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CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA PHASE II

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CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA (CSISA) PHASE II

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International Maize and Wheat Improvement Center (CIMMYT)

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The Cereal Systems Initiative for South Asia (CSISA) is a research-for-development partnership implemented jointly by CGIAR members—the International Maize and Wheat Improvement Center (CIMMYT), the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI), the International Rice Research Institute (IRRI), and World Fish, in close partnership with public and private sector organizations across South Asia. CSISA is funded by the United States Agency for International Development (USAID) and the Bill and Melinda Gates Foundation. CSISA is an integral part of several CGIAR Research Programs (CRPs), connecting and integrating their work in South Asia. These CRPs include: CRP 2: Policies and markets; CRP 3.1: WHEAT; CRP 3.2: MAIZE; CRP 3.3: GRiSP; and CRP 3.7: Livestock and fish. CSISA also has interactions in South Asia with CRPs 1.1: Dryland systems; 1.3: Coastal and aquatic systems; 4: Nutrition and health; 5: Water and land; and 7: Climate change.

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Acronyms and Abbreviations

Acronym	Full Name of Acronym
ACI	Advanced Chemical Industries
AFP	Axial flow pump
AFT	Axial flow thresher
AWD	Alternate wetting and drying
BADC	Bangladesh Agricultural Development Corporation
BARI	Bangladesh Agricultural Research Institute
BAU	Bihar Agricultural University
BHU	Banaras Hindu University
BISA	Borlaug Institute for South Asia
BMP	Best management practices
CCAFS	Climate Change Agriculture and Food Security
CGIAR, CG	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CRS	Catholic Relief Services
CSISA	Cereal Systems Initiative for South Asia
CSISA-BD	CSISA-Bangladesh
CSISA-MI	CSISA Mechanization and Irrigation project
CSISA-NP	CSISA-Nepal
CT	Conventional tillage
DAE	Department of Agriculture Extension
DOA	Department of Agriculture
DQA	Data quality assessment
DSR	Direct-seeded rice
EC	Executive committee
EUP	Eastern Uttar Pradesh
FB	Followed by
FFD	Farmer field day
FTF	Feed the Future
GIS	Geographic information services
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
iDE	International Development Enterprises
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IRRI	International Rice Research Institute
JCF	Jagaroni Chakra Foundation
KVK	Krishi Vigyan Kendra
LCAT	Landscape-scale crop assessment
LDR	Long-duration rice
LDW	Long-duration wheat
LLL	Laser land leveling
LSP	Local service provider
M&E	Monitoring & evaluation
MDR	Medium-duration rice
MT	Management team
MTNPR	Machine-transplanted non-puddled rice
MTPR	Machine-transplanted puddled rice
NARES	National agriculture research and extension systems

NGO	Non-governmental organization
NILs	Near isogenic lines
NM	Nutrient Manager
NMR	Nutrient Manager for Rice
NOPT	Nutrient omission plot technique
NPTR	Non-puddled transplanted rice
ODK	Open Data Kit
OMFED	Orissa State Co-operative Milk Producers' Federation
OUAT	Orissa University of Agriculture and Technology
PAU	Punjab Agricultural University
PTR	Puddled transplanted rice
PVS	Participatory varietal selection
RCM	Rice Crop Manager
RFL	Rangpur Foundry Limited
RP	Research platform
RRF	Rural Reconstruction Foundation
RWCM	Rice–Wheat Crop Manager
RWCS	Rice–wheat cropping system
QTL	Quantity trait locus
SAU	State agriculture university
SDR	Short-duration rice
SDW	Short-duration wheat
SFD	Seed-fertilizer drills
SHG	Self-help group
SI	Sustainable intensification
SP	Service provider
SRI	System of Rice Intensification
SRSPDS	Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh
TNAU	Tamil Nadu Agricultural University
USAID	United States Agency for International Development
ZT	Zero tillage

In recent years, gains in cereal productivity in South Asia have slowed markedly and, simultaneously, issues of resource degradation, declining labor availability, and climate variability pose steep challenges for achieving sustainably intensified cereal-based systems that meet the dual goals of improving food security and rural livelihoods. To address these challenges, the Cereal Systems Initiative for South Asia (CSISA) was established in 2009 to pursue an interlinked set of research and innovation system interventions to catalyze durable change at scale in South Asia's cereal systems through accelerated adoption of sustainable intensification technologies (SI)[1].

Operating in rural innovation hubs in **Bangladesh, India, and Nepal**, CSISA involves partnerships with the public, civil society and private sectors for the development and inclusive deployment of improved cropping systems, resource-conserving management technologies, new cereal varieties and hybrids, livestock feeding strategies and feed value chains, aquaculture systems, progressive policies and strengthened markets. The project is composed of six linked objectives: (1) Catalyzing widespread dissemination of production and post-harvest technologies to increase cereal productivity, resource use efficiency and income; (2) Process-based research into crop and resource management practices for future cereal-based systems; (3) High-yielding, heat- and water-stress-tolerant rice varieties for current and future cereal and mixed crop-livestock systems; (4) High-yielding, heat- and water-stress-tolerant, and disease-resistant wheat varieties for current and future cereal and mixed crop-livestock systems; (5) Improved policies and institutions for inclusive agricultural growth; and (6) project management, data management, M&E and communications.

In the past year, CSISA has made strong progress towards achieving the goals set out in its **results framework** (Appendix C) and towards the over-arching 10-year vision of success for the initiative. During the reporting period, CSISA in Bihar continued the process of creating new service providers (SPs), which increased from 1,018 to 1,290 for zero tillage (ZT), from 22 to 33 for machine transplanting of non-puddled rice (MTNPR), from 14 to 18 for laser land leveling (LLL) and from 8 to 16 for axial flow threshers (AFTs). In Eastern Uttar Pradesh, additional SPs added during the reporting period included 119 for zero tillage, 8 for machine transplanting of non-puddled rice, 5 for laser land leveling and 40 for axial flow threshers. CSISA continued to focus on gaining area under direct seeded rice (DSR) while continuing to develop MTNPR, depending on farmers' needs and in participation with the Department of Agriculture. As a complementary effort, CSISA is working to generate awareness about community nurseries, which can support rice transplanting immediately after the onset of rains, both by mechanical and manual means.

During the reporting period, CSISA saw strong momentum behind the adoption of rice hybrids and herbicides. These two interventions were also critical differentiating factors in improving the performance of MTNPR. Despite bad weather, the use of hybrids alone improved rice productivity from 5.6 t/ha to 5.8 t/ha, and weed management along with hybrids further improved it to 5.9 t/ha. In Bihar, seed sales of hybrid rice in 2014 increased from 5,500 tones to 6,000 tones, which at a seed rate of 15 kg/ha translate into a gain of over 33,000 additional hectares. Since hybrids are shorter duration than the most commonly grown rice varieties, hybrid adoption will also increase the yield potential of winter cropping in many instances by facilitating timely planting of longer duration wheat varieties.

In DSR, productivity growth depends on adequate weed management. Since DSR is dominated by the emergence of complex weed flora, the use of safe and effective herbicide combinations

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[1] Pretty and Bahrucha (2014) define sustainable intensification '….as a process or system where agricultural yields are increased without adverse environmental impact and without the conversion of additional non-agricultural land. The concept does not articulate or privilege any particular vision or method of agricultural production. Rather, it emphasizes ends rather than means…. The combination of the terms 'sustainable' and 'intensification' is an attempt to indicate that desirable out- comes around both more food and improved environmental goods and services could be achieved by a variety of means.'

(bispyribac + pyrazosulfuron) as a post-emergence treatment documented in farmer's fields as the best way forward with an average paddy yield of 5.4 t/ha as compared to 4.9 t/ha with bispyribac applied alone. With the same weed control treatments, the corresponding paddy yield for MTNPR was 6.1 and 5.3 t/ha, respectively, demonstrating the superior yield potential associated with mechanical transplanting. Before CSISA began to evaluate and disseminate information on the superior performance of new classes of herbicides for rice, their use in Bihar and EUP was essentially non-existent. According to information gathered from our partner, Bayer Crop Science, Bihar farmers applied 2,935 liters of bispyribac in 2014 compared to 2,542 liters in 2013, covering more than 9,500 hectares in our core districts in Bihar alone. In Eastern UP, rough estimates made through dealers and distributor-level surveys indicate that the area covered by bispyribac was approximately 58,000 ha in 2014.

In Odisha, paddy yields from **machine transplanted non-puddled rice (MTNPR)** were similar to puddled rice (ca. 6 t/ha), and clearly demonstrate that the financial and resource costs (soil and water) associated with puddling can be avoided without reducing rice yields in mechanically transplanted systems. New service providers recognized the business potential of transplanting services with an increase in SP numbers from 71 in 2013–14 to 101 in 2014–15 that were supported by training from CSISA. Farmers' response so far shows that the direction of technology adoption has begun to change in favor of more precise methods of crop establishment that incur less cost, particularly in coastal areas where labor markets have tightened.

In the plateau region of Mayurbhanj, grain yields of **maize** with **better bet agronomy** (use of hybrids, optimum plant population, proper weed management and nutrient management) were 4.5 and 5.2 t/ha respectively, against an average yield of only 3.0 t/ha under existing farmers' practice. These results were achieved under rainfed conditions during the Kharif season in 2014 on the nutrient-depleted and lateritic soils that dominate Odisha's plateau region. These areas are often dismissed by policymakers as too risk-prone and resource-degraded to support high crop yields. CSISA's work has convinced and encouraged farmers, DOA, and other partners in terms of high yield and economic returns achievable from rainfed maize in these areas. CSISA is also evaluating logic entry points for intensification with a high level of farmer acceptance. Based on 30 on-farm demonstrations, maize grain yield increased by 1.4 t/ha with the simple step of implementing precise stand establishment achieved through line sowing using a multi-crop ZT planter. CSISA continues to work on the design and commercialization of planters for the two-wheel tractor mechanization platforms that are the dominant source of rural traction in the more marginal environments where we work.

CSISA continues to strengthen **strategic partnerships** with the state Department of Agriculture, the Krishi Vigyan Kendras (KVKs), state agriculture universities (SAUs), and NGOs for scaling locally appropriate SI technologies and better-bet agronomic practices. CSISA has also formed partnerships with the private sector to support dealer training and input market development—dealers are the most common source of information and advice for most farmers in India. As part of this strategy, CSISA has fostered closer linkages between the state extension system and the private sector so that extension also supports agents of change (e.g., dealers and service providers), which will help ensure that government investments reach a larger number of farmers through intermediaries.

In **Bangladesh**, by the end of this reporting period, excluding the Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh (SRSPDS) project and the CIMMYT-managed CSISA Mechanization and Irrigation (CSISA-MI) project, CSISA-BD had trained 130,446 farmers and conducted 47,472 trials and demonstrations. If farmers attending farmer field days and exchange visits are included then the project has benefited 216,561 farmers. CSISA-BD trained 3,915 farmers (40% women) in aquaculture technology. In addition, the SRSPDS project was thought to have benefited a further 1,312,935 farmers through seed distribution (999,517 farmers), trainings and farmer field days, and the CSISA-MI project has to date facilitated machinery services for 15,755 farmers. This data shows that the project has far exceeded its original targets. In addition CSISA-BD has developed sets of technologies that have changed the face of agriculture in southwest Bangladesh through variety change, new crops and cropping systems and the introduction of mechanized agriculture. The project has also developed a unique set of cropping pattern recommendations for vegetable production on pond, fresh water gher and saline water gher banks that will help extension staff to advise farmers on the best way to use this underutilized resource.

In July 2013, CSISA launched a new initiative in southern Bangladesh (CSISA Mechanization and Irrigation, or CSISA-M.I.) that focuses on efficient development of surface water resources and precision agriculture with scale-appropriate machinery. This initiative is predicated on compelling private investment in the commercialization of both machinery and associated services. During the reporting period agricultural machinery and irrigation services promoted by CSISA-MI were applied on 2,995 ha. Out of this number, 1,237 hectares were irrigated by service providers using fuel-efficient axial flow pumps. Crucially, RFL and individual service providers invested $450,000 of their own funds to spread AFP services to farmers.

Since October 2014, in CSISA-MI's project domain, 1,096 hectares were cultivated by using seed-fertilizer drills and bed planters, in a suite of crops including rice, maize, wheat, jute, vegetable crops (onion and garlic), lentils, and others. To make this happen, CSISA-MI's private sector partners invested $30,400 of their own funds to expand use of the equipment. An additional 662 hectares of wheat and rice were harvested using multi-crop reapers through local service provision and the action of our private sector partners ACI and Metal who demonstrated and advertised to farmers and potential service provider clients. Sales of reapers to service providers are currently ongoing.

In **Nepal**, CSISA has spent considerable time and effort over the last two years in the Mid and Far West regions demonstrating reapers for two-wheel tractors (2WT) and training service providers (SPs) on how to use them. Until recently, we had little traction in generating demand for reapers or for reaper services. In September 2014, sales of reapers for 2WT began to increase, indicating some convergence of supply and demand, and likely reflecting farmers' frustration with manually harvesting rice and wheat in areas, particularly where labor is scarce. CSISA took advantage of the increase in interest and began a new activity called 'Jump-starting Agro-Machinery Markets' (JAMM), in which we placed 20 new reapers in local markets in the Mid and Far West regions. This initial influx of machines generated interest among farmers and spurred dealers to import and stock more, which **resulted in private sector sales of over 100 2WT reaper/harvesters in this last wheat harvest season (March-April 2015)**.

CSISA-Nepal has also demonstrated that laser land leveling of a field not only improves water distribution but also can significantly increase plot sizes by reducing the bund area because areas previously covered by bunds can be used for crop production. Thus, the costs incurred in making bunds each season, as well as doing traditional land leveling, are saved. An average increase of 8–10% in rice and wheat yields have been recorded after using LLL in CSISA sites in the central Terai and in experiments in India. These studies also suggest that using LLL can save irrigation water by 15–20%.

Crosscutting activities included on-farm evaluations of Rice Crop Manager in 11 districts in Odisha, 123 nutrient omission plot technique (NOPT) trials, 82 modified NOPT trials and 179 RCM trials. The results from NOPT trials have been compiled and analyzed. Maize Crop Manager has been drafted and evaluated in the maize-growing areas of Odisha. In EUP and Bihar, CSISA signed sub-agreements with Bihar Agriculture University (BAU) and Banaras Hindu University (BHU) for the development and evaluation of Crop Manager and CSISA conducted RCM evaluation trials in six districts of EUP and five districts of Bihar. BAU conducted RWCM evaluation and NOPT trials in three districts of Bihar and BHU conducted RWCM evaluation trials and NOPT trials in three districts of EUP. The data generated from these NOPT trials has been used to fine-tune the recommendations of the Rice Wheat Crop Manager (RWCM). Pilot field-testing of RWCM has been conducted in four districts of

EUP and three districts of Bihar. Maize Crop Manager is being drafted and developed for the maize growing areas of EUP and Bihar. In Tamil Nadu, CSISA is working in Thanjavour District for field-testing Nutrient Manager for Rice (NMR) and collaborating with TNAU-TRRI KVKs for testing in non-CSISA districts. Harvest days were organized in collaboration with TRRI and TNAU to show the farmers the yield benefits obtained from NMR.

ILRI has implemented training sessions on **livestock management** to improve farmer knowledge about improved animal husbandry, animal health management, and animal nutrition. Specifically, at least 40 training sessions have been implemented in CSISA hubs in India (Bihar and Odisha), Bangladesh and Nepal on crop residue-based feeding practices and supplementation with homemade concentrate feed and mineral mixtures, with at least 1,900 farmers participating, of which about one-fourth are women participants. Extension materials such as four videos (one on homemade concentrated feed preparation, one on benefits of feeding urea treated maize stover, and one each on benefit of feeding chopped paddy straw and maize stover) and leaflets and a poster have been prepared for disseminating information about these practices to a wider audience.

In **Objective 2,** the results of five years of research at Karnal Research Platform consistently demonstrate that Kharif maize can be a profitable alternative to rice in the rainy season in northwest India to address issues of rising scarcity of water, labor, and energy in the region. In the 5^{th} year, ZT maize provided higher yield (7.7 t/ha rice equivalent) than rice (7.12 t/ha), with 85% less irrigation water. Results from the Patna Research Platform indicate that mustard is a viable diversification option in the Rabi season in eastern India, which also allows 300% cropping intensity as spring-season maize can be taken after the mustard harvest. In Odisha, Kharif 2014 results revealed that optimum plant population (around 70,000/ha), optimum fertilization (140:50:75 kg N, P_2O_5, K_2O/ha), and improved weed management contributed 1040, 900, and 165 kg/ha increase in maize yield over farmer's practice (45,000/ha plant population and 80:40:40 kg N, P_2O_5, K_2O/ha). When all these interventions were layered (best bet agronomy), grain yield increased from 2.90 t/ha (farmers' practice) to 5.28 t/ha.

Objective 3 has made steady progress towards developing elite rice lines with increased yield potential, improved grain quality and superior feeding value, rice for mechanized direct seeding and water-saving irrigation practices, and high-yielding heat-tolerant rice. Five varieties suited for cultivation under DSR conditions have been released in India. New breeding lines with varied plant types and maturity groups with different grain types like medium and short slender, long slender and long bold and medium bold suitable for diverse market segments of northern, southern and eastern parts of India were developed. Many entries recorded < 7.5-8.6 tons grain yield per hectare.

Objective 4 has undertaken similar activities—breeding trials and screening nurseries—in pursuit of high-yielding heat- and water-stress tolerant, and disease-resistant wheat varieties for current and future cereal and mixed crop-livestock systems. During the reporting period, ten new wheat varieties were released, seven identified for release, and more than 1,900 promoted to national/state/regional trials for their further evaluation and subsequent release. In addition 2,010 new crosses were attempted and >18,500 breeding populations were exposed to selection under a range of environments and management conditions, including terminal heat stress and conservation agriculture.

Objective 5 continued to address the policy environment needed to remove constraints to the adoption of new technologies and enhance the benefits of improved agricultural growth. The team convened a high-level international policy conference in collaboration with the Institute of Economic Growth. Then, the team convened a private-sector roundtable in December 2014 that brought together stakeholders to highlight progress made in CSISA partnerships, deepen commitments to future collaboration, and chalk out new areas for technical and strategic cooperation.

Under **Objective 6**, a variety of regional, country-level, and state-level governance and management mechanisms continue to be implemented, including Management Team meetings for India and Bangladesh. CSISA has strengthened its M&E team and associated systems, and has implemented inference techniques for evaluating outcomes. CSISA is also working to integrate the data that it collects through Open Data Kit into the CSISA web site, to improve the utility and transparency of project data.

Objectives 1 and 2

– India

- In Bihar, the number of service providers increased from 1,018 to 1,290 for zero tillage, 22 to 33 for machine transplanting of non-puddled rice, 14 to 18 for laser land leveling and 8 to 16 for axial flow threshers.
- CSISA saw strong momentum behind the adoption of rice hybrids in Bihar. Despite significant drought, the use of hybrids improved rice productivity by 0.2 t/ha; less than in a more favorable year, but also a clear indication that hybrids ‘work’ even under stress conditions.
- As an adaption strategy to avoid flood damage for Kharif maize planting in Bihar, all hybrids achieved better yields when established on beds compared to zero tillage (ZT) and conventional tillage (CT).
- In EUP, estimates made through dealers and distributors indicate that the area covered by bispyribac was approximately 58,000 ha. Bispyribac provides safe and effective control for weeds in rice, especially when used in tank mixtures.
- In Odisha, the performance of mechanically transplanted puddled rice were similar to manual transplanting, demonstrating that the costly, water consuming and soil health deteriorating effects of puddling can be avoided without reducing yields.
- CSISA has partnered with the DOA in Odisha to introduce DSR with line sowing using seed drills. In comparison to traditional broadcast method, DSR with line sowing consistently and substantially improved the productivity of rice.
- In the plateau region of Mayurbhanj, grain yields of maize under line sowing and better bet agronomy were 4.5 and 5.2 t/ha respectively, against an average yield of only 3.0 t/ha under existing farmers’ practice. These results were achieved under rainfed conditions on nutrient-depleted and lateritic soils. These areas are often dismissed as too risk-prone and resource-degraded to support high crop yields.
- ILRI has conducted at least 40 training sessions in CSISA hubs in India (Bihar and Odisha), Bangladesh and Nepal on crop residue-based feeding practices and supplementation with homemade concentrate feed and mineral mixtures, with at least 1,900 farmers participating, of which about one-fourth are women participants.

– Bangladesh

- CSISA-BD has trained 130,446 farmers and conducted 47,472 trials and demonstrations. If farmers attending farmer field days and exchange visits are included then the project has benefited 216,561 farmers
- In CSISA-MI, since October 2014, 1,096 hectares were cultivated by using Seed-Fertilizer Drills and bed planters in a suite of crops including rice, maize, wheat, jute, vegetable crops (onion and garlic), and lentils, among others. CSISA-MI’s private sector partners invested $30,400 of their own funds to expand use of the equipment.

– Nepal

- CSISA-Nepal has shown that laser land leveling not only can improve water distribution but also increases plot sizes while reducing labor requirements by eliminating much of the area covered by bunds. Diagnostic work suggests that 10% increases in rice and wheat production are possible by expanding the area of cultivation with laser leveling.

- Driven by participatory on-farm testing and evaluation, market intelligence provided to the private sector, and strengthened distribution channels, the introduction of reapers in the labor-starved Mid and Far-West development regions resulted in the commercial sales of more than 100 units for two-wheel tractors in areas where there had been none.

Objective 2

- The results of five years of research at Karnal Research Platform consistently demonstrate that Kharif maize appears to be a suitable and profitable alternative to rice in the rainy season in northwest India to address issues of rising scarcity of water, labor, and energy in the region. In the 5^{th} year, ZT maize provided higher yield (7.7 t/ha rice equivalent) than rice (7.12 t/ha), with 85% less irrigation water.

Objective 3

- Five varieties suited for cultivation under DSR conditions have been released in India. New breeding lines with varied plant types and maturity groups with different grain types like medium and short slender, long slender and long bold and medium bold suitable for diverse market segments of northern, southern and eastern parts of India were developed. Many entries recorded < 7.5-8.6 tons grain yield per hectare.

Objective 4

- Ten new wheat varieties were released, seven identified for release, and more than 1,900 were promoted to national/state/regional trials for their further evaluation and subsequent release. In addition 2,010 new crosses were attempted and >18,500 breeding populations were exposed to selection under a range of environments and management conditions including terminal heat stress and conservation agriculture.

Objective 5

- The Objective 5 team convened a high-level international policy conference in collaboration with the Institute of Economic Growth. Then, the team convened a private-sector roundtable in December 2014 that brought together stakeholders to highlight progress made in CSISA partnerships, deepen commitments to future collaboration, and chalk out new areas for technical and strategic cooperation.

Objective 6

- CSISA is now working to integrate the data collected through Open Data Kit on mobile devices into the CSISA web site (www.csisa.org).

Objective 1: Catalyzing widespread adoption of production and postharvest technologies to increase cereal production, resource efficiency, and incomes

Objective 1 focuses on achieving short- and long-term impact on sustained cereal production growth by accelerating the adoption of innovative sustainable intensification technologies, forming private- and public-sector partnerships, identifying sustainable business models and information systems, and undertaking additional activities such as social marketing campaigns that foster impact at scale. Outputs of Objective 1 include participatory testing and technology refinement; translating research into actionable products and insights; mobilizing partnerships for catalyzing impact at scale; and strategic capacity development to support key agents of change.

The **Bihar and Eastern Uttar Pradesh (EUP) Hubs** focus on scalable and sustainable technologies that can have a huge impact on system productivity (such as early sowing of wheat), on change agents who can scale up technologies and carry them forward past the life of the project (such as service providers), and on cropping system optimization interventions that can increase overall productivity and profitability (such as following long-duration wheat by short-duration rice).

India

Bihar Innovation Hub

CSISA hub in Bihar continued the process of supporting the emergence of new service providers (SPs) while expanding the businesses of existing providers. The number of SPs, which is our key performance indicator, increased from 1,018 to 1,290 for zero tillage (ZT) technology, from 22 to 33 for machine transplanting of non-puddled rice (MTNPR), from 14 to 18 for laser land leveling (LLL) and from 8 to 16 for axial flow threshers (AFTs). CSISA is also working to expand the number of SPs for direct seeded rice (DSR) by targeting existing seed drill owners who operate in lowland areas where weed pressure is comparatively low.

Rice Establishment Methods: DSR and MNTPR

In 2014, a rainfall deficit, especially in the month of June, adversely affected area expansion of **DSR**. DSR has performed better in areas with relatively good early rains and in lowland ecologies as compared to upland ecologies. The effect of this deficit was more pronounced in the upland ecologies of Patna, Vaishali, Samastipur, and Muzaffarpur, with average paddy yields with DSR of 3.9 to 4.9 t/ha compared to lowland ecologies of Arra and Buxor where paddy yields in DSR were 5.8 and 6.5 t/ha, respectively. A recently launched CSISA program for machine transplanting of rice under non-puddled conditions (MTNPR), supported by the Department of Agriculture (DOA), is taking hold within the custom-hiring services sector, with about 33 SPs taking up this activity. Based on 67 demonstrations, CSISA saw a difference in average productivity between **MNTPR** and DSR with a yield advantage of 0.6 t/ha in MTNPR (5.3 t/ha) over DSR (4.7 t/ha). As a complementary effort, CSISA is working to generate awareness about community nurseries, which can support rice transplanting immediately after the onset of rains, both by mechanical and manual means.

Rice Hybrids

Two technological choices – the promotion of short and medium duration hybrids and efficient weed management – helped alleviate problems associated with late transplanting and the emergence of complex weed flora. During the reporting period, CSISA saw strong momentum behind the adoption of rice hybrids and herbicides. These two interventions were also critical differentiating factors in improving the performance of MTNPR. Despite bad weather, the use of hybrids alone improved rice productivity from 5.6 t/ha to 5.8 t/ha, and weed management along with hybrids further improved it to 5.9t/ha. Based on data from 26 plots, the average grain yields of the two best hybrids (Arize 6444 and PHB 71) were 5.6 t/ha under MTNPR and 4.7 t/ha under DSR. With these developments, we have laid the foundation for sustainable intensification in the form of short-duration rice (SDR) followed by long-duration wheat (LDW).

The seed sale of hybrid rice in 2014 increased from 5,500 tones to 6,000 tones, which at a seed rate of 15 kg/ha translates to a total of 400,000 hectares under hybrids in Bihar, a development reflecting the strength of CSISA's partnerships with the private sector. This development creates significant opportunities for intensification of existing cropping systems by switching from long duration rice (LDR) followed by short duration wheat (SDW) to short /medium duration rice (SDR/MDR) followed by long duration wheat (LDW).

Two studies conducted by CSISA under controlled-conditions show that paddy yields (Arize- 6444) from both MTNPR and the system of rice intensification (SRI) were the same (7.0 t/ha) on average in 2013 and 2014. However, the average net profits in 2014 were $1,059 for MTNPR, $849 for SRI and $780 for DSR. The average net profits from another hybrid (PRH10) were on the order of $602, $585 and $623, respectively. This was primarily because of significantly higher labor cost in SRI ($275) than DSR ($104) or MTR ($131). The relatively higher availability of seed drills may make DSR an attractive option in areas with labor scarcity but few mechanical transplanters.

Weed Management in Rice

Based on results from 24 demonstrations, it is clear that success of DSR depends on careful weed management. Since DSR is dominated by complex weed flora, the use of bispyribac and pyrazosulfuron together as a post-emergence treatment was seen as the best way forward with an average paddy yield of 5.4 t/ha as compared to 4.9 t/ha with bispyribac applied alone. According to information gathered from our partner, Bayer Crop Science, Bihar farmers used 2,935 liters of bispyribac in 2014 compared to 2,542 liters in 2013. Out of this, we estimated that in CSISA's 10 core districts, bispyribac was used on approximately 9,500 ha.

Nutrient Management

Data on Rice Crop Manager (RCM) showed that paddy yields of 6.4 t/ha were achievable with precision nutrient management in contrast to yield of 6 t/ha with state recommendations. The realization of high yields depended more on nitrogen and potash than on phosphorus.

Kharif Crop Diversification

Due to drought-like conditions that have occurred in the last 5 of 6 years, CSISA team along with partners focused on increasing the area under soybean and maize for the Kharif season as diversification options substituting for rice. In the current year, the area under soybean increased by 2,500 ha and the area under ZT soybean increased to 219 ha. All maize hybrids showed good performance when planted on beds compared to zero tillage and conventional tillage. Based on 57 demonstrations across hybrids and districts, the grain yield averaged 4.6 t/ha under bed planting and 4.3 t/ha under ZT. Double Dekalb and NK 6240 were the best performing hybrids.

Capacity Building

Bihar hub has put in a lot of efforts in sharing information with the extension persons of DOA and hands-on training of SPs and women farmers. Up to March 2015, out of a total of 5,740 individuals trained by CSISA or its partners, 3,421 were producers, 2,096 were extension agents of DOA and 223 people were from the private sector and NGOs. The gap between women and men's access to knowledge is large and to bridge this gap, CSISA offered direct training to almost the same number of women (2,711) as men (3,029) farmers. We also attempted to bring in women farmers as service providers with one SHG participating in the custom-hiring services of machine transplanting.

Machine transplanting was promoted through the “one-to-many” approach where both raising of mat-type community nurseries and then transplanting by machine were done by this group.

Women Farmers and Community Nursery Enterprises

Women farmers in Bihar, perhaps unfamiliar with new technologies like machine transplanting of rice, would normally be unable to adopt new forms of mechanized agriculture. In discussions with women’s groups, CSISA proposed that these women take up custom hire services related to mechanical transplanting, including mat nursery production. Women responded positively to the suggestion, and CSISA is ensuring that they understand their opportunities and value as entrepreneurs, particularly since the male members of their households often work as migrant laborers away from the home, and only visit their homes for one or two months a year.

Women farmers feel that machine transplanting and community nurseries provide them opportunities to take up custom hire services both for nursery raising and rice transplanting by machine or hand. This is an important step for CSISA to bring women farmers as partners in the development and promotion new technologies like machine transplanting of non-puddled rice. In collaboration with MSS, the government-supported women’s federation in Bihar, CSISA has supported a women’s group to obtain a machine transplanter, which has now transplanted 20 acres of rice, of which 15 acres were on a custom hire basis. Two women farmers from this group were awarded for the service they rendered in promoting machine transplanting, zero tillage, early wheat sowing, and weed management. One of them received this award at the time farm fair organized by the Indian Agriculture Research Institute Pusa on April 2, 2015, and the other received this award during the maize field day organized by the Society for Maize Production and Marketing at Matlupur on April 18, 2015.

Eastern Uttar Pradesh (EUP) Innovation Hub

The creation of service providers as scaling agents for sustainable intensification technologies continued, with an additional focus on early harvest of rice fields through the use of axial flow threshers. Additional SPs added during the reporting period included: 119 for zero tillage, 8 for machine transplanting of non-puddled rice, 5 for laser land leveling and 40 for axial flow threshers. CSISA continued to focus on gaining area under DSR while continuing to develop MTNPR, depending on farmers’ needs and in participation with the Department of Agriculture. The growth in area under DSR in EUP has been reasonable in the context of the overall adverse impact of less-than-normal rains in the month of June.

Rice Establishment Methods: DSR and MNTPR

DSR and MTNPR were further expanded through the creation of more SPs. Based on 74 MTNPR plots and 128 DSR plots, average paddy yields were 5.7 t/ha and 5.5 t/ha, respectively. Data collected by

CSISA interns showed that MTNPR surpassed DSR and puddled transplanted rice (PTR). Data also showed that paddy yields are greater when seedlings are 15 days old and also when the transplanting is done during July 1–15. The hub also determined the usefulness of the "Crop Manager" tool and the consolidated results have been included above in the Bihar report.

Rice Hybrids

CSISA sees rice hybrids as complimentary to DSR and MTNPR. Hybrids proved successful and the gains in the paddy yield were greater in hybrids than in varieties. The paddy yield of Arize 6444, a leading hybrid, were 6.1 and 5.3 t/ha for MTNPR and DSR, respectively. Paddy yields across three varieties (Swarna sub1, MTU 7029 and BPT 5204) were 5.6 tonnes/ha under MTNPR and 5.3 tonnes under DSR. Among varieties, the paddy yield of Swarna sub1 was 5.3 t/ha under MTNPR and 4.9 t/ha under DSR.

The paddy yield of Arize 6444 when machine transplanted from 1st to 15th June, 16th to 30th June, 1st to 15th July, 16th to 31st July and 1st August to 15th August were 6.4, 6.0, 5.7, 5.6 and 5.5 t/ha, respectively. To facilitate rice transplanting up to 15th July, we will continue to focus on community nurseries to make manual and machine transplanting operations more responsive to weather conditions and avoid scenarios of crop establishment with old seedlings .

Weed Management in Rice

Herbicide recommendations were passed on to the farmers through logbooks supplied to our SPs and through other partners including grassroots workers of DOA, KVKs and dealers. Estimates made through dealers and distributors indicate that the area covered by bispyribac was approximately 58,000 ha. Since weeds are the major constraints in the adoption of DSR, CSISA concentrated its efforts in devising herbicide-based mixtures supplemented with one manual weeding. With flexibility to offer better solutions for complex weed flora that are dominant in most DSR sites, the tank mixture of bispyribac and pyrazosulfuron was assessed with corresponding yield levels of 6.2 t/ha and 5.9 t/ha following the treatment of bispyribac plus pyrazosulfuron and 5.7 t/ha and 5.3 t/ha following the treatment of bispyribac alone were observed in MTNPR and DSR, respectively. This combination opens up opportunities for finding solutions to the complex weed flora both under MTNPR and DSR.

To avoid early competition from weeds and to promote soil moisture conservation, on-farm agronomic trials assessed the value of creating 'dust mulches' by irrigating and then ploughing prior to crop establishment. This innovative practice decreased weed populations compared to a situation where irrigation was given after seeding rice in a well-prepared field. The weed population in the scenario where soil mulch was created was 84 weeds/m^2 compared to 232 weeds/$m^2$where post sowing irrigation was given. The corresponding paddy yields in the two contrasting situations were 7.7 t/ha and 6.3 t/ha, respectively. The DSR with conventional tillage with pre-sowing irrigation was seen to ameliorate the problem of early weed competition as it needed 29 less labor hours/ha for manual weeding and also reduced the need for post-sowing irrigation for 2 to 3 weeks. This is because soil mulch did not allow the loss of moisture from the root zone or the emergence of weeds due to dry surface soil.

Capacity Building

Up to March 2015, CSISA trained 1,608 producers, 650 extension persons and 327 persons from the private sector and NGOs in sustainable intensification technologies and agronomic practices. A total of 1,165 women farmers and 1,420 men farmers were trained.

In Person: From service provider to business entrepreneur

Mr. Ram Awadh Chaudhary has expanded his service provision business to 5–6 different technologies, reaping himself and his village great rewards.

Mr. Ram Awadh Chaudhary, a 50-year old farmer from Pokharbinda Village, Maharajganj District in Eastern UP is one the most hardworking and innovative farmers in his village. Through his association with CSISA, he has implemented the practices of early wheat sowing and zero tillage. He started as a service provider for combine harvesting with one 30 HP tractor but has now expanded his services into zero tillage, rotavating, laser land leveling, straw reaping and rice shelling. Each custom service technology has contributed to his success this year and has netted him profits of $1,008, $1,517, $1,743, $4,606 and $4,633, respectively. Besides increasing his income from custom services, he has consistently increased his wheat yields by adopting early sowing and zero tillage. His average wheat yield in 2008–09 was around 4.0 t/ha but it increased over time: 4.75 t/ha in 2009–10, 5.5 t/ha in 2010–11, and 6.5 t/ha in 2011–12. He temporarily diversified into mentha (*Mentha arvensis*) in 2013–14, a mint commonly cultivated in his area, but he shifted back to wheat in 2013 with yields of 6.5 t/ha and 6.0 t/ha in 2013–14 and 2014–15, respectively.

He recently purchased a new tractor and now owns one 30HP and one 60HP. After coming into association with CSISA, Mr. Chaudhary now specializes in both the business and the technological aspects. He provides custom services for rotavators on the farms of other growers, but adopts zero tillage at his own farm because he knows that zero tillage is for higher yield and rotavator is for earning money through custom services. He has purchased a straw reaper and rice sheller for better returns. After adjusting for all expenses, he has earned a net income of $13,505.

Mr. Chaudhary was the first person in his area to achieve wheat yields over 6 t/ha in 2010–11 and exceeded that mark with 7.3 t/ha the following year – productivity levels that rival the best farmers in the Punjab. In the field he is CSISA's partner, technician, and community opinion shaper who focuses on his custom services and his own farming at the same time. He says "I feel overwhelmed after serving my own community as a service provider. I feel proud of myself when other farmers come asking for my assistance." These transitions have fundamentally changed the way farmers will start taking up the concept of sustainable intensification by adopting mechanization through custom services.

Odisha Innovation Hub

The **Odisha Hub** works in the districts of Puri, Bhadrak , Balasore, and Mayurbhanj, and on machine transplanting in puddled rice, direct seeded rice, better-bet agronomy for rainfed maize, zero tillage for green gram and mustard, post-harvest technologies, and collaboration with women's groups to disseminate technology that specifically meets the needs of women farmers.

CSISA's Odisha hub promotes conservation agriculture primarily through small-farm mechanization in the four districts of Puri, Bhadrak, Mayurbhanj and Balasore (included recently), focusing mostly on the mechanical transplanting of rice. Rice nursery management, avoiding puddling while transplanting, and DSR remained the core interventions for the rice crop. CSISA also engages in promoting better-bet agronomy for rainfed maize, zero tillage for green gram, black gram and mustard, post-harvest technologies, alternate wetting & drying, and the Rice Crop Manager. The participation of women farmers has been ensured in all of the above interventions.

The Odisha hub pursues its activities through convergence with the policies of the Department of Agriculture and other partners including Orissa University of Agriculture and Technology (OUAT) and some NGOs. The awareness of sustainable intensification technologies among most farmers was essentially non-existent when CSISA began work in Odisha. From a low base, the adoption of CSISA promoted technologies in 2014–15 has been steady, reaching 5,896 farmers on an area of nearly 3,437 ha. Our partnership with the DOA and support to newly created service providers through hands-on trainings has accelerated the adoption of technologies.

Machine Transplanted Rice

In the Odisha hub domain, the performance of mechanically transplanted puddled rice (MTPR) was very good and the average grain yield (n=40) varied from 4.9 to 6.5 t/ha. The paddy yields from **machine transplanted non-puddled rice** were similar to puddled rice). These results clearly demonstrate that the costly, water consuming and soil health deteriorating impacts of puddling can be avoided without reducing rice yields in mechanically transplanted systems. In general, our attempts to discourage puddling were successful as the paddy yields from MTNPR or MTPR were same. Consistently, better paddy yields from MTPR or MTNPR than puddled transplanted rice (PTR) by manual labor has heightened the expectations that machine transplanting will cover a large area in the future. Service providers of machine transplanting did recognize the business potential embedded in these technologies (both community nursery as well as the transplanting service) that led to an increase in their numbers from 71 in 2013–14 to 101 in 2014–15. Farmers' response so far shows that the direction of technology adoption has begun to change in favor of more precise methods of crop establishment that incurs less cost and yield more.

CSISA started activities in Balasore during Rabi 2014–15 with a convergence meeting with key stakeholders in the district in November 2014. First, potential areas for rice cultivation during Rabi were identified, and then service providers were identified. To date, 30 SPs for MT have been identified. CSISA provided these SPs hands-on training on improved mat nursery preparation and operations of MTNPR or MTPR. The performance indicators for the current Rabi season suggest that the adoption of MTNPR or MTPR will be accelerated in the upcoming Kharif season. The cost and returns of rice establishment methods have been studied and the data will be used to quantify and communicate the advantages of machine transplanting.

Direct Seeded Rice

Odisha has a significant area under broadcast-sown DSR that spreads across CSISA's three districts. With this method of broadcasting, farmers generally use high seed rates and subsequently go for a *"beushening system"* of rice cultivation (i.e., post establishment tillage) to thin initially high plant populations and also to control weeds. CSISA has partnered with the DOA to introduce **DSR with line**

sowing using seed drills. Inspired farmers have started purchasing the machines. In comparison to traditional broadcast method, DSR with line sowing consistently and substantially improved the productivity of rice from 6.5 to 6.8 t/ha in Bhadrak and from 4 to 4.5 t/ha in the Mayurbhanj plateau. In areas with double-cropped rice systems, CSISA has encountered some problems related to weed management such as 'volunteer' rice (when seeds from the previous crop germinate), which may limit expansion of DSR in the Rabi season. For this reason, CSISA made a strategic decision to focus on non-puddled transplanted rice in the Rabi season while DSR can be a potential target for the Kharif season.

Laser Land Leveling

Despite proven benefits in terms of saving of resources and amplifying impacts of various technologies, laser land leveling is at introductory stage in Odisha. CSISA has been conducting on-farm demonstrations of LLL to create awareness among farmers to generate confidence among partners to catalyze expansion. Farmers have started showing interest in purchasing new machines and the change is expected to be gradual.

Maize in the Mayurbhanj Plateau

In the plateau region of Mayurbhanj, grain yields of **maize under line sowing** and **better bet agronomy** (use of hybrids, optimum plant population, proper weed management and nutrient management) were 4.5 and 5.2 t/ha respectively, against an average yield of only 3.0 t/ha under existing farmers' practice. These results were achieved under rainfed conditions during the Kharif season in 2014 on the nutrient-depleted and lateritic soils that dominate Odisha's plateau region. These areas are often dismissed as too risk-prone and resource-degraded to support high crop yields. CSISA's work has convinced and encouraged farmers, DOA, and other partners in terms of high yield and economic returns achievable from rainfed maize in these areas. Based on 30 demonstrations, the maize grain yield increased from 2.5 t/ha from farmers' practice to 3.9 t/ha from precise stand establishment achieved with line sowing using a multi-crop ZT planter.

In Mayurbhanj, upland areas unsuited for rice cultivation constitute nearly 43% of cultivable area (437,000 ha). Farmers usually grow maize during the rainy season in these uplands. CSISA identified a gap in the **maize value chain** in Mayurbhanj that can be bridged through establishing forward linkages. Non-accessibility of a maize grain market leads to distress sales of green cobs by farmers in local markets. Non-availability of any nearby large market is also a contributing factor to distress sales. To counter these problems associated with distress sales, CSISA started maize-based post-harvest interventions including efficient maize shelling and linking farmers to markets.

An exposure visit was organized with a team of 20 members from Mayurbhanj to Nabarangpur to know the structure of the already well-established maize markets for poultry feed mills and the motivating factors for grain marketing systems. Key learning achieved during the exposure visit that can be applied in Mayurbhanj are:

- A high capacity maize sheller should be introduced at the local level for bulk shelling and farmers should be trained about its proper use.
- Local aggregators should be created from an existing pool of SPs for the aggregation of products at the village level and their linkages to the market should be established.
- CSISA and the DOA should collaborate with major hybrid maize seed companies in Mayurbhanj to increase the availability of quality seed of hybrid maize.

In association with partners, CSISA will launch a maize value chain management plan to catalyze demand for maize area expansion in the fallow lands of Mayurbhanj.

Crop Diversification

CSISA also focuses on **crop diversification** in Odisha, identifying important niches for crops like wheat and chickpea in partially irrigated areas of the plateau, and green gram, black gram and mustard for rain-fed environments. CSISA introduced the medium-duration wheat variety *BAAZ*, and early feedback from farmers suggests that significant yield gains are possible as *BAAZ* is well suited for these ecologies of limited irrigation water availability. In this season, farmers grow long duration obsolete wheat varieties like Sonalika with the broadcasting method, which results in poor yield (1.5 to 2.0 t/ha). CSISA is screening some heat-tolerant medium/short duration varieties such as *BAAZ* and HD2733 to replace Sonalika. BAAZ is the promising variety with the highest yield (4.5 tonnes/ha) and it has been found that replacement of varieties may lead to increases in yield by about 20%. Hence, there is a huge scope to reduce the yield gap in wheat as well as establish a self-sustaining model of informal seed production to address the problem of late sowing (which usually happens due to the delay caused by the government's seed supply chain).

Many areas of the coastal plain (>50% in some pockets) are un-irrigated and currently are either fallowed or cultivated with 'low input–low output' pulse systems during the winter Rabi season. To speed rice harvest and reduce turn-around time between crops, CSISA has coupled axial flow thresher technology for rice with zero tillage crop establishment methods for green gram (*mungbean*), black gram, mustard, and chickpea. These plans seemed to satisfy farmers and officers of DOA. The main factor behind this activity is the efficient use of residual soil moisture for sowing.

Rice Crop Manager

Rice Crop Manager (RCM) for Odisha has been developed and is being demonstrated and evaluated through on-farm trials by CSISA, involving DOA and in collaboration with OUAT and CRRI. Till date, 123 NOPT trials, 82 modified NOPT trials and 179 RCM trials have been conducted through CSISA and partners (OUAT and National Rice Research Institute-NRRI previously known as Central Rice Research Institute-CRRI) in Puri, Bhadrak, Mayurbhanj, Dhenkanal, Koraput, Sundergarh, Sambalpur, Kendrapara, Keonjhar, Jajpur and Balasore. Initial results have shown comparative advantages (e.g. saving of inputs, increase in yields, and reduction in time for providing fertilizer recommendation) of using "Crop Manager" as a tool of providing site specific nutrient and crop management advisory to the farmers with one or a combination of factors. Rice Crop Manager is available in *Odia* and English.

Alternate Wetting and Drying

To address the issue of the application of excess irrigation water in rice during the Rabi season, CSISA has started dissemination of alternate wetting and drying (AWD) technology for water management in rice in collaboration with NGOs (LWSIT and WISDOM) in Puri.

The selected NGO staff were trained on AWD technology by CSISA and then they had organized awareness meetings on AWD involving farmers' community members in the presence of one technical person from CSISA. In Rabi 2014–15, these two NGOs have installed 265 '*pani* pipes' in 227 farmers' fields, covering 180 acres area across three blocks in Puri.

In Focus: Mechanical transplanting expands in Odisha

Contract Farming is another option in Mechanical transplanted rice

Service provider Tushar Ranjan Biswal from Nudani village in Keonjhar district near Bhadrak has been in contact with CSISA since Rabi 2013–14. After 2–3 meetings Mr. Biswal agreed to implement mechanical transplanting on three acres. He achieved good results and purchased a transplanting machine in Kharif 2014. He has also taken 80 acres on lease and implemented mechanical transplanting. In Rabi 2014–15 he started a seed production business by taking 40 acres on lease at Anara village of Hatadi. This land belongs to 40 farmers. In this village, farmers were not cultivating their land in Rabi season due stray cattle. Mr. Biswal started transplanting rice in Rabi season (2014–15) and convinced two other farmers to do the same. He raised 52 acres of rice through mechanical transplanting (40 leased by himself + 12 others) for seed production this year. He also started seed production of green gram on 50 acres (36 acres under ZT and 14 acres as line sowing) as contract farming with technical support and guidance from CSISA.

In Rabi 2014–15, CSISA significantly expanded its work on mechanical transplanting of puddled and non-puddled rice (MTPR and MTNPR) in Odisha. From a very low base of 40 farmers adopting MTPR on 40 ha in 2013, CSISA now supports uptake of mechanical transplanting for 2,058 farmers covering 2,161 ha. CSISA assists existing SPs to make the best use of their machines and created 30 new SPs in 2014–15. CSISA provided hands-on training for entrepreneurship development around mat-type nurseries and MTR to 74 existing SPs and 187 others with interest in business development services, and technical training on machine transplanted rice to 994 farmers across the hub's three districts. We have been successful in convincing farmers to adopt MTPR or MTNPR because they address the major problems of labor scarcity, high cost of labor and drudgery. CSISA provided hands-on training to SPs for 2–3 weeks prior to the Rabi season so they can become "Master Trainers" for new SPs.

In order to support SPs in Odisha, CSISA is increasing the awareness about mechanical transplanting, linking SPs with machinery dealers and allowing dealers to use CSISA platforms to demonstrate the technology to farmers, facilitating successful SPs to share their experiences with other SPs and helping SPs evaluate the profitability and 'business case' for the technology. SPs are linked with machine dealers not only to increase the catchment area of dealers but to help them negotiate prices.

The success of MTNPR in Puri district has demonstrated an additional pathway forward to save costs and increase cropping system productivity. Transplanting of rice in the Rabi season is hard as puddling requires lot of water and in many cases the land preparation is not possible due to insufficient water. After harvesting of Kharif rice in December–January, farmers under MTNPR tilled their fields only once and then irrigation was applied, maintaining up to 2–3 cm of water. The field was then transplanted by a mechanical rice transplanter using a mat nursery. Weeds were managed through the application of pre- and/or early post-emergence herbicides. This helped in saving the cost of puddling, around $60/ha. In Rabi 2014–15 in Puri, 100 farmers adopted MTNPR covering 115 acres with technical support from CSISA. Achieving critical mass will serve as a multiplier effect in the coming years.

In Person: From fallow to green through cropping intensification

If appropriate actions are taken, a vast area of fallow land can be covered under green gram during the Rabi season. Besides improving the soil health and fertility, it would help to improve the food security and income levels of poor tribal households as green gram and mustard oil are important components of the local food basket.

Traditionally broadcasted mungbean

Hiralal in his line sown mungbean field

In Mayurbhanj, nearly 80% of the land remains fallow during the Rabi season after Kharif paddy harvesting due to limited irrigation potential (15%), non-utilization of existing residual moisture, moisture loss due to delayed harvesting of medium- and long-duration rice varieties and open grazing of stray cattle. CSISA endeavors to convert these fallow lands to green by popularizing zero-tillage mustard, ZT- green gram and line-sown green gram using seed drills. These technologies facilitate early sowing, thus utilizing residual moisture for a second crop. Drill sowing also facilitates the application of a basal dose of phosphorus using a seed drill in pulse crops, especially in phosphorous-deficient soils.

Our experience shows that amid the increasing risk of moisture stress during the active growth stage of green gram on one hand and the advantage of efficient use of residual moisture on the other, it would be important to measure correctly whether ZT works better or CT works better. Based on our experience of line sowing in prepared fields with leaky lateritic soil or heavy clay soil during Rabi 2014–15 where 43 acres of fallow land was converted into green by cultivating green gram under ZT and line sowing, it seems that both ZT and CT will help expand the area depending on the time of sowing and predictability of seasonal rains after sowing.

Hiralal Mohanta owns a 2-ha farm in Shamakhunta village of Mayurbhanj. He grew paddy on 2 ha during the rainy season and he opted to bring 0.8 ha under line-sown mungbean during Rabi. He came to know about this option through his exposure visit to a nearby village (Telibila) where CSISA has done an early season demonstration. Linked to SPs for seed drill machines, he succeeded in the timely establishment of *mungbean* utilizing residual moisture of the preceding rice crop. He also brought a half-acre under moong through the traditional broadcasting method. The rest of his farmland remained fallow during Rabi 2014–15.

Mr. Mohanta obtained a very low yield from the broadcast method. Sub-optimal yield of moong (0.2 to 0.25 t/ha) in traditional broadcasting is due to poor crop emergence, uneven plant populations, and improper nutrient and weed management. Refinement of cultivation practices through seed and fertilizer placement at the right depth, maintaining crop geometry and employing timely intercultural practices led to yield gain without any substantial cost. A much better crop stand pleases Hiralal when he compares the same with his traditionally broadcasted plot. He is now expecting a good harvest. He calculated and compared the cost of cultivation on his own and found it at par with the traditional method. Other farmers of the village have witnessed this change and we are foreseeing many more farmers joining in during the next season.

Haryana Innovation Hub

CSISA's **Haryana Hub** was established to disseminate conservation agriculture-based crop management practices in collaboration with public and private sector partners. These partners included state agricultural universities, state department of agriculture, ICAR's research centers, KVK's, NGOs, private sector companies and farmer cooperatives. CSISA ceased operations at the Haryana Hub in late 2014, when the staff shifted to Odisha, to support that priority geography. Assets and activities were transferred to partners, as outlined in the November 2014 Annual Report.

Punjab Innovation Hub

Though the Punjab Hub phased out on September 30, 2014 with an exit strategy outlined in the November 2014 annual report, the ongoing research trials of two PhD students, one each from PAU and CCSHAU, continued with CSISA financial support. The brief summary of research results during the report period are given below.

1. Sustainable intensification of cotton-wheat system through conservation agriculture based management practices (*Rakesh Choudhary, PhD Student from CCSHAU*):
    - Seed cotton yield, wheat grain yield and net returns were significantly higher in cotton planting on 67.5 cm and 102 cm wide permanent beds followed by relay planting of wheat compared to the conventional cotton–wheat system. Cotton–wheat system productivity (2.44 Mg ha^{-1} of seed cotton + 5.34 Mg ha^{-1} of wheat yield) and system net returns (Rs. 129,186 ha^{-1}) were maximum from cotton-relay wheat–mungbean system planted on 102 cm wide PB. Wheat was relay planted in paired rows in the standing cotton using high clearance 4-wheel relay seeder. The net income from the cotton-relay wheat was 28.2% higher compared to conventional sowing.
    - The results of one year of study, indicates that sustainable intensification of cotton-wheat rotation with intercropping of mungbean in cotton on 102 cm wide permanent beds followed by relay planting of wheat helped in achieving higher productivity and profitability of CW system.
2. Enhancing nitrogen use efficiency in maize-wheat system under conservation agriculture *(Opinder Singh, PhD student of Department of Soils, PAU)*
    a. *Enhancing nitrogen use efficiency through fertigation in maize-wheat system under conservation agriculture*
        - Results of the study revealed that using drip irrigation + residue retention 14 and 7.2% higher maize and wheat yields, respectively with approximately 30% less irrigation water as compared to the furrow irrigation with residue removal at 100% recommended N (120 kg N ha^{-1}, RDN) level. . In maize, fertilizer management using 'Nutrient Expert' decision support guided prescription coupled with and drip irrigation (fertigation) produced higher yield as compared to other N treatments. Relayed mungbean yielded 790 kg grains ha^{-1}. The maize–wheat–mungbean system productivity was higher (12.8 Mg ha^{-1}) with drip irrigation (fertigation) as compared to conventional furrow irrigated (11.0 t/ha) system.

    b. *Evaluation of different rates and methods of nitrogen application and straw management for enhancing nitrogen use efficiency in maize-wheat system under conservation agriculture.*
        - Initial results of the trial revealed that application of 75% RDN drilled/placed on top of bed under residue retention produced grain yields comparable with 100% RDN drilled/placed in furrows or uniformly broadcasted with residue removal, thereby saved 25% of the fertilizer N in maize–wheat system.

Tamil Nadu Innovation Hub

During its final year, CSISA's **Tamil Nadu hub** aims to engage in capacity building with key partners, and hand over CSISA-endorsed technologies and covered areas to its strategic partners. The major partners include the Department of Agriculture, Tamil Nadu Agricultural University, MSSRF (an NGO), and Reliance Foundation.

The Tamil Nadu Hub is in exit mode, with four months remaining in Phase II. The hub is handing over the key CSISA-endorsed technologies to their partners – the Department of Agriculture, Tamil Nadu Agricultural University (TNAU), Tamil Nadu Rice Research Institute, MSSRF and Reliance Foundation. Strong partnerships and collaborations are maintained as part of the exit strategy.

The DOA has developed significant confidence in CSISA-supported technologies and has covered a large area using drill seeding in the Cauvery Delta through their existing schemes. The Tiruvarur district DOA covered around 27,050 acres under direct seeded rice. CSISA's DSR Guideline manual has been distributed through DOA channels to promote DSR across a wide area. The DOA mobilizes seed drills from a variety of districts and service providers, and around 90 CSISA farmers have become DSR service providers. The success of this service provider model will be replicated / scaled out to the other parts of the Delta by DOA and other partners.

CSISA and TNAU ran a season-long DSR training for field-level extension staff from the Department of Agriculture at KVK Needamangalam. Forty-one extension staff were trained in all aspects of DSR and are poised to promote DSR technology in their areas. The CSISA-DOA training course ran for 10 days over the rice season, a period of 5.5 months. The MMSRF extension staff are ready to conduct a season-long training at Tiruvaiyarur in the coming Kuruvai season.

The Tamil Nadu hub has trained technical staff from MSSRF on conservation agriculture technologies and provides technical backstopping to these staff. Training materials were developed jointly by CSISA and MSSRF, some of which has been distributed through the MSSRF fortnightly magazine.

The hub extended technical support for Reliance Foundation Information Services. The *RF Bharat India Jodo Programme* actively transfers DSR technology to farmers in the Sivagangai district through the delivery of 11 seed drills, which will expand DSR outside Cauvery delta area. This program covered a significant area under DSR during the last samba season and it will continue to expand.

Evaluation trials comparing machine transplanted non-puddled rice and machine transplanted puddled rice were conducted during the samba and summer seasons. The result of these trials will be shared with partners in order to generate confidence in the technologies. CSISA will also support the dissemination of machine transplanted puddled rice technology as an alternative resource conservation technology along with DSR in Delta area.

Nutrient Manager for Rice evaluation trials were conducted during the Samba and Thaladi seasons. The hub has been continuously providing technical assistance and capacity building support to various stakeholders in the Cauvery Delta, in part through a series of field days.

Before the end of CSISA Phase II, the Tamil Nadu hub aims to handover assets and any remaining training materials to the hub's partners, including the Department of Agriculture, TNAU, service providers, and other community based organizations.

Bangladesh

CSISA-Bangladesh

The **Cereal Systems Initiative for South Asia in Bangladesh** is implemented through a partnership between 3 CGIAR centers: IRRI, CIMMYT and WorldFish. CSISA-BD is funded by USAID's Feed the Future (FtF) initiative, and aims to test and disseminate new cereal system-based technologies that will raise family incomes for 60,000 farming families.

By the end of this reporting period, excluding the Sustainable Rice Seed Production and Delivery Systems for Southern Bangladesh (SRSPDS) project and the CIMMYT-managed CSISA Mechanization and Irrigation (CSISA-MI) project, the project had **trained 130,446 farmers** and conducted **47,472 trials and demonstrations**. If farmers attending farmer field days and exchange visits are included then the project has **benefited 216,561 farmer**s. In addition, the SRSPDS project was thought to have benefited a further 1,312,935 farmers through seed distribution (999,517 farmers), trainings and farmer field days, and the CSISA-MI project has to date facilitated machinery services for 15,755 farmers. This data shows that the project has far exceeded its original targets. In addition CSISA-BD has developed sets of technologies that have changed the face of agriculture in southwest Bangladesh through variety change, new crops and cropping systems and the introduction of mechanized agriculture.

This update on CSISA-BD presents results from the 2014 monsoon season (Aman season) and the 2014/15 dry season (Rabi season). Some of the main conclusions from the trials and demonstrations conducted during this period are:

- Strip till planted wheat and new wheat varieties BARI gom29 and 30 give the best results in a trial conducted in all six hub sites.
- Storing maize in modified traditional grain stores enabled farmers to store maize up to nine months without substantial grain losses. This allowed them to take advantage of rising maize prices following crop harvest and this improved farmers' income compared with selling maize immediately after harvest. For example, storing for three months gave farmers an extra $25/t while storing for nine months gave farmers an extra $100/t.
- 3,915 farmers (40% women) trained in aquaculture technology
- The project has developed a unique set of cropping pattern recommendations for vegetable production on pond, fresh water gher and saline water gher banks that will help extension staff to advise farmers on the best way to use this underutilized resource.
- Short-duration Aman rice varieties do not yield less than longer-duration varieties. Growing these varieties allows farmers to plant wheat, maize, mustard, sunflower and lentil on time by mid November.
- BRRI dhan52 is still the most productive submergence-tolerant variety available.
- BRRI dhan34 is the best aromatic rice variety available.
- BRRI dhan54 provides good yield and early maturity on Aman season saline soils.
- Some locally grown Aman season rice varieties yield almost as well as modern high-yielding varieties.
- Relay intercropping mustard over standing rice as a means of rapidly establishing the crop after the Aman rice in a rice mustard Boro rice system is popular with farmers.
- 84 new local service providers were set up as machinery service providers, $105,074 was spent by the private sector on importing and marketing new machines and 6,682 farmers received services from LSPs. This includes 1,422 farmers buying crop-harvesting services.

In the reporting period the project trained 17,108 farmers (30% women) and 32,308 farmers participated in farmer field days. In addition to the normal Farmer Field Day (FFD) program the project mounted Farmer Field Day for senior staff from key hub-level partner institutions such as NARS, DAE, NGOs and the private sector. These "stakeholder FFDs" were held in each hub with the objective of showing our partners the work the project has done, to hear farmers' opinions and to encourage key stakeholders to include the same technology in their trial and demonstration programs.

The project, with funding from the region-wide CSISA provided seven grants totaling $110,000 to research institutes within the NARS or at the Bangladesh Agricultural University. These grants were used to conduct applied on-farm research on topics of mutual interest to both these institutes and CSISA-BD. The quality of research done by these research institutes was largely high, showing that this approach to funding agricultural research can be very rewarding.

As the project draws to a close, measuring the impact of the project in terms of technology adoption has become an important activity. A set of surveys that measure adoption of CSISA-BD promoted technology by farmers trained or participating in demonstrations or by farmers learning about this technology from CSISA-BD farmers has been designed. Surveys were conducted with 2012 and 2013 farmers in 2013 and 2014. Surveys of 2014 farmers and a survey of farmers interviewed for the project baseline survey will be conducted in May and June 2015.

The project conducted hub-level internal Data Quality Assessment (DQA) programs to ensure that the monitoring data reported by hub-level staff is correct and accurate. The process ensures that a high standard of data collection and reporting is maintained and that the data reported to USAID by project management is accurate.

The project lost 56 working days due to strikes (hartals) and blockades. Most of these losses occurred in February and March when 36 working days out of a possible 41 were lost. This had an impact on machinery sales and LSP training and on project supervision. Most trial and demonstration programs were completed but many Farmer Field days had to be cancelled

CSISA-Mechanization and Irrigation (CSISA-MI)

Operating under CSISA-BD, the CSISA Mechanization and Irrigation (CSISA-MI) project facilitates the dissemination of crop mechanization technology through partnerships with private sector machinery suppliers. This project will continue to 2018.

As part of developing targeted financial services to support the supply chain for agricultural mechanization products, CSISA-MI signed MoUs with Micro Finance Institutes Jagaroni Chakra Foundation (JCF), TMSS and Rural Reconstruction Foundation (RRF) to ensure that local service providers have access to small-scale and low interest loans for the purchase of reaper machines. During the reporting period, CSISA-MI trained 936 (112 women) LSPs, mechanics, private sector actors and farmers.

The **Cereal Systems Initiative for South Asia - Mechanization and Irrigation** project is a CIMMYT-led initiative that operates under the wider CSISA program in Bangladesh. CSISA-MI is operational in southwestern Bangladesh and is funded by the USAID Mission in Bangladesh under President Obama's Feed the Future (FtF) initiative. In CSISA-MI, CIMMYT partners strongly with International Development Enterprises (iDE) and works to transform agriculture in Bangladesh’s FtF zone by unlocking the productivity of the region's farmers during the dry season through surface water irrigation, efficient agricultural machinery and local service provision.

CSISA-MI also aims to improve the capacity of the public and private sectors to ensure stronger science-led interventions, value chains for agricultural machinery and pumping equipment, and better services to farmers. As such, CSISA-MI strengthens relationships at the national as well as field level with the relevant government institutes and other partner organizations.

LSP demonstrating agri. machinery equipment

In this regard CSISA-MI is also working with the Bangladesh Agricultural Development Corporation (BADC). They have received a grant worth $1.5 million from USAID to clean and rehabilitate irrigation canals to improve access to surface water irrigation in Barisal District. The project currently is excavating 50 km of canal systems, and installing sluice gates in strategic locations, in collaboration with CSISA-MI’s engineers and irrigation scientists. Following rehabilitation, BADC will procure 40-50 AFPs for farmers to improve their ability to access water.

After excavation of a canal - Gournadi upazila, Barisal district

Canal excavation

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

To drive the adoption of more precise and resource-conserving agriculture, CSISA-MI currently promotes four keystone technologies – the fuel saving high volume axial flow pump (AFP) for surface water irrigation, bed planters and seeder-fertilizer drills that can be used for line-sowing and conservation agriculture, and the reaper to address labor bottlenecks at harvest and speed up the time between harvest and the planting of the next crop. These machines help increase yields by maximizing the productive use of soil moisture, fertilizer and seed, while saving farmers' time, labor and money. Through public-private partnerships with machinery manufacturers and importers such as Advanced Chemical Industries (ACI), Metal Industries, Chittagong Builders and the Rangpur Foundry Limited (RFL) Group, CSISA-MI is working to commercialize and catalyze the wide-availability of these machines for LSPs in the FtF zone. CSISA-MI piloted the use and demonstrated a rice transplanter creating awareness for Khulna farmers.

Science-based interventions are part of CSISA-MI's work. Within the project, CIMMYT scientists are conducting research to develop appropriate irrigation and nitrogen fertilizer regimes for maize and other cereal crops. Research is ongoing in using remote sensing and GIS to identify the appropriate environments and soils on which bed planters and PTOS can be used, and where AFPs can be employed to bring dry season fallow and poorly productive land into intensive cultivation. These efforts are combined with applied econometric analyses to identify the factors that influence LSP's investment in agricultural machinery, and to uncover the predominant structure of irrigation water pricing in southern Bangladesh. This will allow the project to develop improved business models for the provision of affordable surface water irrigation. Additional research considers the trade-offs between crop residue use for livestock vs. conservation agriculture, and in partnership with Wageningen University, CSISA-MI is supporting one PhD and one MS student using advanced crop and farming systems design models to propose solutions to these pressing issues. In addition, the project is continuing research to improve the performance of bed planters and domestic production of AFP.

During the reporting period agricultural machinery and irrigation services promoted by CSISA-MI were applied on 2,995 ha. Out of this number, 1,237 hectares were irrigated by LSPs using fuel-efficient axial flow pumps. Crucially, RFL and individual LSPs invested $45,000 of their own funds to spread AFP services to farmers.

Billboards have been displayed in prominent locations in the FtF zone (Barisal).

Since October 2014, 1,096 hectares were cultivated by using Seed-Fertilizer Drills and bed planters, in a suite of crops including rice, maize, wheat, jute, vegetable crops (onion and garlic), Lentils, and others. In order to make this happen, CSISA-MI's private sector partners invested $30,400 of their own funds to expand use of the equipment. An additional 662 hectares of wheat and rice were harvested using multi-crop reapers through local service provision and the action of our private sector partners ACI and Metal who demonstrated and advertised to farmers and potential LSP clients. Sales of reapers to LSPs are currently ongoing.

A total of 6,682 farmers in the FtF zone benefited from the project's activities through interventions implemented by the project and private sector partners. During the same time period, 936 farmers, of which 824 were male and 112 were female farmers, received short-term hands-on training on different agricultural technologies under CSISA-MI, and a total of 160 entrepreneurs received business development training from the project.

An interactive campaign that included baul songs, games, quizzes and promotional videos was conducted in 12 upazilas of 3 districts to motivate the potential buyers of the machines. Promotional gifts were shared and referral coupons were distributed to potential equipment buyers. Through these activities, nearly 15,000 people were reached and exposed to the SFD; and among them 143 would-be customers were identified.

Unfortunately, due to political unrest, especially a series of strikes and blockades during the reporting period, many of CSISA-MI's planned field activities were hampered. But despite these problems, reasonable progress was made.

A key measure of CSISA-MI's success is the willing investment of ACI, Metal and RFL in the machinery technologies supported by the project. All are receiving technical support from CSISA-MI to import and market agricultural machines. In addition LSPs also invested $105,000. RFL imported 246 Chinese SFD units for sale to LSPs. In addition they are importing 200 more SFD for sale outside the FtF zone.

Mechanization demonstration

Metal Private Ltd. signed a a joint venture agreement with CSISA-MI to contribute in the sales of agricultural machines These private sector companies are generating demand for the machinery technologies through promotional activities like video road shows, billboards, local newspapers and cable advertisements and other marketing materials. A number of practical demonstrations in local markets (haat-bazar), dissemination of other communications items to enhance the awareness and to motivate potential clients have been done.

Nepal

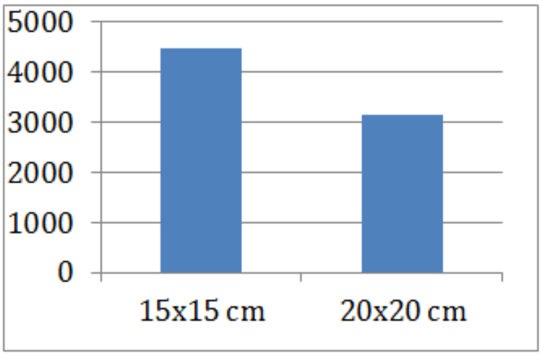
CSISA-Nepal (CSISA-NP)

CSISA's research focus in Nepal is aligned with the staple crop mandates of Feed the Future (FtF): sustainable intensification (SI) technologies for rice, lentil, and maize-based cropping systems. CSISA stages its work in the Mid and Far West development regions from offices in Nepalgunj, Surkhet, Dadeldhura, and Dhangadhi. This section covers Rabi (winter) season 2014–15, and the pre-harvest period for spring season 2015.

The Cereal Systems Initiative for South Asia in Nepal receives funding from USAID Nepal with a co-investment from USAID Washington. In Nepal CSISA's focus is primarily on participatory technology development and verification, inclusive of insights into business and market development for machinery and seeds. Disseminating technologies vetted by CSISA is the responsibility of the Winrock-led KISAN initiative, the USAID Feed the Future project in Nepal.

Coping with Drought and a Variable Monsoon

In the 2014 summer season, the monsoon started very late and farmers were not able to transplant rice on time, typically planting seedlings that were more than 40 days old. This led to a reduction in crop yield and an overall decrease in rice production in 2014 due to the early season drought. Under increasingly unpredictable weather conditions, devising coping strategy for building resilience for rice is becoming increasingly important.



GRAIN YIELD OF RICE PLANTED WITH OLD SEEDLING UNDER DIFFERENT PLANTING GEOMETRY

In response to this threat, CSISA has started to devise and evaluate simple agronomic practices that may build resilience to drought such as changes in planting densities to compensate for the reduced tillering capacity of old seedings. Preliminary results indicate that increasing plant density from 20 cm x 20 cm to 15 cm x 15 cm increased yield by about 1.5 t/ha – a 50% gain in yield with very little cost to farmers. CSISA also conducted a household survey (N=98) in order to understand farmers' perception of various coping strategies for drought. Farmers perceived the value of planting short duration varieties (32%) and expanding irrigation availability and use (28%). Additional research has been planned for summer 2015 that will consider not only planting density adjustments but also interactions with rice varieties.

Operational Land Consolidation with Laser Leveling

MAKING BUNDS TO SPLIT PLOTS IN BARDIYA

Many farmers in the mid and far-western Terai split larger plots into multiple small plots by constructing temporary bunds, which are reformed each season. The primary reason for making temporary bunds is to facilitate the uniform distribution of irrigation and rainwater across larger plots. When water is unequally distributed, resource use efficiencies (water and nutrients) are reduced and crop yields decline. Making bunds and then knocking them down every season in order to address the water problem is labor-intensive and costly. Additionally, area taken up by the bunds cannot be cultivated and results in economic losses.

Laser land leveling (LLL) is performed by a four-wheel tractor (4WT)-drawn laser-guided land leveling attachment. The leveling of the field not only improves water distribution but also increases the plot size by reducing the bund area. The area previously covered by bunds can be used for crop production and the costs incurred in making bunds each season, as well as doing traditional land leveling, are saved. An average increase of 8–10% in rice and wheat yields have been recorded after using LLL in CSISA sites in the central Terai and in experiments in India. These studies also suggest that using LLL can save irrigation water by almost 15–20%. CSISA has introduced a few LLs in our working areas in order to conduct demonstrations and have conducted a survey of 400 households in Banke, Bardiya, Kailali and Kanchanpur districts to characterize the existing cropping systems, the presence and costs of bunds, and the potential for 'operational land consolidation' through LLL. CSISA is working with the manufacturer and dealers of LLLs to improve the market development for this technology in our working domains. The market niche and technology performance assessments conducted by CSISA provides critical location intelligence for LLL in the Mid and Far West development regions.

Dramatic Increase of Mechanical Harvesting with 2WT Reapers for Wheat and Rice

CSISA has spent considerable time and effort over the last two years in the Mid and Far West regions demonstrating reapers for two-wheel tractors (2WT) and training service providers (SPs) on how to use them. Until recently, we had not been getting much traction in generating demand for reapers or for reaper services. In September 2014, sales of reapers for 2WT began to increase, indicating some convergence of supply and demand, and likely reflecting farmers' frustration with manually harvesting rice and wheat in areas, particularly where labor is scarce. CSISA took advantage of the increase in interest and began a new activity called, 'Jump-starting Agro-Machinery Markets' (JAMM), in which we placed 20 new reapers in local markets in the Mid and Far West regions. This initial influx of machines generated interest among farmers and spurred dealers to import and stock more, which resulted in sales of over 100 2WT reaper/harvesters in this last wheat harvest season (March–April 2015).

Cross-cutting Objective 1 Activities

A. Profitability of ZT service provision and competition effects

As earlier presented in CSISA's 2014 Annual Report (p. 20), farmers in Bihar reap substantial economic benefits from ZT in wheat, estimated at \$89 ha^{-1}. Smallholder farmers' access to this beneficial technology hinges on ZT services being provided by wealthier tractor owners. To assess the economic viability of ZT service provision, a census survey was conducted among ZT service providers in Bihar in 2013. The survey shows that, while the average number of farmers serviced remained quite stable over time at around 20 per SP, the average area serviced per SP increased substantially from 32.1 acres in 2010 to 81.3 acres in 2011 and 124.0 acres in 2012. The median acreage serviced increased by 100% from 25 to 50 acres over the same time, indicating a rather skewed distribution, with some SPs servicing up to 400 acres. In 2012, ZT fees amounted to 449 INR per acre on average, and variable costs averaged 240 INR per acre, resulting in an average gross margin of 209 INR per acre. The inclusion of fixed costs in the analysis reveals that there are substantial economies of scale in ZT service provision; fixed costs considered were the depreciation of the ZT drill (assuming a 5-year use period), depreciation of the tractor (proportionate to its use for ZT service provision), and opportunity costs of capital invested in the ZT drill (based on the prevailing savings interest rate of 4%). When comparing different groups of ZT SPs based on the acreage serviced and accounting for fixed costs, the top quartile (servicing > 100 acres) earned a net profit of 85,400 INR from service provision in the 2012/13 Rabi season; net profit amounted to only 4,400 INR among the third quartile (servicing >50 to 100 acres) and was negligible among the lowest two quartiles. The analysis reveals that, under the current 50% subsidy policy for ZT drills, at least 44 acres need to be serviced per year to make ZT service provision a profitable business. In a zero-subsidy scenario, the break-even area would double to 88 acres. This finding demonstrates the importance of CSISA to target SPs who are poised for growth; not only will they give more farmers access to the ZT technology, but they are also more likely to stay in business under less favorable subsidy policies. Our research has shown that it is the 'small among the large' farmers, and those with a relatively low own-farm productivity who are most likely to expand their ZT service businesses to a larger scale (cf. Annual Report 2014, p. 20).

With a growing number of ZT SPs, farmers will make their decisions about whether to engage in service provision – and at what scale to do so – in an increasingly competitive environment. Based on the GPS positions of ZT SPs contained in the 2013 census survey, we counted the number of other SPs in a given radius around each of the SPs, with the radius ranging from 500 m to 20 km (see Figure 1). This allowed us to analyze the effects of the concentration of SPs in a given area on the business decisions taken. We find that in districts with a relatively low ZT SP concentration, the probability to engage in the business *increases* with increasing ZT SP density, i.e., the few existing SPs encourage others to follow their example. In districts where the concentration of ZT SPs is already relatively high, however, the probability to engage in the business *decreases* with increasing ZT SP density. This negative marginal effect is plausible, indicating that an already high concentration of SPs discourages others to engage in the same business. However, we also find that a high concentration of SPs encourages a larger scale of the business, likely due to competition among the SPs. Hence, one can hypothesize that, ultimately, an equilibrium number of relatively large, economically sustainable ZT SPs will be established, while smaller SPs may discontinue their business; this re-emphasizes the importance of an efficient targeting of project efforts to those SPs who are poised for growth.

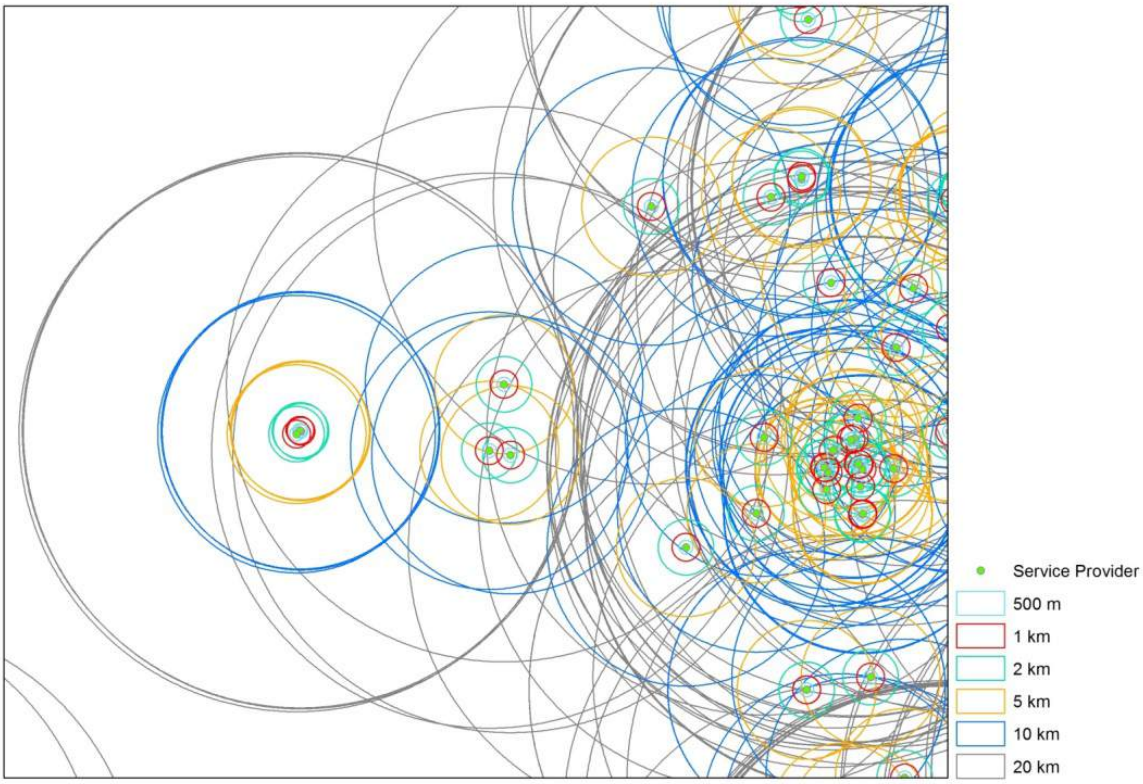


Figure 1. Counting the number of service providers in a given radius around individual service providers permits the analysis of competition effects.

B. Livestock

ILRI's activities have been designed to complement crop-based field activities in the CSISA hubs, and have focused specifically on feeding interventions utilizing crop-residues from rice, wheat and maize, which are predominant cereal crops in these systems. ILRI continues to engage in process and adaptive research with collaborators to identify best practices in feeds and feeding and process research that informs scaling out strategies for these validated best practices. Specific outcomes from the on-farm feeding interventions are highlighted, namely:

- Improved cost-efficiency of feeding practices has engendered net positive benefits from dairy production
- Local Service Providers developed for home-made balanced concentrated feed production and supply in Bihar and Odisha
- Increased demand for chaff cutting machine produced by local manufacturer in Bangladesh
- Partnerships developed between local machine manufacturer and Dept. of Animal Husbandry in Odisha to supply demand for chaff cutting machines in the state involving state-organized dairy farmer cooperatives
- Superior maize hybrid (NK 6240) identified from laboratory evaluation of feed quality traits, and promoted to partners in the hubs (Bihar and Odisha) for dissemination and evaluation in farmers' fields. Arrangements to plant this variety in wider areas in Bihar and Odisha during Kharif season are currently being made in collaboration with hub partners and feeding trials of this variety to be implemented after harvest.

Engendering adoption through exposure and capacity development

Hub-based activities continued to focus on activities aimed to expose target users to feeding practices using locally available feed resources, specifically, crop residues from rice and wheat, and maize stover. Activities included demonstrations on the preparation of homemade balanced concentrated feed and supplementation of mineral mixtures, and improving the quality of basal diets through chaffing of rice and wheat straw and maize stover, and urea treatment of maize stover. Field trials were implemented to showcase the benefits of the feeding practices in the local context, e.g., on farmers' fields. Also, exposure visits were arranged to expose farmers to the successful adoption of improved feeding practices. Joint implementation of field activities with CG partners in the hubs were sought to gain synergies and harness complementarities, and found to be more effective in Bangladesh (with IRRI and CIMMYT), and to some extent in Odisha (with CIMMYT in Mayurbanj).

Training sessions were implemented and included topics on broader livestock management to improve farmer knowledge about improved animal husbandry, animal health management, and animal nutrition. Specifically, at least 40 training sessions have been implemented in CSISA hubs in India (Bihar and Odisha), Bangladesh and Nepal on crop residue-based feeding practices and supplementation with homemade concentrate feed and mineral mixtures, with at least 1,900 farmers participating, of which about one-fourth are women participants. Extension materials such as four videos (one on homemade concentrated feed preparation, one on benefits of feeding urea treated maize stover, and one each on benefit of feeding chopped paddy straw and maize stover) and leaflets and a poster[2] have been prepared for disseminating information about these practices to a wider audience. Continued collaboration with scaling partners such as NABARD, COMFED and OMFED, Directorate of Animal Husbandry in Odisha, and Bangladesh Livestock Research Institute, has contributed in this process. Other outreach activities included participation in state-organized agricultural fairs (Odisha, Bangladesh), presentations in international[3,4] and national conferences and scientific publications.

Linking the lab to the field

ILRI's field-based work in the hubs is complemented by lab-based work on phenotyping to identify superior lines of maize and rice varieties through estimation of NIRS equations based on samples collected from the field. Samples have been collected from Bihar and Odisha and sent to Hyderabad for feed quality assessment and included various types of feed ingredients that farmers use in feeding their animals, homemade concentrated feed prepared by farmers using ILRI-advised formulations, and commercial feeds sold in local markets. Recent outputs from this work identified maize and rice cultivars with potentially superior straw quality for feed. Specifically, two dual-purpose maize hybrids have been promoted in Bihar and Odisha. One of the hybrids, NK 6240, was on par in grain yield with the best other hybrids in the hubs but had by far the highest digestibility. In farmer trials conducted on-station in Hyderabad, digestibility varied – cultivar dependent – from 45 to 55%. Fifty lines of wheat cultivars suitable for semi-arid areas from Bangladesh and India were also analyzed for straw quality and straw–grain relationships. Across all sites, cultivar dependent variations in straw quality were relatively small, while within sites differences in digestibility of about 5% units were observed. Among rice cultivars available, a total of 163 rice cultivars were investigated for rice straw fodder quality traits. Livestock nutritionally highly significant variations were observed

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[2] For example, six leaflets prepared in Bangladesh on feeding Maize Stover to cattle (in English and Bangla), feeding maize stover to the cattle (in Bangla), nutritional values of different crop residues (rice, wheat, maize), benefits of timely deworming of cattle (in Bangla), and benefits of feeding chopped rice straw (in Bangla), and a poster on feeding maize stover to cattle (in Bangla).

[3] International conference of agricultural economists, Savar, Bangladesh, 22–24 October 2014.

[4] 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition, and Environmental Security, Bangkok, Thailand, 30 October – 1 November 2014.

between cultivars. Broad sense heritability for key fodder quality traits were about 0.4. Differences in digestibility between cultivars ranged from about 5 to 10% units.

Fodder markets as emerging opportunities

A study on fodder markets in Bihar highlighted the importance of rice and wheat straw as fodder base in Gaya and Nalanda districts in Bihar state (85.6–87.4%), with both districts experiencing surpluses in fodder and exporting to North Bihar and Jharkhand State. Fodder markets include rural, urban, export and import fodder markets and the key players in the fodder market value chain were famers, agents, traders, retailers and dairy farmers. Farmers receive 2,000 and 2,500 Indian Rupees per ton for paddy and wheat straw sold, respectively, during the season. Paddy and wheat straw prices are 2–3 times higher than farm-gate prices in the export fodder market (i.e., markets outside Bihar state). Rural and urban traders' margin on paddy and wheat straw ranges from 22–80 percent. Contrary to urban wheat and rice straw trading in Patna, no price premium for straw cultivars with higher fodder quality was observed in these rural fodder markets, although wheat straw had a 40% price premium compared with rice straw within each fodder market.

In Person: Enhancing income among Bihar's dairy farmers

With steadily rising demand for milk in Bihar, dairy farmers like Mr. Jha could tap into this expanding market to augment the income he gets from the land he tills.

In 2011, Anuj Kumar Jha, a young farmer from Kalyanpur village, Samastipur district of Bihar, had 0.5 acre of agricultural land but was unsure about what to do with such a small parcel. At a livestock-related CSISA training, Mr. Jha expressed his concerns to the CSISA-ILRI staff conducting the training and learned that, with his existing land and a relatively small investment, he could start a small dairy business.

There is a strong demand for milk in the region where Jha lives, not only for drinking but also for mixing in tea and coffee, and for making ice cream, sweets, curd and butter. Dairy products provide vital nutrition to people, and serve as important sources of income.

Mr. Jha bought a crossbred cow for Rs. 25,000 ($400), which initially yielded about 12 liters of milk/day. With support and training from CSISA, he started preparing a balanced concentrate feed using locally available materials and giving it to his cow. With this concentrate feed, the cow's milk yield increased to 18 liters/day. Motivated by his success, Mr. Jha bought three additional cows, and put his effort into his small but growing dairy business full-time. With four cows, his milk yield was initially 45 liters/day under a mixed feeding regime, but increased to 60–65 liters/day when he fed them all balanced concentrate feed.

Using the scientific formula taught during the program organized by CSISA-ILRI, Jha is preparing his balanced concentrate feed from locally available ingredients for his dairy cattle. The results, he says, are remarkable. Encouraged by this discovery, he further increased his herd to more than 20 crossbred dairy cattle.

Using proceeds from his milk sales, Mr. Jha has also invested in equipment such as a grinding machine for preparing concentrate feed for his own herd. In the future, he plans to grow more green fodder in his land to increase feed availability in his farm for his growing herd of dairy cattle, and explore expanding his farm area by acquiring more land. He also plans to invest in improving the animal shed for his cattle herd. With steadily rising demand for milk in Bihar, dairy farmers like Mr. Jha could tap into this expanding market for augmenting the income he gets from the land he tills.

In Person: Dairy farmer becomes overnight businessman

Desperate times call for desperate measures. Kishore Kumar was forced to turn into a businessman by the need to keep his cattle alive when the dairy board workers went on strike and failed to supply feed.

Guagadia village in Odisha produced an unexpected entrepreneur, when the workers of the feed supplier Orissa State Cooperative Milk Producers' Federation went on strike. Suddenly, Kishore Kumar, a small-scale dairy farmer, found himself asking, 'What on earth was he going to feed his cows?'

Mr. Kumar approached CSISA-ILRI staff for help. The ILRI team quickly arranged a training workshop for the farmers of Guagadia village. The training was organized in collaboration with the Department of Animal Nutrition, College of Veterinary Science & Animal Husbandry and the Odisha University of Agriculture and Technology. Farmers were taught how to prepare balanced concentrate feed, how to improve straw quality through chopping and soaking before being fed to cattle, as well as entrepreneurship skills. Farmers were taught to make the concentrate feed using locally available materials.

Four days after the training, Mr. Kumar started making his own concentrate feed. In three months, he turned out to be an enthusiastic entrepreneur, making feed for his cattle and selling the extra to villagers who either lacked the time or the finances to purchase what they did not have on their farm. Most farmers in six neighboring villages have adopted the concentrate feeding practice and have also now learnt the importance of quality control in concentrate feed production.

The demand for high-quality feed in Guagadia is growing. Farmers have even expressed their willingness to pay more for high quality feed (which results in more milk production), as opposed to a cheaper, lower quality feed. While Mr. Kumar initially produced feed only for his cows, he is now supplying eight other farmers who had attended the training with him, as well as farmers in six surrounding villages. Farmers like the consistency of the feed supplied plus they get to chop their straw at Mr. Kumar's farm when they come to deliver the milk.

From his earnings Mr. Kumar has already bought sacks, a weighing machine and a sealing machine for the feed in a bid to ensure he sells the right quantities and the best quality. He took out a loan with a local financial institution, which he used to acquire a tractor to carry the rice straw from the fields and the ingredients bought from the local market for preparing the concentrated feed for his dairy animals. Mr. Kumar hopes to continue his association with CSISA-ILRI so that his business can continue to grow, and he can continue to meet the feed concentrate needs of his and his village's dairy animals.

Objective 2: Crop and Resource management practices for future cereal-based systems

Karnal Research Platform

In **Objective 2,** CSISA has focused its strategic research on sustainable intensification through conservation agriculture-based best crop management practices. Strategic research is conducted at three platform sites representing distinct agro-ecologies: Karnal, Haryana; Patna, Bihar; and Gazipur, Bangladesh. Four cropping system scenarios are explored at CSISA's research platforms: business as usual—conventional farmers' practices (scenario 1); established 'better-bet' management practices (scenario 2); labor-, energy-, and water-saving practices based on conservation agriculture (scenario 3); and diversified systems (CA 'plus') (scenario 4). In Phase II of CSISA, more emphasis has been given to on-farm strategic research outside of the experimental platforms as well as interdisciplinary work.

The results of five years of research at Karnal Research Platform consistently demonstrate that Kharif maize appears to be a suitable and profitable alternative to rice in the rainy season in northwest India to address issues of rising scarcity of water, labor, and energy in the region. In the 5th year, ZT maize provided higher yield (7.7 t/ha rice equivalent) than rice (7.12 t/ha), with 85% less irrigation water.

Platform research has also showed that weed problems in zero-till wheat reduced overtime, and hence herbicide use in continuous ZT wheat with rice residue mulch decreased compared to the conventional system. After four years, the germinable weed seedbank of *Phalaris minor*, the most troublesome weed of wheat which has evolved multiple resistances to different herbicides, has decreased by 90-100% in continuous ZT wheat with retention of previous crop residues (full rice or 65% maize residues) as mulch compared to conventional till systems. Similarly, the weed seedbank of other weed species also declined in full CA-based cropping systems compared to the conventional system. In rice, we have observed shifts in weed flora with the shift from puddled transplanted (PTR) to direct-seeded rice (DSR). Aerobic weeds such as *Leptochloa chinensis, Dactyloctenium aegyptium* and *Eragrostis japonica* become more dominant in DSR.

After four years, total soil organic carbon content in 0-30 cm soil layer increased by 19% in partial CA-based system (scenario 2) to 40-42% in fully CA-based scenarios (scenario 3 and 4) compared to the conventional business-as-usual system (Scenario 1). In addition, with CA-based practices, other chemical parameters including N, P, and K content in soil increased over business-as-usual practices. The soil physical properties such as soil aggregates, mean weight diameter, steady state infiltration, and soil penetration resistance improved in full CA-based cropping systems (scenario 3 and 4) and the partial CA-based cropping system (scenario 2) compared to the conventional cropping system (Scenario 1). With this improvement in soil properties, component studies have been designed to study the hypothesis whether external fertilizer input can be reduced in CA-based practices in the long run (results awaited).

In another new study initiated from 2013–14 at CSSRI, Karnal, to explore the scope and implications of diversification in Northwest India, DSR yields both under zero or conventional till were at par with PTR. Also, maize yields were at par with rice yields. Irrigation water saving under DSR ranged from 25–28% compared to PTR, whereas, with a shift from rice to maize, water saving ranged from 81–87% compared to PTR and 74 to 83% compared to DSR. Moreover, bed planting in maize further provided 25% water saving over flat bed.

Patna Research Platform

At the Patna Research Platform, wheat yield was 0.45 t/ha higher under ZT (scenario 2 and 3) compared to conventional till (scenario 1). In scenario 4 (short duration rice-mustard-spring maize), wheat equivalent mustard yield was 5.4 t/ha, which was similar to ZT wheat but 0.6 t/ha higher than conventional till wheat, while saving of two irrigations. These results suggest that mustard is a viable diversification option in the Rabi season in eastern India, which also allows 300% cropping intensity as spring-season maize can be taken after the mustard harvest.

To address the terminal heat stress issue in wheat, CSISA in collaboration with Borlaug Institute for South Asia (BISA) worked on two strategies in 2014–15: (1) Escape strategy (escaping terminal heat by planting early so that crop mature before terminal heat starts) – in this study, the 21 best performing genotypes identified last year from 183 genotypes were examined at two locations in Bihar. Similar to last year, all of the 21 genotypes yielded >5 t/ha under early planted conditions (late October planted) and some of them even yielded > 6 t/ha; (2) Coping/adaptive strategies for wheat which is planted a little late and grain filling falls in the terminal heat period – in this study, results showed that cultivar HD-2967 yielded 12 and 24% higher than CSW-16 and HD-2733, respectively, under late November planting conditions. Additional irrigation in March during the grain filling period at the time of terminal heat stress improved the wheat productivity by 8%. Additional irrigation had a positive effect only under conventional till, and ZT without residue conditions and where full rice residue was retained on the soil surface. March irrigation had no significant effect on yield. This suggest that additional irrigation during the grain filling period is more critical for conventional till system and not for CA-based systems because residue conserves soil moisture and buffers the crop against the negative effects of terminal heat.

A new study was started during Rabi 2014–15 season to assess planting patterns and urea placement on wheat productivity and nitrogen use efficiency. The first year result showed that wheat grain yield in the business-as-usual practice of line sowing at 20 cm spacing with urea application in 2 splits at first and second irrigation was either similar to paired row planting with 2 splits (50% drilled at first irrigation and 50% broadcast at 2nd irrigation) or higher than paired row planting with a single split as 100% urea placement by drilling along the rows at first irrigation.

Two studies were initiated in 2013–14 in collaboration with the regional station of Indian Agricultural Research Institute (IARI), Pusa, Bihar. In one study, different tillage and crop establishment methods in rice–wheat systems were evaluated for yield maximization and resource use. The 2nd year data (Kharif 2014) were consistent with the first year data and yields of all crop establishment methods tested ([puddled transplanting (PTR), machine transplanted non-puddled rice (MTNPR), system of rice intensification (SRI), and DSR] were similar. However, net income of MTNPR was higher than SRI mainly because of saving in labor and land preparation cost. In another trial on cropping system optimization/intensification through hybrids/varieties of different maturity classes, it was found that system productivity (wheat equivalent) in the first year (2013–14) follows the following trends: cropping system 1 (CS1)-short duration hybrid rice fb mustard fb spring mungbean = CS2-short duration hybrid rice fb mustard fb spring maize > CS3-medium duration hybrid rice fb wheat > CS4-long duration rice variety fb wheat. Medium duration rice hybrid in CS3 enabled wheat planting on time compared to that after long-duration rice variety, which resulted in a higher wheat yield in CS3 than in CS4. Shorter duration rice also enabled cropping system intensification from 200% (rice–wheat) to 300% in CS1 and 2 (rice–mustard–spring maize/or mungbean). In the second year (2014–15), the rice yield in CS1 where mungbean was included in the system was higher (0.9 t/ha) compared to CS2 where spring maize was included.

To assess the role of field slopes in increasing the water productivity, on-farm trials were established in Vaishali, Bihar during Kharif 2014 comparing farmers' practice against flat (0%) and 0.1% slope in both rice- and maize-based cropping systems. Results suggest that rice yield were similar in plots with 0.0 and 0.1% slope but with 12% less irrigation water in 0.1% slope compared to 0.0% slope plots. In case of maize, yield was higher (0.4 to 0.9 t/ha) under 0.1% slope plots (flat or bed) than in 0% slope (8.4 t/ha versus 7.5 to 7.9 t/ha).

On-farm weed control studies demonstrated that new herbicides can improve cereal yields and can reduce the labor constraints. In rice (Kharif 2014), on the basis of 15 on-farm trials, new herbicides (bispyribac + pyrazosulfuron) on average increased rice yield by >20% compared to current farmers' practice by providing effective control of complex mixed weed flora. Similarly, in Kharif maize, halosulfuron and halosulfuron + tembotrione provided excellent control of purple nutsedge (*Cyperus rotundus*) and purple nutsedge dominated mixed weed flora, respectively.

Gazipur, Bangladesh Research Platform

At Gazipur Research Platform, a change in the cropping system was made in scenario 4. Mustard was grown instead of potato in Boro (dry) season followed by rice in Aus (pre-monsoon) season in phase II of the project. In comparison to farmers' practice (scenario 1), the best management practices (BMPs) alone in scenario 2 increased system productivity by 2.1–2.8 t/ha (23–34%) across two years (2012–13 and 2013–14), which was similar to previous results of Phase I. Similar to scenario 2, the system productivity increase with BMPs under reduced tillage non-puddle condition (Scenario 3) was 3.4–3.6 t/ha (40–41%). The system productivity was increased in scenario 4 with BMPs + crop diversification with mustard in place of Boro rice and intensification with reduced tillage non-puddled rice in Aus season by 2.9–3.7 t/ha (32–46%).

Machine transplanting under both puddled and non-puddled conditions was found promising. Across two years, machine transplanted rice gave 0.3–0.5 t/ha higher yield than manually transplanted rice. Two years' results demonstrate that mustard instead of Boro rice followed by Aus rice are more suitable alternatives crops to replace Boro rice and intensify the system.

An on-farm component study on decomposing Aman season rice yield gaps started at two locations (Gazipur and Kishoreganj districts) during Aman 2014. Across locations, the average yield of farmers' practice ranged 3.8–4.0 t/ha. A single intervention of optimum plant population of healthy seedlings increased yield by 7–9% (0.3–0.4t/ha) over farmers' practice. Another single intervention of optimum fertilizer using Rice Crop Manager (RCM), an ICT-based decision tool for nutrient management, resulted in a yield increase by 12–16% (0.5–0.6 t/ha) over farmers' practice. Layered interventions of best management practices in conventional puddled transplanted rice or by mechanical transplanting in non-puddled soil increased yield by 19–23% (0.8–0.9 t/ha). In another on-farm study on intensification of rice–potato–fallow system by including spring maize, it was found that farmers can earn more benefit by growing maize in between potato and Aman rice without sacrificing yields of both potato and Aman rice. In our study, potato gave 43 t/ha and maize in between potato and Aman gave 6 t/ha yield.

Research in Odisha and Tamil Nadu

In the plateau region of Odisha, CSISA focused on maize on the following topics: site-specific nutrient management, crop establishment methods, yield gap evaluations, and evaluation of maize hybrids of different maturity classes. Based on an average of 8 locations, Kharif 2014 results revealed that optimum plant population (around 70,000/ha), optimum fertilization (140:50:75 kg N, P_2O_5, K_2O/ha), and improved weed management contributed 1040, 900, and 165 kg/ha increase in maize yield over farmer's practice (45,000/ha plant population and 80:40:40 kg N, P_2O_5, K_2O/ha). When all these interventions were layered (best bet agronomy), grain yield increased from 2.90 t/ha (farmers' practice) to 5.28 t/ha. The nutrient omission plot technique (NOPT) trials in maize in red and lateritic acidic soils revealed 4.86, 5.03, and 0.76 t/ha response of N, P and K, respectively, over yields achieved with indigenous sources of each nutrient only, which suggest that these soils are highly degraded. The Maize Crop Manager-based recommendation increased yield from the farmers' practice yield of 3.6 t/ha to 6.0 t/ha.

The research activities in collaboration with Orissa University of Agricultural and Technology (OUAT) have been focused on developing best management practices for non-puddled (transplanted or drill seeded) systems of rice cultivation. The results of one year (two seasons, wet and dry) indicated that good performance of both crop establishment methods – direct seed rice (DSR) and non-puddled transplanted rice (NPTR). In the dry season, the yields of hybrids were better than inbred but it was reverse in the wet season. However both hybrids and inbreds with 10 kPa stress in both establishment methods gave similar rice grain yield as compared to no stress during the dry season. However, a substantial number of irrigations was reduced with 10 kPA as compared to 0 kPa. The results of herbicide screening trials conducted during Kharif 2014 showed that pre-emergence (pendimethalin or pretilachlor) fb post-emergence (bispyribac) controls weeds effectively in DSR. The early seeded crop (both inbred and hybrid of rice) in December was severely infested with blast while there was no blast infestation when seeding was done after January onwards. The work on the optimization of Nitrogen for different rice cultivars in non-puddled conditions during Kharif 2014 indicated high grain yield of hybrids at 120 kg N/ha. However, for inbred varieties (Swarna and Lalat), the maximum yield was achieved with 80 kg N/ha. The preliminary results on potassium optimization in puddled soil indicated that basal application of potassium (40 Kg K ha-1) followed by 1 % KNO3 at panicle initiation stage produced significantly higher grain yield as compared to the remaining treatments. The residue incorporation exhibited impact only in Kharif season. This might be due to warm and humid conditions in Kharif, which hasten the decomposition of residues. On-farm testing of alternate wetting and drying (AWD) is ongoing in Puri districts (3 blocks, each having 3 villages) with the 144 farmers during Rabi 2015 with objective to study the receptivity of technology by farmers. Preliminary results are suggesting that the receptivity of AWD varied based on ownership of pumps, distance from the pump, leveling of the field and weed management**.**

The work on improving land configurations to reduce non-productive water losses has been ongoing. The results are similar at different sites (Cauvery Delta of Tamil Nadu and Bihar) and soil type (clay, clay loam and sandy loam). In sandy loam soil in Tamil Nadu, there was ~15% irrigation water saving with 0.1% slope in 50 m plot length which slightly increased to 16% with 0.2% slope. The saving of irrigation was without any yield penalty. The experiment on studying the N dynamics under manual and non-puddled conditions in two distinct soils of Cauvery Delta is completed and the soil analysis is in progress. The initial results indicated that manual puddled transplanting resulted in more grain yield and B:C ratio. N @ 30 kg/ha as basal resulted in highest yield.

Figure: CSISA PhD Scholar taking data from field trial

Figure: Cropping system trial at OUAT, Bhubaneswar

Figure: Evaluation of rice cultivars (hybrids and inbred) under different water stress treatments

Figure: Optimization of potash application in rice under Odisha conditions, by OUAT scholar.

In Focus: Progress on Crop Manager frameworks

In Odisha, CSISA involved national partners in the development and evaluation of Rice Crop Manager (RCM). On-farm evaluation of RCM has been completed in 11 districts with OUAT and CRRI. One hundred twenty-three nutrient omission plot technique (NOPT) trials, 82 modified NOPT trials and 179 RCM trials have been completed.

The results from NOPT trials have been compiled and analyzed. Pilot testing of an RCM dissemination pathway through the national system has been initiated though KVK (Bhadrak), the Department of Agriculture (Bhadrak) and Reliance Foundation. Initial results indicate benefits associated with using RCM either due to increases in yield, decreases in fertilizer use, or a combination of both.

Maize Crop Manager has been drafted and evaluated in the maize-growing areas of Odisha. A series of workshops was conducted to sensitize new partners and to share results with existing partners. OUAT, CRRI and DOA contributed towards modification and refinement of RCM.

In EUP and Bihar, CSISA signed sub-agreements with Bihar Agriculture University (BAU) and Banaras Hindu University (BHU) for the development and evaluation of CM. CSISA conducted RCM evaluation trials in six districts of EUP and five districts of Bihar. BAU conducted RWCM evaluation and NOPT trials in three districts of Bihar. BHU conducted RWCM evaluation trials and NOPT trials in three districts of EUP. NOPT trials were conducted in three districts of EUP and one district of Bihar.

The data generated from these NOPT trials has been used to fine-tune the recommendations of the Rice Wheat Crop Manager (RWCM). Pilot field-testing of RWCM has been conducted in four districts of EUP and three districts of Bihar. Maize Crop Manager is being drafted and developed for the maize growing areas of EUP and Bihar. A brainstorming session was organized in Patna with the collaborators. Experts from BAU, RAU and, Catholic Relief Services (CRS), along with scientists from IRRI, CIMMYT and ICAR-RCER, discussed the RWCM's refinement and modification.

In Tamil Nadu, CSISA is working in Thanjavour District for field-testing Nutrient Manager for Rice (NMR) and collaborating with TNAU-TRRI KVKs for testing in non-CSISA districts. Harvest days were organized in collaboration with TRRI and TNAU to show the farmers the yield benefits obtained from NMR.

Objective 3: High-yielding, stress-tolerant rice varieties for current and future cereal and mixed crop–livestock systems

Objective 3 develops a new generation of rice varieties and hybrid parental lines for the target regions of South Asia. The target trait specifications used in the variety development pipelines emphasize higher yield potential, adaptation to dry direct seeding and water stresses (partial/non-flooded irrigation), heat tolerance, grain quality, and straw fodder value.

Objective 3.1: **Next generation of elite rice lines with increased yield potential, improved grain quality and superior feeding value.**

Evaluation for yield and yield related traits of the seven recipient parents (PSB Rc82, PSB Rc158, NSIC Rc222 and NSIC Rc238, MTU1010, BPT5204 and Swarna) and the three donors (Habataki, ST6, ST12) was carried out in a replicated yield trial to compare the yield performance. Data collected included days to flowering (DTH), plant height, tiller number, panicle length, primary branching per panicle (SPL1), grain number per panicle (Gn), grain-related traits, culm diameter (lodging resistance), non-structural carbohydrate reserve (NSC) and plot yield (10 sq m). The results indicated significant differences between the recipients and donor lines for the traits with high grain number, panicle branching, culm diameter and NSC suggesting the possibility of increasing yield potential of indica rice cultivars.

One hundred seventy entries grown under machine sown dry direct seeded conditions and 330 entries grown under puddle transplanted conditions were evaluated for straw digestibility traits like nitrogen content (N %), neutral detergent fiber (NDF %), acid detergent fiber (ADF %), acid detergent lignin (ADL %), silica content (%), in vitro organic matter digestibility (IVOMD %), and metabolizable energy (ME). Based on IVOMD, entries were classified into different categories: IVOMD: $\geq$45% = very good, 43–45 = good, 40–42 = medium, 37–39 = poor, and $\leq$36 = very poor. The IVOMD values of the entries tested under DSR ranged from 41 to 54 with more than 80 percent entries in very good category. Among the puddle-transplanted entries IVOMD ranged from 43 to 54 with more than 85 percent of entries in very good group.

Fig. 1. A promising breeding line with improved plant type,bigger panicle and high yield potential.

During the wet season 2014, 36 entries in early, 40 entries each in medium early and medium duration were evaluated under puddle transplanted condition at six locations in India viz Ludhiana, Pantnagar, Sabour, Hyderabad and Maruteru. The mean grain yield advantage of the top five entries over the best check in respective maturity groups ranged from 6-12% over Local check (5.01 t/ha) in early,10-23% over MTU1010 (5.2 t/ha) in medium early and 7-12% over NDR 359 (5.02 t/ha).

Objective 3.2. Rice for mechanized direct seeding and water-saving irrigation

Five varieties suited for cultivation in dry direct seeded situation- CR dhan 201, CR dhan 202, CR dhan 203, CR dhan 204 and CR dhan 205 from breeding lines developed at IRRI have been released in India. An array of new breeding lines with varied plant types and maturity groups with different grain types like medium and short slender, long slender and long bold and medium bold suitable for diverse market segments of northern, southern and eastern parts of India were developed. Many entries recorded more than 7.5-8.6 tons grain yield per hectare. Twelve breeding lines are currently being evaluated in All India Co-ordinated Rice Improvement Program and eight breeding lines are in evaluation in state multi-location trials of Punjab, Uttarakhand, Bihar and Odisha. Some of the newly developed breeding lines showed yield advantage of 12–29 percent over the best check variety MTU1010 under irrigated machine sown DSR situations.

During the wet season 2014, 36 entries in early,40 entries each in medium early and medium duration were evaluated under machine sown dry DSR condition at seven locations in India viz Ludhiana, Pantnagar, Sabour, Jeypore, Aduthurai, Hyderabad and Gangavathi . The mean grain yield advantage of the top five entries over the best check in respective maturity groups ranged from 10-20% over Sahabhagidhan (4.9 t/ha) in early,14-19% over MTU1010 (5.6 t/ha) in medium early and 10-15% over NDR 359 (5.4 t/ha).

Promising entries under machine sown dry DSR condition at IRRI- SA hub,Hyderabad.

Using the QTLs for traits desirable under dry direct seeded situation as well as genes for tolerance to biotic and abiotic stresses, a marker assisted selection (MAS) breeding program initiated earlier at IRRI is moving forward as per the plan. In the MAS, QTLs for anaerobic germination, genes for resistance to blast, brown plant hopper, bacterial leaf blight, gall midge; QTLs for grain yield under dry direct seeded situation, early uniform emergence, grain yield under drought and nematode tolerance are being combined in two high yielding backgrounds- IR09N538 and NSICRc-222. In DS 2015, closely linked peak/gene based markers for different traits in the background of IR09N538 and NSICRc-222 as well as flanking markers in the identified QTLs regions for different QTLs were identified. F_1s combining genes/QTLs for two traits were evaluated for presence of genes/QTLs for two traits, plants with presence of genes/QTLs for two traits were identified and crosses attempted to combine QTLs/genes for the four traits.

Objective 3.3. Development of high yielding heat-tolerant rice varieties

A recombinant inbred line (RIL) population consisting of 246 F9 lines was developed and is being used for high night temperature (HNT) QTL mapping and other heat tolerance studies Near isogenic lines (NILs) with N22 introgression in IR64 background were developed, BC5F5 lines were evaluated in the field along with the early morning flowering (EMF) NILs. A large number of germplasm for early morning flowering were surveyed and many donors were identified and evaluated.

At TNAU, Coimbatore, with a view to develop heat tolerant rice genotypes, crosses have been made between popular rice varieties like Improved White Ponni, CO 51 and CR 1009 and a heat tolerant donor Nagina 22. Marker assisted selection and MABB strategies are followed to introgress two QTLs namely qHTSF1.1 and qHTSF4.1 associated with spiklet fertility under HT stress from the tolerant Nagina 22. SSR markers near the target QTLs were screened for their polymorphism between the parents and two polymorphic SSRs namely RM431 (qHTSF1.1) and RM5757 (qHTSF4.1) are being used for Foreground Selection. All the populations have been forwarded up to F3:F4 generation, and early maturing, high yielding lines harboring target QTLs from Nagina 22 have been identified.

Objective 4: High-yielding heat- and water-stress tolerant, and disease-resistant wheat varieties for current and future cereal systems

Objective 4 strives to develop bread wheat varieties that have higher yields (>5% than current varieties by year 5 and an additional 15% higher by year 10), are well buffered against the vagaries of climate change, and have preferred end-use qualities. Objective 4 aims to develop input-responsive varieties that also have greater resistance to biotic stresses such as leaf, yellow, and stem rusts, and spot blotch/leaf blight, adaptability to CA practices, and have consumer preferred end-use qualities.

During the reporting period, ten new wheat varieties were released, seven identified for release, and more than 1,900 were promoted to national/state/regional trials for their further evaluation and subsequent release. In addition 2,010 new crosses (1,000 by CIMMYT and 1,010 by NARS) were attempted and >18,500 breeding populations (>10,500 by CIMMYT and 8,433 by NARS) were exposed to selection under a range of environments and management conditions including terminal heat stress and conservation agriculture. More than one thousand advanced lines and segregating (F3/F4) generations from South Asia were evaluated in Kenya for screening against Ug99 resistance. Five hundred eighteen participatory varietal selection (PVS) and adaptive trials were planted in farmers' fields by collaborators in Nepal, India and Bangladesh. One hundred forty-five CSISA trials consisting of >1,000 advanced lines from CIMMYT were grown by 40 collaborators. Of these 9 were funded and 10 were from the private sector in India. Seed growers and farmer groups continued seed dissemination of superior lines with the result that breeder seed indent and production figures indicated that CSISA bred lines covered 18% area in India, 24% in Nepal and 34% in Bangladesh.

Leverage seen in objective 4 in south Asia influences by success of new wheat varieties

1. Seeing impact of new wheat varieties, West Bengal (India) government decided to replace an older cultivar PBW 343.
2. Bangladesh government started discouraging cultivation of Boro rice in traditional wheat areas due to increased profit obtained through new wheat varieties.
3. Promotion of early maturing rice varieties encouraged for timely sowing of wheat in Bangladesh.
4. Bangladesh government raised procurement price of wheat from Rs 26/kg to Rs 28/Kg to provide incentive to the farmers for growing wheat.

Spillover seen in objective 4 in south Asia

1. Two wheat varieties from Punjab (PBW 621, PBW 644) that were released for NWPZ covered large acreage in Bihar through government indent.
2. CSISA bred wheat varieties in Bangladesh, have spread to new areas of southern Bangladesh such as districts of Jessore, Faridpur, Khulna, Barisal; barind areas of Rajshahi and Charland areas of Mymensingh (Begun Bari and Jhyalkhan of old Brahmputra), Tangail (The Jamuna) and Rajshahi (The Padma) districts in the north and northwest benefitting more than 10,000 farm families.

Objective 5: Improved policies and institutions for inclusive agricultural growth

Objective 5 continues to address the policy environment needed to remove constraints to the adoption of new technologies and enhance the benefits of improved agricultural growth. It explores strategies to catalyze durable change at scale through improvements in technology development and delivery, private investment in inputs and services, and public-private partnerships. During the reporting period, Objective 5 expanded its research and communications activities to strengthen the policy environment around of the development and delivery of new technologies and practices relevant to CSISA. Particular emphasis was placed on strengthening private investment in inputs and services, and fostering stronger partnerships between the public and private sectors.

The Objective 5 team convened a high-level international policy conference in collaboration with the Institute of Economic Growth. The objective was to engage key policy-makers, academics and other stakeholders to explore innovative ways of accelerating development in India's agricultural sector. Then, the team convened a private-sector roundtable in December 2014 that brought together stakeholders to highlight progress made in CSISA partnerships, deepen commitments to future collaboration, and chalk out new areas for technical and strategic cooperation.

On the policy research side, researchers produced a series of highly regarded working papers, conference papers, and journal articles that covered issues relating to (i) resource conservation, and climate risk management; (ii) technology development and the demand for new agricultural technologies; and (iii) technology adoption dynamics.

Current research under Objective 5 aims to provide new insights on how farmers perceive different CSISA-sponsored technologies, and how these perceptions vary across different types of farmers. This helps CSISA and, more importantly, extension agencies and NGOs, gain a better understanding of what works, where, and why. With insights like this, IFPRI and CSISA are better able to advise policymakers on the types of policies and investments they might make to affect evidence-based solutions that encourage inclusive technological change across South Asia's rural economy.

In the first quarter of 2015, IFPRI researchers have been heavily involved in the design, data collection and initial analysis phases of three major studies, which were rolled out in preparation for the 2015 Kharif rice season. With most of the team members in the field pre-testing surveys, searching for survey respondents, troubleshooting field equipment, the stage has been set for a deluge of data that has already started flowing in. One of the latest studies from the IFPRI team explores farmers' valuation of – and returns to – the use of mechanical rice transplanters in Bihar. Another study examines farmers' preferences for – and uptake of – new stress-tolerant rice cultivars coupled with a weather index insurance product in Odisha. Both studies take their cues from prior IFPRI studies: the former on farmers' willingness to pay for laser land levelers in eastern Uttar Pradesh, and the latter on farmers' preferences for a similar cultivar and insurance product in Bogra, Rajshahi division, Bangladesh. With a better sense of farmers' preferences, these studies will introduce novel products and services for use during the upcoming Kharif season. In

Bihar, selected farmers will receive (and pay for) mechanical transplanting services. In Odisha, selected farmers will receive (and pay for) a drought-tolerant rice cultivar and/or a weather index insurance policy.

At the moment, these experiments – accompanied by village and household surveys followed by distribution of products and services – are underway and in the field. They are complex undertakings, and rely on the support and dedication of IFPRI's partners and the CSISA hub staff. In Bogra, IFPRI is working with Gram Unnayan Karma (GUK), a local NGO. In Odisha, IFPRI is working with the Balasore Social Service Society. And in Bihar, IFPRI is implementing the study with the help of both the CSISA hub and HopUp, IFPRI's go-to company for survey management and implementation. And with collaborators from the University of California, Davis and the University of Georgia, IFPRI is confident that these studies will provide critical insights for CSISA and its wide range of stakeholders.

In Focus: *Gender and the role of agricultural technology*

Enumerators trying to elicit valuation of different attributes of both traditional and mechanical rice transplantation techniques. Picture courtesy: Sumedha Minocha, taken in Patna district, Bihar, India

Female enumerators trying to elicit preference heterogeneity for the technology from female and make farmers individually. Picture courtesy: Sumedha Minocha, taken in Nawada district, Bihar, India

To throw more light on heterogeneous adoption and impacts of new agricultural technology and to tease out the differences between the preferences of men and women in the same households, the CSISA team at IFPRI is busy engaging with farmers from several districts in Bihar. Mechanical rice transplanters, the focus of the present study affects both women and men on several social and economic aspects and, presently, several teams of enumerators are trying to elicit individual valuations for mechanical rice transplanters (MRTs) from female co-heads (FCHs) and male co-heads (MCHs) separately from over 1000 households in Bihar. Using experimental games, the team is also trying to elicit their preference heterogeneity and bargaining power within the household.

The study has three key components. The first component involves measuring power and preference heterogeneity of FCHs and MCHs in randomly selected households residing in the study villages. As part of the second component, both the male and female co-heads are individually introduced to the technology and their valuations of the machine are separately elicited. Finally, as part of the third component using actual experimental auctions, farmers will be randomly provided MRT custom-hired services.

As an end result of the study, we are expecting to measure the impact of the technology for different households on such outcome variables as labor costs and net returns to rice cultivation, as well as the heterogeneity of impacts within households especially gendered labor impacts of MRT adoption within a household. This will also provide us with an assessment of the costs and returns to the MRT operator providing custom-hired services.

Objective 6: Project management, data management, monitoring & evaluation and communications

Governance: The CSISA **Executive Committee** (EC), composed of senior representatives of CSISA's CGIAR partners, meets semi-annually and monitors project progress and work plan development. The EC convened virtually in October 2014. Country-based **Management Teams** (MT) for India and Bangladesh meet monthly and lead strategy development, activity planning, and provide comprehensive technical oversight for the non-breeding objectives of CSISA. The MT is composed of the Country Coordinator (chair) and scientists from each of the CGIAR Centers that lead the activities in Objectives 1, 2, 5 and 6 in that country. The MT met nearly monthly during the reporting period, and was complemented by the seasonal planning meetings.

Objective 6 covers CSISA's governance and project management components, which in Phase II are designed to (1) enable better linkages with national and regional stakeholders, (2) simplify reporting and ensure clear lines of accountability, (3) enable better teamwork and synergy across Objectives and CG partners, and (4) build a more inclusive model for outreach and research that leverages the strengths and addresses the needs of key partners. The reporting period included quarterly Executive Committee meetings, monthly Management Team meetings, semi-annual Advisory and Investment Committee meetings, and semi-annual planning & evaluation meetings. Our communications platforms, M&E techniques and data management tools all matured & expanded.

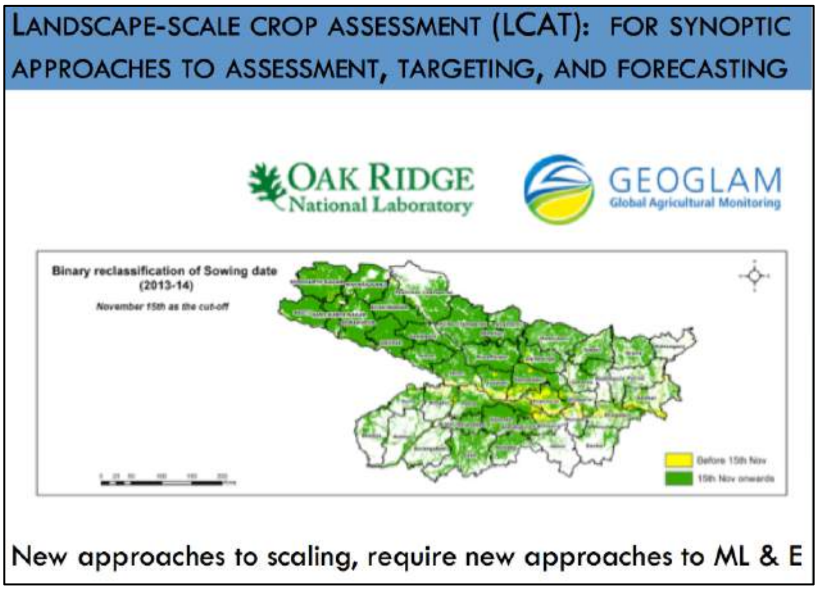
Semi-annual Planning and Evaluation Meetings: Each year, country-specific and objective-specific meetings are held in advance of the Kharif and Rabi seasons to evaluate the past season's work and develop impact pathways for the coming season's activities. Approval of activities and subsequent allocation of funds is done at the subsequent MT meeting. The Rabi season meeting occurred in September 2014 in Jaipur, India and the Kharif season meeting was held in Kathmandu in April 2015.

Data Management: CSISA is continually upgrading its data management protocols and procedures, and improving the ways in which data is collected and shared. In India, CSISA's four CGIAR partners continue to use Surveybe software and portable netbook computers to streamline field-based data collection for socio-economic surveys. CSISA also uses simple survey forms designed with Open Data Kit (ODK) for deployment on Android-based smartphones to capture trainings, locations and types of technology demonstrations, etc. Data collected via ODK is now being integrated into the CSISA web site for better visualization and transparency. The CSISA Bihar and EUP hubs have provided data logbooks to service providers. Standard Operating Procedures for CSISA data management have been developed, including the basic metadata schema to be included with every data set, file-folder naming and organization protocols, data storage guidelines, and data-related roles and responsibilities of staff at each CSISA hub.

Enabling wider access to CSISA data: Several CSISA data sets have been uploaded into AgTrials (http://agtrials.org), a global repository developed by the CGIAR Research Program on Climate change, Agriculture and Food Security (CCAFS), with eight current CGIAR partners. However, while the AgTrials database is powerful, the user interface requires improvement. A CSISA/CIMMYT–CIAT collaboration has been cemented to further develop AgTrials, with current work plans focusing on usability-interface issues, metadata schema and forms, optimizing the search functionality, and making further refinements following user testing. Since this effort requires coordination among multiple institutions and funding sources, progress towards interface completion has been slower than anticipated, but continues. Agronomic trial traits have been developed to enhance the agronomic content in the Crop Ontology (http://www.cropontology.org) used by both AgTrials and the Generation Challenge Program's (GCP) Field Book. A former GCP consultant has worked with CSISA/CIMMYT's data management team and the Bioversity-based GCP semantics and ontology expert to add these traits to the Crop Ontology and to develop an Agronomy Field Book. When completed, CSISA agronomists will use this online Field Book and those working in other projects/centers to standardize data collection templates, facilitate meta-analyses, and better integrate breeding and agronomy data. The Agronomy Field Book will also allow users to analyze data using pre-loaded R scripts, and to store data sets. Via another new collaboration between the GCP and AgTrials, the Field Book will also enable a one-click upload of data from the Field Book into AgTrials. An instance of DataVerse (http://dvn.iq.harvard.edu/dvn/dv/IFPRI) has been installed on a CIMMYT server, and is being evaluated for use as a repository for CSISA's survey and technology tracking data.

Communications: CSISA's web site, **csisa.org**, and its accompanying **quarterly newsletter**, disseminate information about CSISA's activities and outputs across Bangladesh, India, and Nepal. Our internal newsletter, ***CSISA Magazine***, provides information about meetings, new staff, hub and research platform updates, and other important information to the CSISA Phase II team. Five **CSISA Research Notes** have been published, which serve as briefs for the research coming out of CSISA. Our **Facebook** page, **Picasa** account, and **Twitter** feed provide additional mechanisms for sharing information about CSISA's activities with a wide audience.

Monitoring and Evaluation: The CSISA M&E team, complemented by our socioeconomics team, develops tools for directly capturing data on our activities and outputs, and identifies inference techniques for capturing numbers on large-scale impact that expand beyond our ability to capture data directly. M&E activities are identified seasonally during the impact pathway planning process. Examples of activities for which our 'footprint' is comparatively small and we can still capture data directly include mechanical rice transplanting and laser land leveling. Technologies that have been adopted at scale that require the use of inference techniques to estimate adoption numbers include early wheat planting, transitions to hybrids and elite varieties, and improved weed management.



As CSISA's level of impact moves from the field to landscape scale, new tools are required to detect change for monitoring, internal learning and evaluation. CSISA has teamed with Oak Ridge National Laboratory and the GEOGLAM initiative to devise the 'LCAT' concept. Currently under development, LCAT will leverage 'real time' remotely sensed information and geo-spatial analysis to aid certain types of technology adoption assessments (e.g. planting date adjustments), targeting (e.g. fallows development), and crop performance forecasting (e.g., for use in dynamic decision support frameworks for fertilizer management).

Annex 1. New Papers, presentations, and outreach activities

(in chronological order)

Objective 2: Punjab Hub

Parvinder Singh, HS Sidhu, Pankaj Singh, Yadvinder Singh, ML Jat and A. McDonald. 2014. Residue mulching and precision water management in permanent raised bed planted spring maize in northwest India: Crop yield and water productivity. Paper presented in 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security. Bangkok, Thailand, organized by APAARI, CIMMYT, FAO and DOA, October 30-November 1, 2014. ***(Participation of HS Sidhu to make this presentation was supported by CSISA).***

Objective 4

Pask A.J.D., A.K. Joshi, Y. Manes, I. Sharma, R. Chatrath, G.P. Singh, V.S. Sohu, G.S. Mavi, V.S.P. Sakuru, I.K. Kalappanavar, V.K. Mishra, B. Arun, M.Y. Mujahid, M. Hussain, N.R. Gautam, N.C.D. Barma, A. Hakim, W. Hoppitt, R. Trethowan, M.P. Reynolds (2014) A wheat phenotyping network to incorporate physiological traits for climate change in South Asia. Field Crops Research 168, 156-167. http://dx.doi.org/10.1016/j.fcr.2014.07.004.

Vishwakarma M.K.**,** V.K. Mishra, P.K. Gupta, P.S. Yadav, H. Kumar, and Arun K. Joshi (2014). Introgression of the high grain protein gene *Gpc-B1* in an elite wheat variety of Indo-Gangetic Plains through marker assisted backcross breeding. Current Plant Biology 1: 60-67. 10.1016/j.cpb.2014.09.003

Reynolds MP, Pask, A., Torres, A., Chavez, P., Molero, G., Figueroa, P., Solis, E., Barma, N., Joarder, O.I., Kalappanavar, I.K., Sukaru, S.V.P., Dhari, R., Singh, G.P., Sohu, V.S., Raj, G.N., Mujahid, M.Y., Ward, R., Jalal-Kamali, M.R., He, Z., Mossad, M.G., Sharma, I., Chatrath, R., Mavi, G.S., Mishra, V.K., Arun, B., Hussain, M., Guatam, N.R., Firoz Ahmad, A., Rahman, M., Ahmad, G., Joshi, A.K., (2014). Pre-breeding for yield potential: results of the 1st and 2nd WYCYT. In: Reynolds M.P. et al, 2014. Proceedings of the 4th International Workshop of the Wheat Yield Consortium. CENEB, CIMMYT, Cd. Obregón, Sonora, Mexico, 24-25 March 2014. Mexico

Mondal S., A.K. Joshi, Huerta Espino J. and R. P. Singh (2013) Early maturity in wheat for adaption to high temperature stress. 12th International Wheat Genetics Symposium. Book Chapter (In press).

Mondal, S. Ravi P. Singh, Julio Huerta-Espino, Zakaria Kehel, Enrique Autrique (2015) Characterization of heat and drought stress tolerance in high-yielding spring wheat. Crop Science 55(4) DOI: 10.2135/cropsci2014.10.0709

Objective 5:

Peer-reviewed journal articles, book chapters, and books

Krishna, V. V., D. J. Spielman and P. C. Veettil. 2015. "Exploring the supply and demand factors of varietal turnover in Indian wheat." *Journal of Agriculture Science* 153: 1-15.

Ward, P. S., D. L. Ortega, D. J. Spielman and V. Singh. 2014. "Heterogeneous demand for drought-tolerant rice: Evidence from Bihar, India." *World Development* 64: 125-139.

Ward, P.S. and V.O. Pede. 2014. "Capturing social network effects in technology adoption: The spatial diffusion of hybrid rice in Bangladesh". *Australian Journal of Agricultural and Resource Economics* 59: 225-241.

Discussion/working papers

Ward, P. S., D. L. Ortega, D. J. Spielman, N. Kumar and S. Minocha. 2015. *Demand for complementary financial and technological tools for managing drought risk*. IFPRI Discussion Paper 1430. Washington, D.C.: IFPRI

Magnan. N., D. J. Spielman, K. Gulati and T. J. Lybbert. 2015. *Information networks among women and men and the demand for an agricultural technology in India.* IFPRI Discussion Paper 1411. Washington DC: IFPRI.

Arora, A., S. Bansal and P. S. Ward. 2015. *Eliciting farmers' valuation for abiotic stress-tolerant rice in India.* IFPRI Discussion Paper 1409. Washington DC: IFPRI.

Bhargava, A. K. 2014. *The impact of India's rural employment guarantee on demand for agricultural technology.* IFPRI Discussion Paper 1381. Washington DC: IFPRI.

Ward, P.S. and V. Singh. 2014. *Risk and Ambiguity Preferences and the Adoption of New Agricultural Technologies: Evidence from Field Experiments in Rural India.* IFPRI Discussion Paper 01324. Washington DC: International Food Policy Research Institute.

Conferences, workshops and seminars

Ward, P. S., D. J. Spielman, D. L. Ortega, N. Kumar and S. Minocha. 2015. "Demand for complementary financial and technological tools for managing drought risk". Paper presented at the International Food Policy Research Institute, Washington, DC, March 6.

Ward, P. S., D. J. Spielman, D. L. Ortega, N. Kumar and S. Minocha. 2015. "Demand for complementary financial and technological tools for managing drought risk". Paper presented at the American Enterprise Institute, Washington, DC, February 19.

Ward, P. S., D. J. Spielman, D. L. Ortega, N. Kumar and S. Minocha. 2015. "Demand for complementary financial and technological tools for managing drought risk". Paper presented at the International Food Policy Research Institute, New Delhi, February 13.

D.J. Spielman and A. Kennedy. 2015. "Innovation, competition, and productivity growth: Evidence on the impact of growth in Asia's maize seed sector." Presentation given at a regional workshop on Agricultural Transformation: Challenges and Opportunities in South Asia, jointly organized by the Nepal Agricultural Economics Society, the Ministry of Agricultural Development of the Government of Nepal, and IFPRI, Kathmandu, Nepal, February 13-14. http://southasia.ifpri.info/2015/04/01/keeping-agriculture-productive-amid-a-changing-climate-in-nepal/

Lybbert, T.J., N. Magnan, D.J. Spielman, A. Bhargava, and K. Gulati. 2014. "Is laser land leveling a viable technology option for farmers? Evidence from Uttar Pradesh, India." Paper presented at a seminar organized by the International Initiative for Impact Evaluation (3ie) and IFPRI, New Delhi, December 10. http://www.3ieimpact.org/en/events/3ie-delhi-seminars/3ie-delhi-seminar-2014/laser-land-leveling-viable-technology-option-farmers/

Lybbert, T. and M. Carter. 2014. "Bundling Drought Tolerance and Index Insurance to Manage Drought Risk." Paper presented at the National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi, December 9.

Spielman, D.J., N. Cenacchi, and M. Rosegrant. 2014. "Food policy in a world of natural resource scarcity: What role for entrepreneurial India?" Presentation given at a private sector roundtable on "Deepening Private Sector Engagement in the Vulnerable and Underserved Markets of Eastern India," organized by the Cereal Systems Initiative for South Asia (CSISA) and IFPRI, New Delhi, December 8. http://southasia.ifpri.info/2015/01/12/partnership-potential-engaging-the-private-sector-to-improve-food-security-in-eastern-india/

Ward, P. S. 2014. "Innovations for managing drought risk in South Asia." Paper presented at an international conference on "Innovation in Indian Agriculture: Ways Forward," convened by the Institute of Economic Growth (IEG) and the International Food Policy Research Institute (IFPRI), New Delhi, December 4-5. http://www.ifpri.org/event/innovation-indian-agriculture-ways-forward

Spielman, D.J. Ways forward for Indian agriculture. Opening and closing remarks presented at an international conference titled "Innovation in Indian Agriculture: Ways Forward," convened

by the Institute of Economic Growth and IFPRI, New Delhi, December 4–5. http://www.ifpri.org/event/innovation-indian-agriculture-ways-forward

Spielman, D.J., P. Ward, S. Makhija, S. Minocha, V. Singh, V. Nazareth, and others. 2014. Participated in "Innovation in Indian Agriculture: Ways Forward." International conference convened by the Institute of Economic Growth (IEG) and IFPRI, New Delhi, December 4-5. http://www.ifpri.org/event/innovation-indian-agriculture-ways-forward

Spielman, D.J., and A. Kennedy. 2014. "Innovation, competition, and industry performance: Better metrics for measuring the growth of Asia's maize seed system." Paper presented at the 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security, Bangkok, Thailand, October 30–November 1. http://repository.cimmyt.org/xmlui/bitstream/handle/10883/4203/99743.pdf

Spielman, D.J., P. Ward, D.E. Kolady, and H. Ar-Rashid. "Public incentives, Private Investment, and outlooks for hybrid rice in Bangladesh and India." Paper presented at the 4th International Rice Congress (IRC2014), Bangkok, Thailand, October 27–30. https://irc2014science.wordpress.com/

Ward, P. S., D. J. Spielman, D. Kolady and H. Rashid. 2014. "The outlook for hybrid rice in Bangladesh and India". Paper presented at the 8th Asian Society of Agricultural Economics annual meeting, Savar, Bangladesh, October 17. http://asaeweb.org/conferences/8th-asae-conference

Ward, P. S., D. L. Ortega, D. J. Spielman and V. Singh. 2014. "Farmer preferences for abiotic stress tolerance in Eastern India". Paper presented at the 8th Asian Society of Agricultural Economics annual meeting, Savar, Bangladesh, October 15.

Naher, F and D. J. Spielman. 2014. "Towards innovation and growth in Bangladesh's seed sector." Presentation at the IFPRI-PRSSP workshop on "Evidence-based policy options for food and nutrition security in Bangladesh", Dhaka, Bangladesh, October 1. http://www.slideshare.net/ifpri_dhaka/presentation-2-naher-towards-innovations-and-growthoct-1final

Awards

Anil Bhargava received the 2014 Gordon A. King Award for best dissertation in Agricultural and Resource Economics (ARE) at UC Davis. Anil has collaborated with IFPRI on the CSISA studies of laser land leveling in eastern UP and the impact of MGNREGA on labor-saving technology adoption. These two pieces were central elements of his award-winning dissertation titled "Agriculture, Poverty, and Natural Resource Conservation in 21st Century India: Impact Evaluation and Analysis of Rural Development Policy." His work was done with support from David Spielman at IFPRI and Travis Lybbert, his advisor at UC Davis and a key CSISA collaborator.

Media coverage

Dhar, A. 2014. "Strengthening maize policies and public-private partnerships in Asia". Quoted David Spielman. CIMMYT News, November 11. http://blog.cimmyt.org/strengthening-maize-policies-and-public-private-partnerships-in-asia/

Basu, T. 2014. "Patent protection, a key issue for foreign hybrid seed companies." Reference to the International Conference on Innovation in Indian Agriculture. The Hindu Business Line, December 5. http://www.thehindubusinessline.com/industry-and-economy/agri-biz/patent-protection-a-key-issue-for-foreign-hybrid-seed-companies/article6665563.ece

Wall Street Journal. 2014. "The Week Ahead." Reference to the International Conference on Innovation in Indian Agriculture. *Wall Street Journal*, December 4. http://blogs.wsj.com/indiarealtime/2014/12/01/the-week-ahead-arun-jaitley-meets-raghuram-rajan-arvind-kejriwal-goes-on-air/

Appendix B: USAID Indicators

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

Current Selection		
Reporting Organization : USAID		
Indicator / Disaggregation	2015	
	Target	Actual
4.5.2(2): Number of hectares under improved technologies or management practices as a result of USG assistance (RIA) (WOG)		
Technology type	250,000	88,266
crop genetics		0
cultural practices		559
pest management		0
disease management		0
soil-related fertility and conservation		259
irrigation		0
water management (non-irrigation)		12
climate mitigation or adaptation		166
other		87,270
total w/one or more improved technology		88,266
Disaggregates Not Available		0
Sex	250,000	88,266
Male		5,403
Female		522
Association-applied		41
Disaggregates Not Available		82,300

Comment: This is an Objective 1 indicator and at annual reporting time the numbers are divided up between USAID India (Bihar, EUP and Odisha) and USAID Washington (non-priority geographies). For this semi-annual report, targets and actuals are not disaggregated, but will be disaggregated for the annual report. The numbers reported above do not include any numbers from Haryana, and do not capture full Rabi or Kharif seasons, and therefore may appear low compared to the targets.

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

Current Selection		
Reporting Organization : USAID		
Indicator / Disaggregation	2015	
	Target	Actual
4.5.2(5): Number of farmers and others who have applied improved technologies or management practices as a result of USG assistance (RIA) (WOG)		
Producers	750,000	
Sex		116,424
Male		10,941
Female		3,049
Disaggregates Not Available		102,434
Technology type		116,424
crop genetics		
cultural practices		719
livestock management		6,294
wild fishing technique/gear		
aquaculture management		
pest management		
disease management		
soil-related fertility and conservation		80
irrigation		371
water management (non-irrigation)		28
climate mitigation or adaptation		343
marketing and distribution		43
post-harvest - handling and storage		762
value-added processing		3
other		107,781
total w/one or more improved technology		116,424
Disaggregates Not Available		
Others	0	NONE

Comment: This is an Objective 1 indicator and at annual reporting time the numbers are divided up between USAID India (Bihar, EUP and Odisha) and USAID Washington (non-priority geographies). For this semi-annual report, targets and actuals are not disaggregated, but will be disaggregated for the annual report. The numbers reported above do not include any numbers from Haryana, and do not capture full Rabi or Kharif seasons, and therefore may appear low compared to the targets.

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

Current Selection		
Reporting Organization : USAID		
Indicator / Disaggregation	2015	
	Target	Actual
4.5.2(7): Number of individuals who have received USG supported short-term agricultural sector productivity or food security training (RIA) (WOG)	15,000	
Type of individual		6,560
Producers		5,546
People in government		515
People in private sector firms		154
People in civil society		77
Disaggregates Not Available		268
Sex		6,560
Male		5,016
Female		1,544
Disaggregates Not Available		

Comment: This is an Objective 1 indicator and at annual reporting time the numbers are divided up between USAID India (Bihar, EUP and Odisha) and USAID Washington (non-priority geographies). For this semi-annual report, targets and actuals are not disaggregated, but will be disaggregated for the annual report.

4.5.2(11): Number of food security private enterprises (for profit), producers organizations, water users associations, women's groups, trade and business associations, and community-based organizations (CBOs) receiving USG assistance

Current Selection		
Reporting Organization : USAID		
Indicator / Disaggregation	2015	
	Target	Actual
4.5.2(11): Number of food security private enterprises (for profit), producers organizations, water users associations, women's groups, trade and business associations, and CBOs receiving USG assistance (RIA) (WOG)		
Type of organization	1,500	1,963
Private enterprises (for profit)		1,856
Producers organizations		42
Water users associations		4
Women's groups		12
Trade and business associations		9
Community-based organizations (CBOs)		23
Disaggregates Not Available		17
New/Continuing		1,963
New		464
Continuing		1,499
Disaggregates Not Available		

Comment: This is an Objective 1 indicator and at annual reporting time the numbers are divided up between USAID India (Bihar, EUP and Odisha) and USAID Washington (non-priority geographies). For this semi-annual report, targets and actuals are not disaggregated, but will be disaggregated for the annual report. This indicator captures the number of CSISA's service providers, which steadily climbs. Therefore, we have already exceeded our target for this indicator.

4.5.2(12): Number of public-private partnerships formed as a result of FTF assistance

Current Selection		
Reporting Organization : USAID		
Indicator / Disaggregation	2015	
	Target	Actual
4.5.2(12): Number of public-private partnerships formed as a result of FTF assistance (S)	6	15
Agricultural production		3
Agricultural post harvest transformation		1
Nutrition		1
Multi-focus		5
Other		5
Disaggregates Not Available		

Comment: This is an Objective 1 indicator and at annual reporting time the numbers are divided up between USAID India (Bihar, EUP and Odisha) and USAID Washington (non-priority geographies). For this semi-annual report, targets and actuals are not disaggregated, but will be disaggregated for the annual report. Because ILRI has formed a significant number of new PPPs during the reporting period, this number has already exceeded its target.

4.5.1 (24): Number of policies/regulations/administrative procedures in each of the following stages of development as a result of USG assistance in each case: (Stage 1, 2, 3, 4, 5)

Current Selection		
Reporting Organization : USAID		
Indicator / Disaggregation	2015	
	Target	Actual
4.5.1(24): Number of agricultural enabling environment policies completing the following processes/steps of development as a result of USG assistance (S)		
Area	7	
Institutional architecture for improved policy formulation		
Enabling environment for private sector investment		1
Agricultural trade policy		
Agricultural input policy		2
Land and natural resources tenure, rights, and policy		
Resilience and agricultural risk management policy		4
Nutrition		
Other		
Disaggregates Not Available		
Process/Step	7	
Analysis		7
Stakeholder consultation/public debate		7
Drafting or revision		1
Approval (legislative or regulatory)		1
Full and effective implementation		
Disaggregates Not Available		
Total policies passing through one of more processes/steps of policy change		

Comment: This is an objective 5 indicator and at annual reporting time is submitted to USAID Washington.

4.5.2(39): Number of new technologies or management practices in one of the following phases of development: (Phase I/II/III)

Current Selection		
Reporting Organization : USAID		
Indicator / Disaggregation	2015	
	Target	Actual
4.5.2(39): Number of technologies or management practices in one of the following phases of development: (Phase I/II/III) (S)		
Phase 1 Number of new technologies or management practices under research as a result of USG assistance	30	88
Phase 2 Number of new technologies or management practices under field testing as a result of USG assistance	94	90
Phase 3 Number of new technologies or management practices made available for transfer as a result of USG assistance	65	66
Disaggregates Not Available		

Comment: This indicator covers Objectives 1, 2, 3 and 4 and at annual reporting time is reported to USAID Washington. Because many of the objectives indicate that technologies are still under research (perhaps while simultaneously being in other phases), the first Phase has exceeded its target.

Appendix C: Results Framework

Key Milestones	Oct 1, 2014 to Mar 31, 2015	Apr 1, 2015 to Sept 30, 2015	Period Three: Period three update in semi-annual report, May 2015
	Target at period end		
Objective 1. Widespread dissemination of production and postharvest technologies to increase cereal production, resource efficiency, and income			
Sub-objective 1.1. Implementation of a goal-oriented road map for transitioning existing hubs in Punjab, Haryana, Tamil Nadu, and Pakistan, and modalities for operationalizing new hubs in E. UP, Bihar, and Odisha			
1.1.1.1. Road map for transitioning existing hubs in Punjab, Haryana, Tamil Nadu, and Pakistan implemented.	Implement strategy and transition hubs so that no CSISA support is required by Jan. 2015. Strategy revisited and the merit of continued CSISA support evaluated.		The Punjab Hub will wrap up their final Phase II activities by supporting the ongoing work of a few graduate students. The Haryana Hub is now closed and the staff have shifted to Odisha to support that priority hub. The Tamil Nadu Hub is transitioning its work over to the government, university and NGO partners, and will cease operations by 30 Sept 2015.
1.1.2.1. Primary impact pathways for each hub domain defined to provide a goal-oriented road map that combines innovation, product development, and strategic partnerships.	Another 1 million farmers reached through change agents supported by CSISA's impact pathway logic. Impact pathway assumptions and efficacy re-assessed and adjusted (if needed) in advance of the Rabi and Kharif cropping seasons.		Kharif 2015 impact pathway documents were developed at the April 2015 planning & evaluation meeting for Bihar, Eastern UP, Odisha, and ILRI's cross-cutting work. The plans were then refined and finalized in the subsequent month.

Key Milestones	Oct 1, 2014 to Mar 31, 2015	Apr 1, 2015 to Sept 30, 2015	Period Three: Period three update in semi-annual report, May 2015
	Target at period end		
Objective 1. Widespread dissemination of production and postharvest technologies to increase cereal production, resource efficiency, and income			
Sub-objective 1.2. Participatory technology testing and adaptation for sustainable intensification			
1.2.1.1. Production and livestock feed technologies that address key knowledge gaps and specifically address the needs of women.	At least 10 adaptive research trials addressing prioritized knowledge gaps conceived and implemented in each hub, including 6 that meet women's needs during the principal growing seasons.		Targets exceeded in all hubs, with particular emphasis on trials relevant to the needs of women farmers conducted in the plateau of Odisha, Bihar, and in Nepal in maize-based systems where women play a dominant role in management.

1.2.2.1. Prioritized production and livestock feed technologies that have been tested and improved in the context of communities to match the needs of different regions, farmer groups, and women.	At least 25 participatory technology verification trials or demonstrations, and animal feed development groups active in at least 4 hubs, with innovative feed strategies defined and tested during principal growing seasons.	Targets exceeded in all hubs.
	Partial budget analyses of three key technology interventions conducted in each hub.	Target met, with emphasis on seed and mechanization technologies (e.g. DSR, ZT wheat, axial flow threshing, and reapers).
1.2.4.1. Strategies to overcome principal gender-differentiated causes of postharvest cereal losses in each hub domain.	Options to overcome primary causes of postharvest losses demonstrated to men and women in at least four hubs.	Targets met in Odisha, Bihar, Bangladesh, and Nepal
1.2.5.1. Strategies to overcome biophysical, socioeconomic, and policy-related constraints to farmer adoption of key production, livestock feed, and postharvest technologies.	Strategies to overcome adoption constraints implemented as part of the impact pathway-driven planning process.	Input (e.g. for seed, herbicide, machinery) and output (maize) markets strengthened to create an enabling environment for innovation.

Key Milestones	**Period Three**		
	Oct 1, 2014 to Mar 31, 2015	*Apr 1, 2015 to Sept 30, 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 1. Widespread dissemination of production and postharvest technologies to increase cereal production, resource efficiency, and income			
Sub-objective 1.3. Translating research into actionable products and insights			
1.3.1.1. Web and mobile-phone based applications to aid decision-making by men and women farmers at large scale but with context-specific information, including site-specific nutrient management for different crops, cropping systems, and regions.	New approaches, information sources, and decision guides implemented for existing decision tools in collaboration with partners.		Field trials comparing the Crop Manager recommendation with farmers' practices and state fertilizer recommendations were completed with rice in Odisha and Bihar. Results from nutrient omission plot trials have been compiled for use in developing the updated Crop Manager for wider deployment in mid 2015 in Bihar and Odisha. Nutrient Manager was evaluated in field trials in Tamil Nadu.
	At least three versions of Nutrient Manager (NM), NM Mobile, or Nutrient Expert (NE) software released, and demand-driven agronomic information and best practices provided in Bangladesh, India, or Nepal, and constraints to use assessed.		Pilot dissemination of Rice Crop Manager was initiated in Odisha. The promotion of the released Rice Crop Manager continued in Bangladesh. Results from field testing were used to improve beta versions of Crop Manager for rice-wheat in Bihar and eastern UP and rice in Odisha, prior to wider deployment in mid 2015.

1.3.2.1. Strengthened and diversified dissemination pathways for agricultural knowledge and technologies using traditional approaches and ICTs.	At least 10000 farmers and partners exposed to new technologies through community-based demonstrations, trainings, and at least 10 cross-hub exposure visits.	At the point of the semi-annual report, the training totals had reached 6,560. Trainees included farmers, service providers, extension agents, on conservation agriculture technologies, post-harvest technologies, crop establishment methods, and dairy cattle feeding strategies, among others.
	Instructional videos developed based on uptake assessment, and deployed to more than 700 villages; uptake following exposure to videos assessed.	Early sowing of wheat and ZT wheat produced for Bihar and EUP for dissemination through the government. Digital Green videos also produced on fungicide seed treatment in rice; nursery bed management in rice; benefits of chopped straw as fodder in dairy management; pest control in paddy cultivation; disease control in paddy cultivation; and drying and storage of paddy seeds.
	At least 25 new entries incorporated, and at least 10 hub staff and partners in each hub introduced to/updated on CKB.	A wide variety of Fact Sheets produced on topics ranging from better bet agronomy for maize, storage options, open drum threshers, axial flow pumps, maize stover, axial flow threshers, maize shelling, balanced feed for dairy cattle, direct seeded rice, and machine transplanted rice. CSISA also produced an operational manual for mechanical transplanting for rice. The 8 tips for rice intensification has also been produced in Nepali for CSISA-NP. All technical materials are uploaded onto the CSISA web site.
1.3.4.1. Identify and facilitate dissemination of superior dual-purpose rice, wheat, and maize breeding lines and hybrids in South Asia through breeding networks, farmers, and fodder traders.	High-performing dual-purpose rice, wheat, and maize promoted through breeding networks, seed companies, fodder traders, and for demonstration in hubs.	Two dual-purpose maize hybrids have been promoted in the Bihar and Odisha hubs. One of the hybrids NK 6240 was on par in grain yield with the best other hybrids in the hubs but had by far the highest digestibility. In these farmer trials digestibility varied - cultivar dependent - from 45 to 55%. Fifty lines of wheat cultivars suitable for semi-arid areas from Bangladesh and India were analyzed for straw quality and straw - grain relationships. Across all sites, cultivar-dependent variations in straw quality were relatively small, while within sites differences in digestibility of about 5% units were observed.
	Advanced rice lines with superior 'dual purpose' traits subjected to multi-locational testing across CSISA's prioritized production ecologies.	A total of 163 rice cultivars were investigated for rice straw fodder quality traits. Livestock nutritionally highly significant variations were observed between cultivars. Broadsense heritability for key fodder quality traits were about 0.4. Differences in digestibility between cultivars ranged from about 5 to 10% units.

	Heat and disease-resistant maize cultivars with superior grain and stover yields, and good fodder quality promoted with input from partners and national programs including through the IMIC network.	Urea-treated maize stover trials conducted on 6 dairy farmers in four districts of Bihar (Samastipur, Muzaffarpur, Begusarai and Vaishali) showed promising results. The farmers fed an average of 8.33 kg wheat straw/bhusa to their dairy animals as per quantity of milk production. When the wheat straw/bhusa was replaced with urea-treated maize stover, the average dry fodder intake, milk yield, fat% and SNF% increased by 4.08, 16.22, 5.09 and 2.51 per cent; respectively while concentrate feed requirements declined by 9.26 per cent. The results from experimental trials thus suggest that cost of milk production can be reduced by feeding urea treated maize stover (INR Rs. 2.00) in lieu of traditional wheat straw/bhusa (INR Rs. 5.00) while increasing income from milk sales due to higher milk quantity and quality and lower concentrate feed input costs. The urea-treated maize stover also showed better voluntary intake, palatability and digestibility without affecting the milk production, health and reproductive performance, as well as higher dry matter intake and milk production in animals fed with urea-treated stovers compared to untreated maize stover.
1.3.5.1. Business models targeting men and women entrepreneurs for sustaining change through private enterprise and investment.	At least 5 business models developed or strengthened; 2 new types of businesses initiated or existing ventures strengthened by SMEs in hubs; challenges to business development addressed as possible.	In lieu of generic business models, CSISA has focused on training in business development services (e.g. marketing, record keeping, etc.) for service providers as well as business strengthening through market development for dealers and input providers.

Key Milestones			**Period Three**
	Jun 2014	*Jan 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 1. Widespread dissemination of production and postharvest technologies to increase cereal production, resource efficiency, and income			
Sub-objective 1.4. Mobilizing partnerships for catalyzing impact at scale.			
1.4.1.1. Advisory committees and partnerships to help define research and development directions, link other players to hub activities, and promote CSISA technologies and out-scaling methodologies.	TWG, AIC meetings held in each hub to revise workplans in light of learning and new partnership opportunities.		Partnership funds continue to be disbursed and used for strategic research by key partners such as Bihar Agriculture University, Banaras Hindu University, Orissa University for Agriculture and Technology, Krishi Vigyan Kendras, and Indian Council for Agricultural Research.
	At least 5 major partnerships established or strengthened each year in the priority hubs with support from the TWG/AIC.		Partnership funds disbursed through the AIC for another year to Bihar Agricultural University, Banaras Hindu University, and VASFA (NGO in Bihar). Directed funding to OUAT for scholarship and research infrastructure development. New collaborative work in Bangladesh supported through BRRI, BARI, and Department of Fisheries.

Key Milestones	Period Three		
	Jun 2014	*Jan 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 1. Widespread dissemination of production and postharvest technologies to increase cereal production, resource efficiency, and income			
Sub-objective 1.5. Strategic capacity development to support key agents of change.			
1.5.1.1. Capacity development for men and women CSISA staff and public and private sector partners/actors to play leading roles in accelerating impacts at scale for farmers.	Trainings for hub staff and partners conducted, with modules on participatory technology development, user-driven communication strategies, gender in agricultural development.		Trainings and guidance continue to be imparted through our semi-annual evaluation & planning meetings along with direct mentorship through field visits by visiting scientists (e.g. comms team, gender expert, etc.) as well as by Objective leadership team. Specialized trainings on data management, statistical analysis, and communications tools are held on a periodic basis.
	Leadership course conducted for at least 20 women engaged in agricultural research, development, and extension.		SHG leaders trained and mentored in Bihar and Odisha.
	Training course with modules covering at least 5 animal husbandry topics conducted for staff and partners at prioritized hubs.		Some 70 training sessions have been implemented in CSISA hubs in India (Bihar and Odisha), Bangladesh and Nepal on crop residue-based feeding practices and supplementation with home-made concentrate feed and mineral mixtures, with at least 6,000 farmers participating, of which about one-fourth are women. Extension materials such as 4 videos (1 on home-made concentrated feed preparation, 1 on benefits of feeding urea treated maize stover, and one each on benefits of feeding chopped paddy straw and maize stover) have been prepared for disseminating information about these practices to a wider audience. Continued collaboration with scaling partners such as NABARD, COMFED and OMFED, livestock agencies (Odisha Dept. of Animal Husbandry), and livestock research institutes (Bangladesh Livestock Research Institute) has contributed in this process.
	Demand-driven trainings conducted for at least 300 local service providers to improve mechanized, better-bet agronomy and business development skills for new and existing entrepreneurs.		As of the semi-annual report, formal trainings held specifically for service providers had reached 135 service providers on topics such as zero tillage and early sowing of wheat, axial flow threshers. However, the number of service providers continues to grow, and reaches over 1,700 now for services such as zero tillage, machine transplanted rice, laser land leveling and axial flow threshing.
	Two exams administered to about 100 and 250 agro-dealers, student performance reviewed, and successful candidates certified.		Activity deferred due to a lack of an accrediting partner.

1.5.3.1. Next generation of cereal systems scientists and development professionals, especially women, strengthened.			Student research on-going through a strong mix of national (e.g. OUAT, RAU, BAU) and foreign (e.g. University of Nebraska, Wageningen University, University of Illinois) institutions.
	Training modules developed and short-term advanced courses conducted for hub staff (including animal husbandry) and at least 75 young male and female scientists.		Short courses conducted on statistical analysis of agronomic data, socio-economic research methods, and geo-spatial analysis. Courses attended by staff and scientists from partner organizations.
	At least 30 interns (30% female) placed in CSISA hubs and partner institutions.		3 interns (including 1 female) were placed in India during Oct 2014 - Mar 2015.
Key Milestones	**Period Three**		
	Oct 1, 2014 to Mar 31, 2015	*Apr 1, 2015 to Sept 30, 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 2. Crop and resource management practices for future cereal-based systems.			
2.1.1. Optimized cereal-based cropping systems based on performance assessments of new and current technologies that are optimized for productivity, resource efficiency, and GWP.	Four research platforms continued; contributions of cereal residues to livestock, soil quality and livelihoods analyzed; comparative performance of the optimized systems assessed.		Out of four research platforms established in phase-I, three continued (Karnal and Patna in India and Gazipur in Bangladesh) in Phase-II, with some adjustment in futuristic scenario (Scenario 4) at Patna and Gazipur Platforms. In addition, a new strategic research platform was established in Phase-II at Odisha University of Agricultural and Technology, Bhubaneswar. Changes in soil quality parameters from these platforms analyzed and multiple manuscripts have been prepared which are either under internal review or communicated for publication. Maize and rice crop residues have been analyzed and cultivars that are high yielding as well as with good quality residues have been identified.
	In collaboration with NARES partners, CA-based systems evaluated with process-based research trials that will lead toward system refinements.		On-farm and on-station processed-based research trials were conducted in collaboration with NARES (ICAR institutes, BRRI/BARI, and SAUs) partners in respective hub domains. Appropriate solutions including optimum time of sowing/transplanting, cultivar selection, diversification options, precision nutrient management and irrigation scheduling, integrated weed management, climate smart practices including strategies to address terminal heat stress in wheat, identifying entry point for bridging existing yield gaps in cereal crops, GIS and crop modeling approaches, have been identified to optimize/refine systems leading to sustainable intensification of cereal-based systems

2.2.1. Models for assessing cropping system performance under different agro-ecological conditions and climate-change scenarios.	Apply improved validated crop-livestock systems models to exploring new cropping systems and crop management options for at least 4 hubs		Field scale simulation studies conducted to study the impact of diversifying Kharif rice with Kharif maize in NW India and Rabi season wheat with Rabi-season maize in the eastern IGP on crop/water productivity, water balance and resource use efficiencies under different management scenarios and monsoon rainfall scenarios. Within rice, the impact of rice crop establishment methods, transplanting/direct seeding time of planting, cultivars and their duration, irrigation scheduling, fertilizer time were simulated to assess their impact on irrigation water requirement and crop performance using local climate and soil data. To validate these simulation results, field experiments have been established at different sites. MODIS data analysis was done to know the variability in crop types, current farmers practices (rice transplanting and Rabi sowing dates, variety duration etc.), inter-annual and intra-seasonal dynamics of crop productivity in Bihar. From this remote sensing analysis, targeted areas for different technologies to increase the productivity, were identified
2.3.1 Platform trials are adjusted to incorporate key knowledge gaps identified from on-farm adaptive research and technology verification trials. New insights developed at the platforms informs the design of on-farm trials for multi-locational testing.	Joint planning and evaluation meetings held between Objective 2 and Objective 1 teams twice a year.		Dedicated objective 2 meeting was held on 9-10 October 2014 to review and plan strategic research activities for Rabi-season 2014-15. Participants were from India and Bangladesh participated including national partners involved in objective 2 as well as key high-level NARES officials. Another objective 2 meeting, which was supposed to happen in May 2015 was cancelled due to natural disaster in the form earthquake on April 25, 2015 in Kathmandu. However, planning for respective hub were done for Kharif season in consultation with local team in each hub domain area.
Key Milestones	**Period Three**		
	Oct 1, 2014 to Mar 31, 2015	*Apr 1, 2015 to Sept 30, 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 3. High-yielding, heat- and water-stress-tolerant rice varieties for current and future cereal and mixed crop-livestock systems.			
3.1.1. Next generation of elite rice lines with increased yield potential, improved grain quality, and superior feeding value, heat tolerance released.	HYP and high fodder quality lines/hybrids evaluated in CSISA hubs and AICRIP; genotypes identified and intercrossed to develop new breeding populations; predictive models based on empirical data and apply on diverse breeding populations.		Many new breeding lines with better plant type and high yield potential are in advanced stage of testing in AICRIP and state trials of different provinces like Punjab, Uttarakhand, Bihar, Odisha, Karnataka and Tamil Nadu. More than 30 new breeding lines with high grain yield potential and better straw digestibility (IVOMD of > 45 %) traits were identified.

3.2.1. Rice for mechanized direct seeding and water-saving irrigation practices developed and released.	Male sterility-facilitated recurrent selection used to improve germplasm for DSR; QTLs for efficient water and nutrient uptake root traits mapped; pyramided Pup1/AG lines evaluated in on-farm trials.	An array of breeding lines with early stage seedling vigor, better plant type and high yield potential under DSR were developed and shared with NARES partners. Many lines are in country-level or provincial-level multi-location testing program. Many QTLs for efficient water, nutrient uptake and root traits have been identified. Many Sub1 and AG1 lines were developed and AG lines were tested at NARES sites. IR 64 AG1-Sub1-Pup1 line has been developed.
3.3.1. At least two heat-tolerant rice varieties nominated for national varietal testing.	Near-isogenic mega-variety, heat tolerant lines developed and evaluated; inbred lines for HDT generated; mapping populations developed for identifying HNT tolerance QTL; at least 10 elite breeding lines evaluated at 5 sites.	IR 64 NILs with high day temperature tolerance were developed and are being evaluated at Hyderabad and Coimbatore. Many heat tolerant lines were developed and a few are in advanced stage of multi-location testing in India and Bangladesh. IR 64 NILs with EMF was developed. A mapping population consisting of 297 F9 lines were developed.
Key Milestones	*Oct 1, 2014 to Mar 31, 2015* / *Apr 1, 2015 to Sept 30, 2015* — **Target at period end**	**Period Three** **Period three update in semi-annual report, May 2015**
Objective 4. High-yielding, heat- and water-stress tolerant, and disease-resistant wheat varieties for current and future cereal and mixed crop-livestock systems.		
4.1.1. Improved early, medium, and normal-maturing bread wheat varieties for heat- and water-stressed environments.	30 lines tested; at least 200 breeding populations selected; new crosses made; 5 best lines evaluated under CA in multi-location yield trials; at least 3 new varieties released by NARES and private-sector partners.	Achieved through 145 bread wheat trials consisting of >1000 advanced lines planted across 40 locations in South Asia in 2014-15 cycle. More than 2000 new crosses made and >20000 breeding populations selected. Superior lines evaluated under CA in multi-location trials. Ten new wheat varieties were released, seven identified for release while more than 1900 promoted to national/state/regional trials.
4.2.1. Spot blotch-resistant wheat germplasm and molecular markers for resistance to the disease.	Resistance to spot blotch characterized; 3 RIL/DH populations phenotyped/genotyped; resistance genes and robust flanking markers identified	Resistance to spot blotch characterized by evaluating around 2000 genotypes at Mexico. In addition, 2500 lines were characterized by collaborators in South Asia. Four RIL mapping populations were again phenotyped. Genotyping done. Mapping results obtained with flanking markers.
4.3.1. Improved heat and drought tolerance in wheat.	Genetic resources for heat and drought tolerance screened; genomic regions most likely to provide candidates for marker-assisted selection identified.	A panel of new advanced lines comprising high yield and/or biomass characterized based on strategic crosses to combine complementary source-sink traits. Lines with suitable physiological traits providing adaptation to heat and drought stress were determined. Mapping results provided genomic regions for marker assisted selection.
Key Milestones	*Oct 1, 2014 to Mar 31, 2015* / *Apr 1, 2015 to Sept 30, 2015*	**Period Three** **Period three update in semi-annual report, May 2015**

	Target at period end	
Objective 5. Improved policies and institutions for inclusive agricultural growth		
5.1.1. Improved policies and incentives that encourage private investment and public-private partnerships in pro-poor technology development and delivery.	At least 2 examples of changed policies related to input use can be plausibly connected to CSISA policy efforts.	Analysis and recommendations communicated by CSISA to key government officials, policy advisors, corporate decision-makers on: seed systems in Bangladesh and Nepal; input subsidies in India; agricultural R&D priorities in India; and financial risk management and private investment opportunities in eastern Indian agriculture sector.
5.2.1. Improved policies and incentives that address changing labor, gender, assets, and migration dynamics related to pro-poor technology development and delivery.	Gender recommendations communicated to key decision makers.	Analysis and recommendations communicated by CSISA to key government officials, policy advisors, and research partners on: role of gender and female social networks in technology adoption.

Key Milestones	Period Three		
	Oct 1, 2014 to Mar 31, 2015	*Apr 1, 2015 to Sept 30, 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 6. Project management, data management, communication, evaluation, and decision support.			
Sub-objective 6.1. Project management			
6.1.1.1. Effective and efficient project management.	Hold monthly and quarterly meetings with CSISA objective leaders and institutional partners; biannual meetings with advisory and investment committees, annual forum with key NARES representatives from across S. Asia.		CSISA Management Team meetings held approximately monthly, and planning & evaluation meetings held seasonally, for Kharif and Rabi seasons. Now that we are in the planning stages for Phase III, additional meetings have been held with sub-sets of our management team to plan for the proposal.

Key Milestones	Period Three		
	Oct 1, 2014 to Mar 31, 2015	*Apr 1, 2015 to Sept 30, 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 6. Project management, data management, communication, evaluation, and decision support.			
Sub-objective 6.2. Data management and communication			
6.2.1.1. Standardized data collection across project, minimum data set characterized by consistent metadata schema for ease of reuse, data easily retrievable, mined across project.			Surveybe now available for use by socioeconomic and agronomic staff in Delhi as well as at the priority hubs. ODK used to capture data on trainings, service providers, input dealers, and agronomic trials and demos. Data manager circulates to hubs to train staff on data management, standardized file naming, data backup, and other components of the SOPs.

6.2.1.2 Key CSISA datasets made widely available through public access data repositories.	Important CSISA datasets are updated every quarter into publically available data repositories as a regular business practice for the project.	Dataverse, AgTrials, and the CSISA website used as public repositories and dissemination portals for most important CSISA datasets.
6.2.2.1 Improved communication across project personnel and locations, shared learning, record of project, and accountability, improved PR and dissemination of information about CSISA.	Continued maintenance of communication platform and web site.	CSISA has continued to use and improve its primary communication mechanisms: the internal newsletter, the external newsletter, our web site and our reports. We are also investing more resources into strategic videos in order to reach wider audiences more effectively.

Key Milestones	**Period Three**		
	Oct 1, 2014 to Mar 31, 2015	*Apr 1, 2015 to Sept 30, 2015*	**Period three update in semi-annual report, May 2015**
	Target at period end		
Objective 6. Project management, data management, communication, evaluation, and decision support.			
Sub-objective 6.3. Project evaluation of outcomes and impacts			
6.3.1.1. Comprehensive assessment and continual refinement of project processes, outcomes, and impacts, with lessons learned incorporated and communicated to partners, donors, and stakeholders.	At least 1 qualitative case study and 1 quantitative impact assessment conducted in each hub, disaggregated key indicators uploaded, adoption and impact of interventions assessed in baseline survey HH, implications from these reported to stakeholders.		CSISA uses a variety of mixed methods to capture data for its indicators and for its semi-annual and annual reports. Seasonal and monthly refinement of hub-based impact pathways facilitates regular evaluation of our approach, our outputs and our outcomes.