The Cereal Systems Initiative for South Asia

FY 2012 Annual Report

Submitted by the International Center for Maize and Wheat Improvement (www.CIMMYT.org), November 15, 2012

Narrative Summary

CSISA is a research for development program launched in 2009 with co-funding from USAID and the Bill and Melinda Gates Foundation (BMGF). It combines the strengths of several members of the CGIAR in collaboration with a large number of civil society, public, and private sector partners. The overall goal of CSISA is to increase food and income security in South Asia through the accelerated development and inclusive deployment of new varieties, sustainable and productive management technologies, and innovative policies. CSISA also endeavors to place technologies in the context of markets, entrepreneurship, and risk, which are often essential elements for achieving durable agricultural development. Crucially, CSISA seeks to play a catalytic role that fosters system intensification beyond the spatial and temporal boundaries of direct project investments, while prioritizing technologies that minimize trade-offs between increasing production and protecting resource and environmental quality (i.e. *more* sustainable intensification).

FY12 was a period of change for CSISA, as the first phase of the project was both internally and externally reviewed and a Phase II proposal crafted that capitalized on the strengths and addressed lessons learned in Phase I, including ways to more productively engage public and private sector partners. Phase II is now fully sanction as of October 2012, and an adjusted governance structure, refined operating philosophy, and a new geographic emphasis on the eastern IGP is in the process of implementation. Figure 1 illustrates CSISA's evolved approach to innovation, product development, and support to change agents (e.g. small and medium entrepreneurs) for achieving impact at scale. CSISA will not achieve it's ambitions by 'going it alone'. Just as importantly, nearly every innovation requires integrated approaches that unite biophysical and socio-economics considerations; CSISA's new governance and planning process is built to ensure strong trans-disciplinary coordination.

Important operational changes have also been implemented. In India, the existing innovation hubs in Eastern Uttar Pradesh and Bihar are being strengthened and a new hub is being formed in Odisha. In Nepal, a new sub-project ('CSISA-NP') has been co-funded by the USAID mission in Nepal through FtF to work in the western hills and Terai – activities are now under way in these new production ecologies. In Bangladesh, CSISA-BD completed it's second full year of activities with support from FtF and the

Bangladesh mission. In Pakistan, CSISA has been re-oriented for FY 13 to support the emergence of the USAID-funded PSIAP project.

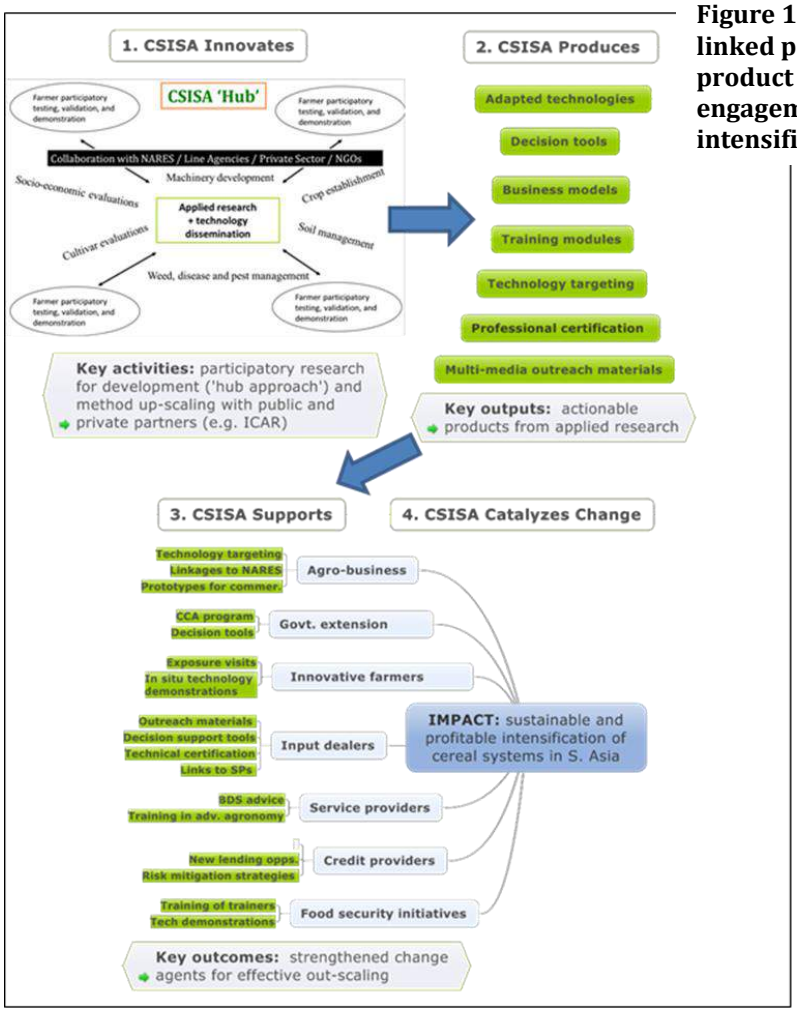

Figure 1. Conceptual model for the linked processes of innovation, product development, and partner engagement to achieve sustainable intensification at scale.

The following general insights and lessons were drawn in FY12:

- *Social marketing works*. CSISA-BD produced a video titled "Save More. Grow More. Earn More," which uses rich visuals and simple language to show pathways toward sustainable intensification and improved livelihoods based on small machinery, conservation agriculture and entrepreneurship. Community screening of the film have already reach 50,000+, with millions more watching on television broadcasts. As a result, awareness of CSISA's priority technologies among policy makers, farmers and the private sector has increased remarkably.

- *Sustainable intensification is a practical reality.* Even in the most high-yielding areas of the IGP, continuous zero-tillage for both rice and wheat can produce on par or even more than conventional systems, with dramatic improvement in the use efficiencies in water, labor, and energy.

- *Significant gains in cereal genetic improvement can be achieved.* Yield gains and tolerance to major biotic and abiotic stresses were demonstrated in the Phase I of CSISA, and additional innovations are in the pipeline. Strengthening seed systems and the varietal release process so that farmer broadly benefit from breeding advances are on-going priorities.

- *Investments in M&E pay-off*. The CSISA expansion project in Bangladesh ('CSISA-BD') made significant investments in monitoring and evaluation, which have improved capacity to report and communicate progress. Just as importantly, strengthened M&E has enabled CSISA-BD to make real-time adjustment in activities as lessons are learnt. The same approach will be deployed across CSISA in Phase II.

Examples of CSISA's achievements in FY12 are highlighted here as 'success stories' as well as in the 'end of project' report that was submitted to BMFG and USAID in October. A copy of that report is included herein as an annex.

Indicative Successes

Objective 1 (achieving impact with farmers)

A. Transforming livelihoods and creating new entrepreneurs with CSISA-support rice and wheat technologies in Eastern UP and Bihar

Ganesh Singh farmers 5.6 ha in Kundur village of Kushinagar district in Eastern UP. Rice-wheat is the major cropping system in the area, with some sugarcane cultivation.

Ganesh's land is low-lying, and in the driest year the water recedes at October-end and in the wettest around the first week of December. In the latter case, farmers are not able to sow their wheat crop until December-end. The yield potential wheat declines by half with late planting crops, and timely planting is the key towards intensifying production and profitability. Zero tillage is a promising technology for achieving timely planting because intensive land preparation is avoided. Conventional land preparation can delay sowing by two weeks or more.

Ganesh bought a zero tillage (ZT) machine in 2007, but did not use it in 2008 because wheat emergence was not uniform in the first season and he did not know where to turn for technical assistance on this new technology. He came in contact with the CSISA team in 2010, and subsequently evaluated zero tillage with guidance from the project staff. After gaining confidence in this technology, he involved more farmers from his village to evaluate ZT in their own fields. During 2011-12 season, Ganesh seeded ZT

wheat on his entire 5.6 hectares. The combination of advance sowing and ZT allowed Ganesh to achieve his highest ever wheat grain yield of 6.7 t/ha, which was approximately double what he had achieved in the past. Inspired by the performance of his ZT seed drill for wheat, he converted all his rice to dry direct sowing in 2012.

Before adopting zero tillage and advance sowing, Ganesh's income from wheat was approximately \$104 ha^{-1}, but after adopting ZT and, will support from CSISA, changing his variety, his net profits from wheat increased to \$886 ha^{-1} in 2011-12. Cost reductions from fuel and labor savings were responsible for 33% of his net profits. Before adopting DSR and better-bet agronomy practices on the advise of CSISA, Ganesh's average profit from rice cultivation was \$102 ha^{-1}, which increased to \$316 ha^{-1} in 2011 and \$785 ha^{-1} in 2012.

Ganesh is not only transforming his own profitability and food security, but also enabling a group to reap the benefits of innovation by providing mechanized crop establishment on a fee basis to his neighbors. During the last two years, Ganesh has provided custom services on 42 ha covering both rice and wheat. Others are joining the game. Two more farmers that have seen Ganesh's success with ZT and service provision have purchase new ZT seed drills to start their own businesses.

B. Responding to labor and water shortages with direct seeded rice in Nepal

Chitwan is one of the six hub districts of the Cereal Systems Initiative for South Asia (CSISA), with an average productivity of 3.2 Mt/ha rice. Rice in Chitwan is generally grown in lowland fields where puddled transplanting rice (PTR) is the most common crop establishment method. It requires a lot of water and is labor-intensive, which is a big issue given the accelerating shortage of agricultural labor due to out-migration, a phenomena which affects almost every household in some Nepali villages. In 2009, CSISA was the first project to demonstrate direct seeded rice (DSR) in Chitwan as a viable option to address these issues.

In the beginning, farmers were not convinced about DSR and were hesitant to adopt the technology. However, farmers like Mr. Tej Raj Pandey, from Patihani village, were worried about being unable to transplant rice on time due to late rain onset and lack of irrigation, and was willing to give DSR a try. Mr. Pandey was informed about DSR technology by his neighbour, Mr. Laxmi Prasad Bhandari, whose DSR field he visited. He was very impressed on seeing the well-established direct-seeded rice crop, and contacted the CSISA hub office in Chitwan for detailed information. The hub staff visited his fields to discuss the technology with him and other farmers. Mr. Pandey and four more farmers requested the staff to demonstrate DSR and sought support to implement it. The CSISA staff advised the farmers to go with short duration varieties in well-drained land. Although it was late in the season, the farmers decided to go ahead and take the risk of late planting. Rice on these fields was direct-seeded on July 25, 2009, and covered 0.83 ha. Mr. Pandey harvested an excellent crop that yielded about 20% more

than the 2008 production from the same field. Despite late seeding, the crop matured earlier than the same variety, under transplanted conditions.

Since then, there has been a large impact of DSR in the Chitwan valley. More than forty men and women farmers visited the site, liked the technology, and applied it. Consequently, the area under DSR increased from about 3.5 ha in 2009 to 155 ha by the end of the project 3 years later. Similarly the number of participating farmers increased from 16 to 135. Economic analysis indicates that the net profit per ha was higher in DSR ($544 ha^{-1}) than via conventionally transplanted rice ($455 ha^{-1}). Farmers found DSR to be an appropriate technology to address labor shortage and to reduce human drudgery. Farmers are very much encouraged with the DSR technology and many individuals and groups are approaching the project to extend the DSR program in their area as well. The monsoon again was late in 2012, and all available drills worked overtime. As a result of CSISA's success, two new machinery importer firms are now supply ZT drills in Nepal whereas before there where none

C. Bumper maize harvests in Bangladesh

Maize demand for the poultry and aquaculture industries has grown remarkably in Bangladesh, and represents tremendous income generation opportunities for farmers. Nevertheless, farmers in many parts of Bangladesh are relatively unfamiliar with the crop and need guidance on both varietal choice and better-bet agronomic practices.

Rabi (winter) maize has been grown in Bashati village of Nandail Upazila in Mymensingh district for the last 4-5 years. International Maize and Wheat Improvement Centre (CIMMYT) project scientists in the Mymensingh hub of the USAID-funded Cereal System Initiative for South Asia-Expansion in Bangladesh (CSISA-BD) talked with village farmers and GO-NGO personnel in October 2011. They knew from discussion that the farmers' 2010 average maize yield was 5645 kg/a, well below the national average (7100 kg/ha) despite the well-suited sandy loam soil. The major causes for this low yield was use of second generation (F_2) seed of

Fig. 1. Maize demonstration in Bashati village of Nandail Upazila in Mymensingh during 2011-12.

NK 40 maize in about 45% of the fields, lack of knowledge about recommended production technologies, and late seeding due to late harvest of *aman* (BR 11 variety) rice. CSISA-BD CIMMYT scientists conducted demonstrations (Fig. 1) in 23 farmers' fields and one farmers' participatory variety trial (PVS) in collaboration with ASPADA—a locally active NGO. The varieties in the PVS trial were evaluated by 20 farmers, so, they now know which varieties are most suitable for their agro-climatic condition.

These demonstrations showed that by using the recommended variety combined with good management increased yield by around 50% over prevailing farmer practices. Farmers were urged to adopt both recommended variety and management together during field days. The average yield in all demonstration plots was 54% higher than the 2011 average (5645 kg/ha) and 22% higher than the national average (7100kg/ha), with farmers who adopted more technologies benefiting more. Investment is needed for seeds, extra fertilizers, laborers etc. over farmers' practice. However, for each 1 BDT investment in Rabi maize at Bashati village, an average return of BDT 1.9 (maximum BDT 3.9) is possible after only five months—a rate of profit not available from investment in any commercial bank. The demonstration of short duration rice varieties in the next T. Aman season should make early maize seeding and even higher profits possible for farmers in this area.

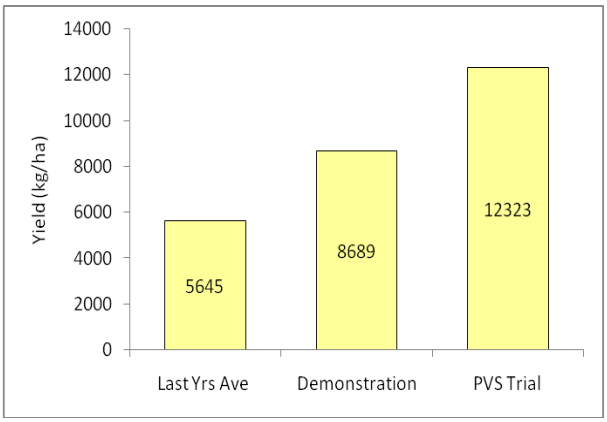

Fig. 3. Demonstration and PVS trial yields in Bashati, Nandail, Mymensingh for 2011-12.

D. Advancing livelihoods through modern varieties and systems integration in Bangladesh

Rashidul Islam lives in northern Bangladesh at Chaora Bala. He is forty-five, and together with his wife supports four children. Rashid is a progressive farmer, with a positive attitude towards trying out new technology; he is also a member of the Kashiram Belpukur Community Seed Bank, established by the community with the help of Research Initiatives Bangladesh (RIB), one of CSISA's partner NGOs. RIB's role is to spread CSISA technologies among their farmer groups; it has six in the Saidpur region and Rashid is a member of one of them, Bala Para.

Rashid was an enthusiastic participant in CSISA training program activities, putting some into practice by first sowing dry seeded rice (DSR) using a power tiller-operated seeder (PTOS) in the *aman* season. This was the first time that DSR had been tried out in this region. His yield increased, and many neighboring farmers followed his example. In the *aman* (wet season) season of 2012, Rashid obtained 500g of short duration BRRI dhan56 rice from CSISA. He sowed the seed at the beginning of June, transplanting it a month later on three *decimals* of his land. On the rest of his land he cultivated other varieties of short duration rice: BRRI dhan33, BINA dhan7 and BRRI dhan52. At the end of September, Rashid harvested the BRRI dhan56 about 7-10 days earlier than the other varieties, and got a bumper yield translating to about 4.6Mt/ha. This early harvesting of his *aman* rice has improved Rashid's food security; his income has also increased from the sale of rice straw and the creation of work. He has kept all 56kg of the grain he produced as seed for the next *aman* season, and plans to distribute BRRI dhan56 seed to four of his neighbors so they can also produce seed. Many farmers of the area have asked about the type of rice he has grown, commenting on the fact that it is ready for harvest earlier than expected; several have asked him for some of the BRRI dhan56 seed. Rashid is now getting ready to grow potato and mustard, after which he will sow his *boro* (winter season) rice. He has recently started this new rice-potato/mustard-rice cropping system, which has given him an extra crop and increased his cropping intensity. In the 2012 *boro* season, he grew BRRI dhan28 on 37 *decimals* of land, following the production techniques learned from CSISA. This gave him 925kg to keep as seed for the next *boro* season.

The benefits of the training Rashid received are not limited to higher yields of better quality rice and knowledge of a profitable cropping pattern to apply in his fields; Rashid has also become a good forward planner. In the 2012 *aman* season, Rashid grew five varieties of rice (BRRI dhan51, BRRI dhan52, BRRI dhan56, BRRI dhan33 and BINA dhan7), introducing all the varieties promoted by CSISA-BD. The CSISA training showed him new cultivation methods, and the knowledge he gained from group meetings inspired him to try a new way of cultivation. Rashid says, "I have 200 *decimals* (two acres) of land but under the earlier system, any cultivation I did was unplanned." He also says, "I used to cultivate Sorna and BR11 rice in the *aman* season and BRRI dhan28 and BRRI dhan29 in the *boro* season – that was what I'd always done – but the results were not profitable, and I was always in a state of crisis. Now I plan, following the cropping pattern system, and RIB and CSISA has given me new life. My cropping system has changed – it's very profitable, and I and my whole family are very happy."

E. Short duration *aus* rice reduces food insecurity in Khulna

The district of Satkhira in southern Bangladesh is often adversely affected by water-logging during the monsoon. The heavy rains of last year meant that most of the wet season *aman* rice was ruined by stagnant water, and flooding like this pushes the local people almost to breaking point. The tradition of farmers in this area is to grow widely adapted, high-yielding, *boro* (winter season) rice, BRRI dhan28. But *boro* season rice is not enough for the whole year, and the floods make production of an additional rice crop in the *aman* season unreliable. The CSISA-BD Khulna hub team working with an NGO partner met with a number of local communities and discussed the option of growing improved varieties of pre-monsoon rice. Improving the reliability of this *aus* paddy – sown before but harvested during the monsoon – could vastly improve the community's food security. The farmers disclosed that the variety of *aus* rice they currently grow is Indian in origin, known locally as 'Jamaibabu'. The CSISA-BD team suggested that they try a high-yielding, shorter duration rice variety (such as BRRI dhan48, BR26, or Parija), which would enable them transplant the succeeding *aman* rice earlier, thus reducing the chance of it being ruined by the rains.

The farmers of Perkukrail, Satkhira, agreed to test these varieties on their land. A group of eight women and 22 men farmers were trained in new methods of *aus* rice cultivation, keeping quality seed from their paddy field and improving their seed storage methods. Nine of them cultivated BR26, BRRI dhan28, and Parija on 1 ha, following the improved method of transplanting younger seedlings in rows, and recommended fertilizer management techniques. Farmers chose BRRI dhan48 as their preferred variety as it matures 10-15 days earlier than Jamaibabu, thus allowing earlier planting of their next crop of *aman* rice.

BRRI dhan48 also has longer panicles with more filled grain, and thus has the potential to produce higher yields. The farmers also noted that the plant is strong, and unlike Jamaibabu, is not susceptible to disease. They also chose Parija as it matured 5-7 days earlier, giving them time to cope with the later onset of rainfall. To date, 19 new farmers have collected 810kg of BRRI dhan48 seed from participating farmers. The farmers kept 1,270kg of this seed in storage, expected to be used before the next growing season. At the same time, 19 farmers collected 390kg of Parija seed and stored 880kg for the next season.

F. Careful accounting and empowering women transforms aquaculture profitability

Until recently, Nargish Begum cultured fish for household consumption in the family's Enayetpur village, Rangpur district pond. She and her husband used traditional methods, paying little attention to the area of the pond, species combination, or size and number of fingerlings. It never occurred to them to keep records, so they were unaware of any costs or profits resulting from their activities. This year however, Nargish successfully cultures fish in her pond and also grows high value nutritious vegetables, the costs, production, consumption and sales for which she keeps records. Nargish carries out most of the activities related to fish culture and vegetable cultivation herself, while her husband and younger brother help with fingerling collection, buying the necessary inputs and selling the fish. Her training in record-keeping enable her to make informed decisions about the management of the pond and her homestead vegetable production. Such decisions are usually preceded by a family discussion, but her view is almost always respected, backed up as it is with the technical know-how gained from the training and the recorded information she keeps. According to her husband and brother, Nargish also has access to and control over the income they make. What was it that brought about this remarkable change?

In 2012, Nargish joined CSISA-BD through the activities of WorldFish. She took part in training, after which her approach to fish farming changed radically. She began to stock mola and carp fingerlings in her 35 *decimal* pond, with a stocking density of 50 carp/*decimal* and 150g mola/*decimal*. She was in constant communication with WorldFish CSISA-BD staff to get technical support and assistance, and put into practice the improved pond management practices she learned. Between April and September 2012, Nargish had already earned an impressive BDT 33,796 by selling 314kg of fish (20kg of mola at BDT 4,000/kg and 294kg of carp valued at BDT 29,796). During this time, her total expenditure was BDT 27,263 (spent on fingerlings, feed, and fertilizer). She currently has an expected biomass of 450kg still in her pond, valued at BDT 45,000. Nargish said that she has never before seen such yields.

The training provided by CSISA-BD also inspired Nargish to grow vegetables such as sweet gourd, long bean, bean and ladies finger on the dyke at the side of her pond and the homestead area. She grew enough last season to feed the whole family, with enough left over to sell (earning BDT 5,340) and even some to give as gifts to her relatives. The nutrient-rich leaves of the orange flesh sweet potato and tubers have now been added to the family's menu: they all say they eat many more vegetables than before the intervention began.

Nargish has already raised vegetable seedlings for the summer season, and has a large reserve of orange flesh sweet potato vines, which she plans to plant, sell, and distribute among her neighbors from November onward. Nargish's role is similar to that of a development agent in her locality, and she is confident about sharing her experience and knowledge with her neighbors.

Objective 2 (strategic research for sustainable cereal systems)

CSISA objective 2 used the concept of "ecological intensification," in which a balance of productivity, profitability, sustainability, and environmental protection is sought through fine-tuning of agroecosystem management. Ecological intensification identifies and explores options for best management practices through a blend of quantitative measurement and participatory evaluation following the principles of conservation agriculture (CA). To apply this concept, CSISA established four production-scale research platforms in close collaboration with NARES partners to evaluate the performance of existing and proposed future cereal-based systems, including quantification of changes in soil and crop performance.

Four sites were chosen for these platforms, representing distinctly different agroecological conditions, and four scenarios were conceptualized, designed for each site, and implemented: (1) business as usual—farmers' practices, (2) known best management practices (integrated crop and resource management), (3) labor-, energy-, and water-saving drivers of change (conservation agriculture practices), and (4) futuristic, intensified and/or diversified systems. These innovative research platforms were also utilized to test new varieties developed by Objectives 3-5, conduct satellite trials on agronomic practices for adaptive research (for Objective 1), support capacity building (scholars, interns, training courses), and showcase new technologies to a wide range of visitors (partners, government agencies, farmers, private companies, NGOs, researchers, politicians, donors, media).

The performance of these systems was studied using standardized experimental and measurement protocols. Categories of performance indicators included (1) annual profit and production of grain (and other marketable produce), (2) yield in relation to the target of achieving at least 80% of the climatic-genetic yield potential in each crop, (3) input-use efficiencies (water, energy, fertilizer, labor), (4) nutrient balance and soil health, (5) ecological resilience to maintain efficient disease and insect pest management, and (6) greenhouse gas emissions/global warming potential.

Results obtained so far have demonstrated great potential for optimizing cropping systems in the key CSISA target areas. In North West India, the adverse effects of puddling on the succeeding wheat crop productivity can be compensated via alternate tillage and crop establishment methods like zero tillage and direct seeding in rice. DSR is also a viable alternative to puddled transplanting to overcome emerging constraints of labor, water and energy and rising cost of cultivation. Happy seeder technology provides

a possible solution for residue management in double zero-till systems. Weeds are a major problem in zero till direct seeded rice. Pendimethaline as pre-emergent herbicide followed by bispyribac or azimsulfuron or bispyribac + azimsulfuron, and sesbania co-culture (growing sesbania with rice for 30 days and then killing with 2, 4-D) shows promise in controlling weeds.

Maize has shown potential to replace *Kharif r*ice in northwest India and *Rabi* wheat in eastern India. Maize-wheat-mungbean in Northwest India and rice-maize+potato-cowpea in Eastern India are promising alternate cropping systems to the conventional rice-wheat system. In regions dominated by rice-rice cropping systems, the mechanical transplanting of rice together with best management practices (ICRM) is promising. Increasing the intensity of the Boro-Aman cropping system by including a non-rice crop is challenging due to pre-monsoon rainfall and poor drainage in lowlands that have been puddled for many years.

GHG monitoring from present and future cropping systems show that N_2O emissions in maize were significantly higher than that in wheat, probably related to the low temperature during the wheat season. On the average, the N_2O emission factor for maize was found to be about 3 times more than for wheat. CH_4 emissions were 90% lower in unpuddled transplanted rice with water management as compared to that in conventional puddled rice with continuous flooding. Inclusion of maize in rice-rice-rice cropping system during the summer season with minimum tillage and water management can lead to significant GHG mitigation.

Objective 3 -5 (breeding)

Rice successes

In order to enhance genetic yield potential of intensively grown irrigated transplanted rice, a strong CSISA-funded breeding program was initiated. Over 100 elite high yielding rice lines were shared between partners and evaluated for higher yield in replicated field experiments conducted within target environments at multiple sites. Based on 2 years of testing, about half a dozen promising breeding lines were identified. Genetically diverse lines have also been used by CSISA project partners to initiate breeding programs aimed at increasing the yield potential of future rice varieties.

Over 250 rice entries including varieties, hybrids and breeding lines were evaluated under mechanized dry direct seeded conditions at multiple sites. Based on MET at 5 locations, six promising hybrids; two each in early, medium-early and medium maturity groups and a variety and a breeding line were identified. New breeding lines with different plant types having high yield potential, desirable grain quality, relatively tall stature (>100 cm) with strong culms, early stage seedling vigor, better and faster growth with water saving irrigation practices, different maturity groups and anaerobic germination ability are being developed for direct seeding conditions, and more than 40 breeding populations have been developed, with segregating generations being

screened under zero tillage conditions. Breeding networks involving NARES partners are being strengthened, and an off-season facility is being provided to North Indian NARES centers. Strong breeding network involving NARES partners is important in accelerating the development of commercially viable breeding products.

N22 is currently the major donor for heat tolerance breeding and it has also been used extensively by drought breeding groups at IRRI. Novel heat shock proteins obtained from proteomic studies were confirmed and published, and have now been successfully cloned, with transformation having been initiated. Sequence analysis followed by qRT-PCR expression studies for 16 putative heat and drought-tolerant genes were completed. Based on comparative sequence analysis between the cloned N22 genes and reference genomes, SNPs have been identified in two of the candidate genes. Additionally three Heat Shock Proteins which showed significantly high expression levels at the transcript (RT-PCR and qRT-PCR) and at the proteomics levels have been included in the functional validation pipeline. Over a hundred new breeding populations were developed and advanced lines are being tested in observational yield trials. Promising lines will be entered in multi-environment trials beginning in 2012. For shuttle breeding, a set of 1033 breeding lines derived from crosses with putatively heat tolerant parents were shared with NARES partners in Bangladesh & India.

Significant progress has been made to understand the mechanism of sheath blight resistance. This includes: (1) Networked field experiments conducted at 5 locations in India and at IRRI in which mega-varieties have been tested for their susceptibility to sheath blight, as putative recipients of resistance traits. (2) Potential donors have been identified from the testing at IRRI of 163 rice genotypes which had been reported to have quantitative resistance to sheath blight, using the phenotyping methods developed within this project. (3) A screening method has been designed and shared with partners in India, Nepal and Bangladesh.

Nutritional status and rice straw quality parameters were studied in more than three hundred entries and a few promising entries with high grain yield and better straw quality were identified for popularization among farmers.

Wheat

Wheat breeding activities were aggressively pursued from the start of CSISA Phase I, largely owing to the urgency for breeding Ug99 rust-resistant lines for south Asia that carry a "package" of essential traits such as yield potential, water use efficiency, heat tolerance, resistance to all three rusts and spot blotch, earliness and acceptable end-use quality. To speed up the process promising materials from the ongoing breeding programs of south Asian collaborators and CIMMYT were evaluated at Njoro, Kenya and also in hot spots of other biotic and abiotic stresses. Shuttle breeding between Mexico – Kenya/Ethiopia – South Asia and South Asia-Kenya-South Asia was employed with increased numbers of breeding populations.

The shuttle breeding and large scale multi-location yield evaluations in a range of management conditions led to the identification of superior wheat lines. These lines were immediately taken up for identification and release by national research systems, resulting in high-yielding, rust resistant wheat varieties being released in all four CSISA countries: Bari Gom 26, BARI Gom-27 (Francolin), and BARI Gom-28 in Bangladesh; BL 3063 (Vijay), BL 3235 and BL 3503 in Nepal; DPW621-50, HD 2967, and HD 2985 in India; Dharabi 2011, Punjab 2011, and NARC 2011 in Pakistan. The private sector was also engaged in breeding and seed production, so that two CIMMYT varieties, Super 152 and Super 172, were released and extensively promoted by a private company (Sri Ram Fertilizers Ltd) in India.

For greater impact, wheat cultivars developed in south Asia were evaluated in farmer fields using participatory approaches and seed disseminated using farmer-to-farmer contact. Linkages with other projects, especially USAID famine seed project, was used for seed dissemination in Pakistan, Nepal and Bangladesh. Consequently, not only were varieties released, but their seed was also disseminated in a significant manner. The new Ug99 resistant varieties cover around 5% area in the CSISA South Asian countries. Early maturing, heat and drought tolerant CIMMYT-derived participatory varietal selection (PVS) varieties such as Baj#1 are also becoming popular in eastern India, including Bihar. The chain of activities has now gathered momentum and in the coming phase more progress is anticipated

Objective 6 (policy)

Targeting CSISA technologies to reduce poverty and conserve resources: Experimental delivery of laser land leveling to farmers in Uttar Pradesh

One of the most significant challenges facing policy researchers is communicating the findings and implications of their work. During the course of CSISA Phase I, IFPRI researchers and collaborators from the University of California, Davis have been exploring the extent to which heterogeneity in the demand for resource-conserving technologies—in this case, laser land leveling services in eastern Uttar Pradesh—can be leveraged to make service provision profitable to local entrepreneurs while simultaneously promoting improved management practices among specific types of smallholders. The study relied on a combination of complex tools—experimental auctions with farmers, randomized trials of leveling services, economic simulations, and a lot of legwork and ground-truthing in the field—to arrive at some very nuanced findings. Importantly, the study (results of which are forthcoming in 2013) demonstrates the inherent tradeoffs between increasing the amount of land that is leveled and expanding the number of farmers adopting the technology.

Communicating these nuanced findings to the full range of CSISA's stakeholders has been an exciting challenge. Presentations given over the course of this study to agronomists and other agricultural scientists working with CSISA helped solidify some of

the basic science and intuition behind the study. Presentations to audiences of economists in the academic community helped validate and improve the conceptual, methodological, and empirical findings of the study with input from peers, while presentations to CSISA's management has helped ensure the study's relevance to the overall project.

However, the greatest challenge has been communicating findings to three of CSISA's most important stakeholder groups: policymakers, or those who decide on the allocation of scarce public resources to promote technologies such as laser land levelers; farmers, or those who stand to benefit from the technology; and rural entrepreneurs, or those who can potentially make a profitable business from the technology. A series of events conducted in India in 2012 aimed at reaching precisely these audiences. By all accounts, the content and tone of discussion at these events demonstrated the importance of bringing real evidence to the table when considering alternative policy incentives and business decisions in support of a new technology. Of course, while these events may have helped change attitudes and perceptions of how the technology (and similar technologies) might be promoted, changes in real decision-making at all levels remains a little distant. Despite this, CSISA's efforts have helped communicate issue of heterogeneous demand, market segmentation, and resource-conserving technologies squarely on the agenda of public and private decision-makers.

Appendix

End of project report for Phase I (submitted to BMGF and USAID in October, 2012)

TABLE OF CONTENTS

1	Glossary of Acronyms and Abbreviations	02
2	**Objective 1** Widespread delivery and adaptation of production and postharvest technologies to increase cereal production and raise incomes	03
3	**Objective 2** Crop and resource management practices for sustainable future cereal-based systems	06
4	**Objective 3** High-yielding, abiotic stress-tolerant, and disease- and insect-resistant rice varieties and hybrids for current and future cereal and mixed crop-livestock systems	10
5	**Objective 4** High-yielding, abiotic stress-tolerant, disease-resistant wheat varieties for current and future cereal and mixed crop-livestock systems	12
6	**Objective 5** High-yielding, heat-tolerant, and disease-resistant maize inbred lines and hybrids for current and future cereal and mixed crop-livestock systems	13
7	**Objective 6** Technology targeting and improved policies for inclusive agricultural growth	15
8	**Objective 7** Creating a new generation of scientists and professional agronomists for cereal systems research and management	18
9	**Objective 8** Project management, communication, and impact assessment	19

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ASA	American Society of Agronomy
AWD	alternate wetting and drying
BARI	Bangladesh Agricultural Research Institute
BMGF	Bill & Melinda Gates Foundation
BRRI	Bangladesh Rice Research Institute
CA	conservation agriculture
CCA	Certified Crop Advisor
CIMMYT	International Maize and Wheat Improvement Center
CKB	CSISA Knowledge Bank
CSISA	Cereal Systems Initiative for South Asia
DAE	Department of Agricultural Extension
DSR	direct-seeded rice
GDS	Grameen Development Society
HAU	Haryana Agricultural University
HCP	Hub Communication Platform
IAAS	Institute for Agriculture and Animal Sciences
IARCs	International Agricultural Research Centers
ICAR	Indian Council of Agricultural Research
ICRM	integrated crop and resource management
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IRRI	International Rice Research Institute
KVKs	Krishi Vigyan Kendra
NARC	National Agriculture Research Council
NARES	national agricultural research and extension systems
NGO	nongovernment organization
NIRS	near infrared reflectance spectroscopy
PACS	Primary Agricultural Cooperative Societies
PAU	Punjab Agricultural University
QPM	quality protein maize
RCTs	resource-conserving technologies
RPAU	Rajendra Prasad Agricultural University
SAU	State Agricultural University
SMEs	small and medium enterprises
SNPs	single nucleotide polymorphisms
SSR	simple sequence repeat (markers)
SWOT	strengths, weaknesses, opportunities, and threats
TWG	Technical Working Group
USAID	United States Agency for International Development

II. Project Final Results

CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA
CSISA was established in 2009 with the mandate of enhancing farm productivity and farmer livelihoods across the South Asian countries of India, Pakistan, Bangladesh, and Nepal. It is being implemented by the CGIAR centers IRRI, CIMMYT, ILRI, and IFRI, with numerous regional and national partners. CSISA is divided across eight key themes, four countries, and five distinct agroecological zones. Given the size, scale, and complexity of the project, this report covers the results, sustainability, scalability, and challenges for each objective, which will encapsulate the entire project in a holistic manner.

Objective 1:	**Widespread delivery and adaptation of production and postharvest technologies to increase cereal production and raise incomes**

Activity 1.1 Synthesis and application of research-based cereal farming knowledge for greater impact
The success of CSISA is predicated on the dissemination of prioritized and geographically differentiated technologies to a range of farmers who, in turn, decide to innovate and to invest. This is possible only with close consultation and collaboration with a wide range of stakeholders to develop appropriate work plans.

The CSISA Knowledge Bank (CSISA KB; www.knowledgebank.irri.org/csisa, launched in 2010, 4,000+ page views) was introduced as an accessible medium for compiling, synthesizing, and disseminating knowledge on localized best-bet technologies. Hub-specific collaborations have been established with various components of the knowledge network, from the "grass roots" to the established NGOs and NARES partners (e.g., ICAR, BARC, NARC, HAU, PAU, TNAU, CSSRI, KVKs, Digital Green, Syngenta, etc.). KB materials can be sorted according to technology, cropping system, type, and geographic relevance. Materials are available in English, Hindi, Urdu, Bangla, Punjabi, Tamil, Nepali, and Santhali.

Numerous modes of outreach along with practical training, with conventional materials such as fact sheets, posters, calendars, and brochures, complemented with creative tools such as videos, radio programs, jingles, and community dramas were created and disseminated. Higher-level training materials for front-line public and private extensionists and government and KVK's staff were also prioritized in the form of manuals and technical bulletins. The complete list (175 materials) of outreach and training materials created for different audiences is annexed. The need for printed material was quickly realized and much of the CSISA KB material (>15,000 direct printed pages in seven languages) was printed and distributed through the hub architecture. In each hub, at least 30 public- and private-sector extension leaders were trained in the use of e-learning (CKB, other modules), extension methodologies, access to the latest research results, participatory research, communication skills, and documenting case studies. Nearly 25 case studies from CSISA have been compiled and a compendium of them is being published. Innovative partnerships to achieve scale and sustainability have been piloted under the CKB with NGOs such as Digital Green in Bihar (two districts, two languages, 13 videos), the result of which has been an MoU between Digital Green and IRRI. The report of this pilot has been published.

Activity 1.2 Design and implement pilot schemes for improved delivery of seeds and modern technologies for crop, fertilizer, water, pest, residue, feed, and postproduction management
Bangladesh: CSISA in Bangladesh has also been an incubator for developing new modes of partnership for accelerating change at scale. For example, CSISA is collaborating with CARE through the Shouhardo II project in Rangpur and Mymensingh District. A clear value proposition exists for both CSISA and CARE. CARE handles social mobilization and has direct presence in hundreds of villages; CSISA takes advantage of these networks through "training of trainer" activities coupled with technical innovation and backstopping. In total, the two original hubs in Bangladesh collectively

organized **214** training events involving **20,572** stakeholders composed of **736** agricultural professionals and **19,836** farmers, including **5,006** women.

Strong progress has also been made in Bangladesh on building and testing an ICT-based decision support framework for site-specific nutrient management (Nutrient Manager). On-farm evaluations for rice are in progress to be followed by maize.

CSISA is also playing a very strong catalytic role with the public and private sectors in Bangladesh toward building sustained access to high-quality agricultural machinery through market development approaches. An initial value chain study (with iDE) strongly suggested that insufficient attention to commercialization was the most limiting factor for accelerating adoption. CSISA is working across the value chain with importers, distributors, and service providers and providing a unique mix of business development advice and technical training. With encouragement and support from CSISA, the private sector has been motivated to coordinate training of service providers as a means toward developing a more robust market for machinery, thereby ensuring sustainability after project support is withdrawn.

India: CSISA hubs and partners have jointly conducted **14,573** large-scale participatory demonstrations across five hubs in India. The progressive increase in the number of demonstrations over time with partners has accelerated the pace of technology dissemination and adoption.

Keeping in view the present agricultural scenario, capacity building, field demonstrations, exhibitions, traveling seminars, and training courses were conducted to ensure that stakeholders gear up to meet the changing technological and sociological scenario with innovative agricultural practices. In India, a total of **441** training events focused on CA-based crop management technologies, communication skills, and data management reached a total of **36,454** stakeholders, including **3,718** agriculture professionals and **32,736** farmers (**1,857** women).

A large number of partnerships (300+), including public, private, NGOs, farmer cooperatives, and service providers, were developed that helped in creating awareness and this accelerated the adoption of new technologies. Key state governments have now invested in the technologies promoted and advocated by the CSISA hubs. Punjab has invested INR 70 million on subsidizing the Turbo Happy Seeder, Haryana has developed an action plan on CA, Bihar has made large investments in CSISA-prioritized technologies and mechanization and, in Tamil Nadu, INR 200 million has been sanctioned toward CA-based mechanization. CA-based technologies have achieved economic gains (laser land leveler: US$150–250/ha; residue management: $150–170/ha; direct-seeded rice: $100–145/ha; unpuddled transplanting of rice: $100–250/ha; zero-tillage: $200–250/ha). The Department of Agriculture of India has included some CSISA-prioritized technologies in several well-funded investment programs (e.g., National Food Security Mission, Bringing Green Revolution in Eastern India, Rashtriya Krishi Vikas Yojana, etc.). Farmers in Indian hub domains have purchased over 8,000 zero-till seeders and laser levelers (up by an estimated 60% since 2009) and the area under CA-based technologies has increased substantially. DSR has been broadly accepted as a key technology to overcome the emerging challenges of labor, water, and energy shortages and it is estimated that more than 100,000 hectares have been converted in northwest India.

A database of 25,000-plus farmers was developed and evaluated for delivery of SMS using cell-phone technology. Print and electronic media have been used widely with 300-plus news items published in local and national newspapers in addition to approximately 50 radio and TV talks.

CSISA has also helped strengthen a large number of seed production companies/associations (Vishwa Bharati Krishi Swayambar Goshthi Kulgachi, Nadia, PACS, BRBN, SFCI, HKB, young farmer cooperatives in Haryana, etc.) and these have been engaged in the production of foundation, certified, and truthfully labeled seed of improved cultivars/hybrids of rice, maize, and wheat.

Nepal: A total of **54** training programs were organized with a focus on DSR, nutrient management, and weed management, involving **318** agriculture professionals and **1,020** farmers (**279** women).

In many areas of Nepal, the private sector is not well organized and there is a general reluctance to pay for services. "Service provision" is a relatively new concept, but one that is taking hold quickly since most Nepali farmer households are suffering the consequences of widespread labor shortages but are too small to adopt precision and labor-efficient management approaches directly by purchasing their own equipment. Based largely on CSISA's efforts, an emerging private-sector presence is now importing and re-selling agricultural implements that were previously

available only to those who were willing to purchase them in India. This has accelerated the uptake of technologies such as DSR and laser land leveling.
CSISA has also developed strong relationships with women's self-help groups (SHGs) such as the Himali women's group as an entry point for needs assessment for supporting women-headed households as well as an organizing mechanism for facilitating group training.
Pakistan: CA-based technologies and other companion technologies were jointly evaluated through 400 large-scale participatory demonstrations. Through **129** training events focused on seed production, CA-based technologies; CKB, HCP, etc., capacity of **7,392** stakeholders (1,098 women), including **3,363** professionals from the public sector, private sector, and NGOs, and **4,029** farmers, was strengthened.

The adoption of new technologies championed by CSISA has increased substantially (approximately 8,000 ha zero-tillage, **45,000** ha relay cropping, >0.6 million ha laser land leveling). The average farm profitability with zero-tillage increased by $181/ha as a joint contribution of cost savings ($116/ha) and yield enhancement ($65/ha). Based on collaboration with CSISA, CA practices are now included in a package of practices supported by the government of Pakistan.

CSISA has supported the emergence of national manufacturers and around 40 units of a newly designed zero-till drill are now with farmers and service providers.

Activity 1.3 Monitor performance, distill location-specific lessons learned, synthesize these lessons across hubs, and design rules that can be applied more widely
CSISA hubs in India, Nepal, and Bangladesh were characterized and the production system constraints and strategic entry points in different hubs were assessed. Farmer uptake of prioritized technologies has been tracked and dynamically mapped with more than 25,000 data points entered into the systems to date. Overlaid maps (e.g., land type, market proximity, road networks, etc.) have been developed to guide investments in maize market development in Bangladesh. Ongoing work in Bangladesh is combining a variety of geo-spatial data streams (including remote sensing) to delineate the target domain for axial flow pumps, a technology that promises to revolutionize agriculture in the impoverished south by bringing thousands of hectares of winter-fallowed land into production. Application domains for stress-tolerant varieties and innovative production practices have been mapped in India.

Activity 1.4 Design business models, social marketing, and out-scaling strategies for large-scale rollout of technologies through different public- and private-sector channels
Strengthening of small and medium-scale entrepreneurs is core to CSISA's approach; significant strides were made with respect to providing technical and, just as important, business development advice to mechanized service providers (e.g., zero-tillage, laser land leveling, postharvest), seed companies, and agro-dealers. These service providers potentially reach >5,000 households per hub. An aggregation model for laser leveling services was also concept-tested with an E-UP NGO, Grameen Development Services, in which aggregation of demand was done by interns from KIIT. CSISA also formed strong relationships with larger agricultural input companies such as Bayer Crop Science (BCS), Syngenta, etc., offering market intelligence and linkages with dealers and champion farmers and cemented through joint demonstrations. BCS and Syngenta have shared over 2,000 kg of hybrid rice and hybrid maize seeds for farmer demonstration and feedback. Several technical and farmer feedback inputs have also been provided to machine manufacturers such as Dashmesh, National, etc., to improve the design of their farm equipment.

CSISA has also embraced the opportunities of social marketing with a broad-based engagement with local and national media. Initial pilots with Digital Green have strengthened their unique selling point/proposition and are now maturing into full-fledged partnerships in Odisha and Bihar. With GrainPro, work has progressed in hermetic storage, with field trials with >40 farmers, two videos being made and disseminated to >1,000 farmers, and a "field test protocol" being developed to document hermetic bag trials. In consultation with Agroinsight, CSISA-BD has just produced a video titled "Save More. Grow More. Earn More," which details in rich visuals and simple language pathways toward sustainable intensification and improved livelihoods based on small machinery and conservation agriculture.

Lessons learned on sustainability, scalability, and the challenges of implementing science-based food security + livelihoods initiatives at scale

Sustainability

- Numerous partnerships with state governments, DoA, government programs, NGOs, and the private sector have helped popularize these technologies and approaches. Many of them have been integrated in their development programs as well.
- Embracing commercialization, including SMEs, is essential to long-term success. Technologies can be translated into sustained practices only when farmers tap into market-based systems that reliably supply key goods and services, enhance incomes, and lead to better economic returns. The service provider model for contract services is a step in this direction.

Scalability

- Going to scale requires explicit support and engagement with change agents who interact with large numbers of farmers such as linking with government agencies such as the KVKs (55) and government schemes (NFSM, NRLM, etc.) and other partners who have a significant footprint. Regular framing and monitoring of activities along impact pathways help revise and fine-tune work plans to scale.
- When forming new partnerships to achieve outcomes at scale, it is essential to understand what motivates each partner so that there is a clear value proposition, common understanding, and commitment on both sides (e.g., GDS in eastern UP, CSISA–Digital Green pilot in Bihar leading to larger collaboration across Asia, CARE in Bangladesh, FORWARD in Nepal). Institutional landscaping and SWOT analysis are ongoing for this purpose in Bihar and Odisha.
- The value of multilingual social networking (CSISA YouTube, Facebook, slideshare, Web site, IRRI bulletin, KB, publications) and marketing (service provider model, HKB FM radio, farmer field/harvest days, farmer fairs) for awareness and demand generation cannot be underestimated, and will continue to be leveraged.

Challenges

- Evolving a stronger sense of ownership with TWG partners at the hub level to ensure accountability and performance.
- Innovative institutional arrangements are required to foster a true sense of joint ownership of project-supported activities that, ideally, align and complement other government investments.
- Ultimately, sustainability is governed by private investments and private choices and it's important to understand that no project can "guarantee" adoption.
- Complex "big tent" projects pose significant challenges for governance and coordination at the hub level.

Objective 2: Crop and resource management practices for sustainable future cereal-based

Bangladesh: Pressure on land in Bangladesh is the highest in the world, and CSISA's applied research program in Phase I here focused on identifying and exploiting underexplored niches. In Gazipur, CSISA worked with farmers to perfect boro + mustard co-culture that increased profitability by $1,200/ha. In Mymensingh, charlands are riverine deposits that are not commonly cropped. CSISA has led participatory technology evaluation trials demonstrating that wheat can be grown here at yield (approx. 3.8 t/ha) exceeding the national average, generating new income of $750/ha.

India: A large number of component technologies (crop establishment; residue management; cultivar choices; water, nutrient, weed, and crop management; crop geometry; intensification; etc.) were refined through participatory adaptive research trials under diverse production ecologies. The results of these adaptation trials were synthesized and linked to demonstration and outreach activities in the respective domains.

Engineering advances were also prioritized with eight new CA machines developed and linked to delivery, including collaboration with the private sector on the design of a zero-till drill (National Agro-industries) and laser land leveler (Precision Cultivation Aids) for a

two-wheel tractor.

Nepal: CSISA trained 13 graduate students (3 PhD, 10 MSc) in its applied research program. Research topics involved site-specific nutrient management, weed control in DSR, optimizing intercropping under high- and low-fertility conditions, CA for rice-maize rotations, and coping with winter cold damage in rabi maize. Results from the last study are potentially transformative for the maize industry in Nepal as they highlight simple planting data and "companion" planting practices (with open-pollinated varieties) that can eliminate much of the risk of cold damage and permit farmers to continuing to cultivate and generate income from this highly remunerative crop in the terai.

Pakistan: Replicated adaptive research trials were conducted to fine-tune bed planting, zero-tillage, cultivar choices, relay planting, etc., and the results were linked to delivery. A zero-till-cum-bed planter (CSISA planter) was developed, tested in the field, and the same has been accepted by farmers.

Activities 2.3: Experimental platforms for designing a new generation of resource-efficient, high-yielding cereal systems that are based on principles of conservation agriculture and **2.4: Analysis of the long-term performance of future cereal systems within key scenarios of agricultural change**

Key actions taken

- Completed five seasons of the four distinct agroecological production-scale sites and scenarios for strategic measurement of key indicators of existing and futuristic cereal systems and budgeting of different agronomic, soil, and environmental factors at Karnal, Patna, Aduthurai, and Gazipur research platforms.
- Data analysis complete to identify key indicators of water-use efficiency (WUE), labor-use efficiency (LUE), energy-use efficiency (EUE), nutrient budgets, greenhouse gas (GHG) emissions, soil health, and pest and weed dynamics.
- Data collected and analyzed for additional support trials on GHG estimations of emissions and weed management at Karnal and Aduthurai.
- The APSIM farming systems model (www.apsim.info) calibrated and validated for Karnal research platforms. Potential yields of rice and wheat for 30 years simulated for Karnal.
- System performance data presented and reported at various forums.
- Results of each site were shared with the delivery hub team of Objective 1 for further adaptive trials as well as demonstration on a large scale.
- Completed evaluation of different crop simulation model: RICEPEST, WHEATPEST, and DSSAT.
- CSISA Objective 2 meetings organized every 6 months to review the progress at each platform and to discuss constraints.
- Workshops on crop modeling using INFOCROP and APSIM models conducted periodically to train the research platform coordinators.
- DSSAT is being tested for CA and ecological intensification-based cropping system performance for different soil moisture regimes, residue conditions, and yield-limiting and yield-reducing factors to exploit management and reduce factor effects under different RCTs.
- Database for all important soil health parameters using samples from all four CSISA platforms and farmers' fields being continuously updated.
- Soil sample analysis completed for baseline samples from all four CSISA platforms, for samples of each season for Karnal platform, and for samples after 2-year rotation for Aduthurai and Patna platforms. Samples after 2-year rotation at Gazipur imported for analysis.
- Update of extensive review of literature to identify vital processes sensitive to management in progress.
- Writing of research papers for each research platform for two cropping years in progress.
- Final report for CSISA Phase I completed for all four research platforms.
- Data collected from all four platforms being compiled for common depository.

Lessons learned

India—Karnal, Haryana

- Puddling has adverse effects on succeeding wheat productivity.
- Continuous zero-tillage in rice followed by upland crops (wheat in the main season and other crops such as mung bean between main crops) is feasible in northwest India without any yield penalty; rather, system productivity over time was higher with more efficient use of water, labor, and energy.
- Happy Seeder technology is a potential solution to manage residue as mulch vis-à-vis burning. This improves wheat yield by regulating the canopy and soil temperature.
- Relay mung bean is feasible and a good alternative to drill sowing after the wheat harvest, especially if rice is direct-seeded for achieving higher grain yield. However, there is a need for adaptive trials to refine this further. Inclusion of mung bean has positive effects on system productivity. Mung bean should be broadcast only 10–15 days before the wheat harvest for its success.
- Maize likes zero-tillage with residues. There are clear positive effects of continuous ZT on maize grain yield. However, there is a need to watch out for cutworm and stem rot diseases.
- Maize has potential to replace *kharif* rice in northwest India and can be grown with >90% less irrigation water. Maize also has positive effects on the productivity of a succeeding wheat crop compared to when grown after puddled transplanted rice. Hence, maize-wheat-mung bean is a promising cropping system and can be a viable alternative to a rice-wheat or rice-wheat-mung bean cropping system.

Patna, Bihar

- ZT-rice-maize + potato intercropping–ZT cowpea relay with maize (Scenario 4) is a highly profitable cropping system in eastern India. With this, 400% cropping intensity is feasible.
- Wheat yields were higher when grown after ZT-DSR or unpuddled transplanted rice (RT-UPTR) than after puddled transplanted rice (CT-PTR).
- In rainfed conditions, ZT-DSR–ZT-lentil–ZT-green gram can be used with complete residue recycling of lentil and green gram and 1/3 of rice residue.
- To achieve high yields of a summer legume crop in a crop rotation in Scenarios 3 and 4, unpuddled transplanted rice performs better with residue recycling of a legume crop and 1/3 residue of rice and wheat/potato + 1/3 maize.

Aduthurai, Tamil Nadu

- Mechanical transplanting of rice together with available best management practices (ICRM) is very promising for the rice-rice system in Tamil Nadu.
- Zero-till direct-seeded rice can be used instead of puddled transplanted rice during the kharif (*kuruvai*) season to overcome the emerging problem of labor shortage in the region.
- Growing maize in kharif (*kuruvai*) is not encouraging because of untimely rainfall and poor drainage in lowlands that have been puddled over the years. However, ZT maize in rice stubbles is a possibility during the summer season, which requires further testing. The cropping sequence changed to rice-rice-maize.
- Mechanization (machine transplanting in both puddled and unpuddled fields and harvesters) has enormous potential to counteract the labor shortage. The use of a transplanter will also encourage diversification.
- Herbicides such as glyphosate (preplanting), pendimethalin, pretilochlor (pre-), and bispyribac sodium (post-) are effective in controlling weeds, especially in dry-seeded rice.

Gazipur, Bangladesh

- The best available crop management and resource-use practices (ICRM technology package) for irrigated boro rice and partially irrigated (if needed) aman rice cultivation are developed and ready to deliver and disseminate.

- The use of an ICRM technology package increased rice yield by 2.1–2.6 t/ha/year, net returns by $515–805/ha/year, decreased production cost by 3–10%, and saved irrigation water by 200 mm and electricity use by 300 kWh/ha/year compared with the existing farmers' practice of rice cultivation in the boro–T. aman cropping system.
- Increasing intensity of the boro–T. aman cropping system by including a nonrice crop between boro and aman is very challenging due to premonsoon rainfall. Research needs to be further strengthened with newly released rice varieties. Mustard, lentil, maize, and tomato have been included as additional nonrice crops other than potato. Among them, mustard and lentil were found promising.
- A rice transplanter is a potential alternative to transplanting to reduce transplanting cost and save labor in the aman season but it needs further study in seedling raising, particularly in the boro season.
- Reduced tillage (2–3 passes instead of 4–6 passes by a power tiller) in unpuddled conditions is also a potential option but needs further study for making recommendations.

Component trials

- **Weed management**: Pendimethalin as a preemergence followed by bispyribac or azimsulfuron or bispyribac + azimsulfuron and *Sesbania* co-culture (growing *Sesbania* with rice for 30 days and then killing with 2,4-D) were found to be effective in controlling weeds and had yield similar to weed-free plots.
- **GHG:** The N_2O emissions in maize (Karnal and Aduthurai) and winter wheat (Karnal) increased with increasing fertilizer N rates (0–300 kg N/ha). The N_2O emission factors (estimated by linear regression) for maize averaged 0.036 and, for wheat, 0.0022 and 0.006 kg N_2O-N per kg N applied under conventional and futuristic systems. The higher emission factor for wheat under the futuristic maize-wheat system was due to the application of residues. The fertilizer-induced N_2O-N emissions (N_2O-N with fertilizer – N_2O-N without fertilizer) increased exponentially with surplus N (the difference between N applied and Δ crop N uptake due to fertilizer) for both maize and wheat. There was a sharp increase in N_2O emissions from surplus N of around 100 kg/ha onward with a faster rate of increase in maize (about 7 times) than in winter wheat due to a temperature effect.
- In Karnal, the annual (average over four N rates) global warming potential (CH_4 + N_2O) for the futuristic maize-wheat system was higher (2,992 kg CO_2 eq per ha) than that for the conventional rice-wheat system (1,581 kg CO_2 eq per ha). The CO_2 emissions from dark respiration were not significantly different between the two systems despite the addition of residues in the maize-wheat system.
- In Aduthurai, the total productivity of a 1-year rotation of an intensive system (maize-rice-maize) was about 50% higher than that of a conventional system (rice-rice-black gram), with about a 3-fold reduction in global warming potential. In wet-season rice, CH_4 emissions in an intensive system declined by 10-fold (66.6 to 6.5 kg CH_4 per ha) compared with that of the conventional system. The conventional system included farmers' practices with tillage and water management whereas the intensive system had minimum tillage and need-based water application.
- **Varietal trial:** Out of the varieties being tested under DSR conditions, US323, Arize97158, and JK 2007 were found to be performing well in the early entry category and NK6303, RH 1531, and NK 6754 were performing well in the mid entry category.
- Data being collected from two new component trials—"Interaction of residue load and date of sowing on wheat productivity and weed suppression" at Karnal, EP, and "Assessing the impact of machine harvesters on soil compaction, crop establishment, and yield in the rice-based cropping system" at the Aduthurai research platform.

Training of young researchers

- Four PhD students (two completed), one MSc student, and two interns were working on research platforms on different aspects of conservation agriculture and ecological intensification.

Constraints

- Frequent electric power failures and voltage fluctuations causing problems with timely irrigation.
- Labor and other running costs are increasing, leading to a higher budget requirement.
- More research is required to refine crop management practices for future cereal systems.
- Small combines are required for plot harvesting.
- Nutrient Manager was unavailable; hence, a uniform SSNM approach is difficult to follow.

Activity 2.5: Assess opportunities for livestock integration in future cereal systems

A total of 2,400 farmers were included at all four sites (Haryana—400, Bihar—800, central Terai, Nepal—800, northwest Bangladesh—400) to conduct farmer-led experimental feeding trials and training sessions. The farmers were aggregated into groups to carry out the trials more efficiently. Quantitative trial adoption data were collated from the four sites to document the output of the current phase and as a basis for estimating outcomes. These will be mainly assessed by the extent to which the new feeding strategies and the improved knowledge will be disseminated further by the local partners.

Although the trials already allow the participating farmers to experience the effects of improved feeding, their main aim is to practically illustrate the content of the training sessions conducted with a far larger number of farmers (at least 2,000 farmers at each site). This has already proven to be effective and will therefore be expanded to cover a larger number of farmers and generate interest and awareness within a short period of time. Based on experiences and the material created at the four sites, a training module template will be developed that can then easily be adapted to local contexts. We will also optimize the intensity and design of the trials to most efficiently support the training activities, so that partner organizations can easily include them in their larger development activities. Partner organizations already involved in the trials and training activtities are the National Dairy Research Institute (NDRI), Karnal, Haryana; the Bihar Veterinary College, Patna, Bihar; Primary Agricultural Cooperative Society (PACS), Sarai Ranjan, Bihar; self-help group Sarai, Ranjan, Bihar; Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Chitwan, Nepal; CARE Bangladesh; Bangladesh Livestock Research Institute (BLRI), Dhaka.

Looking at the contribution of women in dairy, special care was taken to include women farmers in the group. It was found that mixed-gender training groups were more effective instead of separate gender-targeted training programs. On the other hand, we also found women-led self-help groups to be especially receptive to new ideas on feeding and livestock management for improving incomes and household nutrition.

Lessons learned

The identification of types of partners is essential and primary. Existing local farmer groups enable interventions and knowledge to quickly reach large numbers of farmers and to achieve local ownership. Locally based technical experts are required to link CSISA scientists with local farmer groups and to guide field workers who coordinate these groups. These experts are crucial for moderating the discussions on prioritization of technology interventions and training contents among local partners and CSISA scientists. Although scientific awareness is needed in these technical experts, a wider perspective on rural development at scale is essential for reaching out to a significant number of farmers.

The most rewarding result of these interventions was the response of the involved farmers. At all sites, farmers were greatly surprised by the effects of relatively modest changes in their feeding regime. In Nepal, an involved farmer cooperative restarted its concentrate production due to increased farmer demand for its new compound feed and this is helping farmers with procuring chaff cutters. In Bihar, female-led self-help groups are securing funds to set up their own feed-mixing unit to meet their members' demand. Links to the local university will offer them the resources to increase their knowledge of feeding practices and to adapt their feed formulation to changing conditions.

Challenges

- Initially, livestock feed improvement activities were linked to the research platforms. However, the platforms have only limited links to farmers, essential for participatory trials and training activities. Therefore, the focus then shifted to the project hubs, which do have strong links to farmers and their organizations. However, the farmers targeted by the agronomic technology interventions differed considerably from the farmers interested in improving their dairy production. Also, it was not easy to synchronize hub staff activities and schedules with the requirements of livestock activities. Thus, new partners had to be identified for this project section. It was learned that these partners had to have both a solid grounding in field work as well as the institutional and academic capacity to collaborate with international research institutions.
- It took a considerable effort to bring the diverse group of partners to a common understanding of current feeding constraints and processes for identifying development options.
- Identifying the most suitable farmers for successful participation in the field activities proved to be critical. The most promising candidates should be economically resilient to be willing to bear risks, but at the same time should be sufficiently dependent on livestock to have a real interest in improving their profitability.
- The livestock interventions are specifically aimed at improving dairy profitability. However, a tradition of subsidy-oriented development interventions has created an expectation for only direct support and asset transfer. It was a challenge to convince partners and participating farmers that the main goal is changing practices in dairy feeding to improve productivity and profitability through improved knowledge and demonstrations of innovative technologies.
- It was a challenge to quickly move beyond the geographic boundaries of the initial activities: at all sites, they have so far been restricted to only one district. In Nepal, the CSISA hub will move to a new region and in Odisha a new hub will be established. Based on the experiences gathered so far, we expect to establish partnerships and interventions at these new sites within a shorter time period and more efficiently.
- Finally, adoption tracking and impact assessment received less attention than required to generate evidence of the effectiveness of CSISA's approach.

Objective 3: High-yielding, abiotic stress-tolerant, and disease- and insect-resistant rice varieties and hybrids for current and future cereal and mixed crop-livestock systems

Progress:

- *Irrigated transplanted rice*: >100 elite high-yielding lines shared between partners; six promising breeding lines identified; selected promising lines crossed with location-specific mega-varieties to develop breeding populations for further selection.
- *Mechanized dry direct-seeded rice*: >200 entries (varieties, hybrids, and breeding lines) evaluated at five locations for 3 years; six promising hybrids identified.
- *Zero-till rice*: >40 breeding populations developed; segregating generations being screened.
- *Heat tolerance*:
  - N22 identified as a major donor for heat-tolerance breeding.
  - Novel heat shock proteins obtained from proteomic studies confirmed and published; cloning and transformation initiated.
  - Sequence analysis followed by qRT-PCR expression studies for 16 putative heat- and drought-tolerance genes completed; based on comparative sequence analysis between the cloned N22 genes and reference genomes, SNPs identified in two candidate genes.
  - Efforts ongoing to identify polymorphic SNPs flanking candidate genes.
  - Three heat shock proteins that showed significantly high expression at the transcript (RT-PCR and qRT-PCR) and proteomics levels included in the functional validation pipeline.
  - >100 new breeding populations developed and advanced lines being tested in observational yield trials.
  - Some 1,033 breeding lines derived from crosses with putatively heat-tolerant parents sent to Bangladesh, Tamil Nadu (India), and Punjab (India) for shuttle breeding.

- Using SSR and SNP markers to assay 158 F_2 progenies of an IR64/N22 cross, two QTLs on rice chromosomes 1 (*qHTSF1.1*) and 4 (*qHTSF4.1*) explaining 12.6% and 17.6% of the total phenotypic variation, respectively, identified.
- SNP markers being used to fine-map these QTLs in order to develop markers to be used in molecular breeding.
- Advanced breeding lines (F_5 and F_6) for heat-tolerance breeding were sent to many locations in India, Bangladesh, and Pakistan for large-scale evaluation.

- *Sheath blight resistance*
  - Networked field experiments conducted at five locations in India and at IRRI in which mega-varieties have been tested for their susceptibility to sheath blight, as putative recipients of resistance traits.
  - Potential donors have been identified from the testing at IRRI of 163 rice genotypes that had been reported to have quantitative resistance to sheath blight, using the phenotyping methods developed within this project.
  - A screening method has been designed and shared with partners in India, Nepal, and Bangladesh.
  - Genotyping of the 163 rice genotypes that have been phenotyped for their resistance to sheath blight is under way in order to identify putative QTLs for partial resistance to sheath blight.
  - Crosses have been made at IRRI between selected donors for resistance and recipients.

- *Resistance to planthoppers*
  - Greenhouse and field experiments conducted using a series of near-isogenic lines (NILs) with resistance to brown planthopper (BPH). Plants were developed using T65 as a recurrent parent, and had *Bph15* or *Bph26* introgressed for monogenic resistant lines and both genes together in a pyramided line (*Bph25 + 26*). Experiments demonstrated higher resistance of the pyramided line.
  - A series of NILs developed for resistance to green rice leafhopper (GRL) was further tested for resistance stability under different nitrogen regimes. Results indicate that pyramided lines had higher resistance than monogenic lines, and allowed rice plants to produce grain even under high GLH infestation.
  - Using a range of hybrid lines developed at IRRI with their corresponding parental lines (28 in total), the possible benefits of hybrid vigor in bestowing plant tolerance of three rice pests (BPH, whitebacked planthopper, WBPH, and yellow stem borer, YSB) were studied. In general, hybrids are more tolerant against herbivores than the parental lines and the redistribution of resources led to overcompensation in root biomass production and grain production when plants were attacked by WBPH.

Impact: As a result of CSISA project activities involving different stakeholders, the area under mechanized DSR is expanding rapidly in Punjab, Haryana, Uttar Pradesh, and Bihar. An acute shortage of labor and the availability of good machines and a few varieties/hybrids increased profitability, and effective public-private partnership is responsible for the rapid increase in DSR. During the wet season of 2011, the cumulative area under DSR in these four states was estimated to surpass 100,000 acres. In Punjab and Haryana, it is estimated to be in excess of 80,000 acres.

Collaboration: Technologies generated at the research platform were verified and demonstrated on a large scale in farmers' fields through different CSISA hubs. Periodical training, capacity building, traveling seminars, farmers' fairs, etc., in collaboration with NARES partners and private-sector companies have helped spread the technologies faster. Rather than independently developing technical solutions and relying on existing service providers for dissemination, the CSISA approach aims at linking technology adaptation to enthusiastic local farmer-oriented institutions such as self-help groups, farmers' cooperatives, and primary producer associations in close coordination with the CSISA hubs under Objective 1.

Objective 4: Wheat breeding: high-yielding, abiotic stress-tolerant, disease-resistant wheat varieties for current and future cereal and mixed crop-livestock systems

Activities 4.1: Develop improved bread wheat varieties for the eastern Gangetic Plains, 4.2: Develop improved bread wheat varieties for the western Indo-Gangetic Plains, and 4.3: Develop improved bread wheat varieties for central India and west Pakistan

i. High-yielding, rust-resistant wheat varieties released in all four countries: Bari Gom-26, BARI Gom-27 (Francolin), and BARI Gom-28 (Bangladesh); BL 3063 and Vijay (Nepal); PBW621, HD 2967, and HD 2985 (India); and Dharabi 2011, Punjab 2011, and NARC 2011 (Pakistan). Two CIMMYT varieties, Super 152 and Super 157, were released and promoted by a private company in northwestern India. Early-maturing, heat- and drought-tolerant CIMMYT-derived PVS varieties such as Baj#1 are also becoming popular in eastern India, including Bihar.
ii. Around 70 CIMMYT international trials and nurseries, most with adequate to high resistance to all three rusts (including Ug99), were distributed each year to NARES and private-sector partners within and outside the CSISA project.
iii. Each year, over 10% of the distributed entries showed significant superiority (>10%) over local checks across test sites in each country. Selected lines are in various stages of testing in national programs.
iv. More than 1,000 crosses/backcrosses (developed annually by CIMMYT and partners) and segregating populations were exposed to selection in different locations of South Asia. Numerous crosses involved heat- and drought-tolerant, spot blotch-resistant, and Ug99-resistant parents.
v. For the first time, segregating (F_3/F_4) generations from South Asia were screened in Kenya for Ug99 resistance.
vi. Around a dozen new wheat varieties were given to hubs for testing and seed dissemination.

Activity 4.4: Develop germplasm and identify molecular markers for wheat resistance to spot blotch

i. More than 1,000 genotypes were evaluated for spot blotch tolerance at Agua Fría, Mexico, and 800 lines in South Asia. A CSISA spot blotch nursery was developed at CIMMYT, and elite spot blotch-resistant germplasm was distributed and tested at multiple sites in South Asia. Five percent of the lines were selected for further yield trials and use as parents by NARES partners.
ii. Three targeted mapping populations for spot blotch resistance were developed. These will be available for phenotyping in the region during the 2012-13 season.

Activity 4.5: Apply physiology and genetics to improve heat and drought tolerance in wheat

i. Selected high-yielding germplasm was characterized for heat and water stress tolerance.
ii. Labs, equipment, and protocols were set up with NARES scientists for the application of physiological tools in breeding. Preliminary physiological models were made for each major region of South Asia.
iii. QTL analysis for the mapping population (167 Seri/Babax RILs) was conducted. A molecular genetic linkage map including 425 marker loci associated with 29 linkage groups was used for QTL analysis. Important genomic regions were identified on chromosome 4A contributing to yield and canopy temperature and no co-location of these QTLs was observed with other QTLs associated with phenology. The results (including environments in India and Central and West Asia and North Africa) have been accepted for publication in *Theoretical and Applied Genetics*.
iv. An association mapping panel (288 elite lines) phenotyped in South Asia. QTL analysis for heat tolerance is under way.

Activity 4.6: Analyze straw quantity and fodder quality, identify molecular markers for wheat straw quality, and explore inclusion of wheat straw traits

i. Near infrared reflectance spectroscopy (NIRS) equations for prediction of wheat straw quality traits were validated and refined. A new NIRS instrument (FOSS Forage Analyzer 6500) was calibrated with the updated NIRS equations (for wheat straw).
ii. Use of wheat straw in crop-livestock systems was investigated from the farm to fodder traders to feed processors.

iii. A wide range of CIMMYT wheat germplasm (CSISA Heat-Tolerant Early and Normal Maturity, Semi-Arid Wheat Yield Trial, Elite Spring Wheat Yield Trial, and 1st and 2nd CSISA Drought-Tolerance Yield Trials) was investigated across several environments in South Asia (India, Nepal, Bangladesh). Results showed that straw fodder quality and grain yield were inversely associated but that some cultivars incorporate favorable grain and straw fodder quality traits.

iv. Association mapping was used to better understand the relationship between genetic structure and wheat straw fodder quality differences.

Lessons learned

- The demand for CSISA trials/nurseries is growing among collaborators (including several small and large private companies) in South Asia. Hence, a larger number of trials/nurseries must be prepared to meet the extra demand.
- A collaborative multidisciplinary network of centers, including national programs, can produce realistic and rapid gains in developing and releasing more high-yielding varieties for diverse target regions.
- Shuttle breeding of segregating populations between NARES and Kenya could enhance the development of adapted Ug99-resistant varieties and germplasm.
- Early-maturing, heat- and drought-stress-tolerant wheat germplasm developed in Mexico is adapted to the eastern Gangetic Plains and central India.
- Participation of private seed companies is increasing in India. However, they need encouragement in other countries in order to enhance our capacity for varietal testing and seed dissemination.
- There is considerable scope for the concomitant improvement of grain and straw fodder traits in wheat, thus increasing the overall income and livelihood from wheat cropping.
- Wheat is a high priority for NARES and CIMMYT, and strong national and international partnerships, including the private sector, have been enhanced through CSISA and are expected to continue breeding efforts.

Scalability

- Project partners will use the knowledge and technology generated to seek new funds.
- The objectives of CSISA are already embedded in CRP WHEAT. Three projects have been granted to national partners in India, Nepal, and Bangladesh under this program.

Challenges

- Sending segregating generations to Kenya was an anticipated challenge as this was a new venture for the collaborating nations and, for some countries (e.g., India), only released varieties can leave the country. This was resolved by defining this activity in the project, in MoUs, and through a sustained approach to convince administrative bodies. Valuable support from BGRI and KARI helped significantly.
- Submitting straw samples to ILRI, India, from other countries was an unanticipated challenge. This was resolved through an active joint role played by the national programs, ILRI, and CIMMYT.
- Fast-track release of varieties continues to be a challenge. The private sector is taking on an important role in this area through sustained engagement.

Objective 5: High-yielding, heat-tolerant, and disease-resistant maize inbred lines and hybrids for current and future cereal and mixed crop-livestock systems

Activity 5.1: Development of maize inbred lines and hybrids tolerant of major—but often neglected—diseases of maize: downy mildew (DM) and banded leaf and sheath blight (BLSB)

Downy mildew (DM) resistance

- A study confirmed a breakdown of DM resistance in 19 CMLs released during 2000-02 as DM resistance sources. Out of 19 DM-resistant CMLs, most of them were found susceptible to *Perenoscelospora sorghi*, except for CML 433, 465, 466, and 472.

- Screening of a large set of new inbred lines from CIMMYT-Asia and partners resulted in the identification of a set of yellow maize lines with reasonable DM resistance (disease score of 0.0 to 25%), which was used as base germplasm in developing a new generation of lines with enhanced DM resistance across two major *Perenoscelospora* species in South Asia (*P. sorghi* and *P. heteropogoni*).
- The DM resistance in new DM lines was further improved through selection under artificial inoculation nurseries. Fourteen new DM-resistant lines (including 10 new and 4 old DM-resistant CIMMYT Maize Lines), recommended as DM donors for use in a breeding program targeting DM-resistant cultivars (*Appendix* Table 1), were made available to South Asian maize breeding programs of the public and private sector through a CIMMYT maize field day in 2011.
- DM pedigree populations (named DMC-Pop01 to DMC-Pop013) were developed using improved DM-resistant lines for the extraction of a new generation of lines combining DM resistance and desirable agronomic traits, including high grain yield. Also, one DM synthetic population (DMC-Syn) was developed by combining the eight best DM-resistant lines with good per se yield and test-cross yield.
- A new generation of DM-resistant lines was derived from both DMC pedigree populations (190 F_4 lines) and DMC-Syn (132 F_2 lines), which are being evaluated for DM resistance and agronomic traits, including yield and yield traits.
- Apart from normal maize, the study on quality protein maize (QPM) confirmed that, in general, QPM lines, irrespective of their genetic background, showed very poor resistance to DM. The results suggest that special attention is needed to combine DM resistance and QPM traits, especially when QPM hybrids are promoted by national maize programs in South Asia.
- A glasshouse-based screening technique (*sandwich method*) commonly used for screening sorghum germplasm against DM was standardized with certain modifications and validated for screening maize genotypes against DM.
- Comparative study of glasshouse-based sandwich and field based screening (spreader row method) confirmed that sandwich method was the best method for identifying promising genotypes with high DM resistance, with strong spillover to DM results under field conditions for both *P. sorghi* and *P. heteropogoni,* but not vice-versa. Screening is most favorable for disease development, which creates high and uniform disease pressure without any possibility of escape (Rashid et al 2012).

Banded leaf sheath blight (BLSB) resistance

- Under CSISA, CIMMYT-Asia took initiative on BLSB during the summer-rainy season of 2002, when a line evaluation trial comprising 2,025 lines (both yellow and white) was evaluated at four hot-spot locations across Asia, including Guangxi (China), South Sulawesi (Indonesia), and Pantnagar and Delhi (India). The top-ranking best lines across locations were selected and new breeding populations (biparental and multiparent) developed.
- Progenies of BLSB populations were evaluated, and selected top-ranking genotypes with stable performance across locations and years were identified. On the basis of test-cross performance, out of the 10 lines with high BLSB resistance, six (in bold and *italics* in Table 2 in the Appendix) are identified as BLSB resistance donor lines and are made available to partners (public- and private-sector maize breeding programs of South Asia) as sources of BLSB resistance.
- Eight new BLSB-CSISA populations (BCS01 to BCS08) were developed by combining elite BLSB-resistant lines with good agronomic performance. Out of eight populations, two were closed at the F_2 stage and, from the other six populations, a total of 150 S3 lines were derived (25 lines from each population, with good agronomic traits and good yield), which are being evaluated across hot-spot sites for BLSB disease to identify the most promising lines with combined traits of high BLSB resistance and high yield along with other desirable agronomic traits.

Activity 5.2: Maize germplasm improvement for heat-stress tolerance during flowering and early to mid grain filling

- Commercial hybrids (124 entries) were evaluated under heat stress (>40 °C during flowering stage) across 10 locations, including six locations in India—Delhi, Hyderabad, Ludhiana, Karnal, Pantnagar, and Jalna—three locations in Nepal—Rampur, Parwani, and Nepalganj—and at Sahiwal in Pakistan. The top-ranking heat-tolerant hybrids among existing hybrids were identified (see Appendix Table 3).
- Among the top-ranking hybrids, PAC-740, GK-3060, PAC-339, and HTMH-5401 evaluated at CSISA hubs in India during the spring season of 2011 under different CA practices indicated, in general, that all four hybrids were better than the commercial checks under heat stress. The system of furrow planting with residue was the best system for further enhancing the performance of heat-stress-tolerant hybrids.
- The genetics of inheritance of heat-stress tolerance indicated that both dominant and additive gene action are important for this trait, and therefore population improvement through a reciprocal recurrent selection approach would be the most suitable approach for enhancing heat tolerance in maize.
- Six multiparent heat-stress populations within a heterotic group (HTC-01 to HTC-06) were developed using the most promising lines identified on the basis of per se and test-cross performance for yield. A large set of early-generation lines was derived and evaluated under managed heat stress across several locations in India. A total of 64 most promising heat-tolerant lines (S3) combining heat tolerance, higher grain yield, and resistance to common foliar diseases were developed, which are ready to use in heat-stress breeding programs for South Asia.
- Dissection of various stress-adaptive traits indicated that anthesis-silking interval, C/N ratio in leaves, leaf firing, chlorophyll content, internodal length, ears per plant, and number of kernel rows per cob were significantly associated with heat-stress tolerance in maize. However, the value of these traits to be used in a selection index is yet to be confirmed.
- A screening protocol for field-based screening for heat stress under natural conditions is developed. After one season of re-validation of the stress-adaptive traits, the protocol will be released for South Asian maize programs for use in heat-stress screening/phenotyping.

Lessons learned

1. There is a strong need to work on genetic enhancement for multiple stress tolerance (especially combined tolerance of drought and heat stresses), as maize crops in farmers' fields in South Asia are often subjected to combinations of these stresses, particularly during the main season (rainfed/kharif), which is vulnerable to unpredictable and often inadequate rainfall as well as high temperatures (often exceeding 35 °C during the flowering stage).
2. To enhance the heritability in heat-stress screening, we need to establish a semi-controlled screening platform (free-air temperature enhancement, FATE) facility.
3. The poultry sector is the major driving force for the boom in maize demand in South Asia. However, little attention has been paid so far to developing yellow maize germplasm that can effectively address the most important requirements of the rapidly growing poultry sector—that is, maize with high-methionine and high-oil traits.

Objective 6: Improved policies and institutions for inclusive agricultural growth

The success of technological innovations developed and promoted by CSISA and its partners depends acutely on the policy environment that influences their adoption. Putting the right policies and incentives in place raises the probability that the gains of innovation—resource conservation, productivity enhancement, or poverty reduction—will be realized by a larger portion of South Asia's rural population. In a region where the state plays a very active role in managing agricultural production through pricing, subsidies, and regulations, what exactly are the "right" policies?

At the macro level, research has shown that cereal supply and demand projections for South Asia do not predict acute shortages in cereal availability that will threaten national or regional food security. Although this is comforting, it does not imply that the region can absolve itself of further investment in fostering technical progress in further improving cereal yields and output. Rapid economic growth and fast-paced urbanization trends across the region have meant that there is competing demand for the use of land and water for nonagricultural purposes. Competing demand for land and water is also found within the agricultural sector due to the relatively fast growth of high-value market segments (fruits, vegetables, dairy, and meat) compared with cereals.

In this context, it is critical for Bangladesh, India, Nepal, and Pakistan to pursue technical progress in cereals to increase yields and reduce area so that food security is maintained and resources are released for alternative economic activities that improve overall land- and water-use efficiency. For this to occur, the policy environment governing both input and output markets must be reoriented dramatically.

At the micro level, such policy changes include dramatic improvement in the incentives for private investment in agriculture. New technological opportunities in cultivar improvement have generated well-documented gains for certain crops, traits, geographies, and markets in the region. However, the rules and regulations governing commercialization of public research, seed markets, and biotechnology have not provided sufficient incentives to accelerate private investment. Opportunities for the private sector in the areas of high-yielding varieties and hybrids, better quality seed, the introduction of new abiotic stress-tolerance traits, and other innovations will depend acutely on policies in Bangladesh, India, Nepal, and Pakistan that encourage private investment.

The same is true in the market for resource-conserving machinery and information services that are essential to the widespread adoption of conservation agriculture practices in the region. Here, private investment incentives combined with public support mechanisms may play a critical role in creating markets for new products and services in areas where farmers are still unfamiliar with these practices. A study of laser land leveling illustrates the potential of public-private solutions in eastern Uttar Pradesh, and provides lessons for a wider range of similar technologies and partnerships.

Sustainability

Partnerships continue to remain critical and emphasis will be placed on (i) national and regional service providers supporting CSISA's work at scale and helping larger private firms to develop strategies to serve resource-poor smallholders and other underrepresented market segments in South Asia and (ii) promoting sustainable commercialization of CSISA-sponsored technologies to 2014 and beyond. Local partners include, for example, DSCL's Haryali Kisaan Bazaar; seed and technology firms such as Mahyco, Arcadia Biosciences, Shriram Bioseeds, and Ceres in India; BRAC and ACI in Bangladesh; and Four Brothers and Ali Akbar Group in Pakistan.

Additional partners will include the national research and state extension systems that can support—and stand to benefit from—partnering with these firms. These partnerships will translate into long-term sustainability for (and local ownership of) the project's key interventions.

Furthermore, results from all current and planned CSISA studies will continue to be shared with CSISA management and its partners in the public and private sector to enable them to continue collaborating on pricing and delivery strategies that are pro-poor and inclusive, but also profitable.

Scalability

CSISA will continue scaling up of studies on policy solutions for (i) accelerating investment in science, technology, and innovation; (ii) fostering a vibrant and competitive seed and biotechnology industry; (iii) improving the efficiency with which public subsidies for agricultural inputs and technologies are used; and (iv) creating a favorable policy environment for rural enterprise development and farmer-based enterprises.

CSISA has pursued a partner-driven approach for research and delivery of technologies so that scaling out is both faster and more sustainable. Specific issues that would be better addressed in Phase II are the identification and evaluation of potential strategic partners; the development of negotiating positions for CSISA; analyzing the viability of local service providers to deliver CSISA technologies; and continued development and refinement of alternative approaches. Others include a

more rigorous evaluation of the performance and effectiveness of alternative CSISA business models already in operation by present and potential CSISA partners.

Challenges

- Ensuring coherence of CSISA as a regional initiative while recognizing differences among the four countries of operation: India, Pakistan, Bangladesh, and Nepal.
- Creating a governance structure that creates more ownership by the national programs and buy-in from all sectors at the appropriate scale, but also has clear reporting lines for all involved.
- Ensuring integration of policy (O6) with research on future systems (O2), breeding (O3–5), and the adaptive research and partner-driven delivery activities in the hubs.
- Data management, including an efficient spatial monitoring and information delivery platform, as well as efficient project monitoring and evaluation.
- Constraints associated with studies of the gender dimensions of labor-saving technology adoption and assessment on gender gaps in assets in resource control at the household level.

Lessons learned

- Many of our research findings on the policy side are targeting state-level policies and policymakers. State-level policy communications will be a challenge without strong hub- and management-level support.
- Research can achieve impact for the malnourished and poor only when it is relevant and accessible to those who can use it. High-visibility communication activities are needed to ensure two-way dialogue with stakeholder groups. Scaling out will be more efficient and sustainable with communication activities and debates among partners in the public, private, and civil society sectors at the regional, national, and hub level.
- Strategic and innovative interactions around policy dialogue with both traditional and nontraditional partners, multistakeholder advocacy platforms, mass and specialized media, and project-level initiatives operating in South Asia's policy space will be critical to success.

Objective 6:2 Micro-level constraints to rapid productivity growth and adoption of resource-conserving technologies in the rice-wheat system: gender dimensions

Key findings

Findings reveal that the proportion of female labor contribution (unpaid and paid labor) in crop production varies by country, degree of mechanization, cropping system, farm size, socioeconomic status, and availability of male members. Female labor inputs in relation to male labor range from 40% to 60% in eastern UP, Tamil Nadu, and Bihar, India. In Gazipur (Bangladesh), female labor participation in rice production is less than 10% due to social norms. Women's economic activities such as postharvest, processing, livestock care, and poultry production are confined within their homesteads because of social norms. Women are also mainly engaged in vegetable production and raising fish in small ponds. Despite their participation in agriculture, they face constraints to technology adoption such as a lack of access to and control of key assets such as farm land, machinery, large animals and resources, technical knowledge, and agricultural extension services. Thus, women have less participation than men in making farm-related decisions that are necessary to improve farm production and income. The adoption of labor-saving machines such as the combine (harvester-thresher) has differential effects on different socioeconomic categories of women. Women from households with land benefit by reducing their drudgery and time in harvesting and threshing. However, this machine has reduced the demand for women from marginal farming and landless households; thus, there is a need to introduce other livelihood opportunities for them. In Bangladesh, the shift in production systems (subsistence rice to commercial rice-fish systems) has increased household income but has changed women's roles in ensuring food security.

Challenges

- In India, gender concerns were addressed in Objectives 6.2 and 8. Thus, more team efforts and financial support should be allocated to implement the gender-focused milestones and activities in CSISA Phase II (addressing gender concerns in technology development and dissemination (Objective 1 of Phase II). This will require strong support and a change in attitude among research managers and hub managers, and strong partnerships with NARES and NGOs that are already working with rural women in India, Bangladesh, and Nepal.
- A Gender Strategy Plan for CSISA Phase II was developed to ensure that gender concerns are adequately tackled in initial problem diagnosis, constraints and opportunities assessment, technology design, participatory experiments, dissemination, monitoring and evaluation, and impact assessment.
- Socioeconomic research will be conducted on emerging gender issues (labor, migration, technology adoption decision making, government policies, etc.) for gender-responsive policies, technology design, development, and dissemination.
- CSISA will continue to address and improve gender diversity in staffing (researchers, interns, and administrative personnel) to overcome gender problems in the workplace and research with guidance from social scientists with expertise on gender research. The greatest challenge is the implementation of project activities that target women farmers.

Lessons learned

Social scientists' involvement, including gender specialists, are necessary at the early stages in the project implementation under Objective 1, particularly in project diagnosis, identification of technology needs, preferences, participatory experiments, monitoring and evaluation, etc. Gender-disaggregated information from baseline socioeconomic surveys should be properly collected by trained enumerators, preferably female members of the team, particularly in countries where women have social restrictions. There is a need to have frequent dialogues among the team members to coordinate plans and work, to strengthen partnerships, as well as to build trust and harmony in their work. More deliberate efforts need to be made to involve male and female farmer participation in project activities (strategic research, gender mainstreaming, which includes participatory field experiments, demonstrations, and field visits, as well as training and workshops). Monitoring the participation of male and female farmers (at least 50% in postharvest, processing, seed management, livestock care) in all the CSISA project activities should be implemented to ensure that women are involved in technology design, development, and dissemination.

Objective 7: Creating a new generation of scientists and professional agronomists for cereal systems research and management

7.1 Creating a new generation of agricultural scientists for South Asia through training and capacity building

In conjunction with Objective 1, 63,419 people have been trained (16% women) and 151 (18% women) have interned with CSISA. The training database of CSISA can be viewed at https://sites.google.com/site/csisaportal/Home/training-capacity-building. Milestones/outputs of Objective 7, activity 7.1 have been achieved and several significantly exceeded the original plan. The proportion of women is slightly lower than what was foreseen in the original project document. The reasons are several, but principally it is very significantly lower numbers of females studying agricultural disciplines and the proportion of women in NARES centers (e.g., in Nepal, there is not a single woman in wheat and maize research departments).

Output 1: (PhD scholarships) was well accomplished. The project was able to support 17 PhD students and 17 MSc students from India, Nepal, and Bangladesh, of which 10 (29.4%) were women. The research work of all 34 scholars was aligned with CSISA research objectives. PhD scholars in

particular had an opportunity to participate in international scientific events and training courses. Most MSc students already graduated, while PhD students are finishing in 2012. Because of logistical constraints, unfortunately, no students from Pakistan were supported.

Output 2: (interns) was well accomplished. A total of 151 students or recent graduates from local colleges and universities have improved skills through CSISA field research internships. Of these, 18% (27 interns) were women. Despite the slow start in 2009 that was caused mainly by the limited mentoring skills of most hub staff, CSISA's internship program became well incorporated into hub activities in 2011 and 2012 in all four countries.

Output 3: (advanced short training courses for early career scientists). A total of 127 wheat and maize scientists participated in various regional and international training courses lasting from 1 to 13 weeks. Of these, 18 (11%) were women. In addition, a total of 221 rice scientists participated in various regional and international training activities on advanced rice breeding and management research lasting from 1 day to 1 month. Of these, 30 participants (13.6%) were women.
Short-term training courses focusing on young scientists seems to be the most direct and quick way of disseminating new research findings and trends and their promotion/incorporation into NARES research strategies. It is also a very important promotion of regional and international research networks and collaboration.

Activity 7.2: Creating a professional workforce for extension by establishing a Certified Crop Advisor (CCA) program in South Asia

The milestones/outputs of Objective 7, activity 7.2 have been achieved.

The CCA program is now well established in India under the leadership of the Indian Society of Agribusiness Professionals (ISAP, http://isapindia.org/project-cca.aspx) and CSISA's role has been successfully reduced to a minimum. So far, India has 230 Certified Crop Advisors, mostly from the private sector. One of the challenges remaining is to have full participation of the public sector, which ISAP is pursuing with the leaders of various public-sector institutions.

Objective. 8: Project management, communication, and impact assessment

Activity 8.1: Project coordination and scientific leadership
Regular project recruitment has taken place; however, turnover has been almost 15% due to staff members joining government/PhD programs/internationally recruited staff positions. All recruitment went through an induction process for project and intercenter alignment, which also covered visits to CSISA hubs/platforms. Likewise, standard operating procedures for HR, finance, administration, brand management, and communication were implemented, thereby streamlining and standardizing processes in a transparent and efficient manner.

Objective-wise monthly activity updates are shared by the 10th of every month and discussed in depth in the CSISA-MT monthly teleconferences (the third Thursday of every month), minutes, and action plans, which are subsequently uploaded onto the CSISA portal (https://sites.google.com/a/irri.org/csisa/mom). CSISA-ET conference calls, held every quarter, in which core issues were discussed with donors and partnering CG center representatives, and these matters are subsequently shared and discussed with the CSISA-MT for action. Constitution of the CSISA Advisory Board is near completion and will be taken up as a priority in Phase II.

Activity 8.2: Project meetings
Numerous workshops under all objectives were held on a regular basis, at which progress and annual work plans were discussed and strategies evolved. These were held with stakeholders across regions and centers to ensure better accountability and implementation. Likewise, numerous CSISA awareness meetings/interactions conducted with officials of IFAD, ICAR, SAUs, industry associations

(CII, FICCI), NGOs (GDS, FORWARD, CARE, Digital Green, etc.), multilateral agencies (World Bank, UNDP), etc., were frequently held.

Activity 8.3: Reports and public awareness

- Annual and semi-annual progress reports have been consistently submitted on time.
- The CSISA public Web site, accessible at http://csisaportal.org, with a repository of all CSISA-related news and information, is being updated regularly.
- The CSISA intranet (https://sites.google.com/a/irri.org/) with limited access is also available as a repository of management documents.
- The CSISA Bulletin (e-newsletter) is circulated fortnightly to a group of selective stakeholders (with a mail listserv of over 500 users). The bulletin features topical news, events, and updates on CSISA activities. Fortnightly e-newsletters (40 issues) have been published and circulated so far. Also, CSISA mailers with regular updates on agricultural news, policies, changes, and CSISA activities have been circulated to CSISA stakeholders. CSISA brochures, posters, flyers, calendars, etc. have also been regularly published and circulated.
- CSISA brand management guidelines were published detailing the positioning of the CSISA brand at various internal and external fora and were disseminated to hubs and stakeholders.
- The Hub Communication Platform (HCP) Web page on the CSISA portal features aWhere applications such as aWhere Weather and an adoption survey tool. These features are now accessible directly through the CSISA portal, enabling users to access the information they require.
- CSISA social networking efforts are as follows and are available to users.
- CSISA presentations can be viewed at www.slideshare.net/csisaproject. Sixty slideshares of presentations and documents have been uploaded for viewing by all stakeholders.
    - The CSISA portal has a dedicated YouTube channel to give users access to CSISA videos, media clips, etc. As of now, 12 videos, including a complete film on Laser Land Leveling and an interview featuring "Krishi Darshan" are available (www.youtube.com/user/ProjectCSISA).
    - The CSISA Facebook page (http://engb.facebook.com/pages/CsisaProject/141606969236846) is regularly updated with news alerts and important features related to agriculture in a CSISA context. CKB materials and other important announcements are regularly featured on the CSISA page.
    - A CSISA image gallery (https://picasaweb.google.com/irri.csisa) on Picasa Web Albums (80 Gb) is regularly updated. CSISA hub managers have been provided with uploading rights for the creation and sharing of albums.
- Print and electronic media were widely used for creating awareness and large-scale adoption of improved technologies. More than 300 publications covered CSISA-related activities in both regional and national newspapers (https://sites.google.com/site/csisaportal/Home/announcements).

Activity 8.4: Project monitoring and impact assessment

Activity monitoring: Data collection to track field dissemination activities and initial adoption was implemented. Extensive instances of technology use have been surveyed to date using the tool. A beta version of the survey for Android phones has now been coded by project staff, and is linked into an automated database and real-time mapping engine that also feeds results into phone map display tools for use in project management. This is still awaiting feedback from Objective 1 staff as a bottleneck to implementation. Key decisions on the future of this activity need to be undertaken by the new evaluation team in Phase II.

Technology case studies: Case studies have begun at the farm level and on environmental effects of CSISA-promoted technologies, which will be used in conjunction with the adoption data to assess early impacts. The first of these cases is on water productivity effects of dry direct seeding in rice, with data collection begun in kharif 2011 in Punjab and eastern Uttar Pradesh through a repeat visit survey of input-output data for 300 fields, with detailed data collection on irrigation practices. The survey has been conducted, data encoded and entered, and preliminary data cleaning has taken

place. Data collection is planned to continue through the second phase, with a 50% increase in sample size, as a CSISA-associated activity.

Ex ante impact assessment: Work started on an intensive and groundbreaking multidisciplinary effort to assess the impact potential of alternative technologies for rice production systems from 2012 to 2035 in terms of economic, poverty, and health goals for producers, consumers, and hired labor. The focus includes major current CSISA emphases on rice, the foci of other related BMGF grants, such as STRASA and Green Super Rice, as well as other alternative options for sustainable productivity improvement. The effort will be completed in Phase II.
Sustainability: Several of the activities enumerated above will continue outside of CSISA as IRRI activities. The remaining activities have been implemented with the involvement of partners who will be leading this work in the future so they can make decisions about future directions based on an understanding of activities to date.

Challenges: First, there were few operational resources for the survey work that is needed to implement evaluation and impact assessment studies, as resources and personnel were located under a separate Objective (6.2). Second, attempts to try to engage personnel from other centers involved in the separate Objective with resources were hampered by organizational constraints and high staff turnover (e.g., some of the main Objective 6.2 economists from one of the IARCs departed prematurely during the first phase). This meant that data resources, such as the baseline survey, were left (and remain) partial with unresolved issues. Third, trying to initiate processes of systematic reporting and activity monitoring required a cultural change on the part of the project, which took considerable time to pursue. Fourth, slow progress in terms of adoption and diffusion of promoted technologies meant that few cases are "ripe" for ex post impact assessment.

Lessons learned: Evaluation and impact assessment are facilitated by the presence of a clear impact logic for the value and, with explicitly articulated associated assumptions and milestones, which evaluation should help to follow up on. Additional interest in and attention to this issue by CSISA leadership would facilitate evaluation planning. In the first phase, the placement of the evaluation leader separate from operational resources, and in only one center, impeded effective coordination of data collection and analytical efforts. This suggests that an effective arrangement needs to involve all centers, with the leader provided means to incentivize coordination toward project needs across all involved.

CSISA Phase II proposal
CSISA Phase II proposal: The CSISA senior team members met in Nepal in April 2012 and discussed the donor and reviewer feedback on the earlier proposal submitted in February 2012. It was decided that CIMMYT lead the CSISA Phase II and, accordingly, the revised proposal was submitted to donors in July 2012 for their approval. The key learnings from all the Objectives in CSISA I, have been incorporated in the CSISA II proposal.

Project challenges
CSISA was conceptualized as an Integrated science and livelihoods project. However, it was initially staffed with teams with a strong research background only versus a delivery and extension and integrated background. Key people in Objective 1 struggled with this distinction before extended exposures and cross-section discussions helped bring about a change in approach.

Partner ownerships. Essential to impact and scale is the support and ownership of partnerships—local, national, and regional. There were negligible budgets for joint programs and partner support, thereby leading to lower accountability and sense of ownership.

Role of innovation. CSISA was designed as an innovative model with an "*integrated*" approach that aligned multiple disciplines and skill sets to provide creative solutions to chronic problems that affected farm productivity and farmer livelihoods, much in contrast to the traditional "silo"-based approach. This involved developing new models and pilots and attempting to create value across the

whole chain. However, concepts such as business models, ICT tools, marketing, risk management/postharvest, and data management are still taking time to get integrated across the objectives. Diverse skill sets are essential for a project with such a mandate and this took some time to become established.

Postharvest and market linkages. Critical components such as postharvest losses compromise farm productivity gains. Likewise, a poor marketing infrastructure precludes a farmer from getting a fair economic return on his produce. This is an endemic system challenge in key geographies in South Asia. The activities covered in the project document were neither sufficiently funded nor adequately skilled in the project activities.

Cross-CGIAR center alignment. A complex project such as CSISA called for smooth intercenter coordination across HR policies, administration, accounting, project alignment, etc. This initially took time in synergizing, leading to delays and poor optimization of time and resources.

Lessons learned

Scale: A project of this magnitude, mandate, and scale needs to have the complete buy-in of the implementing centers and key partners with a clear and transparent governance and accountability structure as well as key deliverables. Being the first of its kind project, this took a while to get established. The preproject proposal, conceptualization, and writing should have deep engagement of all the stakeholders and key NARES partners. Though this appears to be time-consuming, it eventually leads to streamlined operations and better accountability. This was followed in the CSISA Phase II proposal.

Stakeholder buy-in and Impact pathways. Likewise, there should be deeper engagement with key national partners and a cross section of implementing stakeholders to ensure better ground truthing and a clear definition of the impact pathways. This would lead to better partner accountability and eventually the sustainability of the technologies and practices being delivered to the farming community. This is being followed for the new hub in Odisha.

Partnership development and networking skill sets. Partnerships are critical and eventually partners have to take up the onus of delivery and implementation compared to CSISA on its own. Sustainable partnerships need to be developed on a clearly articulated value proposition. This would involve enhancing the skill sets of key hub staff and developing a framework for network mapping and a gap/demand analysis. At times, capacity building of partners is critical to the process.

Hub-level objective integration and synergy with partners. The hub is the core of all CSISA activities, and the design is to have a diversified multiskilled stakeholder team to develop work plans and milestones. Skill sets at the hub level are critical for integrating the various objectives of CSISA and networking with partners. The TWG was essentially envisaged to be the think tank and implementing body for designing hub activities and partnerships for delivery. However, its role was reduced to that of a discussion/advisory group with limited accountability. More decision making with budgets is designed for the reconstituted TWG in CSISA Phase II.

Sustainability

Farmer acceptance and demand generation. Eventually, farmer acceptance is the key to the success of the project. In-field demonstrations and conducting farmer field days/farmer fairs/champion farmers have demonstrated the advantages of the adoption of CSISA technologies. This is expected to hasten farmer acceptance and generate additional demand. Capacity building of key stakeholders is essential to develop the customizable and scalable solutions.

Revenue generation models. Economic and revenue generation models will encourage swifter dissemination and acceptance of CSISA technologies. For example, in the area of agricultural mechanization (laser land leveler, zero-till machines, Turbo Happy Seeder, mechanical transplanters,

etc.), the service provider model has proven to be effective as, because of the labor shortages, there is a greater acceptance of these services. This is a win-win model that will create robust small and medium agri-entrepreneurs, thus enhancing the village economy and creating demand-driven services for the farming community. On the marketing side, farmers should be able to derive a better economic return that will motivate them to sustain these technologies.

Given the risk associated with trying out new technologies in different agro-climatic conditions, it was necessary to provide incentives to and hold hands with key farmers to demonstrate such technologies and practices in their fields. This was through initial cost sharing/subsidized efforts (machines/seeds/fertilizer inputs) with CSISA partners and champion farmers. CSISA has been able to convince farmers to try out new technologies, as farmers have now absorbed and invested in such CSISA-promoted technologies. Likewise, proven CSISA technologies are being integrated in MoA work plans to popularize these among the farming community through frontline extension officers.

Scalability

Key engagement with critical partners to scale: Scalability can be achieved only once it is integrated with the larger government and partner programs. Without such an integration, scale will always be a challenge. As such, CSISA technologies will need to be integrated with work plans of key partners in NARES and the private/NGO sector. The initial tie-ups with the KVKs (ICAR) are leading to a wider reach for the farming community. Likewise, this has been demonstrated with the linkages with the DoA, in dissemination through their district-level functionaries.

Policy-level recommendations. As part of larger government initiatives on agriculture, the numerous evidence-based field studies conducted by CSISA (on agri-technologies, gender, postharvest, etc.) will be able to inform and advise for policy recommendations at the country and state levels. This would ensure that the CSISA advisories/recommendations are mainstreamed into the larger government framework for agricultural development. Examples of this could be feedback that can be integrated to GoI programs such as NFSM, NRLM, BGREI schemes, etc., and similar ones in Bangladesh, Pakistan, and Nepal.

These learnings across the various CSISA objectives and project management have been incorporated into the preparation of the CSISA Phase II proposal.