total of 252 farmers in 2012-13, 360 farmers in 2013-14, and 174 farmers in 2014-15 were trained on best production and preservation practices of wheat seed.

Of these, approximately 30% were women. During the 2012-13 rabi season, the Faridpur, Khulna, Mymensingh, and Rangpur hubs conducted demonstrations and/or training on wheat seed production, preservation, and storage featuring BARI Gom 25, 26, 27, and 28. Jessore hub was added the following year (2013-14) and, in 2014-15, BARI Gom 29 and 30 were added to the other four varieties while seed production was limited to Faridpur and Mymensingh.

As Table 18 displays, in total during the project period, wheat seed production from CSISA-BD farmers was at least 272.5 tons, which is enough for approximately 11,220 households to plant, on average, 50 decimals of land to wheat. Note that 95% of the production amount listed for 2014-15 includes on-farm seed production (only 14.4 tons came from training/demos) across all hubs, and is based on CSISA-BD population projections estimated from data collected from Year 2 and Year 3 farmers that were re-interviewed during the final project survey. This means that almost all of the 2014-15 production came from CSISA farmers that previously received training on seed production (and continue to apply what they learned) or from CSISA farmers new to this activity who have come to adopt it as well.

Table 18. Seed production of wheat varieties promoted by CSISA-BD, in tons.

Variety	2012-13	2013-14	2014-15*	Total
BARI Gom 25	7.1	6.1	17.6	30.8
BARI Gom 26	54.5	24.1	86.0	164.6
BARI Gom 27	1.4	6.1	16.0	23.5
BARI Gom 28	0.6	12.8	38.9	52.3
BARI Gom 29	--	--	0.81	0.81
BARI Gom 30	--	--	0.46	0.46
Total	63.6	49.1	159.8	272.5

* Values include training/demo production in Faridpur and Mymensingh hubs (14.4 tons), plus on-farm seed production in all hubs as based on population estimates from surveys.

CSISA-BD efforts have improved farmers' access to quality wheat seed locally, and have also helped to enhance farmers' skills on quality seed production and entrepreneurship. This benefits project farmers directly by increasing their income, but it also helps resource-poor farmers to access quality seed of their preferred varieties locally at an affordable price. Thus, many farmers beyond the project will benefit from improved wheat genotypes, and planting of these varieties reduces the risk of crop failure due to their stress tolerance traits such as terminal heat tolerance (BARI Gom 26, 28, 29, 30) and stem rust tolerance (BARI Gom 26, 27, 30).

As mentioned above, CSISA-BD facilitates relationships between producers and seed dealers. The source seed was obtained from the Wheat Research Centre (WRC) under BARI. As part of the quality control regimen, the seed plots of CSISA-BD farmers were inspected by personnel from WRC, DAE, and CSISA-BD on a regular basis. The seed produced by CSISA-BD farmers was distributed through farmer-to-farmer transactions, and sold directly to BADC in Jessore and Faridpur hubs, as well as to seed traders such as the Joint Agro-Business Centre (JABC) and Kishan Agro Service (both located in Mymensingh hub). JABC also provided farmers with training (with assistance from CSISA-BD) and it sells the seed in 10-kg and 20-kg packs.

Bangladesh Seed Summit 2012

In order to improve wheat seed systems in Bangladesh, the Seed Summit was jointly organized by the Bangladesh Ministry of Agriculture (MoA) and the International Maize and Wheat Improvement Center (CIMMYT) in 2012. The purpose of this event was to bring together representatives from government agencies, private-sector firms, and nongovernment organizations in order to begin a dialogue with the goal of improving the seed sector in Bangladesh. The ultimate objective of the summit was to build strategic public-private partnerships wherever practical, and develop and implement a roadmap for uniting advances in research, policy, and investment that will culminate with a responsive and sustainable seed sector in Bangladesh. Meeting participants concluded that government alone cannot satisfy the country's needs, stating that the private sector can contribute significantly and has to be encouraged to jointly address (with the public sector) the issue of increasing the accessibility of poor and marginal farmers to affordable quality seeds at the right time and in the right place.

3.2 Nutrition/Household Food Diversification Through Aquaculture-Based Production Systems

More than 60% of the people in Bangladesh do not receive enough vitamin A, iron, and zinc from their diet to meet nutritional requirements—with young children and pregnant and lactating women being particularly vulnerable. Inadequate intake of fruits, vegetables, fish, and other animal-source foods is a direct cause of micronutrient deficiency.

Interventions initiated include polyculture of carp and/or tilapia with small nutrient-rich fish, such as "mola" (*Amblypharyngodon mola*), as well as encouraging the production of vegetables on pond dikes. Training sessions provide nutrition education, including the benefits of eating diversified nutritious food such as mola fish and orange sweet potato (OSP), the importance of a balanced diet, how to process and cook food so that the nutritional value is not lost, and the consumption requirements of pregnant and lactating women. For this training, women are targeted as they have the primary role for ensuring intra-household food distribution, they are more vulnerable to malnutrition than men, and they can be conveniently involved in nutritious food production from underused homestead resources.

In the project period from Year 1 to Year 5, 4,904 new women farmers were given training on polyculture mola fish with carp and vegetable production, including orange sweet potato, and on nutrition awareness. In addition, 3,373 women trained during prior years were given refresher training.

Horticulture

WorldFish introduced nutrient-rich vegetables and orange sweet potato in the different aquaculture systems and homestead area in an integrated approach. Underused but potential areas such as spaces in the homestead, dikes of ghers, rice fields, and ponds, both commercial and homestead, have been brought into productive use under CSISA-BD. This serves to provide not only extra income but also year-round nutritious food options and resilience against lean periods. Women have been the main target for these horticulture interventions, with low investments required, the homestead being convenient for their involvement, and they being responsible for the household's nutritional intake.

Reviewed horticultural production model

WorldFish reviewed the contextual settings of the three developed production models and selected crops along with a crop calendar for disseminating horticultural technologies and varieties. These models (Table 19) were initially developed considering the different geographic context, farmers' existing resources, market opportunity, nutritional value, harvesting time, and crop duration. These models include the (A) household-/homestead-based pond system production model in which emphasis is given to women-appropriate technologies and involvement for the production of nutrient-rich vegetables; (B) the production model at gher dikes where consideration is given to commercial use in light of market demand and the value of vegetables in certain seasons and geographic contexts; and (C) the production model at pond dikes, which is similar to the previous model B.

Table 19. Household-based production models at homestead, pond dikes, or its banks.

Resources	Rabi season	Kharif-1	Kharif-2
Pond dikes and its edges	Tomato, bottle gourd, country bean, orange sweet potato, sweet gourd/pumpkin, knolkhol	Bitter gourd, ash gourd, okra, cucumber, sweet gourd/pumpkin, kangkong, papaya	Cucumber, bitter gourd, bottle gourd, ash gourd, kangkong
Fallow cultivable/open land of homestead	Carrot, orange sweet potato, tomato, cauliflower, knolkhol, cabbage, country bean, bottle gourd, spinach, red amaranth, sweet gourd, chili	Kangkong, chili, red amaranth, Indian spinach, okra, sweet gourd, bitter gourd, ash gourd, bottle gourd, papaya	Indian spinach, bitter gourd, kangkong, red amaranth, ash gourd, bottle gourd
Roofs of houses	Country bean, sweet gourd, bottle gourd	Ash gourd, sweet gourd, Indian spinach	Ash gourd, sweet gourd.
Nonfruit trees	Country bean, bottle gourd	Ash gourd, sponge gourd, ridge gourd, sweet gourd	Ash gourd, sponge gourd, ridge gourd

The crops that were selected in accordance with the aforementioned models are provided in Tables 20 and 21.

Table 20. Vegetable production model at gher dikes/banks.

Places/resources	Rabi	Kharif
Gher dikes/edges	Tomato, country bean, knolkhol, OSP	Bitter gourd, cucumber, bottle gourd, ash gourd, okra, sweet gourd, long yard bean, ridge gourd

Table 21. Vegetable production model at pond dikes/banks.

Places/resources	Rabi	Kharif
Pond dikes/edges	Tomato, country bean, knolkhol, bottle gourd, OSP	Bitter gourd, cucumber, bottle gourd, ash gourd, okra, sweet gourd, long yard bean, ridge gourd

Vegetable mini-pack seed distribution

In partnership with Lal Teer, CSISA-BD and WorldFish distributed customized vegetable mini-packets of seeds containing seven different types of seeds suitable for homestead area to 4,904 women trainees in 20 districts. These packets were customized, keeping in mind a household’s nutritional needs and for additional income. The aim is to link these women, who usually have access to only small pieces of land, to low-cost but quality mini-packet seed networks that do not require purchasing more than what is necessary.

Promotion of vitamin-A rich orange sweet potato (OSP) as a means of family nutrition and additional income

To address the nutritional deficiency in rural farming households, WorldFish, with the support of BARI and BRAC, has taken initiatives to promote orange sweet potato (OSP) cultivation at a small scale in the homestead area by involving women. Some 456,890 OSP vines were given out to 4,904 women project farmers by CSISA-BD from October 2010 to October 2015. As a part of this promotion, WorldFish distributes 507,020 OSP vines to other projects for women as vine-selling entrepreneurs.

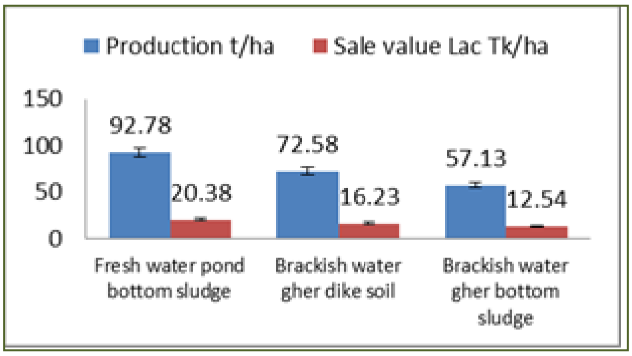

Fig. 57. Production and returns in different soil type.

Adaptive research trials on development of year-round vegetable farming technologies in brackish-water shrimp gher dikes in southern Bangladesh

There are approximately 64,000 hectares of freshwater prawn and 149,000 hectares of brackish water shrimp gher in the southwestern coastal region of Bangladesh. While vegetable cultivation on freshwater ghers has been very common for a long time, an estimated 10–15% of the land used for raising brackish-water gher dikes remains unused year-round mainly because of high saline content. To find a solution, the CSISA-BD Khulna hub conducted an adaptive trial amending dike soils with freshwater pond-bottom sludge and using different vegetable models.

Fig. 58. Vegetable experiments in brackish-water gher system.

The trials were conducted in two seasons: for summer from June to mid-October and for winter mid-October to March. In both seasons, it has been found that soil amendment of saline gher dikes applying sludge from the freshwater pond bottom greatly increased production. The use of brackish-water gher bottom sludge for the same purpose (dike soil amendment) also produced very satisfactory results. But, better performance was shown by freshwater pond-bottom sludge for production and returns (Fig. 57). For the vegetable model, Table 22 illustrates the best performance from tomato and sweet gourd in winter and also found a better combination in the summer season from bitter gourd and yard-long bean or bottle gourd and okra.

Table 22. Effect of different vegetable models on production and sale value.

<table>
<tr><th>Vegetable model</th><th>Sale value (BDT/10 m^2)</th><th>Production (kg/10 m^2)</th><th>Sale value (BDT/ha)</th><th colspan="2">Production (t/ha)</th></tr>
<tr><td>M1 Summer (bitter gourd & yard-long bean)</td><td>1,267.36</td><td>35.81</td><td>12.67</td><td colspan="2">35.81</td></tr>
<tr><td>M1 Winter (sweet gourd & tomato)</td><td>2,642.72</td><td>135.33</td><td>26.42</td><td colspan="2">135.33</td></tr>
<tr><td>M2 Summer (bottle gourd & okra)</td><td>1,006.54</td><td>51.35</td><td>10.06</td><td colspan="2">51.35</td></tr>
<tr><td>LSD 5%</td><td>116.55</td><td>16.28</td><td>11.65</td><td colspan="2">5.87</td></tr>
<tr><td colspan="2">LSD 1%</td><td>160.58</td><td>22.43</td><td>16.05</td><td>11.45</td></tr>
<tr><td colspan="2">Level of significance</td><td>**</td><td>**</td><td>**</td><td>**</td></tr>
</table>

** = significance at 1% level of probability.

Finally, we recommend freshwater pond-bottom sludge to amendment brackish-water gher dike soil and bitter gourd and yard-long bean in summer and tomato and sweet gourd vegetables in winter season, respectively, for year-round vegetable production in brackish-water gher dikes.

3.3 Women's participation in food security activities

CSISA-BD aims to reduce the technology adoption gap between men and women by ensuring that both men and women farmers are involved in the technology development and dissemination process. Since the start of the project, 47 women farmers have participated in project-sponsored adaptive trials and demonstrations and 300 women farmers have been trained in fish production. An additional 22,379 women farmers have participated in farmers' field days and cross-farm visits.

Not only that, CSISA attempts to identify different avenues for women's involvement, considering the socioeconomic context. Accordingly, technologies and interventions are designed that are appropriate for women and thus specifically target them. Some such technologies are the homestead-based pond polyculture with horticulture on dike and homestead area, the participatory action research on shaded ponds, cage aquaculture technology, and different postharvest technologies.

Trial of new extension approaches for targeting women

CSISA-BD has reassessed the way it delivers technologies to women. This is because evidence from a study on the impact of these two women-targeted aquaculture technologies (i.e., cage aquaculture and pond polyculture) on women in four villages from the Barisal and Khulna hubs has shown that just providing technical solutions for women may not be enough to enable sustained use and equitable benefits from technologies. This discrepancy between expected and actual outcomes arises because women, and men, exist in a multidimensional system of gender relations that influence women's ability to adopt technologies, gain and apply knowledge and skills to adapt them, achieve anticipated production and consumption outcomes, and share equitably in their benefits. Results from the study have informed a trial of a new aquaculture technology dissemination approach in two villages of CSISA-BD's Faridpur hub. The technology package has been re-designed to combine technical aquaculture training with gender consciousness-raising exercises derived from HKI's *Nurturing Connections* manual. Families are involved from the beginning of the intervention and the training is modularized to interact with the different stages of the production cycle and address any social and gender issues that may arise as a result of applying new knowledge. Changes in production and in knowledge, attitudes, and practices (both technical and social) are being monitored among participating women and their spouses through survey research methods and process documentation.

CSISA-BD is also looking into solving further constraints that women face within the homestead to allow successful adoption of aquaculture or agriculture. Accordingly, in recognition of women's preference toward homestead ponds that are shaded with trees and therefore secluded from outsiders, CSISA-BD is testing which fish varieties grow within these shaded conditions in a different research in development (RinD) extension approach where the women themselves are the researchers. Similarly acknowledging women's roles in postharvest activities, IRRI has introduced different postharvest technologies that make it convenient for women to perform these activities.

Connecting and mentoring potential women entrepreneurs in business

In November 2013, a workshop funded in partnership with UN Women was held in Khulna for women who have already initiated small businesses. Many of these businesses were related to seed production, particularly of rice, fish farming, and handicraft production. The workshop had two objectives: to identify the constraints faced by women in establishing and expanding a business and to link women-managed businesses in southwest Bangladesh with supermarket chains, food processors, and women's enterprise associations.

Another approach to the development of women's entrepreneurship has been to initiate a program to test the concept of "InfoLadies." In this program, women are provided with bank loans to buy laptops and Internet connections. They use these to sell web-based services to rural communities such as applications for passports, school exam results, and Skype connections for contacting relatives working outside Bangladesh. For CSISA-BD, the aim of this intervention is to determine whether InfoLadies can also sell agricultural information services to farmers. These might include services such as fertilizer recommendations generated from the *Rice Crop Manager* website, crop production technology through viewing online videos, and links to buyers. Using funds from the IRRI GRiSP program and CSISA-BD, nine InfoLadies are to be trained by two local NGOs: Pride from Jessore and Dnet from Dhaka.

Mechanical rice transplanters introduced

4 PROJECT IMPACTS

4.1 Adoption and Impact

This section presents some of the key results of the CSISA-BD project in terms of adoption of technologies and management practices promoted by the project, as well as CSISA's impact on farm households with respect to agriculture-related income and overall total household income. The next few paragraphs offer a brief description of the methods/procedures employed in order to understand the information and data provided. For further details regarding the methodology, please see Annex Z.

The CSISA-BD Baseline Survey (CBS) employed a multi-level, stratified, and clustered random sampling approach. As shown in Table 4.2-1, it consists of 2,415 respondent households covering 108 villages in 30 districts of the CSISA domain area. All districts under the six hubs were selected,[3] and then two upazillas per district were selected—one "working" upazilla was selected randomly from a list of upazillas where CSISA-BD was implementing field activities at the time of sample selection, and one upazilla was selected randomly as a "control" from a list of upazillas where CSISA-BD had no activities at the time. For the Khulna hub, since only three districts comprise this hub, three upazillas per district were selected from this hub: two "working" upazillas and one control upazilla per district. Two unions were then randomly selected per each upazilla already selected as described above (e.g., Khulna hub had a total of 18 unions selected), and finally one cluster village per chosen union was selected randomly.

The CSISA-BD Endline Survey (CES) returned to a subset of the CBS sample; it comprises 1,213 respondents in 67 villages of 25 districts. The villages selected for re-interviewing include all seven "project" villages in which CSISA-BD had already implemented activities (two villages) at the time of the CBS, or did so later (five villages), as well as 29 "working" villages and 31 control villages. The CES was conducted at the same time (mid-May to mid-July 2015) that CSISA-BD conducted the project's final M&E survey efforts: (i) the Adoption and Impact Survey of Year 4 Farmers (AIS-Y4F), (ii) a second revisit to 50% of the Year 2 (AIS-Y2R2) project farmers that were sampled in 2013, and (iii) an initial revisit to 50% of the Year 3 (AIS-Y3R) respondents sampled in 2014 (Table 23).

Table 23. Sample observations in the comparative surveys, by location.

Survey/zone	CSISA-BD	FtF zone	Northern hubs
CSISA-BD Baseline Survey (CBS)	2,415	1,619	796
CSISA-BD Endline Survey (CES)	1,213	887	326
CSISA-BD Adoption & Impact Survey, Year 5 Cross-section (Y5X)	2,039	1,398	641

These three adoption and impact surveys are stratified by CGIAR center, with random selection of farmers within each stratum made from their respective lists of project beneficiaries; the AIS-Y3F and AIS-Y4F also contain an additional stratum of "combined" farmers.[4] Since these surveys (i.e., AIS-

[3] Note that the project area expanded slightly (by three districts in the northern hubs) at some point following the completion of the sample design and selection of the sample.

[4] A combined farmer is one who has received training from any two, or all three, of the CSISA-BD core partners (CIMMYT, IRRI, and WorldFish).

Y 4F, AIS-Y3R, AIS-Y2R2) were administered late in Project Year 5, and record data for the same recall period (2014 aman season, 2014-15 rabi season, 2015 boro season), they were aggregated to form a cross-section of CSISA-BD farmers to represent all of the direct beneficiary households that CSISA-BD reached during the project period. As such, this cross-section is referred to as "AIS-Y5X." Finally, recall that the CES and the AIS-Y5X were administered concurrently: this means that both share the same recall period, which allows for direct comparison of variables without being encumbered by problems attendant to comparing different production years (e.g., weather variability affecting yields; inflation and price variability affecting costs and revenues).

Finally, the statistical software *Stata* is used to generate population totals based upon the sampling design of the survey and associated parameters, such as the size of the sample frame and the number of respondents randomly selected from the frame. This information is also used to calculate and apply probability weights in order to correct for the bias introduced by the sampling design.

Adoption of technologies/management practices

The first three columns of Table 24 display the stratification of the CES into control, "working," and "project" villages. No actual CSISA farmers of the latter were sampled during the CES, so the sample data drawn from these seven villages should be indicative of indirect impacts at the most immediate level (i.e., within CSISA villages). The data of the first three columns represent technology adoption as assessed from a "full suite" of 75 technologies and management practices that were promoted by CSISA-BD in training and/or as part of on-farm demonstrations and trials. The last three columns represent technology adoption as assessed from a "restricted suite" of 45 technologies and management practices.

As shown in Table 24, the estimated population of non-project farmers adopting technologies/management practices promoted by CSISA-BD is actually higher in the control villages than in the combination of "working area" villages and "project" villages (columns 2 + 3 and column 5 for the full and restricted suites, respectively). Although adoption of technologies by control area farmers was anticipated, such a high level as shown in Table 24 was unexpected. What are the reasons for this observed level of adoption? It could be that the project's impact has spilled over into the control area rather impressively, or perhaps these farmers have been influenced by other development projects (some with ties to CSISA-BD) and their implementing organizations, of which there are myriad in Bangladesh. Note also that many of CSISA-BD's partners, both governmental and NGOs (e.g., DAE, BRRI, BARI, BRAC, TMSS, Jagorani Chakra Foundation), operate at a national level and are likely exposing farmers to new technologies and management practices outside of the actual areas in which the project actually worked.

Table 24. Estimation of technology adopted by non-project beneficiaries during the project period, based on respondent farmers sampled during the CSISA-BD Endline Survey (CES).

Stratification	Control village	"Working" village	"Project" village	All CES villages	"Working" + "Project"	"Control" village
Variable/tech. suite	Full	Full	Full	Restricted	Restricted	Restricted
No. of Endline villages	29	31	7	66	35	30
Pop. of farmers adopting at least one tech./mgt. practice	574,514	401,685	127,560	787,887	357,746	430,141
Mean no. of tech./mgt. prac.. adopted, per farmer	3.6	3.1	3.5	2.3	2.2	2.4
Total area (pop.) under adopted tech./mgt. prac.	529,748	405,165	127,548	490,510	255,450	235,061

In addition, survey data from actual project participants reveal that farmer household locations often differ from project M&E records. This can result from a farmer of a given village attending a training event in another village or a farmer may have his fields (or working his father's land) in a village other than that of his homestead. Some farmers migrate to other locations where relatives live, as well. Such scenarios explain how technology adoption can be diffused into control villages, some of which may even be located in the proximity of actual CSISA-BD villages.

Regardless of all possible reasons for the observed technology adoption within the CES control locations, the end result precludes the use of a differencing approach to estimate the level of technology adoption by indirect beneficiaries of the project. Instead, an alternative perspective must be considered. The penultimate column of Table 24 represents technology adoption from the restricted suite of 45 technologies/management practices by farmers in the "working" and "project" villages. This provides a conservative estimate because the restricted suite generally represents technologies that allow a tighter attribution to CSISA-BD, since these are less likely to be widely promoted by other entities besides CSISA-BD and its local partner NGO partners and its government partners (e.g., BRRI, BARI, DoF).

In the three tables that follow, adoption projections are presented (by CGIAR center) for individual technologies/management practices that comprise the restricted set discussed above. These tables are derived from data collected in Year 5, and display the population estimates of direct-beneficiary adopters trained by CSISA in Year 3 and Year 4, as well as population estimates of indirect adopters from the CES with associated numbers of hectares on which a given technology/management practice was applied. Note that aggregating the number of farmers across technology categories will overestimate the total to a certain extent because farmers typically have adopted multiple technologies and/or management practices (two to three, on average). In contrast, double-counting of area under new technologies is allowed for FtF reporting; thus, each table displays aggregated indirect total hectares that are estimated to have been applied in Year 5.

Rice varieties and management practices; mustard and sunflower as new crops

Table 25 presents 15 different rice and rice-based technologies and management practices promoted by CSISA-BD, and used by direct and indirect beneficiary farmers of the project. These technologies are broadly categorized into five groups: (i) improved rice varieties, (ii) improved management practices, including seedling and fertilizer management, (iii) introducing cash crops in the cropping system, (iv) mechanization, and (v) water-saving technologies.

Table 25. Technology and management practices promoted by CSISA-IRRI.

Technology/best management practice	CSISA farmers (Y3-Y4)	Indirect farmers	
		Farmers	Area (ha)
Saline-tolerant rice	1,314	9,964	2,315
Submergence-tolerant rice	1,947	4,306	496
Short-duration rice	5,284	80,599	20,673
Aromatic rice	1,253	13,005	3,454
Mustard as a new crop		32,018	5,290
Sunflower as a new crop		2,043	386
Power reaper used to harvest rice	1,749	838	343
Younger seedlings	12,140	63,847	23,625

Recommended early planting applied	6,927	24,027	10,442
Line transplanting applied	12,521	109,242	29,053
Recommended 2–3 seedlings per hill applied	12,105	83,392	27,043
Recommended urea application rate applied*	5,222	25,112	6,114
Recommended timing of urea application	9,623	43,339	16,124
Recomm. other fertilizers applied basally	8,331	36,935	11,003
Alternate wetting & drying (AWD)	995	5,887	2,531
		Total	**158,892**

* Year 4 farmers only.

The number of project direct-beneficiary farmers using the technologies shown in Table 25 varied widely from approximately 1,000 farmers (AWD) to more than 12,520 farmers for line transplanting. These technologies have reached a large number of project indirect-beneficiary farmers in the neighborhood of the project area. The number of indirect-beneficiary farmers using the project-promoted technologies varied widely from about 840 farmers using a power reaper to harvest rice to more than 109,240 farmers using line transplanting for rice. The area under individual technology adoption ranged from more than 340 ha for the power reaper to more than 29,050 ha for line transplanting. Compared with the initial adoption study (data not shown), a good positive trend toward adoption of these improved rice and rice-based technologies and management practices is observed.

Improved rice variety adoption: Among the improved rice varieties promoted by the project, the short-duration rice varieties were most popular. The number of farmers using short-duration rice varieties is around three to four times more than other varieties for direct farmers, and 6–20 times more for indirect farmers. The number of farmers using stress-tolerant and aromatic rice varieties was relatively low. The main reason to adopt this variety is to create an opportunity to cultivate an additional crop on the same piece of land. Indirect farmers adopted this variety on more than 20,670 ha of land, whereas other varieties were cultivated on approximately 6,270 ha.

Management practice: A large number of direct and indirect farmers used best-bet rice crop management practices, such as the use of younger seedlings, early planting of seedlings, line transplanting, planting the recommended number of seedlings (two to three per hill), use of the recommended rate of fertilizers, and timely application of fertilizers. The number of direct-beneficiary farmers using the rice crop management practices ranged from about 6,930 for recommended early planting to more than 12,520 for line transplanting. For indirect farmers, the most popular rice crop management practice was line transplanting (109,242 farmers on more than 29,000 ha), followed by the seedling per hill recommendation (83,390 farmers on 27,040 ha) and younger seedlings (63,847 farmers on 23,635 ha).

Introducing cash crops in the cropping system: In places where agricultural lands were fallow or only one or two crops per year were cultivated, the project introduced and promoted cash crops such as sunflower and mustard. As a result of the project, more than 32,000 farmers adopted mustard as a new crop on 5,290 ha and more than 2,000 farmers adopted sunflower as a new crop (on 390 ha). The cultivation of cash crops resulted in more sustainable intensification and crop diversification in the project areas, thereby increasing land productivity and farmers' income.

Mechanization and water-saving technologies: The project promoted power reapers to mechanize rice (and wheat) harvesting, and the number of farmers (particularly CSISA farmers) using this incredibly labor-saving technology is increasing fast. In the third and fourth years of the project, the number of farmers using a power reaper was found to be 1,749 direct farmers and 838 indirect farmers. The use of this machine not only overcomes the observed labor crisis during harvest time (thus reducing harvesting costs) but it also reduces the turnaround time between two crops, thus enabling timely planting of the next crop. AWD is an irrigation method used to save water and irrigation costs; it was applied by nearly 1,000 direct farmers and by approximately 5,900 indirect farmers. Large-scale adoption of this technology can greatly improve water-use efficiency in rice farming.

Technologies and management practices for maize and wheat

Table 26 shows the restricted set of technologies/management practices that were promoted by CSISA-CIMMYT as part of training activities, demonstrations, and/or trials. The first column identifies the number of CSISA Year 3 and Year 4 farmers adopting a given entry, whereas columns two and three cover indirect farmers and the total area to which they applied a given technology or management practice. Aside from maize and wheat as new crops, the attribution to CSISA-BD for adoption by indirect farmers should be fairly tight. Although CSISA-BD promoted cropping system changes designed to incorporate maize and wheat (often as new crops to a given farmer), the indirect adoption values shown for maize and wheat as a new crop are likely overstated somewhat. This is because farmers on their own will be responsive to relative output prices for cereals; for example, as maize prices have declined the past two years, farmers are switching to wheat. On the other hand, the increased presence of these crops across the landscape due to CSISA's efforts, especially in Mymensingh and certain areas of the south, may have concurrently been influential on farmers' decisions to adopt these crops as (new) alternatives.

Table 26. Technology and management practices promoted by CSISA-CIMMYT.

Technology/best management practice	CSISA farmers (Y3-Y4)	Indirect farmers	
		Farmers	Area (ha)
Maize as a new crop*	3,489	46,855	8,231
Intercropping leafy veg. or legumes with maize	1,067	3,182	255
Wheat as a new crop*	1,529	80,799	11,386
New wheat varieties (BARI Gom) 25,26,27,28) *	3,306	7,670	1,546
Bed planting*	4,113	12,871	2,770
Power reaper used for harvesting wheat*	532	195	52
Powered maize sheller*	1,730	13,615	3,191
Recommended wheat sowing date applied	3,768	26,500	4,230
Straw residue retained on field (at least 8")	1,942	9,040	1,088
Recommended seed & row spacing (maize)	4,338	13,588	2,449
Recommended fertilizer doses applied*	8,782	23,076	4,096
Recommended fertilizer application times	6,718	19,054	11,337
Recomm. irrigation rate & timing info.	6,104	17,093	3,587
		Total	**54,219**

* Includes Year 2 farmers.

During much of the project period, CSISA-CIMMYT promoted four new wheat varieties developed by BARI (Bari Gom 25, 26, 27, and 28). Table 26 indicates that more than 10,000 farmers have adopted one of these varieties, which was a key intervention of the project in order to help increase wheat productivity and introduce germplasm that is tolerant of biotic stresses (e.g., stem rust, Ug-99). On a lesser scale, sweetcorn and popcorn varieties were adopted by an estimated 828 and 174 CSISA farmers, respectively (data not shown). Although these specialty maize crops show only limited adoption, CSISA-BD promoted them as a way of laying the groundwork for longer-term cropping and dietary changes required in the future.

Much of the success for CSISA-CIMMYT, in terms of technology adoption, has been with respect to the application of best management practices taught to farmers during the training events that spearhead each particular intervention (in addition, many farmers received pocket reference booklets covering all the best practices they learned in the training). Table 26 shows that, even factoring in some double-counting, well over 100,000 direct and indirect farmers adopted key crop management recommendations designed to increase productivity by better optimizing input usage. Among these are recommended rates and application times of fertilizer and irrigation, recommended sowing dates for wheat, and recommended seed and row spacing for maize.

Technologies and management practices for aquaculture

Table 27 shows the estimated population for CSISA farmers (direct beneficiaries) and non-project (indirect beneficiary) farmers that have adopted improved aquaculture practices promoted by CSISA-BD, as well as the estimated total area applied by indirect farmers. For CSISA farmers, the practice of counting fingerlings during pond stocking was the most applied recommendation, with 6,573 farmers; the second most applied practice was preparing the pond using lime (6,174 farmers). What is remarkable about the aquaculture improved-practice adoption numbers for CSISA farmers is that they exhibit a relatively narrow range (3,422 to 6,573 farmers) compared with the ranges observed for rice, maize, and wheat. This is perhaps a reflection that, from the very beginning of the project, CSISA-WorldFish promoted a set package of 10 key improved management practices designed to dramatically increase aquaculture productivity.

Table 27. Key technology and management practices promoted by CSISA-WorldFish.

Technology/best management practice	CSISA farmers (Y3-Y4)	Indirect farmers	
		Farmers	Area (ha)
Prepare pond/gher with lime	6,174	39,410	16,045
Count fingerlings during stocking	6,573	15,390	9,801
Recom'd. fingerling stocking rate	5,403	713	29
Recom'd. size of tilapia/carp fingerlings	5,686	19,982	12,226
Acclim. fingerlings before release	4,583	14,828	n/d
Regular sampling applied	5,544	11,743	7,698
Homemade supplemental feed	4,078	29,631	13,460
Feeding frequency: 2 times/day	3,422	16,492	17,155
Pelleted, granular, or floating feed	4,189	25,025	15,352
Fertilizer to increase water productivity	5,376	31,220	15,961
Maintain water level in pond/gher	3,425	11,391	4,332

Use of aeration	5,314	31,422	16,648
Adopted pond aquaculture as a new system	n/d*	20,838	7,144
Adopted gher rice-fish prod. as a new system	n/d	11,460	6,871
Adopted gher rice-shrimp prod. as a new system	n/d	4,535	1,824
		Total	**144,547**

* n/d = no data

With respect to the wider application of improved practices, by a good margin the recommended practice most adopted by indirect farmers was the preparation of ponds using lime, with more than 39,000 farmers applying this on a total of more than 16,000 ha. Table 27 also shows that more than 31,000 indirect farmers applied aeration and fertilizers to increase water productivity, and the use of homemade supplementary feed was applied by 29,631 farmers. Almost all of the improved practices are robust in terms of widespread adoption, with the puzzling exception of the recommendation for fingerling stocking rate, which is only 713 farmers. Note that the adoption by CSISA farmers of this recommended practice is rather good (near the middle of the range previously mentioned), so it appears that the problem is confined to indirect farmers only. Further field-level investigation of this issue is warranted in order to uncover the cause of this discrepancy.

In terms of the improved practice having the highest adoption area among indirect farmers, “Feeding frequency: 2 times per day” was applied on 17,155 ha. “Use of aeration” (16,648 ha) and “Prepared ponds using lime” (16,045 ha) were the second and third most-applied recommendations, respectively. Finally, it was estimated that a total of 20,838 non-project farmers adopted pond aquaculture as a new production system on a total of 7,144 ha. Another 11,460 indirect farmers adopted “gher rice-fish production” as a new system on 6,871 ha, while “gher rice-shrimp production” as a new system was adopted by 4,535 indirect farmers on 1,824 ha.

Household income

Income derived from on-farm agricultural and aquaculture production was collected as sales revenue in the cost and returns modules and the marketing module. The survey also collected income data from regular employment with either paid wages or salary, and from other sources of non-agricultural income (e.g., household business, remittances). The employment module acknowledges that households have different sources of off-farm income derived from working for another person or organization, namely, employment as agricultural labor on someone else’s farm, non-agricultural labor, or as a salaried employee (e.g., teacher, bank teller).

Table 28 presents the median and mean total annual income per household across the overall CSISA domain area for the inflation-adjusted CBS, the Year 5 cross-section, and the undifferentiated CES. The table also provides mean income values for selected subcategories of interest (note that these are not additive over the subcategories). Comparing the overall medians and means for the CBS and CES reveals very little difference, whereas the median income ($2,245) and mean income ($3,189) from CSISA farmers are significantly higher than both the CBS and CES. The latter is also true of the “CSISA crops and aquaculture” category, which specifically focuses on income from crops promoted by the project, namely, rice, maize, wheat, mustard, sunflower, fish, prawns, and shrimp. The difference between CSISA (Y5X) and the CBS and the CES is $464 and $320, respectively.

Table 28. Mean annual income (US$) per household by category and zone.

Category	Baseline	CSISA (Y5X)	Endline
Median total HH income	**1,898**	**2,245**	**1,819**
Mean total HH income	**2,704**	**3,189**	**2,734**
Income categories (means)			
CSISA crops & aquaculture (C + A)	478	942	622
Other agricultural products	887	827	1,205
Employment (salaried/wage labor)	1,198	1,874	1,362
Household businesses	653	1,229	901
Remittances	2,027	2,813	2,970
Sale of assets	2,118	3,264	1,492
Rental income	321	618	443

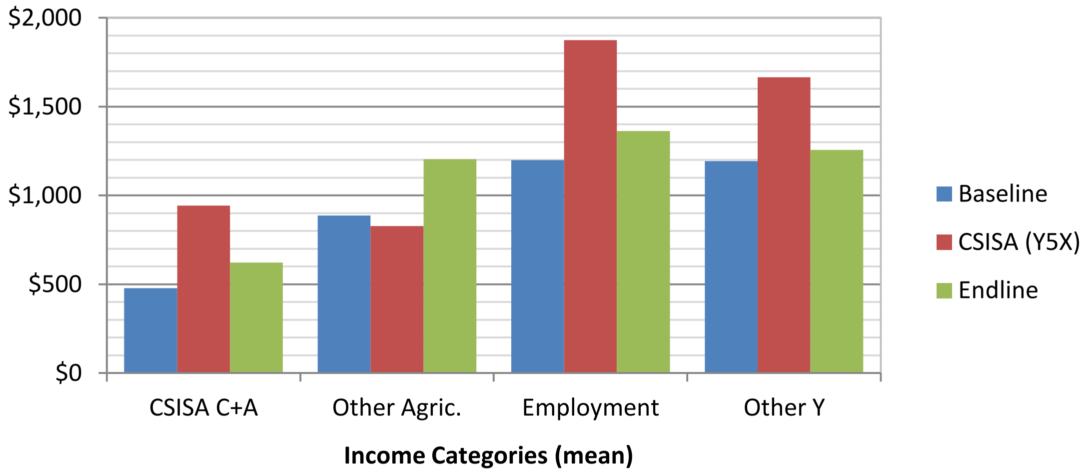

Fig. 59. Mean household income by income quintiles.

Figure 59 contrasts mean income per household of the CSISA crops and aquaculture (CSISA C + A) category with other agricultural products, off-farm employment, and other key sources of income (e.g., household businesses, remittances). It is clear that the latter two categories are quite substantial in terms of contributing to overall total household income (in each survey), but it is also clear that the CSISA crops and aquaculture income category has gained in relative importance for CSISA farmers surveyed (Year 5 cross-section). This is again indicative of a positive impact of the project. Note that CSISA farmers have a sizable advantage in terms of remuneration from off-farm employment and household business (Table 28) as well. This may suggest that CSISA farmers are more energetic, entrepreneurial, and/or proactive.

As shown in Table 29, these differences are highly statistically significant (*P* = 0.000), indicating that CSISA-BD had a robust impact on household incomes of direct project beneficiaries, particularly in comparison to the baseline survey. Table 29 also shows the percentage share of total aggregated household income, as distributed across five income quintiles. Note that the profile is skewed rightward and suggests that households of the southern hubs are better off, on average, than those of the northern hubs. This finding is similar to the conclusion drawn from observing the consumption expenditure data. Figure 59 clearly indicates that, within the top two income quintiles, FtF zone households account for significantly more of the overall total income generated by all the sampled households than do the northern hubs; they also account for a lesser percentage of the total aggregated income in the lowest two income quintiles (i.e., the poorest 40%).

Table 29. Differences in mean income per household, by category, between surveys.

Variable	CSISA (Y5X)	Baseline	Diff. in mean	t statistic	*P* value
Total household Y (YT)	$3,189	$2,704	$485	93.367	0.000
CSISA crops/aqua (Ycca)	$942	$478	$464	143.52	0.000
CSISA cereal crops (Yagc)	$586	$190	$396	287.89	0.000
CSISA aquaculture (Yaqc)	$1,054	$744	$310	40.974	0.000
Variable	**CSISA (Y5X)**	**Endline**	**Diff. in mean**	**t statistic**	***P* value**
Total household Y (YT)	$3,189	$2,734	$455	55.338	0.000
CSISA crops/aqua (Ycca)	$942	$622	$320	148.16	0.000
CSISA cereal crops (Yagc)	$586	$494	$92	70.205	0.000
CSISA aquaculture (Yaqc)	$1,054	$1,026	$28	2.26	0.025

SUCCESS STORY

Maize changing lives of char farmers in Mymensingh

CSISA-CIMMYT has introduced both maize and new production technologies to char farmers in Mymensingh

Photo: CIMMYT MYMENSINGH

"Thanks to the training and assistance received from CIMMYT through USAID, my life has changed: I built a pucca house, purchased two cows, I have some savings in the bank, and my family livelihood has improved."

- Adbur Razzak, CSISA-BD maize farmer, Mymensingh

In Dhala Amian char village in Mymensingh District, T. aman-boro (rice-rice) was the major cropping pattern. Most farmers there did not obtain a good profit from boro rice because of its low yield and high production cost (requirement of around 40 irrigations). In addition, maize was grown under conventional practice only on 200 decimals (dec.) of land and shelling was done by hand. This situation began to change in June 2012, however, when CIMMYT, through CSISA-BD, demonstrated a maize shelling machine with maize harvested from the 200 dec. (0.81 ha). This experience encouraged farmers in the village since they learned that the performance of the maize sheller reduces production costs remarkably. Thus, they became interested in increasing maize area in 2012-13 and requested CIMMYT to provide training on modern maize production technologies. During this demonstration, CIMMYT personnel emphasized the need to intensify the farmers' cropping pattern, and they advised the farmers to change their current rice-rice pattern to a short-duration rice (SDR)-based aman-maize-jute (SDR-M-J) cropping pattern.

Mr. Abdur Razzak, a smart young progressive farmer, was one of the farmers in the village who decided to transplant SDR variety BINA-7 on 18 dec. of land in July 2012. In conjunction with a good yield (298 kg of rice or 4.1 t/ha), farmers in the village were very happy to see the early harvest during this food-deficit period, which encouraged him and other farmers to invest for fairly cost-intensive early maize cultivation. Thus, in October 2012, a farmers' group with 20 interested farmers was formed and trained on modern hybrid maize production technologies. Five of these farmers, with Abdur among them, were also selected to conduct hybrid maize demonstrations, for which CIMMYT provided only the seeds of the preferred hybrid maize variety Elite.

Thus, Abdur seeded maize on 12 October 2012 and harvested on 30 March 2013. He obtained a yield of 550 kg/18 dec. (7.5 t/ha) and sold maize grain for BDT 9,400 (production cost was BDT 4,900), which gave him a net return of BDT 4,500 (US$797/ha). Before CIMMYT training, his net profit from boro rice was BDT 2,350/18 dec. (BDT 416/ha), but, after receiving training and planting maize, his profit increased by 91.5% in comparison with that of boro rice. Because of the early maize harvest, he was able to grow jute, obtaining a net return of $323/ha. Thus, by changing his cropping pattern, Abdur's gross margin increased from $702 under a rice-rice pattern to $1,418 under the CSISA-BD recommended pattern (SDR-M-J).

After such a great profit, in 2013-14, Abdur increased his maize area to 500 dec. (from 18 dec.), again under this recommended pattern. He also became involved in maize marketing. In 2013-14, he purchased 72 tons of maize grain from Dhala Amian and neighboring villages, and earned a profit of $903 in two months, while in 2014-15 he purchased 80 tons and earned a profit of $1,355, selling the grain to millers and other large businesses. Thus, Abdur Razzak is helping other farmers in his village by purchasing their grain. As a result, maize cultivation is increasing in Dhala Amian and in neighboring villages. In 2011-12, maize area was 0.81 ha. It increased to 8.1 ha in 2012-13, to 51.8 ha in 2013-14, and to 58.3 ha in 2014-15 in Dhala Amian.

Maize fertilizer research

5 PROJECT MANAGEMENT

5.1 Project monitoring and evaluation

CSISA began in Bangladesh (i.e., CSISA-BD) in October 2010, and began implementing field-level activities in June 2011. Currently, CSISA-BD has one common M&E system that serves reporting requirements from USAID and the data requirements of the three core partners or CG centers (IRRI, CIMMYT, and WorldFish). However, this was not the case during the first two years of the project, when data from activities conducted were recorded on different forms produced by each CG center. During the first year of CSISA-BD, only WorldFish had an M&E specialist. By the second year, an M&E manager and IRRI M&E specialist were recruited at the end of the first quarter, and a CIMMYT M&E specialist at the end of the second quarter. During that year, the project did not have an operational M&E system with supporting protocols, but there were some attempts to have some procedures in place. For example, a review of forms used to collect data at the hub level from project activities was initially conducted in order to produce common data collection formats for the project. In addition, procedures started to recruit hub-level M&E officers (six) with the idea that hub M&E officers were going to implement the day-to-day monitoring of the hubs' activities and assist hub managers and ADOs in this process.

By the middle of the third year, common data collection forms for the project were implemented[5] as well as a set of guidelines for folders and data organization at the hub level. Later on, in January 2014, these forms and guidelines were improved based on field experience and put together with guidelines on information management, documentation, evaluation, and assessment into what became version 1 of the CSISA-BD M&E and Information Management Guideline. This guideline provides clear instructions for organizing CSISA-BD documents at the hub level, which makes the data easily accessible to all CSISA-BD staff as well as outside auditors. In addition, following recommendations made by the USAID Data Quality Assessment (DQA) team, an annual internal DQA process has been institutionalized within the project to ensure that data quality is maintained.

Parallel, in December 2013, the project finalized revisions of the CSISA-BD Performance Monitoring and Evaluation Plan (PMEP) and submitted it to USAID for approval. The M&E plan includes the project's development hypothesis and an updated and reworked Results Framework (RF). During the first three years of CSISA-BD, the project reported on its progress against nine FtF indicators; however, after the update, CSISA-BD agreed with USAID Bangladesh Mission to report on six FtF Indicators: three output indicators and three outcome indicators (i.e., 4.5.2-2 Number of hectares under improved technologies or management practices; 4.5.2-5 Number of farmers and others who have applied improved technologies or management practices; and 4.5-16,17,18 Gross margin per hectare, animal, or cage of selected product; and 4.5.2-7 Number of individuals who have received USG-supported short-term agricultural sector productivity or food security training; 4.5.2-13 Number of rural household benefitting directly from USG interventions; and 4.5.2-37 Number of MSMEs, including farmers, receiving business development services from USG-assisted sources). Thus, project personnel, in consultation with USAID, reviewed the project objectives and matched them with the corresponding indicators. In addition, two custom indicators were created to measure results for cases in which there were no corresponding FtF indicators (i.e., Number of farmers who have used improved agricultural services and Value of private sector investment in agricultural machinery and equipment resulting from project intervention).

---

[5]Previously, a common system to organize project records was lacking and there were different forms/templates for data collection (among CG centers and among hubs). As a result, the reporting process was rather inefficient.

Continuing improvement of the CSISA-BD M&E system, in April 2014, the project implemented an offline database system using Access in order to compile all data from all activities conducted, to have an organized system for data on all the project direct beneficiaries, and to have specific templates for reporting purposes; a third party was hired to create this database. Thus, significant improvements have been made in the last two years in terms of the CSISA-BD M&E system, and, more importantly, in the attitude of CSISA managers and field staff who had started considering more seriously the M&E process.

It is important to recognize that M&E is a continuing process and CSISA-BD personnel are constantly striving to make improvements in its implementation. The DQA conducted in October 2013 by USAID was very helpful in this respect, and the input from USAID personnel to hub staff regarding the importance of their role in M&E was extremely beneficial for the overall process—not only in being able to properly assess and verify the project achievements, but also for creating awareness of their own accountability with respect to the project's work.

Some of the key learnings follow:

- To make the project staff accountable for the M&E system, it is necessary to involve them from its design phase; it is also important to include M&E functions/roles within the staff's job responsibilities, which will be assessed during year-end staff performance reviews.
- To ensure data quality, it is necessary to incorporate the observations/recommendations coming from the internal data quality assessment procedure within the specific time interval. Through this internal DQA process, the project is able to capture the learning coming from the documentation process.
- Real-time data management encourages that management personnel make the right decision at the right time, and it also helps to ensure data authenticity.

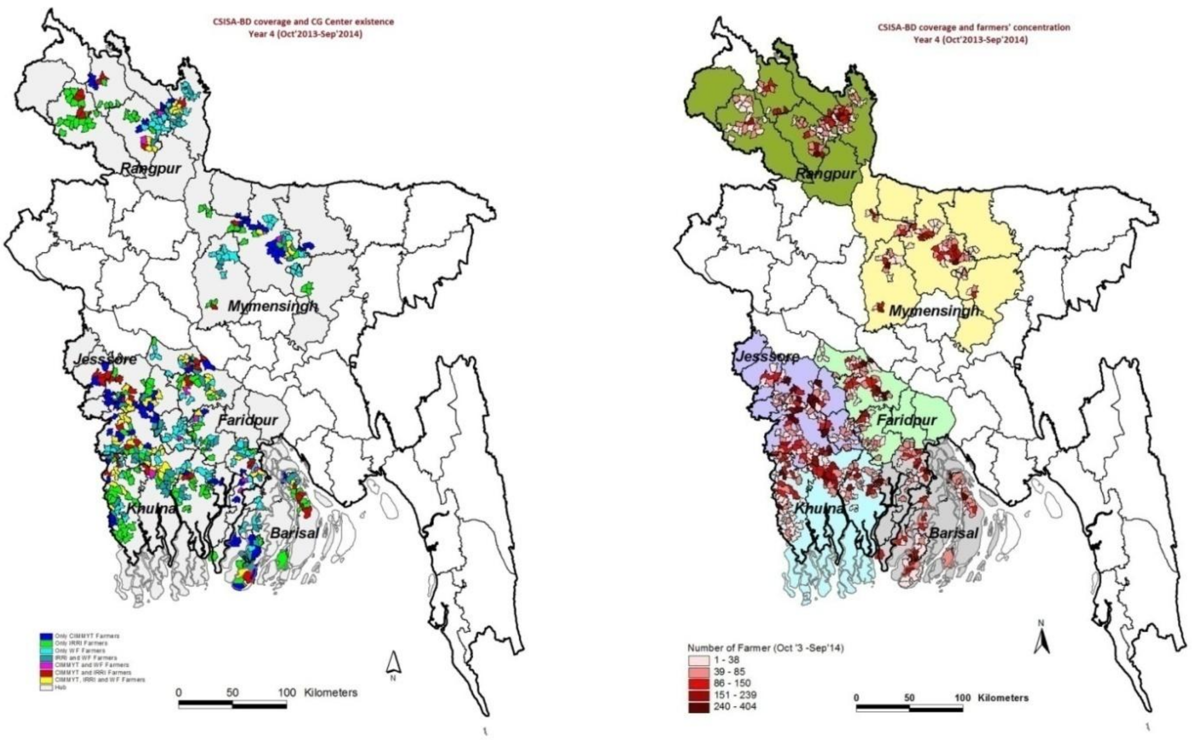

Fig. 60. CSISA-BD coverage in Year 4.

The CSISA-BD Database project designed a unique database for the storage of project information in a systematic manner. Through this database, the project staff are provided with a unique ID for each project-participating household and household member. This ID helps them to identify the event and CG center that provided a farmer with support. The GIS-generated maps (Fig. 60) show where the project works and the location of trials and demonstrations.

5.2 Partnerships

CSISA-BD works with a wide range of partners from GoB agencies, NGOs, and the private sector, in addition to farmers. Strengthening of project partnerships involves mobilization (through LoA/MoU) and capacity building of the selected partners to effectively engage them in their respective project roles locally, regionally (hub), and nationally.

In the reporting period, CSISA-BD works with other USAID partners (e.g., IFDC, IFPRI, and iDE) and other FtF projects (AIP, AIN, and an agricultural extension project) as well as the MYAP partners CARE and Save the Children. It is also working with partners of ACIAR-funded projects (Rice-Maize project, Climate Change Adaptation project, and Rice-Pulse project), the IFAD-funded Climate Change Adaptation project, and the BMGF-funded STRASA project.

5.2.1 Partnerships with government organizations

IRRI, CIMMYT, and WorldFish have long-standing partnerships in Bangladesh with government agencies such as BARC, BRRI, BARI, BFRI, DAE, and DOF that have been continued through CSISA-BD. In the reporting period, a total of four LoAs were awarded by the project for three partners, BINA, BARI, and BRRI. Out of these four, IRRI and CIMMYT both awarded two contracts for a total of US$54,374.

5.2.2 Partnerships with NGOs and private organizations

The project implements field activities through partner NGOs (PNGO) that provide field staff with bicycles for transportation. They help the project organize farmer meetings, training events, and field days. They participate in training events by giving some of the training and in implementing and collecting data from trials and demonstrations. Project staff support the PNGO staff by providing them with ToT, supporting them when training farmers, and supervising the implementation of trials and demonstrations.

In the reporting period, a total of 41 LoAs, MoUs, and service contracts were awarded by the three CG centers for 22 partners (including NGOs and private companies). In the reporting period, a total of $1,096,866 was disbursed to the partners, out of which $916,728 (84%) was disbursed to the NGO partners, followed by the private sector ($125,764; 11%) and government organizations ($54,374; 5%) (Fig. 61). Among the three CG centers, IRRI disbursed $728,387 (67%), followed by WorldFish ($234,362; 21%) and CIMMYT ($134,117; 12%).

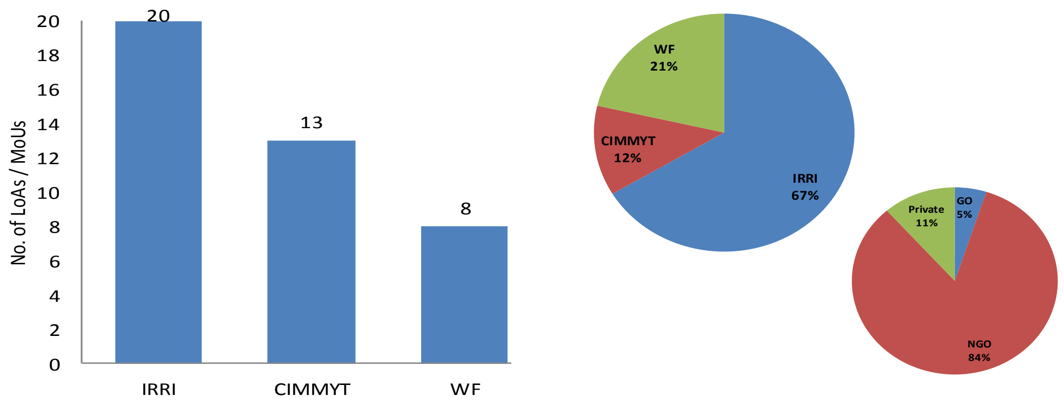

Fig. 61. Summary of partnerships with GOs, NGOs, and private organizations.

Common partners in hubs: During the reporting period, JCF, TMSS, BDS, and SDC are common partners in Jessore, Khulna, Barisal, and Faridpur, as shown in Table 30. GJUS, ST, APEX, and Solidarity are common partners of IRRI and CIMMYT in Barisal, Mymensingh, and Rangpur hubs, respectively.

Table 30. Common NGO partners among the CG centers, by hub.

Hub	IRRI	CIMMYT	WF
Barisal	BDS	BDS	BDS
	GJUS	GJUS	--
	ST	ST	--
Faridpur	SDC	SDC	SDC
Jessore	JCF	JCF	JCF
	BS	--	BS
Khulna	TMSS	TMSS	TMSS
Mymensingh	APEX	APEX	--
Rangpur	Solidarity	Solidarity	--

JCF = Jagoroni Chakra Foundation, TMSS = Thenga Mara MohilaSobuj Sanga,

BDS = Bangladesh Development Society; ST = Speed Trust,

SDC = Society Development Committee,

GJUS = Grameen Jano Unnayan Sangstha.

5.3 Capacity Building

5.3.1 CSISA-BD aquaculture-horticulture capacity building (training) activities

The Cereal Systems Initiative for South Asia in Bangladesh (CSISA-BD) project is implemented through a partnership among three CGIAR centers (IRRI, CIMMYT, and WorldFish), funded by USAID's Feed the Future (FtF) initiative. CSISA-BD's goal is to increase the household income, food security, and livelihoods in agriculturally dependent regions of Bangladesh. CSISA-BD worked to maximize farming income and productivity through improved technologies and varieties in agro-aqua systems and to improve nutrition, dietary diversity, additional income, and women's empowerment in six domains or hubs.

Training is an effective approach to increase knowledge and skills and bring about changes in attitudes. Knowledge plays a key role in the promotion of improved technology. As a part of CSISA-BD project objective-3 (**Capacity building for researchers, extension workers, and service providers from public, private, and NGO sectors to enable the rapid dissemination and adoption of improved technologies and management approaches),** different types of training and capacity-building activities were conducted for farmers, extension staff, value chain actors, project stakeholders, and CSISA staff members.

The overall objectives of WorldFish capacity-building initiatives were to increase the knowledge of stakeholders for the wider dissemination of improved aquaculture and horticulture technology for more production and household income. Therefore, recognizing the needs to enhance the skills and knowledge of different stakeholders, various modules were developed and training courses were organized at two levels: (i) field-based training for farmers and (ii) residential training courses (ToT) for project staff and service providers.

Farmers' capacity building

Training and refresher training: For the promotion of improved aquaculture and horticulture technology, a two-day training course was organized for the project beneficiaries (direct farmers) over the period (Table 31). Each day's duration was 5 hours. A total of 27,495 farmers (35% were women) attended in organized courses over the period, in which usually the courses were facilitated by the project staff (both WF and partner staff). The course coordinator (respective ADO) made a training plan prior to organizing the farmers' training course. The discussion topics, practical sessions, and delivery methods based on FGDs are mentioned in the training plan. Different types of participatory methods (PAL, group discussion, practical session, etc.) are followed when conducting the course. A gender and nutrition awareness session is also included in the two-day farmers' training course. Based on the demand, WorldFish provided training certificates to 10,319 direct farmers.

Figure 62: Farmers' Training

Table 31. Number of farmers attending two-day basic training courses.

System	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Improved pond-based aquaculture technology	1,235	3,617	2,738	3,301	3,098	13,989
Improved rice field/gher-based aquaculture technologies	1,247	2,366	2,041	1,352	1,596	8,602
Household-based aquaculture and horticulture	494	1,063	1,234	1,027	1,086	4,904
Total	**2,976**	**7,046**	**6,013**	**5,680**	**5,780**	**27,495**

After receiving 2-day basic training, farmers started to implement the training knowledge practically in their own fields. One participatory farmer's trial (PFT) is established in each farmer's group through the most interested and dedicated farmer in the group with the support of the partner staff.

As per project strategy, CSISA-BD continued with a group of farmers up to two years. A one-day refresher training course was organized for the same farmers' group in the following year. In refresher training, farmers reviewed their previous year's learning and experience. So, the session conducted was based on farmers' need. During the project period, a total of 828 batches of refresher course were conducted, at which 19,267 farmers were present.

Coaching: Regular farmers' coaching sessions were organized to discuss and solve issues arising during practicing technical knowledge gained from training (Fig. 63). In the coaching sessions, DoF staff were also invited to

Fig. 63. Farmers in coaching session.

discuss the issues about which farmers wanted to learn. Thus, farmers were linked with the government body, which created direct collaboration. During the project period, 1,389 coaching sessions were organized, in which 29,992 farmers (19,238 males and 10,754 females) participated.

Exchange visit: The purpose of this event is to share the knowledge and experience of successful farmers with a group of farmers for further adoption of the technology from one place to another. The impact of exchange visits in some cases is very high, because farmers could see the results and share experiences directly with successful farmers. A total of 685 farmers (492 males and 193 females) participated in the exchange visits in 40 batches during the project period. The best example of the impact of exchange visits is the adoption of the gher farming system in the northwest region. A group of 11 farmers visited Jessore hub to see the gher farming system in 2013. They realized there was a great opportunity for practicing the system in their own area. Therefore, after returning home, seven farmers of the group decided to renovate their rice fields to start gher farming. Observing the success, around 500 farmers received training on improved farming of fish-rice-vegetables (the gher system) in this region.

Linkage events: After the end of the participatory farmers' trials, with the help of the project, the farming group organized a linkage event to share the results and experiences of the improved practices and/or varieties (Fig. 64). Stakeholders, including local DoF/DAE staff; market actors such as feed dealers, seed producers, and input suppliers of the surroundings; and neighboring farmers were invited to the events. The lead farmer, on behalf of the farming group, presented the production system and analyzed the cost-benefit of his production. In fact, the linkage events created a win-win situation for the farmers, market actors, and other stakeholders, including boosting marketing opportunities. During the project duration, a total of 639 linkage events were organized and 18,645 direct farmers and 36,639 indirect farmers participated in the events.

Fig. 64. Linkage event.

Capacity building on fish nursery management:

Quality fish seed plays an important role for more production. WorldFish observed that available nurseries in hub areas did not have adequate knowledge about carp nursery management. As a result, to address the issue of quality fingerlings, training on improved fish nursery management was organized in all hubs. These courses introduced the importance of pre-stocking pond preparation, the use of seed from reputable hatcheries, stocking in proper density, good water quality management, and feed use. The demand for large-sized and over-wintered fingerlings among the farmers was also analyzed in these sessions. As a result, the farmers are motivated to produce the same for business profit. A total of 298 fish nursery operators received training in Year 1 (89) and Year 2 (209) to ensure quality fish seed to supply among grow-out fish farmers.

Capacity building of implementing partners staff

ToT and refresher course on aquaculture & horticulture extension and training methodology

Fig. 65. PNGO staff field visit.

CSISA-BD has conducted a 6-day ToT course on aquaculture & horticulture extension and training methodology each year for the implementing partner extension staff, followed by a 3-day refresher course in the following year. A total of 109 partner staff (11% women) were trained in the project period. Implementing partner NGOs (PNGOs) played a vital role in technology dissemination with their increased knowledge and skills from the training and on-the-job support. The content of the course focused on the fundamentals of fish biology, aquaculture, various fish diseases and preventive and curative measures, how to organize/facilitate farmer meetings and training sessions, and communication skills. Moreover, during field visits by hub managers and ADOs, PNGO staff were mentored in terms of effective delivery of services as well as given guidance and instructions with respect to record-keeping (Fig. 65). The staff later in the following years received 3-day refresher training.

Training for market actors on improved aquaculture

A total of 141 input dealers/traders (seed, feed, and other input suppliers) were trained for enhanced technical capacity to ensure better services to their farmer clients on improved aquaculture technology in six different hubs during 2014.

The aims of the training course were to

- Improve knowledge and skills on aquaculture management of value chain actors.
- Build local capacity of private actors, so they could extend technical assistance as part of their business.
- Establish effective linkage among public-private-farmers.
- Make value chain actors aware of the importance of providing effective information to the farmers for their sustainable business.

A training course was conducted focusing on participants' expectations. They were trained about the basics of aquaculture. They learned about several management issues such as pond preparation, stocking density, supplementary feeding, fish diseases, etc.

The participants' opinions about this training program were very positive. Some of them believed that this training would develop better linkage with their clients. They felt more confident to provide suggestions on aquaculture. This will help them a lot to publicize improved aquaculture technology and thus handle a sustainable business.

Initiative on training on improving fish seed quality

Fish seed accounts for approximately 30% of production costs; thus, the use of poor-quality seed in aquaculture production systems results in low and ineffective growth, leading to poor economic returns for farmers. It is observed recently that most of the existing carp and tilapia hatcheries are affected by some kind of genetic deterioration. Most of the hatcheries somewhat ignore basic genetic principles and also violate hatchery rules and regulations. The hatcheries are producing sufficient numbers of fish seeds but the seeds produced, in most cases, are reported to be of poor quality. To overcome this problem, CSISA-BD worked with 30 private hatcheries (carp and tilapia) in

Rangpur and Mymensingh hubs to test experimental methods of producing quality fish seed. Capacity building of the relevant associates is one of the major activities under the initiative. This involves the following activities.

Training course for private hatchery and nursery operators

CSISA and WorldFish arranged a capacity-building course for hatchery and nursery operators to address the current constraints and challenges faced by the hatcheries. A total of 51 hatchery and nursery operators were trained during 2014 to enhance their technical knowledge and skills on the particular matter of improving seed quality.

However, stocks will continue to deteriorate until the proper principles of genetic management are applied and implemented in the hatcheries. The stock deterioration has negatively affected the growth in grow-out systems. Therefore, steps were taken to remedy this situation.

Training/workshop for government officials

According to the seed quality improvement strategy development workshop recommendation, a capacity-building course for Department of Fisheries officials on "Seed Quality Improvement Initiative" of Mymensingh and Rangpur hubs was organized in 2014. The objectives of the training/workshop were

- To improve the system for broodstock replacement of carp with the application of improved management practices, including the use of genetic principles.
- To establish a tilapia breeding nucleus (TBN) and its impact on improved quality seed production and use by grow-out farmers.
- To develop effective strategies for implementation of the Fish Hatchery Act and Regulations.

A total of 49 upazilla officials participating in the training course are associated with seed production. Participating DoF officials were updated about the current status and potential of this initiative in the course. Therefore, DoF officials could monitor the activities of the private-sector hatcheries (carp and tilapia) effectively, including broodstock management and replacement, tilapia breeding nucleus, dissemination of quality fish seed to grow-out farmers, implementation of the Fish Hatchery Act and Regulations, etc. (Fig. 66). Based on the lessons learned in the course, participants identified their roles for the sustainable production and dissemination of improved quality seed. The course outcome highlights that the cooperation of all stakeholders will ensure equitable and effective dissemination of the necessary strategies that can ensure enhanced production of quality fish seed for future growth of the aquaculture industry in Bangladesh (Table 32).

Fig. 66. TBN farmer explaining cohort breeding protocol.

Table 32. Organized capacity building activities for seed quality improvement Initiative.

Sl. no.	Activities	Number of participants
01.	Workshop on "Formulation of Strategies for Quality Fish Seed Production"	97

02.	Training course for private hatchery and nursery operators	51
03.	Training/workshop for government officials	49

Overseas training/study tour: Four government staff (two from Bangladesh Fisheries Research Institute, two from the Department of Fisheries), and two WorldFish staff attended the "**International Training on improved seed production and aquaculture technologies"** training course, especially the broodstock management and the cryopreservation of carp gametes, held from 25 September to 9 October 2011 at the Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, Odisha, India. The major learning outcomes for participants in the training course were acquisition of knowledge on procedures for the cryopreservation of carp milt; ability to assess the quality of carp milt; knowledge of principles of selective breeding multiple induced breeding in carps; methods of tagging and marking in carp; and principles of broodstock management for carp hatcheries.

Fig. 67. Participants of the Aquaculture Value Chain Analysis training course.

WorldFish arranged training on Aquaculture Value Chain Analysis (Fig. 67) and training and a study tour for DoF and WorldFish staff organized by Aquaculture and Aquatic Resource Management (AARM) in the field of study of the Asian Institute of Technology (AIT) on 21-27 September 2012. A total of 12 participants from WorldFish and the Department of Fisheries participated in the course. The program provided thorough knowledge and observations of aquaculture development happening in Thailand, including the analysis of value chains, which was useful in the Bangladeshi context.

WorldFish also organized an exposure visit for two WorldFish staff in Malawi in 2012 to obtain experience on the extension approach.

A paper on Evaluation of Productivity and Dissemination Strategies for Promotion of Nutrient-Rich Mola (*Amblypharyngodon mola)* in Different Pond Aquaculture Systems was presented in Adelaide, Australia, organized by the World Aquaculture Society in 2014.

The project leader also shared ideas in Australia in a workshop arranged by WorldFish.

Capacity building of WorldFish staff

WorldFish organized a **Training of Trainers course** for staff at the beginning of the project period (Fig. 68). The main target of this workshop was to develop ToT manuals on aquaculture extension methodology and different improved aquaculture technology. It was a 15-day residential course. It was aided with group work and the participants developed draft manuals. Later, the project staff followed those manuals to organize courses with different project beneficiaries.

Fig. 68. WorldFish staff in a group work session.

A total of 26 WorldFish staff attended a training course on "**Research Design and Writing Skill Development**" for building capacity to improve the knowledge and skills of appropriate research proposal development for adaptive research trials (ARTs) and to develop analytical capacity on writing, presentation, and communication skills of the participants. The course focused on five major thematic areas: (I) Research Methodology, (II) Research Design and Analysis, (III) Considerations of Socioeconomics, Nutrition, and Gender Issues in research proposal development, (IV) Practice on Proposal Development for Participatory Action Research, and (V) Writing Skills for Communication Product Development.

Most of the participants were from CSISA-BD (all the hub managers, the aquaculture development officer, and the horticulture development officer), including one from the FtF AIN project. The course was designed and delivered by national and international scientists of WorldFish and Bangladesh Agriculture University, Mymensingh, and a communication specialist.

Capacity building of private feed company staff on commercial aquaculture management

To improve knowledge and skills on commercial aquaculture management, CSISA-BD conducted a 2-day training course for 22 marketing officers of Spectra Hexa Feed Ltd. (Mega feed) (Fig. 69). They are directly linked with 177 feed dealers also involved in mono-sex tilapia fry selling and around 4,000 commercial fish farmers who regularly use Mega brand feed on their farms. As a result, improved technical knowledge will be disseminated among those clients of the company through the trained staff. The participants of the course opined that they learned more new knowledge and information through this training, which will help to build their professional career and assist with their clients' dealers and commercial fish farmers.

Fig. 69. Participants of the course.

Capacity building for local and international interns

CSISA-BD initiated an internship support program for national and international students to give the opportunity of working in a practical field. During the project period, a total of six local interns were supported in different fields of activities (three in fish hatchery business plan development, two in a seed quality improvement initiative, and one in gender transformative approach analysis). One international intern from the University of Stirling, UK, was also supported in the field of seed quality improvement.

Assistance to the PhD research program

WorldFish provided funds to four research fellows for conducting research on the following topics:

1. **Biology and Production of Nutrient-Rich Small Fish Mola and Darkina in Rice Field and Pond Condition by Subrata Mondol:** This research program enriched our knowledge of the breeding biology of nutrient-rich small mola and darkina fish from on-station trials.
2. **Community-Based Fish Culture in the Public and Private Floodplains of Bangladesh by A.B.M Mahfuzul Haque:** This research identified how a community-based organization managed open-water fisheries resources in order to improve productivity, livelihoods, and quality of natural resources.
3. **Development of low-cost feed using sunflower cake for freshwater *gher* aquaculture system and livelihood improvement in southwestern Bangladesh by Md. Mokarrom Hossain:** This study will assess the performance of low-cost feed for prawn and tilapia using

locally available sunflower cake as an alternative source of fish meal and other plant-based protein.

4. **Development of Saline-Tolerant Improved Strain of Tilapia in Bangladesh by Azhar Ali:** Through this research, we learn about the survival and growth rate of GIFT tilapia (*Oreochromis niloticus*) in different salinity exposures and at the same time know about the production performance of newly developed tilapia strains in comparison with local strains in the highest salinity.

Development of training materials

Training materials are key components of a training program that helps facilitators present training topics (Fig. 70). On the other hand, training materials also help participants learn new topics quickly. So, it is very important to select appropriate training materials based on participants' category. We found that, after training, farmers also need some easily understandable farming guide books and extension materials. On consideration of the issues, a list of training materials was developed that was used in CSISA-BD training courses and is given below:

- **i)** Aquaculture Extension and Training Manual (100 copies) supplied to course facilitators to use in CSISA ToT courses.
- **ii)** Training Manual on eight different Improved Aquaculture Technologies (3,140 copies) used in facilitating farmers' training by project and partner staff.
- **iii)** Guidebook on eight Improved Aquaculture Technologies (95,000 copies) used in farmers' training linkage events and other events as extension materials.
- **iv)** Poster on (i) good shrimp culture (2,200 copies), (ii) festoon with simple scientific messages (30 sets of 7 items), and (iii) water quality parameters for carp and tilapia hatcheries (40) used in farmers' training as training tools by project and partner staff.
- **v)** Leaflets on nutrition value and production techniques on orange sweet potato (7,000) and Koi farming techniques (2,000 copies) for distribution in different events.

Fig. 70. Sample of several training materials.

Interventions led to improved and increased food production

Annex 1. List of LoAs, MoUs, and Service Contracts

Table 33: List of LoAs, MoUs, and service contracts, IRRI

Sl. no.	Title of LoA/MoU/service contract	Authorized person and organization	Objectives	Start date	End date	Amount (US$)
1.	Letter of Agreement (LoA) between IRRI and Speed Trust for implementing activities under CSISA-BD project for Barisal hub	Head of mission, Speed Trust	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	22,524
2.	Letter of Agreement (LoA) between IRRI and BDS for implementing activities under CSISA-BD project for Barisal hub	Executive director, Bangladesh Development Society (BDS)	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	29,674
3.	Letter of Agreement (LoA) between IRRI and GJUS for implementing activities under CSISA-BD for Barisal hub	Executive director, GrameenJanoUnnayanSangstha (GJUS)	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	21,260
4.	Letter of Agreement (LoA) between IRRI and ADO for implementing activities under CSISA-BD project for Khulna hub	Executive director, Area Development Organization (ADO)	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	26,007
5.	Letter of Agreement (LoA) between IRRI and Ashroy Foundation for implementing activities under CSISA-BD project for Khulna Hub	Executive director, Ashroy Foundation	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	14,629
6.	Letter of Agreement (LoA) between IRRI and SEDOP for implementing activities under CSISA-BD project for Khulna hub	Executive director, Socio Economic Development Organization for the Poor (SEDOP)	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	26,007

7.	Letter of Agreement (LoA) between IRRI and Uttaran for implementing activities under CSISA-BD project for Khulna hub	Director, Uttaran	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	26,007
8.	Letter of Agreement (LoA) between IRRI and TMSS for implementing activities under CSISA-BD project for Khulna hub	Executive director, Tengamara Mohila Sabuj Sangha (TMSS)	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	46,443
9.	Letter of Agreement (LoA) between IRRI and Jagoroni Chakra Foundation (JCF) for implementing activities under CSISA-BD project for Jessorehub	Executive director, Jagoroni Chakra Foundation (JCF)	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	69,764
10.	Letter of Agreement (LoA) between IRRI and People's Resources in Development Enterprise (PRIDE) for implementing activities under CSISA-BD project for Jessorehub	Executive director, PRIDE	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	48,485
11.	Letter of Agreement (LoA) between IRRI and RIB for implementing activities under CSISA-BD project for Rangpur hub	Chairman, Research Initiative Bangladesh (RIB)	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/12/2013	31/9/2014	27,566
12.	Letter of Agreement (LoA) between IRRI and Solidarity for implementing activities under CSISA-BD project for Rangpur hub	Executive director, Solidarity	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	29,520
13.	Letter of Agreement (LoA) between IRRI and the Society for UDDOG for implementing activities under CSISA-BD project for Rangpur hub	Executive director, Society for UDDOG	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/11/2013	31/9/2014	32,284
14.	Letter of Agreement (LoA) between IRRI and Society Development Committee	Executive director, Society Development	Collaborate on CSISA-BD activities, including training, farmer field days,	1/10/2013	31/9/2014	53,404

	(SDC) for implementing activities under CSISA-BD project for Faridpurhub	Committee (SDC)	demonstrations, etc.			
15.	Letter of Agreement (LoA) between IRRI and APEX for implementing activities under CSISA-BD project for Mymensingh	Executive director, APEX	Collaborate on CSISA-BD activities, including training, farmer field days, demonstrations, etc.	1/10/2013	31/9/2014	66,186
16.	Letter of Agreement (LoA) between IRRI and People's Resources in Development Enterprise (PRIDE) for implementing the InfoLady agricultural entrepreneur project under CSISA-BD project for Jessorehub	Executive director, PRIDE	Integration of InfoLady model into the agricultural sector for providing farmers with Internet-based agricultural information that could be replicated on a larger scale	1/1/2014	28/2/2015	27,020
17.	Letter of Agreement (LoA) between IRRI and Bangladesh Institute of Nuclear Agriculture (BINA) under CSISA-BD project in coastal areas	Director general, BINA, BAU Campus, Mymensingh	Rapid mass screening for salt tolerance of local coastal rice varieties, purification, characterization, and promotion	1/6/2013	31/5/2014	12,000
18.	Letter of Agreement (LoA) between IRRI and Bangladesh Rice Research Institute (BRRI) under CSISA-BD project	Director general, BRRI, Gazipur	Implementation of CSISA-BD project activities	1/1/2013	31/6/2014	33,760
19.	Agreement between Participatory Management Initiative (PMID) in association with Bangladesh Centre for Advanced Studies (BCAS) with CSISA-BD project	Md. Rafiqul Islam, managing partner, PMID	Annual survey for technology adoption of the project-supported farmers	1/11/2013	15/5/2014	17,411
20	Agreement between Dexis, USA, and CSISA-BD project	Mihir Desai, chief executive officer, Dexis Consulting Group, USA	Conduct mid-term evaluation of the project	15/3/2014	15/5/2014	98,436
	Total (individual: 18; common: 2)	**20**				**728,387**

Table 34: List of LoAs, MoUs, and service contracts, CIMMYT

Sl. no.	Title of LoA/MoU/service contract	Authorized person and organization	Objectives	Start date	End date	Amount (US$)
1.	Subgrantletter between CIMMYT-Bangladesh and APEX	Dr. BilkisMortujaParven, executive director, APEX	To establish a mutually beneficial relationship between CIMMYT-BD and APEX to contribute to efforts in developing and sustaining local farming systems in Mymensingh through training, establishment of linkages, formation of farmers' groups, etc.	1/10/2013	30/9/2014	14,317
2.	Subgrantletter between CIMMYT-Bangladesh and Solidarity	Mr. S.M. Harun Ar Rashid Lal, executive director, Solidarity	To establish a cooperative and mutually beneficial relationship between CIMMYT-BD and Solidarity in order to implement initiatives to improve maize, wheat, and vegetable production, as well as to establish local maize marketing linkages in Rangpur.	1/10/2013	31/7/2014	9,313
3.	Subgrantletter between CIMMYT-Bangladesh and Jagorani Chakra Foundation (JCF)	Mr. Md. Wahiduzzaman, director microfinance, JCF	To establish a collaborative partnership between CIMMYT-BD and JCF for conducting field activities (group organization, training events) in Jessore.	1/10/2013	30/9/2014	28,171
4.	Subgrantletter between CIMMYT-Bangladesh and Bangladesh Development Society (BDS)	Mr. S.H. Kabir, executive director, (BDS)	To establish a collaborative partnership between CIMMYT-BD and BDS for conducting field activities (group organization, training events) in Barisal.	1/10/2013	30/9/2014	15,982

5.	Subgrantletter between CIMMYT-Bangladesh and GrameenJanoUnnayanSangstha (GJUS)	Mr. Zakir Hossain Mohin, executive director, GJUS	To establish a collaborative partnership between CIMMYT-BD and GJUS for conducting field activities (group organization, training events) in Barisal.	1/10/2013	30/9/2014	13,445
6.	Subgrantletter between CIMMYT-Bangladesh and the Society for People's Education, Empowerment, and Development (Speed Trust)	Mr. A.H.M.Shamsul Islam, mission head, Speed Trust	To establish a collaborative partnership between CIMMYT-BD and Speed Trust to conduct field activities (group organization, training events) in Barisal.	1/10/2013	30/9/2014	9,359
7.	Subgrantletter between CIMMYT-Bangladesh and Social Advancement Community Organization (SACO)	Mr. KaziSoyebFokrul, executive director, SACO	To establish a cooperative and mutually beneficial relationship between CIMMYT-BD and SACO that contributes to various field efforts (e.g., training, forming groups, etc.) on maize production and marketing in Barisal.	1/10/2013	30/9/2014	6,667
8.	Subgrantletter between CIMMYT-Bangladesh and DakDiye Jai (DDJ)	Mr. Md. ShahjahanGazi, executive director, DDJ	To establish a cooperative and mutually beneficial relationship between CIMMYT-BD and DDJ that contributes to various field efforts on maize production and marketing in Barisal.	1/10/2013	30/9/2014	6,667

9.	Subgrantletter between CIMMYT-Bangladesh and Society Development Committee (SDC)	Mr. KaziAshraful Hassan, executive director, SDC	To develop a collaborative partnership between CIMMYT-BD and SDC that contributes to various field efforts on maize and wheat production (e.g., training, group formation) as well as marketing in Faridpur.	1/10/2013	31/7/2014	9,806
10.	Subgrantletter between CIMMYT-Bangladesh and TMSS	Dr. Hosne-Ara Begum, executive director, TMSS	To establish a collaborative partnership between CIMMYT-BD and TMSS for conducting field activities (group organization, training events) in Khulna.	1/10/2013	30/9/2014	11,776
11.	Subgrantletter between CIMMYT-Bangladesh and Bangladesh Agricultural Research Institute (BARI)	Dr. Rafiqul Islam Mondal, director general, BARI	To establish a collaborative partnership between CIMMYT-BD and BARI to conduct trial experiments to intensify current cropping systems under environments with good soil quality and water availability in RARS, Jamalpur.	1/10/2013	30/9/2014	6,153
12.	Subgrantletter between CIMMYT-Bangladesh and Bangladesh Agricultural Research Institute (BARI)	Dr. Rafiqul Islam Mondal, director general, BARI	To establish a collaborative partnership between CIMMYT-BD and BARI to conduct trial experiments to improve productivity and soil fertility in wheat-based cropping systems in RWRC, BARI-Rajshahi.	1/10/2013	31/10/2014	2,461

13.	Letter of Agreement between CIMMYT-Bangladesh and Christian Commission for Development in Bangladesh (CCDB)	Mr. JoyantaAdhikari, executive director, CCDB	To establish a collaborative partnership between CIMMYT-BD and CCDB on agricultural development initiatives in selected indigenous communities in Rangpur.	1/10/2013	30/9/2014	--
	Total	**13**				**134,117**

Table 35: List of LoAs, MoUs, and service contracts, WorldFish

Sl. no.	Title of LoA/MoU/service contract	Authorized person and organization	Objectives	Start date	End date	Amount (US$)
1.	MoA between WF and BRAC under CSISA-BD for Mymensingh, Faridpur, Barisal, Jessore, and Khulna hubs	Executive director, BRAC	Collaborate to implement CSISA-BD activities on improving aquaculture farming technologies among wider farmers' groups through training and demonstration and other extension approaches.	October 2013	September 2014	118,167
2.	MoA between WF and Jagorani Chakra Foundation under CSISA-BD for Jessorehub	Executive director, JCF	Collaborate to implement CSISA-BD activities on improving aquaculture farming technologies among wider farmers' groups through training and demonstration and other extension approaches.	October 2013	September 2014	27,323
3.	MoA between WF and BanchteShekha under CSISA-BD for Jessorehub	Executive director, BS	Collaborate to implement CSISA-BD activities on improving aquaculture farming technologies among wider farmers' groups through training and demonstration and other extension approaches.	October 2013	September 2014	7,704

4.	MoA between WF and Bangladesh Development Society under CSISA-BD for Barisal hub	Executive director, BDS	Collaborate to implement CSISA-BD activities on improving aquaculture farming technologies among wider farmers' groups through training and demonstration and other extension approaches.	October 2013	September 2014	9,009
5.	MoA between WF and RENAISSANCE (SamajSebaSangstha) under CSISA-BD for Khulna hub	Executive director, RENAISSANCE	Collaborate to implement CSISA-BD activities on improving aquaculture farming technologies among wider farmers' groups through training and demonstration and other extension approaches.	October 2013	September 2014	7,400
6.	MoA between WF and TengamaraMohilaSabuj Sangha under CSISA-BD for Khulna and Rangpur hubs	Executive director, TMSS	Collaborate to implement CSISA-BD activities on improving aquaculture farming technologies among wider farmers' groups through training and demonstration and other extension approaches.	October 2013	September 2014	38,849
7.	MoA between WF and Society Development Committee under CSISA-BD for Faridpurhub	Executive director, SDC	Collaborate to implement CSISA-BD activities on improving aquaculture farming technologies among wider farmers' groups through training and demonstration and other extension approaches.	October 2013	September 2014	15,993

8.	Agreement between Participatory Management Initiative (PMID) in association with Bangladesh Centre for Advanced Studies (BCAS) and CSISA-BD project	Md. Rafiqul Islam, managing partner, PMID	Annual survey for technology adoption of the project-supported farmers	November 2013	May 2014	9,917
	Total	**8**				**234,362**









Cereal Systems Initiative for South Asia in Bangladesh
House 9, Road 2/2, Chairmanbari, Banani,
Dhaka 1213, Bangladesh
Tel: +88 02 9898011
Fax: +88 02 9899676