Cereal Systems Initiative for South Asia Phase III

Semi-Annual Report April 2018

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Acronyms and Abbreviations

Acronym	Full Name
AAS	Agricultural Advisory Services
ADS	Agriculture Development Strategy
AIRN	Agriculture Inputs Retailers' Network
AMTRC	Agricultural Machinery Testing and Research Center
BARI	Bangladesh Agriculture Research Institute
BRRI	Bangladesh Rice Research Institute
CE	Choice experiments
CIMMYT	International Maize and Wheat Improvement Center
CSISA	Cereal Systems Initiative for South Asia
CSISA-MI	Cereal Systems Initiative for South Asia-Mechanization and Irrigation
DADO	District Agriculture Development Office
DAS	Days after sowing
DAE	Department of Agricultural Extension
DFTQC	Department of Food Technology and Quality Control
DSR	Direct-seeded rice
fb	Followed by
FtF	Feed the Future
GIS	Geographic information systems
HRS	Healthy rice seedlings
HW	Hand-weeding
iDE	International Development Enterprises
IFPRI	International Food Policy Research Institute
IRRI	International Rice Research Institute
KISAN	Knowledge-based Integrated Sustainable Agriculture and Nutrition
LCM	Latent class model
MNL	Multinomial logit
NARC	Nepal Agricultural Research Council
NARES	National Agriculture Research and Extension System
NGO	Non-governmental organization
NSAF	Nepal Seed and Fertilizer project
PERSUAP	Pesticide evaluation report and safer use action plan
PMAMP	Prime Minister's Agriculture Modernization Project
PNM	Precision nutrient management
PQR	Premium quality rice
RARS	Regional Agricultural Research Station
USAID	United States Agency for International Development

CSISA Phase III

Context, Approach, and Theory of Change

Following the food price crisis of 2007–8, agricultural research and development efforts in South Asia have received considerable public, private sector, and donor investment, particularly in the relatively impoverished areas of the Eastern Indo-Gangetic Plains. Nevertheless, re-investments in agriculture have been less adept at supporting transformative change than was originally envisaged. While progress has been made in addressing some of the systemic weaknesses that contribute to low rates of rural growth, many persist:

- **Research organizations** narrowly construe their mandates and are only partially oriented towards the clients of research outputs;
- **Extension** primarily focuses on single technologies or generalized 'packages of practices' that are not underpinned by rigorous field evaluations that lead towards better targeting;
- **Livelihoods** initiatives do a commendable job of reaching underserved communities, including women farmers, but rarely have the technical competence to match their reach;
- The **private sector** – although learning quickly – lacks deep experience in the emerging markets in the region along with the types of location intelligence that can steer engagement;
- **Small entrepreneurs** generally lack access to support services, both business development and technical;
- Progressive **policies** ostensibly support farmers, but just as often impede private investment;
- **Cooperation across organizations** in the agricultural research-for-development space is, in most cases, limited.

Layered onto these dynamics are the risks inherent in cropping in areas where weather patterns are erratic, water resources are poorly developed, heat stress is a binding constraint, and timely field operations are often compromised by a diminishing supply of rural labor. Despite these shortcomings and production challenges, there is considerable promise that the many individual strengths within the innovation system[1] in South Asia can be marshaled and coordinated to spur and sustain transformative change.

With support from the Bill & Melinda Gates Foundation and U.S. Agency for International Development, the Cereal Systems Initiative for South Asia (CSISA) has worked as an eco-regional initiative to support agricultural development in South Asia since 2009. **CSISA's aim is to use sustainable intensification technologies and management practices to enhance the productivity of cereal-based cropping systems, increase farm incomes, and reduce agriculture's environmental footprint**[2]. As a science-driven and impacts-oriented initiative, we reside at the intersection of a diverse set of partners in the public and private sectors, occupying the 'messy middle' where research meets development. By engaging with a network of partners,

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[1] The World Bank (2012) defines innovation systems as '…. a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance.

[2] 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.'

CSISA is built on the premise that transformative development typically requires not one single change, but the orchestration of several.

In **Phase III** (2015–20), CSISA places emphasizes ensuring that partners in the public and private sectors are better poised to contribute to change on a sustaining basis by addressing areas of systemic weakness (as listed above). By addressing these areas and fostering new connections and collaborative efforts across the innovation system, CSISA will seek to mainstream elements of our approach and to ensure a successful exit at the termination of Phase III.

CSISA Phase III pursues four **inter-linked primary outcomes**:

1. Widespread adoption of sustainable intensification technologies and management practices in South Asian cereal systems
2. Mainstreaming innovation processes into the programming of national, state, and district-level government institutions in order to improve the impacts achieved with current and future investments in agricultural R&D
3. Generating critical knowledge and research-based products that will support technology scaling and impact generation
4. Improving the policy environment to support sustainable intensification, prioritizing scaling up work with national partners to address policy constraints and improve the policy environment for realizing sustainable intensification futures in CSISA's target geographies.

Major Activities and Accomplishments

BANGLADESH

- Funding shortfalls and delays presented significant challenges to the implementation of CSISA activities in Bangladesh in 2017–18. Several partner organization contracts and staff members had to be terminated, and a number of activities were drastically reduced to cope with the lack of fund distribution. Despite these challenges, CSISA was able to accomplish a number of work goals, with strong outcomes for research on **directly sown rice, integrated weed management, deploying decision making and behavioral science to better understand farmers' interests and risk aversion to cropping systems intensification, and methods to mitigate the threat of wheat blast**.
- **Promising weed control strategies for labor- and water-saving directly sown rice** have been identified on a preliminary basis, although further funding and support are required for planned validation experiments in August 2018.
- A number of viable agronomic strategies that can be employed by farmers to mitigate the wheat blast (*Magnaporthe oryzae* pathotype *triticum*) fungal disease were validated in a second year of field and laboratory experiments in partnership with the Bangladesh Agricultural Research Institute (BARI), though low disease pressure conditions in early 2018 indicate that a subsequent year of field trials would be of use in assuring consistency in our research results. **Two promising candidate low-toxicity and PERSUAP-approved fungicides were reconfirmed as being effective in reducing wheat blast incidence and severity at the field scale**. Based on these findings, CSISA and BARI are actively working with partners and wheat farmers in blast-affected areas to advise on how to safely and effectively administer fungicides to reduce disease pressure.
- Following on the successes reported in the previous CSISA annual report, CSISA has continued to support BARI in efforts to popularize the **wheat blast-resistant and zinc-**

enriched wheat variety 'BARI Gom 33' through awareness raising and technical support efforts. BARI Gom 33 seed is being multiplied by BARI with CSISA's technical advice in the current wheat season; seed will be distributed to farmers at a larger scale in late 2018 so that farmers can multiply and grow the seed in the 2018–19 winter season.

- Despite suspending activities promoting the use of healthy rice seedlings in mid-2017 due to budget delays, follow-up studies of rice farmers who participated in CSISA rural educational video screenings and training events on healthy rice seedlings during the 2017 monsoon season shows that large numbers of farmers have continued to use healthy rice seedling techniques in the 2017–18 winter *boro* rice season. An estimated **51% of the 17,736 farmers who engaged in video shows and trainings in the monsoon season on healthy rice seedlings have continued to use these better-bet agronomic management techniques to grow yield-raising seedlings on more than 4,700 hectares in the winter season**. Crucially, this has continued on an independent basis with no intervention from CSISA.

- CSISA completed choice experiments to better understand **farmers' preferences for crop intensification practices in areas of coastal Bangladesh where farmers typically fallow their land during the dry season**. Resulting data provide strong evidence of farmers' interest in growing alternative crop species in consideration of market and agronomic production risks. Further data analysis is underway to unpack which types of farmers are more likely to prefer different crops and crop combinations. These results will be fed back to policy makers and extension partners working in coastal Bangladesh prior to the upcoming winter 2018–19 season, thereby allowing CSISA's partners to better target and fine-tune advisories and messaging in light of farmers' risk preferences and profiles.

- Large numbers of farmers continue to grow **premium quality rice varieties on more than 29,000 hectares in Bangladesh's Feed the Future Zone**, while also benefiting from the direct marketing networks and value chains developed by CSISA in previous years of the project. These observations indicate that CSISA's pioneering popularization of PQR varieties in partnership with the Bangladesh Rice Research Institute and other national partners is having an important and durable effect.

- Responding to demand for training in the use of geographic information services (GIS) and spatial analysis from national research partners and students within Bangladesh, **CSISA released a book entitled 'Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh.'** It provides a set of learning modules introducing young scientists and researchers to GIS and spatial analysis using the open-source QGIS platform, and complementary R, SAGA and GRASS Platforms. The 13 learning modules in the book can be used for self-directed learning or to teach courses. Exercises on how to produce aesthetically pleasing and informative maps are also included. By the time students complete working with these modules, they should be proficient in QGIS and spatial data analysis, and able to continue using these tools on an individual basis without considerable extra coaching.

- **Integrated weed management** activities under CSISA in Bangladesh were challenged this year as a result of delayed funding and budget cuts. The project was unable to maintain a number of key staff who have been instrumental in integrated weed management research, extension, and scaling. But despite these challenges, CSISA persevered and has continued to conduct research by leveraging partnerships with the Bangladesh Rice Research Institute (BRRI). As a result of the comprehensive research conducted by BRRI in partnership with CSISA, the project initiated work with herbicide companies/dealers to investigate the potential for making these herbicide molecules (mefecenat + bensulfuron methyl, bispyribac sodium, and penoxsulam) available to farmers through commercial pathways following verification and approval of PERSUAP status.

NEPAL

- Due to funding uncertainty for FY18, we have significantly reduced our field staff and project activities. However, we have retained a strong focus on providing **strategic support for the government-led Prime Minister's Agriculture Modernization Project (PMAMP)**, both at the local and central levels, to meet their ambitious agricultural development, research and extension goals, and to generate scientific evidence. During the reporting period, CSISA has helped the PMAMP leadership convene the first national forums for maize, wheat, rice, and mechanization that united public, private, and civil society organizations towards common goals and enhanced collaborations required to reach them.
- CSISA has also provided **PMAMP staff technical guidance** on seasonal activity planning and facilitated cross-learning events and 'trainings of trainers' on how to prioritize, correctly implement, and to scale sustainable intensification technologies. As part of this approach, CSISA has equipped PMAMP staff with a host of training materials and extension materials, including simple 'tips' extension guides, training videos, and key messaging for social marketing platforms such as FM radio.
- Data from CSISA's household survey conducted in the western Terai indicate that, **for rice production in the Terai, there is about a 3 t/ha yield gap and >US$ 500/ha profit gap** in current production systems. The major yield limiting factors to rice intensification are the lack of irrigation facilities, paucity of N and P fertilizer, and late transplanting dates. By documenting 'bas of the pyramid' investments, CSISA is helping the PMAMP and other partners set the right investment priorities for extension and technology scaling.
- Rice production largely depends upon the onset and cessation of the monsoon as > 70% rice is grown under rainfed conditions. In this context, CSISA analyzed the long-term rainfall trend (1976–2014) from 72 weather stations, finding that **rainfall during the rice season is highly variable and there is a 19% probability of drought**. There is strong correlation between rainfall variability and rice grain yield, such that <1,700 mm of rainfall during the rice growing season is correlated with a 17% yield reduction in rice.
- To understand farmers' perceptions regarding the constraints and opportunities for direct-seeded rice (DSR), a technology that assists farmers cope with a weak onset of the monsoon, CSISA conducted a **survey of DSR adopters** in its working districts in the Nepal Terai. Factors identified as disincentives for DSR adoption included weed pressure and the unavailability of herbicides, seeding machinery and skilled service providers. The driving forces of DSR adoption included the elimination of the need for seedling raising and transplanting, low field preparation and crop establishment costs, greater opportunity for timely crop establishment, reduced drudgery and labor requirements, higher profits and no yield reduction.
- In collaboration with the government-led Maize Super Zone program and machinery traders, CSISA provided hands on-training on the operation of the seed drill and power weeder for potential service providers and technicians from the Super Zone and traders in order to help increase mechanization in maize production. The use of a seed drill for seeding and a weeder for earthing up and weed management reduces cultivation costs by 50% compared to current farmers' practice. **With CSISA's facilitation, more than 200**

ha of maize were seeded using a seed drill and service provision in new areas in this reporting period.

- Aflatoxin contamination of food staples is widespread in Nepal, posing both long-term health threats and near-term harm to nutritional outcomes. Although many efforts have been made to characterize the problem, few have offered practical solutions on how to mitigate this issue at the agriculture and nutrition interface. CSISA and the Department of Food Technology and Quality Center (DFTQC) assessed aflatoxin levels in maize and how these levels change with improved agronomy and post-harvest management. Research found that the pre-harvest aflatoxin level can be minimized through better fertilizer management and **post-harvest aflatoxin levels can be dramatically reduced by taking maize grain off the cob and sun drying the grain before storage**. The latter intervention also aligns with CSISA's emphasis on scale-appropriate mechanization solutions for smallholders.
- By programming across the value chain and supporting service providers, machinery importers, and government partners by encouraging public-private partnerships, CSISA's ongoing support for reaper-harvester sales has led to over **2,200 machines purchased that are providing harvesting services on over 11,000 hectares of rice and wheat to date**. In 2014, this technology was not present in Nepal and has only emerged with the support of CSISA.

POLICY

- CSISA has been able to generate evidence to support efforts for **increasing the scope and reach of agricultural risk management** throughout the region. In particular, CSISA generated the first field-level evidence on the efficacy of an innovative risk management tool that bundles a novel index insurance product with a yield-enhancing (specifically, reducing yield variability) stress-tolerant rice variety. Additionally, CSISA demonstrated how having insurance generates both ex ante risk mitigation effects as well as ex post income effects, resulting in an expansion in area under higher-value crops and increased investments in modern agricultural inputs during the monsoon season, and more intensive rice production and higher rice productivity during the subsequent dry season.
- CSISA co-organized a high-level **regional stakeholder engagement** to discuss country- and state-level experiences with crop insurance. The goal of the workshop was to provide a platform whereby experiences and ideas can be shared among various stakeholders and across disciplinary and geographic boundaries, all for the enhancement of rural livelihoods in South Asia.
- Many activities have been suspended during the current reporting period as a result of continuing uncertainty in project funding. In particular, activities around seed systems and markets and mechanization have effectively been reduced to nil, though activities around seed systems can be reinvigorated if there is renewed interest and more assured funding to support these activities.

***Note**: This report reflects a 6-month period when the project's funding became both uncertain and delayed. At one point, it appeared that funding would be dramatically reduced and possibly eliminated. As a result, most of the activities were thereafter suspended or shrunk as we wait to see if funding for FY18 becomes available. This report reflects that status.*

A. Innovation Toward Impact

A.1 Reducing Risk to Facilitate Uptake of Sustainable Intensification Practices

A.1.1 Directly-sown rice to address labor and energy constraints to precision rice establishment

Dry direct-seeded rice (DSR) is an innovative approach to rice crop establishment to overcome labor scarcity problems increasingly faced by farmers who would typically manually transplant rice. DSR can reduce production cost and save water, although widespread adoption by farmers is challenged by a number of agronomic constraints. Competition from weeds in particular is a major problem in DSR. In comparison to hand transplanting into flooded soils, in which rice seedlings are taller and older than weeds and thus have a competitive growth advantage, in addition to the weed suppressive advantages accrued from flooding the field, DSR is sown from seed into dry fields. As a result, weed management is a considerable challenge that necessitates a change in farmers' management practices. Most farmers using DSR control weeds by using herbicides, but knowledge of best-bet, less environmentally damaging, and affordable herbicides for weed flora encountered in DSR fields in Bangladesh is limited.

CSISA evaluated different DSR weed control techniques in six farmers' fields in the monsoon rice season beginning in August 2017. The weed control options included a combination of new classes of herbicides – pendimethalin (pre-emergence herbicide), bispyribac sodium or penoxsulam (post-emergence herbicide) – and hand weeding, each compared to farmers' typical management practices (only hand weeding) in DSR.

Use of pendimethalin at two days after seeding (DAS) followed by bispyribac sodium at 20 DAS followed by one hand weeding at 40 DAS reduced labor requirements to grow the rice crop by 134 person-days/ha, saved weeding cost by US$ 655/ha. It also increased grain yield by 1.1 t/ha compared with farmers' weed management practices (three hand weedings at 15, 30, and 45 DAS, see table below). Other weed control options except for the use of pendimethalin followed by four subsequent hand weedings compared with farmers' weed management practices significantly reduced labor and costs, but gave similar results in terms of grain yield. A comprehensive conclusion on the best weed control option requires reconfirmation of these results through the continuation of the study for at least one more season, although we are currently unsure about our ability to continue the study due to the lack of funding available to CSISA at this time.

Table 1. Grain yield, labor use, and weeding cost in different weed control options for directly sown rice in August 2017. DAS = Days after sowing. HW = Hand weeding. fb = followed by

Weed control options	**Yield (t ha^{-1})**	**Labor (person-days ha^{-1})**	**Weeding cost ($ ha^{-1})**	**PERSUAP STATUS**
Pendimethalin 2 DAS fb 1 HW at 20 DAS	3.4	79	385	Unrestricted[1]
Bispyribac sodium 15 DAS fb 1 HW at 40 DAS	3.1	78	380	Unrestricted[1]
Bispyribac sodium + 2, 4-D 25 DAS fb 1 HW at 50 DAS	2.9	92	447	Unrestricted[1]
Penoxsulam 15 DAS fb 1 HW at 40 DAS	3.1	78	380	Unrestricted[1]
Pendimethalin 2 DAS fb 1 HW at 30 DAS	3.6	109	532	Unrestricted[1]
Pendimethalin 2 DAS fb 1 HW at 40 DAS	3.5	119	581	Unrestricted[1]
Pendimethalin 2 DAS fb Bispyribac sodium at 20 DAS fb 1 HW at 40 DAS	3.9	48	232	Unrestricted[1]
Pendimethalin 2 DAS fb penoxsulam at 20 DAS fb 1 HW at 40 DAS	3.6	56	273	Unrestricted[1]

Three times HW (15, 30, 45 DAS)	2.8	182	887	--
Weed-free (Pendimethalin at 2 DAS fb 4 times HW at 20,30, 40, and 60 DAS)	4.3	179	875	--
Significant differences ($LSD_{0.05}$)	**0.9**	**31**	**153**	

[1] CSISA in Bangladesh follows the countrywide Programmatic Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) for all non-research and on-farm activities. For the chemicals listed above, application is permitted in accordance with USAID policy by trained professionals with use of protective human and environmental health measures.

A.1.3 Agronomic and variety recommendations to reduce the threat of wheat blast

Until 2016, the fungal disease wheat blast (*Magnaporthe oryzae* pathotype *triticum*) was found only in South America. Blast disease is among the worst in wheat and can significantly reduce yield. Wheat blast unexpectedly appeared in Bangladesh in 2016, and re-emerged in 2017 and 2018 with consequent reductions in wheat area as farmers in epidemic zones either fallowed their fields or opted for alternative crops. Making matters worse, preliminary analysis indicates that suitable climatic conditions for blast in South Asia could sustain the disease in the long term, making it a consistent and reoccurring threat. Three hundred million people in South Asia consume over 100 million tons of wheat annually. Wheat blast therefore presents a formidable threat to food security in South Asia and in Bangladesh in particular.

A farmer field day to create awareness of wheat blast control methods and resistant varieties in Faridpur, Bangladesh. Photo: M A Arafat

After the first 2016 outbreak of wheat blast, CSISA worked with Bangladesh's national research and extension organizations to advise farmers on which varieties are more susceptible to the disease, thereby providing recommendations for more appropriate crop varieties and management practices in wheat producing areas. These recommendations were given through CSISA-supported factsheets distributed to farmers, extension agents, and agricultural input dealers, in addition to NGOs and Feed the Future partner organizations working in affected areas in Bangladesh. This information was used widely to advise farmers and reduce hearsay regarding how to best manage the disease, which ultimately gave many farmers increased confidence to grow wheat again in the 2017–18 wheat season. Combined with reduced inter-annual climactic suitability, a lower incidence of sporadic blast infection was observed in the current season than in previous years. This year's blast-affected area has not yet been officially declared by CSISA's Government of Bangladesh partners, but visual assessments of blast's incidence and severity appeared lower than even in 2017. The most severe infections were also found in late-sown wheat crops, providing further basis for CSISA's work in early wheat sowing (see C.2 Managing risk by coping with climate extremes, C.2.1 Early wheat for combatting heat stress).

Although research to mitigate the threat posed by wheat blast in Bangladesh was constrained by the lack of new funding to CSISA in 2017–18, the project has nonetheless continued to support strategic and applied research through the Bangladesh Agricultural Research Institute (BARI) to validate the previous season's field research. Our objectives were to confirm a suite of actionable agronomic methods that can be used by smallholder wheat farmers to reduce the risk posed by wheat blast disease in Bangladesh. Activities and preliminary results include the following:

Efficacy of foliar fungicides: As in the 2016–17 wheat season, tests were conducted in the 2017–18 season to reconfirm the viability of low-cost and effective fungicides for wheat blast under highly controlled research station conditions. To this end, a number of alternative fungicides were tested, each of which was applied by trained professionals employed by BARI. The following fungicide combinations were reconfirmed as inexpensive and ideal candidates for reducing blast infection under conditions of low disease incidence (Table 2).

Table 2: Second year's results of foliar applied fungicides on wheat blast control in southern Bangladesh

		Infection level or severity (%)			PERSUAP status[1]
Trade name	**Common name**	**Infected heads (0-5)**	**Head area (% infected)**	**Percent disease severity**	
Nativo 75 WG	Tebuconazole 50% + Trifloxystrobin 25%	4	47	1.9	Tebuconazole restricted, Trifloxystrobin unrestricted
Trooper 75 WP	Tricyclazole 75%	5	53	2.78	Banned
Folicur 250 EC	Tebuconazole 25%	5	47	2.49	Restricted
Opponent 75 WG	Tebuconazole 50% + Trifloxystrobin 25%	4	47	1.92	Tebuconazole restricted, Trifloxystrobin unrestricted
Filia 525 SE	Propiconazole 12.5% + Tricyclazole 40%	4	50	2.24	Propiconazole restricted Tricyclazole Banned
Amistar Top 325 SC	Azoxystrobin 20%+ Difenoconazole 12.5%	4	47	1.68	Both unrestricted
Control	Unsprayed	19	80	14.98	

[1] CSISA in Bangladesh follows the countrywide Programmatic Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) for all non-research and on-farm activities.

Amistar Top and Nativo were reconfirmed as relatively effective in controlling wheat blast. Both are commercially available in Bangladesh. As previously reported, Amistar Top 325 SC is not PERSUAP restricted and has low mammalian toxicity. Nativo is also not constrained by USAID's PERSUAP recommendations. They are therefore likely to be initial best bets for controlling wheat blast with fungicides, although extension advisories for farmers on how to use these fungicides must also be accompanied by personal and environmental safety messaging. In the coming year, CSISA will again support BARI to conduct these tests but under conditions of high disease pressure through artificial field inoculation, which is now approved for the Jessore BARI Regional Agricultural Research Station (RARS) by the Ministry of Agriculture. These results will provide final and clear evidence of the efficacy of these fungicides, after which CSISA will work with public and private sector partners to assure availability of these products at prices that can be afforded by farmers in wheat blast-affected districts as part of broader integrated disease management programs.

Efficacy of seed treating fungicides: Laboratory tests showed that Provax 200 WP (Carboxin 37.5% + Thiram 37.5%), Vitaflo 200 FF (Carboxin 17.5% + Thiram 17.5%), Rovral 50 WP (Iprodione 50%) and Goldman 80 WP (Mancozeb 80%) were effective in controlling seed infection with improved germination. These results reconfirm the research conducted in the previous season, though none of these chemicals were approved PERSUAP products. Further research on approved options is planned for the next year with the support of CSISA, pending funding availability.

Evaluation of elite wheat lines for blast resistance under inoculated conditions: Twenty-five elite wheat lines were screened at the Jessore RARS in the field and in Dinajpur under artificially inoculated laboratory conditions. Three advanced lines including BAW 1272, BAW 1280 and BAW

1286 showed resistance with a low level of spike infection (<10%). Borlaug 100 and recently released Zn fortified blast-resistant BARI Gom 33 were reconfirmed as best-bet varieties to control wheat blast under lab and field conditions; both were nearly free from the disease and had a very low level (<1%) of disease severity. Based on these results, CSISA will continue to support Government of Bangladesh partners to increase farmers' awareness of these varietal options, with particular emphasis on educating farmers scaling up the use of BARI Gom 33 in wheat blast-affected areas.

Comprehensive evaluation of wheat germplasm and wheat blast under field conditions: CSISA co-supported a researcher evaluating new wheat varieties for their resistance to wheat blast under field conditions at the Jessore RARS in the 2017–18 wheat growing season. Among the 408 varieties screened under low-disease pressure, some were provisionally identified as moderately resistant, although most were moderately susceptible blast disease. Susceptible check varieties however had 60–100% disease severity. Harvesting of these trials was completed only briefly before the time of writing; as such, full analysis of the data is not complete. Preliminary results however indicate some potentially promising lines that could be brought into production in Bangladesh over time. More comprehensive results will be provided in this year's annual report.

A.2 Adding value to extension and agro-advisory systems

A.2.2 Building precision nutrient management approaches around scaling pathways

Although precision nutrient management (PNM) has been an important component of CSISA's activities in Bangladesh, research under this activity has been suspended temporarily due to funding constraints. CSISA field staff however continued to advise farmers, Department of Agricultural Extension (DAE) and agricultural input dealers on appropriate crop and nutrient management strategies through one-to-one interactions, in meetings, and during farmer field days.

B. Systemic Change Toward Impact

B.1 Partnerships for inclusive growth around commercial pockets and neglected niches

B.1.1 Deployment of better-bet agronomic messaging through input dealer networks and development partners

Scaling-out information on better-bet agronomy

CSISA provides a bridge between agricultural research and the application of research results, insights, and technologies by farmers. The project therefore works to develop accessible guides to better-bet maize, rice, and wheat agronomy that summarize research findings in easy-to-understand recommendations and formats. In the last year, guides were disseminated through governmental, NGO and private sector partners, including other Feed the Future projects in Bangladesh. Despite funding shortfalls, nearly 160,000 of these guides were distributed over the last year as described in the table below. Funding shortfalls at USAID have, however, reduced the number of field M&E staff that CSISA can employ. As such, we are working now to assess the impact of these guides on farmer adoption and use of better-bet agronomy though 'light' telephone surveys and other estimation methods. Further results will be presented in the upcoming annual report.

Name of Better-bet agronomy materials	Quantity
Factsheet on Wheat Blast	70,000
Leaflet on Early Wheat Sowing	70,000
Pocket Book on Healthy Rice Seedlings	500
Leaflet on Healthy Rice Seedlings	8,000
Pocket Book on Mung Bean	10,000

Healthy Rice Seedlings

Using healthy rice seedlings (HRS), farmers can easily increase yields by 7–10%. CSISA typically raises awareness among farmers of the benefits of HRS through (i) mass media, (ii) hands-on training of trainers in HRS production principals, (iii) encouraging young entrepreneurs to start businesses growing and selling HRS to farmers. Lastly, (iv) CSISA has worked to scale-out HRS practices through development partner networks and aligned rural livelihoods projects in the Feed the Future Zone.

Funding shortfalls however forced the suspension of these activities in the 2017–18 winter *boro* rice season in Bangladesh. CSISA nonetheless conducted a follow up survey with farmers who had been previously exposed to HRS awareness-raising efforts. Our objective was to assess if and how many farmers who learned about HRS in the preceding 2017 monsoon *aman* rice season continued to use HRS practices in the winter *boro* season. In other words, we sought to measure independent and sustained adoption of HRS practices without intervention by CSISA in the *boro* season. Our survey results indicated that out of the 17,736 farmers who viewed the HRS video shown by CSISA and our partners in village film screenings prior to the monsoon season 2017, 51% continued to use the HRS principles they learned through CSISA's efforts to grow their crop in the 2017–18 *boro* season. Their average land size transplanted to HRS was 0.52 ha, indicating sustained adoption on more than 4,704 hectares in the Feed the Future Zone.

B.1.3 Rabi fallows development in coastal Bangladesh

Farmers' preference for cropping intensification in polder and non-polder environments of coastal south-central Bangladesh

Large portions of coastal Bangladesh within the Feed the Future Zone are under low levels of crop intensification – with farmers either fallowing their fields or growing low-input and relatively low-output rainfed crops during the drier winter season. Identification of suitable land area and crop options, as well as mechanisms for interventions to overcome farmers' low risk-bearing capacity for crop intensification, has been a research focus of CSISA in the third phase of the project. Leveraging methods and insights from behavioral science to better understand farmers' interest in and preferences for crop intensification options in these coastal areas, CSISA carried out a series of decision choice experiments (CE) with farmers in mid-2017. This CE survey followed a preliminary farm typology survey carried out in 2015 of 502 households. In the CE survey we surveyed a sub-sample of 300 households from the preliminary survey of 502 respondents, which included 50 samples each from the three farm types. Sampling farmers belonging to different farm types helps assure improved inclusiveness of farmer preferences in the data of different types of farmers. Resulting information can help development planners and policy makers better target investments in consideration of different types of farmers, rather than treating farmers as a single homogenous group.

The following scenarios are explored through the CEs for which different crop type yield and economic benefits were compared for (1) *boro* rice, (2) maize, (3) wheat , (4) mungbean and (4) fallow as *status quo* scenario. The heterogeneity of farmers' decisions to intensify cropping in the winter *rabi* season was modeled using the latent class (LCM) and multinomial logit (MNL) frameworks. We modeled crop choice data farmers in polder and non-polder environments (polders are tracts of low-elevation land protected by dykes meant to limit oceanic intrusion and flooding) separately. A risk preferences analysis was also carried out using the choice experiment data considering production risks and farmers' risk aversion for growing a particular crop.

What do farmers prefer for cropping intensification in coastal farming systems of south-central Bangladesh?

Among the sampled farms outside of polder areas, a majority (62%) selected mungbean as their primary hypothetical choice of crop for winter season crop intensification, followed by maize (22%), *boro* (8%), fallow (4%) and wheat (4%). The LCM identified two class structures within sampled non-polder farms: Class 1 (small farms with sharecropping) and Class 2 (marginal farms with off-farm activities and tenure rights). For both classes, net returns to crop intensification was found to be driving their selection of crops for the *rabi* season. The MNL model also identified the influence of attribute levels and socio-economic variables on crop choices.

While an increase in irrigation and fertilizer costs negatively influenced farmers' decision to select *boro* rice for crop intensification, the choice of wheat crop was positively influenced by the low fertilizer and irrigation costs that influenced competitively higher net returns, indicating wheat's suitability for farmers with low investment capacity. In case of the decision to grow maize, net return was the sole influencing factor among attributes. The choice of mungbean was primarily driven by net return. However, modeling an increase in fertilizer costs is expected to negatively affect mungbean cultivation among the sampled non-polder farms.

Turning to sampled polder farms, given the choice scenarios, almost 66% of the surveyed farmers also chose to grow mungbean as a hypothetical crop for winter season intensification, while 22% selected maize, followed by wheat (5%), *boro* (4%) and the remaining 3% choosing continued fallowing. The LCM of sampled polder farms identified two the same farming classes, despite farmers being located within polders and thus in a different biophysical production environment. Though net return had a positive sign, none of the attribute levels including net return, costs of irrigation and fertilizer and net returns from crops had any significant effect on crop choices for class 1 farmers. For class 2 farms, crop choices for intensification are driven by an increase in net returns and considerations regarding fertilizer use, while increased irrigation costs had a significant negative relationship with farmers' interest to engage in cropping intensification. Further investigation using the MNL model indicates that farmers with more land are more likely to grow crops in the order of maize followed by mungbean and wheat. The coefficient for tenure rights was significant and positive for all crop choices, indicating the importance of tenure security for fallow intensification.

Production risks and farmers risk attitude in crop choices

The cumulative probability distribution graphs shown below are based on actual crop choices of farmers showing the risk spread for different crops. At conservative levels of production risk (60th percentile), sampled non-polder farmers could make a net profit of US$ 450/ha and US$ 650/ha from mungbean vs. maize. The net returns for sampled polder farmers at the 60th percentile are also likely to gain US$ 410/ha and US$ 500/ha for mungbean and maize, respectively. Our analysis however shows a wider risk spread for net returns from maize ranging from US$ 250–1,000/ha in regions outside of polders, and US$ 100–1,000/ha within polders. This indicates that despite high profit potential, maize could be a riskier crop in polders than non-polder areas. Growing *boro* and wheat on the other hand considerably less profitable in polder and non-polder

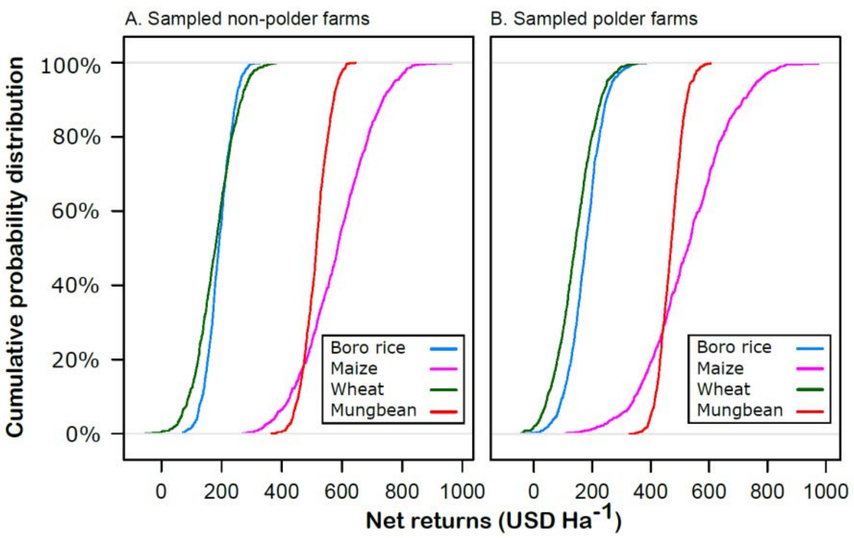

FIGURE 1. FARMERS' PREFERENCE FOR CROPPING INTENSIFICATION IN POLDER AND NON-POLDER ENVIRONMENTS OF COASTAL SOUTH-CENTRAL BANGLADESH: SIMULATION OF PRODUCTION RISK FROM CROP CHOICE DATA

environments, fetching < US$ 200/ha, even at high probability levels. These results are important because they provide insights for development planners and policy makers to improve the targeting of their investments and promotion/training on different crop alternatives in consideration of different types of farmers, as opposed to treating farmers as a single homogenous group. The results of this work are currently being assembled into report and paper formats, and are expected to be presented to CSISA's partners working in coastal areas within the next reporting period.

B.1.4 High-value, premium quality rice expansion Bangladesh

CSISA works as a catalyst to expand premium quality rice (PQR) production in the Feed the Future Zone. This activity can increase farmers' profits from rice farming up to US$ 200 per hectare. CSISA's PQR interventions have included PQR variety awareness creation among farmers, facilitating links between private and government partners to assure the timely availability of PQR seeds, leveraging partners to train farmers on better-bet agronomy of PQR varieties, and organizing farmers into groups for collective marketing. A lack of funding in 2017–18 however has meant that CSISA has not been able to continue work on PRQ in the 2017–18 winter *boro* rice season. We however did work to collect information from Department of Agricultural Extension on area coverage of PQR in the winter *boro* 2017–18 season. The PQR variety BRRI Dhan 50 and BRRI Dhan 63, both of which were introduced and popularized with support from CSISA in the project's second and early third phase, were planted on 29,363 ha in Barisal, Faridpur and Jessore hubs. These data indicate that PQR has matured as an intervention, and that rice value chains have emerged to sustain farmers' continued cultivation of these varieties. Although CSISA cannot claim full responsibility for these results, the project's pioneering popularization of these varieties and efforts to catalyze rice value chains has had an important and lasting effect.

B.2 Bringing participatory science and technology evaluations to the landscape and back again

B.2.1 Increasing the capacity of NARES to conduct participatory science and technology evaluations

Despite funding constraints in 2017–18, CSISA continued to work to support the capacity of national research and extension (NARES) partners to conduct advanced research using new methods and tools. One of the most frequently requested types of capacity development and training in Bangladesh is the use of geographic information systems (GIS) to conduct spatial analyses. To this end, CSISA released a book in April 2018 that can be used by students or instructors to learn and teach GIS independently or as part of a group.[3] The book, 'Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh,' provides a set of learning modules introducing young scientists and researchers to GIS and spatial analysis using the open-source QGIS platform, and complementary R, SAGA and GRASS Platforms.

The 13 learning modules in the book can be used for self-directed learning or to teach courses. Practical exercises that utilize spatial data for Bangladesh are included, and all required spatial data can be downloaded from an open-source website. The modules provide an overview of GIS, spatial data visualization techniques, and exercises in working with Global Positioning System (GPS) data, tabular, and raster data. Students will also learn terrain and spatial analysis, and also how to do georeferencing Google Earth image with QGIS and to develop new vector datasets and digitizing. Exercises on how to produce aesthetically pleasing and informative maps are also included. By the time students complete working with these modules, they should be proficient in QGIS and spatial

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[3] Ahmed, Z.U., Krupnik, T.J., Kamal, M., 2018. Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh. Cereal Systems Initiative for South Asia (CSISA) and the International Maize and Wheat Improvement Center, CIMMYT. Dhaka, Bangladesh.

data analysis, and able to continue using these tools on an individual basis without considerable extra coaching.

The book 'Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh' is available for free download from the CSISA website, with all accompanying spatial data and shapefiles for students available from the CSISA Data Verse Website.

C. Achieving Impact at Scale

C.1 Growing the input and service economy for sustainable intensification technologies

C.1.1 Integrated weed management to facilitate sustainable intensification transitions in rice

Integrated weed management activities under CSISA in Bangladesh were challenged this year as a result of delayed funding and budget cuts. The project was unable to maintain a number of key staff who have been instrumental in integrated weed management research, extension, and scaling. But despite these challenges, CSISA has continued to conduct research by leveraging partnerships with the Bangladesh Rice Research Institute (BRRI). With the technical support of CSISA, BRRI scientists conducted on-farm trials on different weed control options for transplanted rice across Jessore and Faridpur hubs following during the monsoon *Aman* season of 2016 (prior to large budget shortfalls), and the winter *Boro* season of 2016-17 and subsequent *Aman* 2017 season (the latter two seasons despite large budget shortfalls). Although CSISA maintains focus on directly sown rice (see A. Innovation Toward Impact, A.1 Reducing Risk to Facilitate Uptake of Sustainable Intensification Practices, A.1.1 Directly sown rice to address labor and energy constraints to precision rice establishment).

The weed control options evaluated include a combination of new classes of herbicides – pendimethalin and mefenacet + bensulfuron methyl (pre-emergence herbicide), bispyribac sodium or penoxsulam (post-emergence herbicide), mechanical and hand weeding compared to farmers' typical management practices (pretilachlor pre-emergence herbicide followed by two hands weeding) in transplanted rice. Two weed control options involving the use of mefecenat + bensulfuron methyl followed by either bispyribac sodium or penuxsulam followed by one hand weeding produced the highest grain yield which is either higher or similar with farmers' weed management practice across seasons and hubs (see table below).

Table 3. Grain yields in different weed control options of transplanted rice in Aman 2016, Boro 2016–17, and Aman 2017

Weed control options	Grain yield (t ha^{-1})						PERSUAP status
	Jessore hub			Faridpur hub			
	Aman 2016	Boro 2016-17	Aman 2017	Aman 2016	Boro 2016-17	Aman 2017	
Farmers' practice	4.4	6.6	4.6	3.5	6.3	5.2	--
Pendimethalin fb 1 Hand weeding (HW)	4.1	6.4	4.8	3.6	6.3	5.1	Unrestricted[1]
Mefenacet + Bensulfuron methyl fb 1 HW	4.3	6.6	4.8	3.5	6.2	5.6	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb 1 MW	4.1	5.8	4.8	3.6	6.1	5.7	Currently restricted[2]
Bispyribac sodium fb 1 HW	3.9	6.2	4.8	3.3	5.7	5.6	Unrestricted[1]
Penoxsulam fb 1 HW	3.8	6.2	4.6	3.4	5.7	5.0	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb Bispyribac sodium fb 1 HW	4.5	6.7	4.9	3.8	6.6	5.0	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb Penoxsulam fb 1 HW	4.4	6.9	4.8	3.7	6.4	5.0	Currently restricted[2]
1 MW fb 1 HW	4.4	6.5	4.9	3.6	6.3	5.5	--
Weed-free	4.5	7.0	5.0	3.9	6.4	5.6	--
Significant differences ($LSD_{0.05}$)	**0.3**	**0.4**	**ns**	**0.5**	**0.3**	**0.6**	

HW = Hand weeding. fb = followed by

[1] CSISA in Bangladesh follows the countrywide Programmatic Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) for all non-research and on-farm activities. For the chemicals listed above, application is permitted in accordance with USAID policy by trained professionals with use of protective human and environmental health measures.

[2] CSISA tests PERSUAP restricted chemicals only when applied and used by trained professionals and on an experimental basis to assess herbicide effectiveness. In accordance with PERSUAP policies, recommendations to farmers to use these herbicides are not given.

These weed control options were compared with farmers' standard average weed management practices. Use of the new classes of herbicides reduced labor use by 20–26 person days (8-hour days)/ha in Jessore hub and by 10–18 person days/ha in Faridpur hub (see tables below).

Table 4. Labor use in different weed control options of transplanted rice during Aman 2016, Boro 2016-17, and Aman 2017

Weed control options	Labor use (md ha^{-1})						PERSUAP STATUS
	Jessore hub			Faridpur hub			
	Aman	Boro	Aman	Aman	Boro	Aman	

	2016	2016-17	2017	2016	2016-17	2017	
Farmers' practice	41	44	32	28	34	25	--
Pendimethalin fb 1 Hand weeding (HW)	31	35	17	22	32	16	Unrestricted[1]
Mefenacet + Bensulfuron methyl fb 1 HW	26	34	14	15	29	13	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb 1 MW	18	16	9	15	17	6	Currently restricted[2]
Bispyribac sodium fb 1 HW	27	39	16	15	32	13	Unrestricted[1]
Penoxsulam fb 1 HW	32	37	17	16	21	14	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb Bispyribac sodium fb 1 HW	16	24	11	10	24	15	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb Penoxsulam fb 1 HW	15	24	11	13	24	15	Partially restricted[1,2]
1 MW fb 1 HW	37	37	22	20	28	14	--
Weed-free	52	63	46	37	44	41	--
Significant differences ($LSD_{0.05}$)	**11**	**17**	**4**	**3**	**12**	**3**	

HW = Hand weeding. fb = followed by

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Use of these new weed control options also reduced weed control costs by US$ 72–99/ha in Jessore hub and US$ 25–65/ha in Faridpur hub (see table below).

Table 5. Weed control costs of different weed control options in transplanted rice in Aman 2016, Boro 2016-17 and Aman 2017

Weed control options	**Weeding cost (US $ ha^{-1})**						**PERSUAP STATUS**
	Jessore hub			**Faridpur hub**			
	Aman 2016	**Boro 2016-17**	**Aman 2017**	**Aman 2016**	**Boro 2016-17**	**Aman 2017**	
Farmers' practice	149	160	170	102	123	138	--
Pendimethalin fb 1 Hand weeding (HW)	113	128	112	80	117	106	Unrestricted[1]
Mefenacet + Bensulfuron methyl fb 1 HW	94	123	82	55	108	76	Currently restricted[2]
Mefenacet +	65	58	58	56	62	42	Currently

Bensulfuron methyl fb 1 MW							restricted[2]
Bispyribac sodium fb 1 HW	98	140	88	55	116	74	Unrestricted[1]
Penoxsulam fb 1 HW	117	135	107	59	78	91	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb Bispyribac sodium fb 1 HW	59	88	71	37	88	100	Currently restricted[2]
Mefenacet + Bensulfuron methyl fb Penoxsulam fb 1 HW	54	86	83	47	87	113	Currently restricted[2]
1 MW fb 1 HW	134	136	108	72	104	69	--
Weed-free	189	231	229	135	159	204	--
Significant differences ($LSD_{0.05}$)	**40**	**62**	**23**	**11**	**42**	**13**	

HW = Hand weeding. fb = followed by

[1] CSISA in Bangladesh follows the countrywide Programmatic Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) for all non-research and on-farm activities. For the chemicals listed above, application is permitted in accordance with USAID policy by trained professionals with use of protective human and environmental health measures.

[2] CSISA tests PERSUAP restricted chemicals only when applied and used by trained professionals and on an experimental basis to assess herbicide effectiveness. In accordance with PERSUAP policies, recommendations to farmers to use these herbicides are not given.

[3] CSISA tests PERSUAP restricted chemicals only when applied and used by trained professionals and on an experimental basis to assess herbicide effectiveness. In accordance with PERSUAP policies, recommendations to farmers to use these herbicides are not given.

As a result of the comprehensive research conducted by BRRI in partnership with CSISA, the project initiated work with herbicide companies/dealers to investigate the potential for making these herbicide molecules (mefecenat + bensulfuron methyl, bispyribac sodium, and penoxsulam) available to farmers through commercial pathways following verification and approval of PERSUAP status. Unfortunately, these out-scaling activities have however been put on hold due to lack of funds during reporting period.

C.1.3 Commercial expansion of two-wheel tractor based machinery and associated service provision models for reapers and seeders

This intervention focused on scaling the use of multi-crop reapers and two-wheel tractor-based seeding equipment in CSISA's working areas in northwestern Bangladesh, as a complement to the successful market initiatives undertaken in southern Bangladesh's Feed the Future zone through the USAID/Bangladesh Mission-funded CSISA-Mechanization and Irrigation initiative, in which CIMMYT partners with International Development Enterprises (iDE). CSISA was successful in signing joint venture agreements with partner machinery companies including ACI the Metal (Pvt.) Ltd. to create demand and increase commercial availability of machineries in the Dinajpur hub areas. The NGO TMSS was also engaged provide financial support farmers interested in purchasing machinery through low-interest and accessible loans. These scaling activities were however suspended in northern Bangladesh in mid 2017 following advice from CSISA's Activity Manager to conserve funds in anticipation of funding delays and budget cuts. All sub-grants and joint venture agreements that were signed have been either cancelled or put on hold pending further information on the availability of funding to support this work. As a result of these actions, iDE was also forced to terminate contracts for three staff involved in market demand creation activities in northern Bangladesh, indicating significant set-backs for this activity in the latter half of 2017 and into 2018.

C.2 Managing risk by coping with climate extremes

C.2.2 Early wheat for combatting heat stress

Bangladesh's climate is warm and humid, with a short winter season spanning from mid-November through March. Although wheat is Bangladesh's second most widely grown cereal crop, the climate is typically less than suitable for high wheat yields. Wheat sown after mid- to late-November will encounter high temperatures in February–March when the crop is at flowering and grain filling stages. This 'terminal heat stress' can reduce yield considerably. After that, wheat yield declines by 1.3% or 43 kg/ha/day for each day delay seeding after November 30 on a national basis. More location-specific research conducted by CSISA found that the highest wheat yield occurred when the crop was established between 15–22 November in Jessore. Each day that wheat is sown late after that yield reduces at 32 kg/ha/day. In Dinajpur, however, which is in the cooler north of the country, yields resulting from crop establishment from 15 November to 6 December are nearly identical. Late sowing after 6 December however results in yield declines at 22 kg/ha/day. Focus group research conducted by CSISA in 2016 and into late 2017 revealed that excessive post-monsoon season soil moisture at seeding time is the number one cause of late wheat seeding. This was followed by a low-level of farmers' knowledge on the benefits of early seeding. As a result, CSISA works with national agricultural research and extension partners, including NGOs, to spread awareness among farmers of the benefits of earlier and timely sowing, and to overcome key constraints to establishing early wheat crops.

One of the main mechanisms CSISA has used to raise farmer's awareness of the benefits of early wheat sowing has been the distribution of informational leaflets and guides that are distributed by CSISA's partners to wheat farmers. Despite funding shortfalls in the 2017–18 wheat season, CSISA continued to distribute information in this fashion. CSISA also seized upon inexpensive opportunities to raise awareness of the importance of early wheat sowing, including motivational speeches and discussions held at farmer field days and other activities conducted by CIMMYT in aligned and complementary projects. A short awareness raising video, in which farmers describe the ways in which they modified their cropping practices to facilitate early wheat sowing was also prepared, although funding cuts have meant that the project has been unable to show the video through village film screenings or trainings. Earlier wheat sowing was also challenged in the 2017–18 season by late and unexpectedly heavy rains near seeding time; this set back sowing considerably in a number of the project's working areas.

Average rainfall in Dinajpur, Faridpur, Jessore and Bhola regions were 130, 246, 664 and 216 mm respectively during October, November and December of 2017. Combined with farmers' risk aversion to wheat following the subsequent two years of wheat blast disease, these late rains reduced national wheat area by 16% in comparison to the previous year. Despite these challenges, the great overall potential benefits of earlier wheat sowing means that CSISA will resume work to popularize early wheat sowing in combination with efforts to mitigate wheat blast (see A. Innovation Toward Impact, A.1 Reducing Risk to Facilitate Uptake of Sustainable Intensification Practices, A.1.3 Agronomic and variety recommendations to reduce the threat of wheat blast: Agronomic and variety recommendations to reduce the threat of wheat blast) when funding resumes.

Challenges faced during the reporting period

The key challenge faced in the 2017–18 reporting period for CSISA in Bangladesh has been the significant delay in funding. This problem affects not only CSISA but also other FtF and USAID-funded programs within the region and globally. In consultation with CSISA's Activity Manager at USAID, we reacted to the delay and budget reduction by de-emphasizing a number of CSISA's scaling activities and refocusing our work on strategic research and partnerships that could assure that our research products could be effectively extended to and utilized by farmers. Yet as indicated in the proceeding text, all of the activities on CSISA's work plans were impacted by the delay and reduction in funding – some quite severely.

In addition to cutting back on activities, most of the CSISA staff from both CIMMYT and IRRI have been terminated, retrenched, or transferred into other projects. In CIMMYT, a total to 15 full-time equivalent staff were transferred to other projects. Two CIMMYT staff were terminated. At IRRI, six full-time staff have been terminated so far; another two will be terminated in September of 2018 if funds do not arrive in time. This leaves just one Senior Associate Scientist II and one Specialist-Agricultural Research and Development at IRRI to assist in coordination of CSISA's work in Bangladesh (see Appendix 1 below).

Considering CSISA's partners, and despite the financial uncertainty, sub-contracts with both AIRN and AAS worth more than US$ 35,000 were completed successfully. CSISA's initiative to the commercialization of smart and appropriate agricultural machinery in northern Bangladesh (Dinajpur) was also stopped, with CIMMYT's sub-grant with iDE suspended. This resulted in iDE's termination of three full time staff. Conversely, CSISA's sub-grant with Bangabandhu Sheikh Mujibur Rahman Agricultural University on Precision Nutrient Management has been fully suspended. CSISA's sub-grant with BARI has also been placed largely on hold, and will be modified and amended. Key remaining staff and partners' scenarios are detailed in tabular form in both Appendix 1 and Appendix 2.

A. Innovation Toward Impact

A.1 Reducing Risk to Facilitate Uptake of Sustainable Intensification Practices

A.1.1 Directly-sown rice (DSR) to address labor and energy constraints to precision rice establishment

Due to outmigration and an aging rural workforce, seasonal scarcity of agricultural labor is one of the biggest challenges to the viability and profitability of Nepalese agriculture. Traditional rice establishment practices of manually transplanting rice seedlings into puddled fields cost farmers time, labor, energy and money. Machine-sown direct seeded rice (DSR) is a cost-effective technology that avoids the costs of raising rice nurseries and transplanting seedlings in the main field. In this context, DSR can be a suitable alternative to conventional transplanted puddled rice.

Despite these benefits, DSR can be riskier than transplanted puddled rice due to higher weed pressure and the possibility of stand mortality with early rains. The selection of suitable land, deployment of trained service providers, timely crop establishment, along with the utilization of integrated weed management practices are pivotal for reliably obtaining good yields with DSR.

DSR seven years on: Who continues and why?

CSISA has been evaluating and promoting drill-sown direct seeded rice for the last seven years in select western Terai districts of Nepal. Despite several efforts, the adoption rate of DSR is not moving as quickly as expected. Reasons for low adoption rates vary across locations, years, farmers, management conditions and several other factors. Adopter-farmers' perceptions of DSR have not been systematically documented in an effort to understand if scaling can be accelerated.

CSISA used survey-based assessment techniques to explore individual farmers perceptions' of DSR, including 18 reasons why farmers do not adopt (constraints) and nine reasons why farmers adopt (opportunities). Answers were collected using the Likert scale from 5 (the reason would not strongly decrease yield and profit) to -5 (the reason would strongly decrease yield and profit). The study was carried out in four western Terai districts (Rupandehi, Bardiya, Kailali and Kanchanpur), where CSISA is working to scale DSR technology. Twenty-nine DSR adopters from those four districts were interviewed individually and the data were analyzed using the Likert package in R.

Constraints to DSR adoption: Factors strongly correlated with the non-adoption or the dislike of DSR as compared to transplanted rice included increased weed pressure and the unavailability of herbicides, seeding machinery and skilled service providers (Figure 2). Additional factors expressed were a low level of confidence in the technology, a poor success rate in crop establishment, a need for assured irrigation and a well-leveled field, the need for intensive knowledge and frequent field monitoring. CSISA's experience indicates that these problems are manageable through awareness raising, training, strengthening private service providers and improving market development for machinery and herbicides.

Factors driving DSR adoption: Despite many constraints to DSR adoption, farmers still continue to use the technology because it eliminates the need for seedling raising and transplanting, as well as lowers the cost of field preparation and crop establishment, increases the opportunities for timely crop establishment, reduces drudgery and labor requirements, increases profit and does not reduce yields compared to the transplanted rice (Figure 3). The driving factors mentioned by farmers are important to recognize in light of increasing rainfall variability and labor wage rates, as well as declining labor availability and low net profits from rice production through conventional transplanting methods.

With partners such as the PMAMP and the Rice Super Zone program, CSISA is working aggressively to ensure that more farmers and service provides fully understand the benefits of DSR along with management methods to reduced down-side risks.

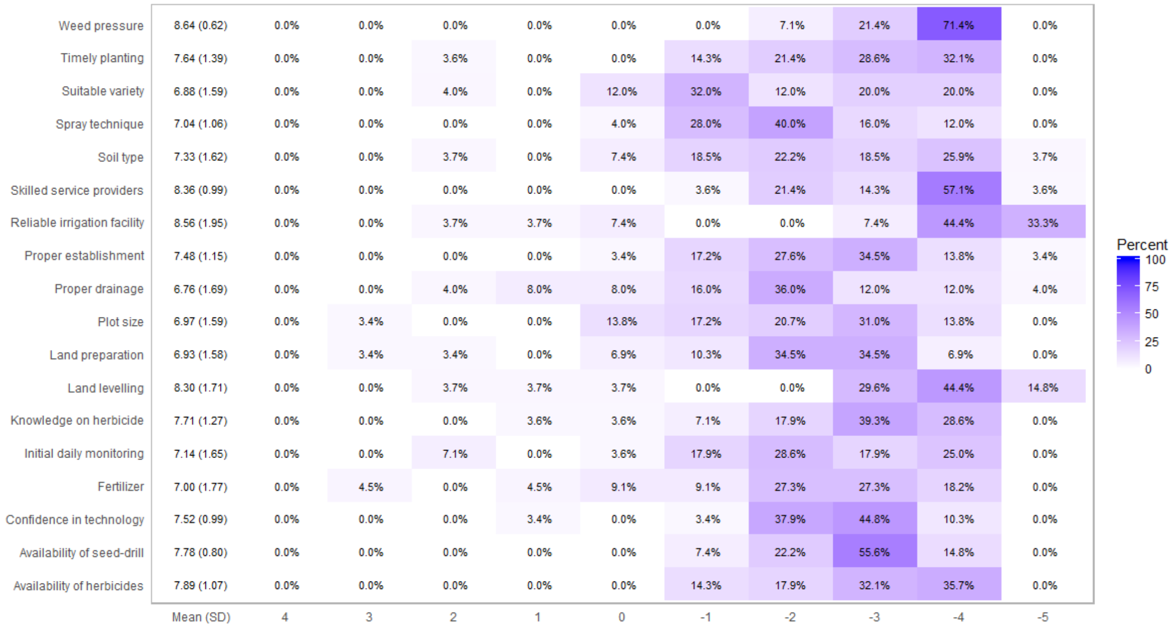

FIGURE 2. PROPENSITY SCORES ESTIMATED ON A LIKERT SCALE (+5 NO YIELD REDUCTION <---- > -5 HIGHLY LIKELY TO YIELD REDUCTION) TOWARDS CONSTRAINTS ON DSR TECHNOLOGY FROM THE PERSPECTIVE OF DSR ADOPTER FARMERS' IN FOUR WESTERN TERAI DISTRICTS.

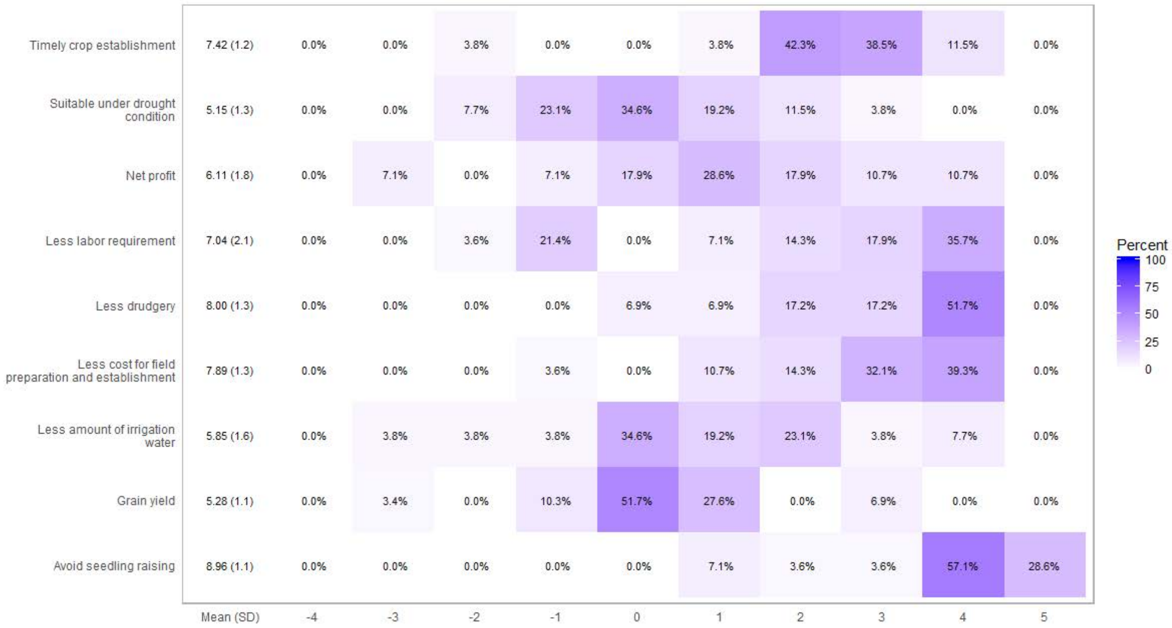

FIGURE 3. PROPENSITY SCORES ESTIMATED ON A LIKERT SCALE (+5 HIGHLY PREFERRED <---- > -5 HIGHLY NOT PREFERRED) TOWARDS OPPORTUNITY ON DSR TECHNOLOGY FROM THE PERSPECTIVE OF DSR ADOPTER FARMERS' IN FOUR WESTERN TERAI DISTRICTS.

Potential yield and optimum sowing dates for DSR

Potential yield of DSR in Nepal Terai: The benefits of adopting DSR, including the opportunity for timely crop establishment, a reduction in production costs and drudgery may not be sufficient incentives for farmers to adopt DSR if they perceive that the yield potential is lower compared to alternative establishment methods. The fine-tuning of production packages for different sites and climatic conditions are key to achieving rice yield potential.

Given the sensitivity of rice to temperature and rainfall variability, optimizing the seeding date and using adapted varieties are of central importance to enhancing DSR yields. CSISA conducted a simulation study using the rice growth model ORYZA-3 to assess the yield potential of varieties from three different maturity classes: Radha-4 (120 days), Sabitri (135 days) and Sworna (150 days)) across a range of seeding dates starting from the end of April to the end of July.

The attainable yield potential for all three maturity classes short-, medium- and long-duration) is more than 8 t/ha under optimum sowing dates in irrigated conditions (Figure 4). Averaged across the districts, the best simulated sowing date for short-, medium- and long-duration varieties varied from 1–15 July, 20 June to 5 July, and 10–25 June, respectively. For the short-duration variety, yield decline starts after 15 July, while it declines after 10 July in medium- and after 25 June in long-duration varieties. Under irrigated conditions, DSR can be seeded from the beginning of May to the end of July. Optimum seeding date could be later if varietal duration decreases. However, field access by the seed drill machines for seed sowing are typically a binding constraint that delays seeding.

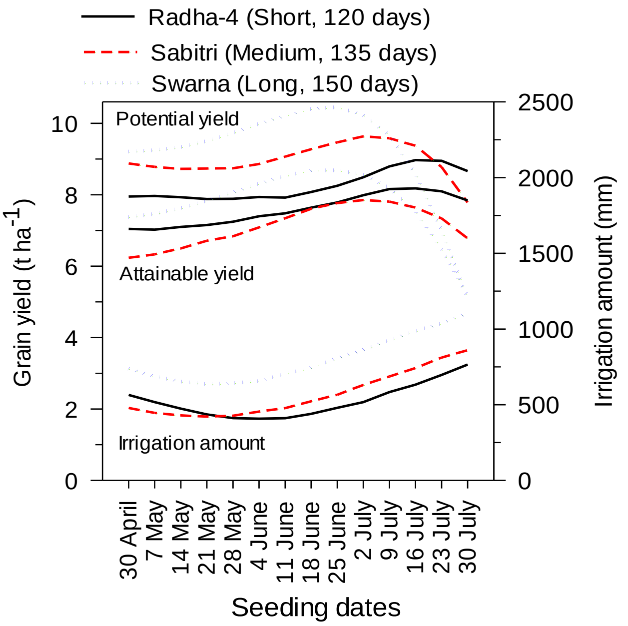

FIGURE 4. YIELDS UNDER SIMULATED SOWING DATES FOR SHORT-, MEDIUM-, AND LONG-DURATION RICE VARIETIES

During the optimum seeding period, the irrigation requirement varies across the variety, with the short-duration variety requiring 559 mm irrigation water, the medium-duration variety requiring 554 mm and the long-duration variety requiring 724 mm. Seeding before or after these optimum dates could increase the irrigation requirement to meet the early or late stage crop water demand.

B. Systemic Change Towards Impact

B.1 Partnerships for inclusive growth around commercial pockets and neglected niches

B.1.1 Deployment of better-bet agronomic messaging through input dealer networks and development partners

Generating knowledge for messaging: Rice yield and profit gaps and entry points for sustainable intensification

Rice yield and profit gaps

Slow productivity growth rates (low yield growth rate in Nepal compared to India and Bangladesh) and the increasing volume of rice imports (~US$ 300 million in 2017) provide incentives closing the rice yield gap in Nepal. CSISA's household survey carried out in 1,052 households in 2016 were used to calculate the yield and

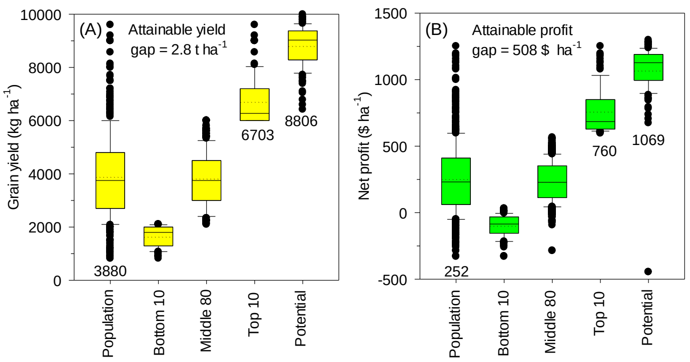

FIGURE 5. YIELD (A) AND PROFIT (B) GAPS OF RICE. GAPS ARE THE DIFFERENCE BETWEEN THE TOP 10 PERCENTILE FARMERS AND THE POPULATION MEAN

profitability gaps associated with current farmers' practices across the western Terai districts. The top 10% of farmers obtained a yield of 6.8 t/ha whereas the population mean yield was 3.8 t/ha, showing an attainable yield gap of 3.0 t/ha. Also, the top 10% of farmers obtained a net profit of US$ 760/ha whereas the population mean obtained a net profit of US$ 252/ha, indicating an attainable profit gap of more than US$ 508/ha (Figure 5). Also, very high spatial and temporal variability exists in yield and profit gaps across districts and years (data not shown).

Major entry points for closing yield gaps: The same survey and crop-cut data was analyzed using machine learning approaches. This analysis revealed that the number of irrigations followed by the amount of rainfall from 15–30 June, amount of N fertilizer applied, seeding date, and the amount of phosphorus fertilizer applied are the major yield limiting factors for rice in the Terai (Figure 6A).

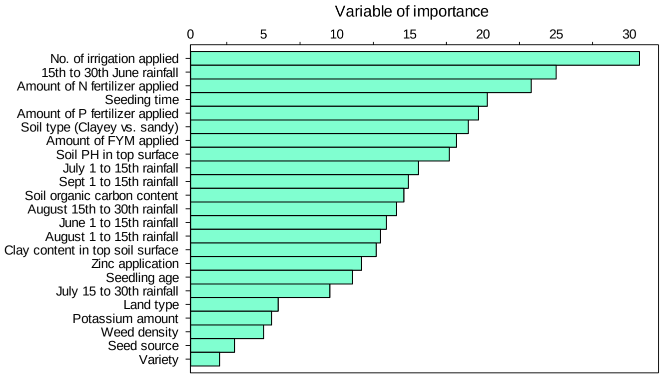

FIGURE 6A. IMPORTANCE OF PREDICTOR VARIABLES FOR EXPLAINING THE RICE YIELD IS THE FUNCTION OF SEVERAL FACTORS OF RICE PRODUCTION

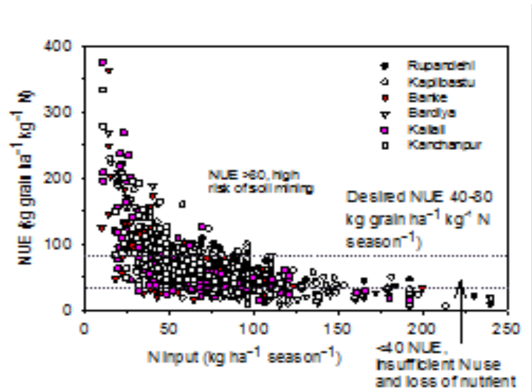

FIGURE 6B. NITROGEN USE EFFICIENCY IN RICE IN WESTERN TERAI DISTRICTS

Since more than two-thirds of the rice is produced under rainfed conditions, the paramount importance of early rainfall and the application of irrigation is not surprising. This survey data showed farmers' NPK application rate in rice is less than half of the recommended rate (N <50, P <20, and K <15 kg/ha) and the majority of farmers are mining indigenous soil fertility. Also, input use efficiency is low due to the rainfed system and poor crop management, so use efficiency amongst most farmers is also fairly low (Figure 6B). This analysis shows not only that nutrient quantities are yield-limiting but so are the low efficiencies of applied nutrients (N and P) and irrigation water. Further, this study found that the simple step of planting rice hybrids can increase yields by 730 kg/ha and net profit by US$ 75/ha.

Extending agronomy basics

In Nepal, government and development partners often focus on new technology introductions without retaining a focus on the basics of sound management that provide the foundation for sustainable intensification. Consequently, many farmers report a low-level of knowledge of research-based management recommendations and achieve low yield levels and profitability accordingly. To close this gap, CSISA collaborated with the commodity programs of the National Agriculture Research Council (NARC), including the National Rice Research Program, the National Maize Research Program and the National Wheat Research Program, to develop better-bet agronomy 'tips' covering production practices for rice (including healthy seedlings), maize and wheat. In very simple terms and with an emphasis on actionable advice, the factsheets explain low-risk options for improving management practices from seeding to harvest and storage. CSISA is deploying better-bet agronomic messaging through a range of public and private sector partners, with a companion focus on the development of master trainers so that better-bet agronomy is effectively mainstreamed and fully owned by these partners. Progress in the reporting year by crop was as follows:

	TIPS DISTRIBUTED	REPRINTED BY PARTNERS?	TOT TO PARTNERS (#)	HH APPLYING NEW TECHNOLOGY*	AREA UNDER NEW TECHNOLOGY (HA)*
RICE	10,000	Yes	400	8,177	1,501
WHEAT	2,500	Yes	247	2,138	948
MAIZE	5,000	Yes	212	1,436	400

** Note: Household and area estimates for technology adoption do not capture farmers reached through the efforts of partners to reprint CSISA's outreach materials or otherwise incorporate CSISA's materials in their programs. Those figures are pending.*

B.1.2 Income-generating maize production in neglected hill and plateau ecologies

Promotion of low cost technology for maize intensification in the Terai

Despite the considerable cultivated area (2nd only to rice in extent), Nepal imports about 400,000 tons of maize grain per year, primarily to supply feed mills that support the rapidly growing poultry industry. With the increasing demand, the area under winter and spring maize is increasing in the Terai districts of the FtF zone where irrigation facilities are available. Manual line seeding of maize, particularly with hybrid seed, is the most common seeding method, particularly in winter and spring maize. However, this practice is tedious and requires more labor and time, which increases the total production cost and reduces the net benefit from maize production.

AWARNESS PROGRAM TO THE TECHNICIANS AND LEAD FARMERS REGARDING THE USE OF SEED DRILL FOR MAIZE SEEDING

CSISA's evaluation of different machines for seeding and weed management found that the use of mechanized seeding and weed management reduces the costs of those practices by 50% compared to manual seeding and weeding. CSISA, in collaboration with machinery traders and the Prime Minister's Agriculture Modernization Project, facilitated the adoption of mechanized seeding and intercultural operations in new areas. **During the reporting period, more than 200 ha of maize was seeded using seed drill machines provided by service providers in the Maize Super Zone.**

DEMONSTRATION AND TRAINING OF MINI-TILLER MODIFIED INTO POWER WEEDER FOR WEED MANAGEMENT AND EARTHING UP IN MAIZE IN DANG

For mechanized weeding and earthing up in the Terai, CSISA has been supporting the adoption of mini-tillers, found commonly in the markets of hilly areas for primary tillage. Prior to this year's maize season, CSISA, in collaboration with the Maize Super Zone program and local traders, organized a service provider training and awareness-raising campaign regarding mechanized maize seeding. In Satabariya, Dang, the Maize Super Zone command area, there are now four seed drill service providers and five new mini-tiller-power weeder service providers who, after seeing the demonstrations, purchased mini-tillers and started to provide services during this winter season. CSISA plans to help scale the use of mini-tillers for weeding and earthing up in other areas through mini-tiller importers who can now market this additional 'new use' of their mini-tiller in maize and other row crops in Nepal.

Characterizing maize quality with respect to aflatoxin contamination in farmers' storage under different ecological conditions

Aflatoxins are carcinogenic mycotoxins produced mainly by two types of mold – *Aspergillus flavus* and *A. parasiticus.* When ingested for sustained periods they can be acutely toxic to livestock and humans based on causal associations with diseases such as liver cancer. Moreover, even shorter-term exposure can be hazardous with childhood growth stunting also associated with aflatoxin consumption.

Aflatoxin has been found in grain and feed samples in Nepal. The Department of Food Technology and Quality Center (DFTQC), a governmental body, documents that about 20% of the maize samples assessed contained aflatoxin at levels greater than the safety limit of 20 ppb.

The USAID-funded Nutrition Innovation Lab (Tufts University) has started to document aflatoxin levels in pregnant women and children. Preliminary results document that 95% of the sampled individuals in the Nepali Terai had a detectable aflatoxin levels.[4] Global research shows that the risk of aflatoxin contamination is highest during the rainy season under hot and humid conditions.

In Nepal's mid hills, maize is mainly grown for food or livestock feed. Consumption of aflatoxin-contaminated maize grains as food or feed can affect both animals and humans. However, there is little documentation regarding how aflatoxin contamination varies according to pre-harvest and post-harvest management practices. Therefore, CSISA collaborated with Nepal's Department of Food Technology and Quality Control (DFTQC) and the Post-Harvest Directorate to:

- assess the level of aflatoxin contamination in maize under farmers' storage conditions in different production ecologies
- understand how pre-and post-harvest management practices affect aflatoxin contamination

Better fertilizer management reduces risk of pre-harvest aflatoxin contamination in maize: Pre-harvest infection and contamination of maize by *A. flavus* is correlated with insect damage and low soil fertility. To determine the influence of soil fertility management on aflatoxin in the mid-hills, CSISA conducted on-farm evaluations of maize under three different fertilizer management regimens: farmers' practice (application of only urea fertilizer), medium fertility (60:30:30 kg NPK/ha) and high fertility level (120:60:40 kg NPK/ha) in six different farmers' fields in Nuwakot, an FtF district. Harvested maize grains were analyzed for aflatoxin levels by the DFTQC laboratory using the ELISA (Enzyme-Linked Immunosorbent Assay) method. The results showed that maize grown under farmers' fertilizer management has high levels of aflatoxin contamination with 40% of the samples exceeding the toxicity threshold of 20 ppb (Figure 7). Under moderate fertilizer application (60:60:60) all of the samples have very low aflatoxin levels of less than 1 ppb. Similarly, with a high level of fertilizer application, around 40% of samples had aflatoxin levels of 1–10 ppb and 60% of the samples had aflatoxin levels below 1 ppb (Figure 8). The higher level of aflatoxin under farmers' fertility management was also associated with the appearance of stalk rot disease in the field.

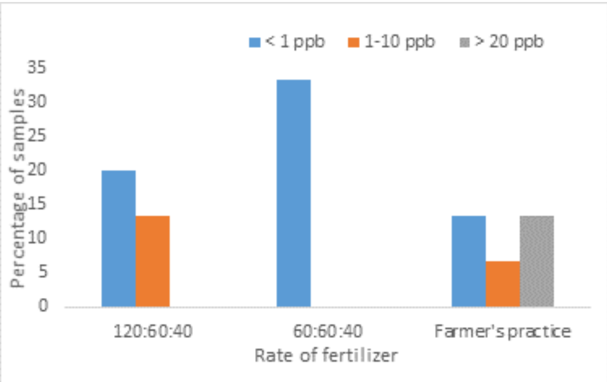

FIGURE 7. AFLATOXIN LEVEL IN MAIZE GROWN UNDER DIFFERENT FERTILIZER MANAGEMENT CONDITIONS

These results highlight the crucial importance of improving soil fertility management to limit the entry of aflatoxin into the food chain. CSISA is working with the NSAF project to both verify results and to ensure that a broad range of partners hears the core message.

[4] CSISA supported the development of the agriculture module for the Nutrition Innovation Lab survey on aflatoxin: http://www.fasebj.org/content/31/1_Supplement/639.42.

Better post-harvest management reduces aflatoxin contamination in maize in wet summers: Research conducted in different parts of the world has consistently shown that post-harvest contamination by aflatoxin is more severe than pre-harvest. Improper harvesting, delays in processing, and poor storage practices can increase the risk of aflatoxin contamination.

In the hills of Nepal, most farmers store maize on the cob with the husk intact. To assess cost-effective and practice methods for mitigating post-harvest aflatoxin issues in maize, CSISA again collaborated with DFTQC to evaluate different post-harvest management practices, including taking the grain off the cob, sun drying, and then storing it in a variety of improved (i.e. hermetically sealed) and local plastic storage bags. In the improved storage method, maize grains were taken off the cob immediately after harvest and sun dried. When the grain moisture reached 12%, grains were stored under four different types of hermetic bags available in the Nepalese market, with a common non-hermetic plastic storage bag as a check. Maize samples were analyzed for aflatoxin contamination at the beginning of storage and three months after storage. Maize samples were also taken from 18 farmers' houses where maize cobs were stored without de-husking, mostly kept in stacks on the side of the house. Aflatoxin levels under all improved practices were < 1 ppb. However, under farmers' storage practices – storing without de-husking – more than 50% of the samples had aflatoxin levels exceeded the safety standard of 20 ppb (Figure 8). This shows that storing maize after taking the grain off the cob and drying it immediately after harvest minimizes aflatoxin contamination during storage. Samples were also taken after six months of storage and are under analysis in the laboratory. Result will be presented in the next annual report.

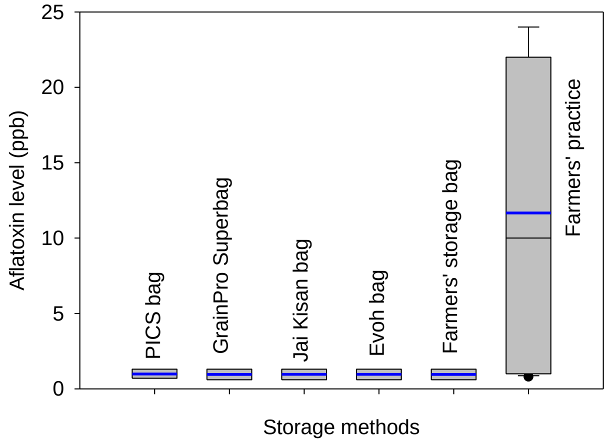

FIGURE 8. AFLATOXIN LEVEL IN MAIZE UNDER DIFFERENT STORAGE PRACTICES

Contamination of maize consumed by farmers and fed to animals exceeds safety standards: To understand the quality and aflatoxin contamination levels of maize that farmers consume or feed to their animals in different hill and inner Terai ecologies, we collected 100 maize samples from 10 local flourmills in Nuwakot and Dang, where farmers from different areas bring maize for grinding. Most of the samples had been stored for 5–6 months without de-husking, stacked inside the house. The samples were analyzed for aflatoxin contamination immediately after collection. CSISA found that 52% of the samples brought to the mill had aflatoxin levels that exceeded the safety standard, i.e., > 20 ppb (Figure 9). This shows how important it is to raise awareness among farmers and major value chain actors about improved pre and post-harvest management practices that can reduce aflatoxin contamination.

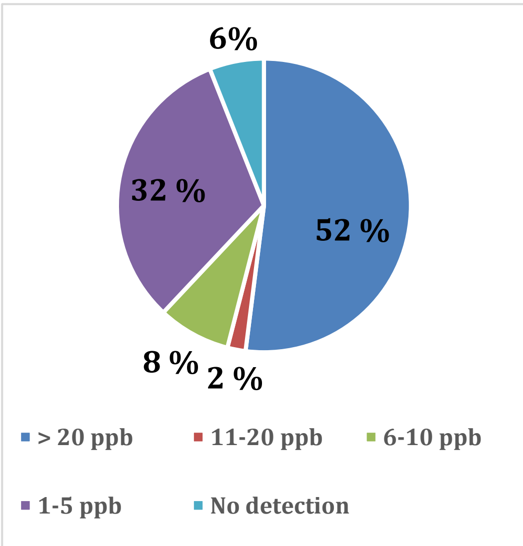

FIGURE 9. AFLATOXIN LEVEL IN MAIZE GRAINS COLLECTED FROM THE LOCAL FLOOR MILLS FROM NUWAKOT

Machinery for improved post-harvest management

Research indicates that maize left on the cob dries much more slowly than off the cob and that maize stored on the cob is likely among the earliest post-harvest vectors for infection or incubation. The cob is a large moisture reservoir that keeps grain moisture levels high while the cob slowly dries down. Mechanisms for getting maize off the cob quickly and more easily than hand shucking offers smallholders an easier and faster opportunities for ambient, solar or even mechanical dry down times, thereby reducing aflatoxin infection rates. Manual hand-cranked and small horsepower de-huskers and shellers that enable faster dry-down are relatively easy and inexpensive, are commercially available, and are already spreading in the Nepal market.

Farm-level drying: A collapsible dryer for faster drying

Drying maize and rice during the summer season is challenging, mainly due to frequent rainfall and high humidity. Grain quality can deteriorate if they are not dried properly. Grain Pro has developed a special tarpaulin that farmers can use to dry maize and other grains. In collaboration with the

FIGURE 10. DRYING MAIZE GRAIN ON COLLAPSIBLE DRYER

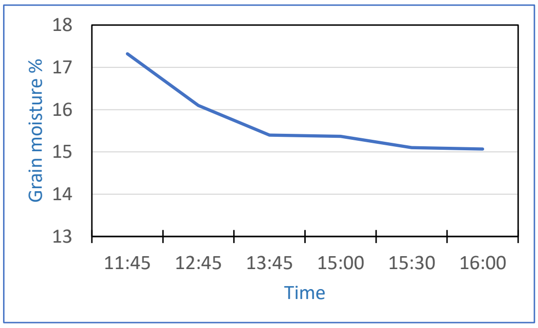

FIGURE 11. MEASUREMENT OF GRAIN MOISTURE PERCENT OVER TIME ON MAIZE DRIED UNDER COLLAPSIBLE DRYER

District Agriculture Development Office, Mero Agro Pvt. Ltd (private suppliers) and farmers groups, CSISA has demonstrated the collapsible dryer for maize in Nuwakot district. Researchers measured the grain moisture content over time during the demonstration, which showed that in four hours (11:45 am to 3:45 pm) the grain moisture dropped by 2.3% (from 17.3% to 15%) (Figure 11). Farmers were happy with the dryer as it helped reduce grain loss through spillage and could be conveniently and quickly closed if it rained. However, the initial price for the dryer is very high and is not affordable for individual farmers. The availability of the dryer on a rental basis could facilitate uptake. CSISA has shared the outcomes of the demonstration to the post-harvest directorate and PMAMP during the joint planning meeting. Further study is needed to evaluate different drying options that are safe, affordable and economical for farmers.

Cooperative-level drying: Small or medium capacity batch driers

CSISA has also explored a farmer cooperative-level option – small- and medium-sized batch driers for which prototypes are currently being evaluated by NARC for technical and market readiness. These dryers range from 2 ton to over 20 ton capacity and in Nepal would likely be targeting large farmer cooperatives or mid-size private grain or feed mills who would offer services to the farmer cooperatives.

Cooperative-level drying: Large capacity commercial dryers

Cooperatives could conceivably enter into agreements for drying and possibly storage with the many large, private, commercial driers that are owned and operated by large private feed and grain mills located across the Terai. If there were any excess storage capacity within these mills, then the cooperatives could also potentially arrange additional bulk storage at these mills.

These technologies and their potential business models were recently discussed with a team from Hellen Keller International, which showed interest especially for the extension phase of their

Nutrition Innovation Lab, PoSHAN (Policy and Science for Health Agriculture and Nutrition), funded by USAID.

Partnership with the Prime Minister's Agricultural Modernization Project (PMAMP) for commercialization of major cereal production

With a planned commitment of more than US$ 100 m and a 10-year performance period, the Prime Minister's Agriculture Modernization Project is the centerpiece of the Nepal Government's efforts to implement the *Agriculture Development Strategy* (ADS) that was passed by parliament in 2016. The ADS provides a roadmap for investment and aims to make the country self-reliant in agriculture production through targeted science-led innovation, progressive policies, and support to the emerging private sector. The PMAMP is organized around 'super zones' (commercial areas of more than 1,000 ha), zones (> 500 ha), blocks (> 50 ha) and pockets (> 10 ha). After consultation with the PMAMP leadership and by invitation, CSISA has initiated deep collaborations with the commodity programs for wheat, maize and rice that extend into the FtF zone. For example, the Maize and Wheat Super Zone programs have included CSISA in their technical and advisory committees and joint work plans were developed for the 2017–18 wheat, maize and mung bean seasons. Key activities include:

- Demonstrating mechanized crop establishment in new areas by mobilizing CSISA service providers;
- Contributing to the development of new commercial pocket areas (> 10 ha each) for maize, wheat and mung bean by linking input and output value chain actors with producer groups;
- Organizing technical trainings on sustainable intensification production technologies for key intermediaries from the PMAMP, Department of Agriculture, and private sector;
- Sharing extension publications in the forms tips, posters, booklets and videos that draw from CSISA applied research programming.

Under this partnership, the first national Maize Forum (October 9–10, 2017) and Rice Forum (December 14–15, 2017) were organized, which included more than 35 key public and private stakeholders for each crop. To frame the discussion, CSISA scientists presented a synthesis of findings from production practice surveys as well as on-farm experiments conducted in different seasons and geographies. Discussion at the forum then emphasized the identification of proven best practices for sustainable intensification, consideration of scaling pathways for knowledge and technological innovations, areas for future research, and joint work plan development for both rice and maize for the coming season. Similar events were also held for wheat (Q3 2017) and farm mechanization (Q4 2017).

Going forward, CSISA sees the PMAMP as the core mechanism for scaling sustainable intensification technologies for cereals in Nepal. As such, CSISA will continue to make contributions to the PMAMP at the strategic and operational levels.

C. Achieving Impact at Scale

C.1 Growing the input and service economy for sustainable intensification technologies

C.1.1 Integrated weed management to facilitate SI transitions in rice

In Nepal, manual hand weeding is the most common method of weed control in rice. Because of the scarcity of labor and consequently increase in labor wages, manual weed control is becoming expensive and laborers are often not available at critical weeding times, leading to late weeding and more yield losses (sometimes even up to 40%).

Recently, a proportion of farmers have started using herbicides for achieving timely and economical weed control, but there is almost no data available on the types of weeds that are most common, or on the contemporary control strategies implemented by farmers and supported by the private sector. To address these gaps and best target integrated weed management (IWM) interventions, CSISA conducted a field survey of current weed management practices and began gathering spatial information on problematic weeds across the landscape.

Surveys covered >350 households across six Terai districts in the FtF zone across two years. Forty weed species belonging to >15 families including annual grassy weeds, broad-leafs, and sedges were documented in rice and wheat. In both years *Cyperus sps*., *Echinochloa* sps., *Cynodon* sps., *Fimbristylis sps., Alternanthera* sps in rice and *Anagalis sps*., *Chenopodium sps*., *Medicago sps*., *Vicia sativa*, *Sensecio sps.* in wheat were the top five major weeds found in rice–wheat systems (Fig. 12). Besides the diverse weed species, the high weed density in the beginning of crop growth stage, i.e., more than 80 weeds in rice more than 45 weeds m^{-2} indicates the importance of timely weed management in both crops (Figure 13). A companion survey of input dealers revealed that almost all stock herbicides but only one or two products, mostly Butachlor for rice and 2, 4-D for wheat. Because weed flora is complex in these environments, the same herbicide may not control all weeds in all locations. Selecting economically and environmentally efficient herbicides and linking these herbicides to value chain actors could greatly benefit rice farmers.

Based on 2016 weed survey results, and to generate actionable information for the private sector, CSISA collaborated with the Nepal Agricultural Research Council to identify the most effective and economical weed management options for transplanted rice through on-farm research. Eight different weed management treatments using new and safe herbicide molecules combined with hand weeding were evaluated at nine farmers' fields in Bardiya and Rupendehi Districts. Results showed that a combination of two herbicide molecules (Bispyribac + pyrazosulfuron or Fenoxaprop + Carfentrazone) was better able to control the diverse weed spectrum common in rice. Similarly, rice yields in herbicide-based weed management treatments were either higher or at par with farmers' practice but have a better economic return through labor savings. Based on these findings, CSISA is working with herbicide importers and the Plant Protection Directorate for the registration and market availability of those herbicides.

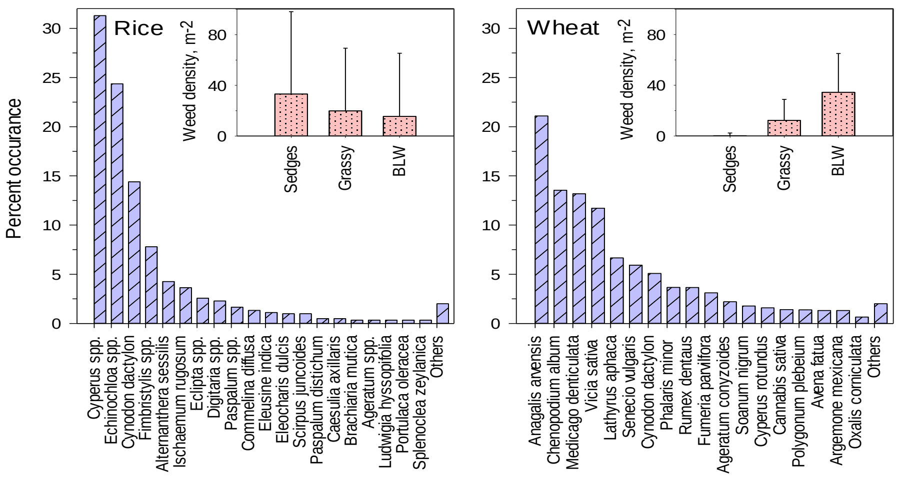

FIGURE 12. PERCENT OCCURRENCE OF DIFFERENT WEED SPECIES AND WEED DENSITY IN RICE AND WHEAT FIELDS IN WESTERN TERAI REGION OF NEPAL

C.1.2 Zero-till wheat to tackle energy and economic constraints and to enhance crop production

Scaling mechanized wheat through service providers

In Nepal, the national average wheat productivity is far below other Asian countries with similar production ecologies. A CSISA survey conducted across the Terai's wheat growing districts in 2016 showed that >25% of the wheat farmers suffer net financial losses, mainly due to high production costs and low productivity. Zero tillage significantly reduces the cost of sowing wheat and helps facilitate early seeding, especially in lowland areas, thereby reducing production costs and increasing productivity while significantly reducing risk and boosting resilience by helping farmers avoid terminal heat stress. CSISA is facilitating mechanized wheat sowing by facilitating the emergence of well-trained service providers. CSISA's collaborative effort with partners in 2017–18 facilitated 1,545 farmers to adopt mechanized wheat on 700 hectares. Most encouragingly, mechanized seeding adoption has been achieved through the increased private sector provision of seed drills.

C.1.3 Commercial expansion of scale-appropriate machinery and associated service provision models for reapers and seeders

Developing markets for seeders

Service providers are key to increasing access to capital-intensive mechanization technologies by making them available for a fee to small- and medium-scale farmers who do not have the financial resource to purchase their own machinery. With technical and market development support from CSISA, more than 200 service providers have purchased seed drills in the Terai region. CSISA conducted a survey of 85 service providers in six Terai districts to help develop a 'service provider profile'. On average, each provider operates within a 20 km area and charges on average US$ 12–15 per hour. Figure 13 shows the distribution of service providers located in CSISA working districts and the circle indicates the maximum distance that each service provider reached to provide services to farmers.

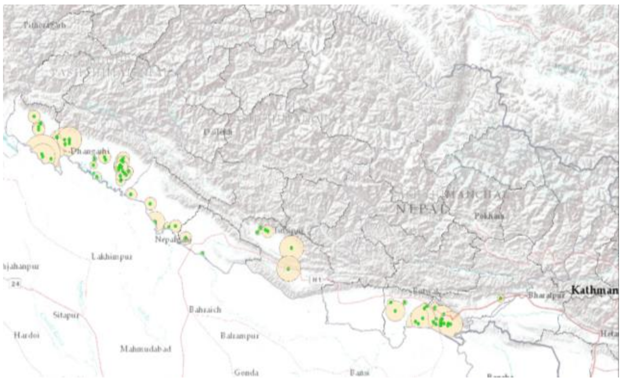

FIGURE 13. DISTRIBUTION OF SEED DRILL SERVICE PROVIDERS LOCATED IN CSISA WORKING DISTRICTS. THE CIRCLE INDICATES THE MAXIMUM DISTANCE TRAVELLED TO REACH FARMERS.

In four mid- and far-western Terai districts, there were almost no seed drills commercially available before CSISA intensified its market facilitation efforts in 2014. Nearly all of the seeding operations for rice, wheat, maize and lentil are done by hand. However, with CSISA's market development efforts for seeders and strengthening the service economy the number of seed drills available for service reached 102 at end of 2017 (Figure 14). This number was significantly higher than at the end of 2016, when only 31 seed drills were available for service provision in these districts.

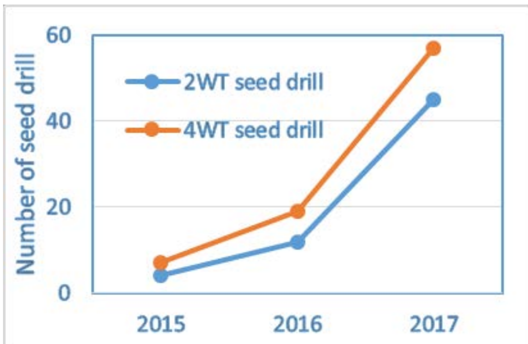

FIGURE 14. INCREMENT IN SEED DRILL SALES IN FOUR MID AND FAR-WESTERN FOUR TERAI DISTRICTS

Building relationships across the machinery value chain

In the first five years of CSISA (2009–14), the project focused almost exclusively on new technology introductions with concomitant activities for demonstrations and training. Seeing some initial demand building in a few target areas CSISA recognized that demand-side activities were not enough to bring about the changes that were sought. Thus CSISA began to emphasize marketing campaigns, building backward linkages with machinery manufacturers (Indian and Chinese), and government cost-share programs that served to stimulate private sector investments.

This supply-side activities included providing introductions, facilitating tours to launch linkages, providing advice, and strategically nudging both parties along the way to move potential partnerships towards completion. Table 6 below highlights these relatively new business partnerships for the supply of various modern machinery planters, harvesters, laser land levelers and other equipment for both 2-wheel and 4-wheel tractors.

Table 6. CSISA's facilitation efforts across the machinery value chain in the FtF zone of Nepal

Exporter / Location	Importer	Partnership Established	Product(s)
Khedut India	SKT (initially) BTL and Global Trading (currently)	March 2016 January 2017	Lower-cost seed drills for minitiller Lower-cost seed drills for two-wheel tractor (2WT) Lower-cost seed drill four-wheel tractor (4WT) Lower-cost manual planters, jab planters and pull planter
National Agro India	The Habi Kubir and Sons	December 2015 Apr – Dec 2016	Premium four-wheel tractor seeders and planters
KGBK, Jharkhand	Kubir and Sons	March 2016	Hand tools (weeders, etc.)
Durga Engineering Odisha, India	SKT	May 2016	Open drum thresher
Dharti India	Kubir and Sons	December 2016	Lower-cost minitiller, 2WT, & 4WT seeders
Various Chinese suppliers	BTL SKT Kubir and Sons Tikapur	Before project 2014 2014 2016	2WT reapers
Various Chinese suppliers	BTL	July 2016	Premium vertical plate maize planter
Various Chinese suppliers	SKT and AMC	2016	Hand-cranked seed and fertilizer spreader
Various Chinese suppliers	Shrestha Agro, SKT, BTL, AMC	2015	Irrigation-water pumps for mini-tillers

Sales of reaper-harvester boost mechanized harvesting in Nepal's Terai

CSISA's efforts to scale the reaper-harvester have been effective, and as of March 2018, traders have sold 2,197 reapers. In the past season, farmers have used these reapers to harvest 11,000 ha of rice and wheat (Figure 15). More than 95% of service providers purchased reapers at their own cost without any subsidy. With increased demand, the number of importers/suppliers has also increased. Whereas in 2016 four traders were involved in importing reapers, the number has increased to seven in 2018. Reapers save cost, time and drudgery over manual harvesting, and increase the likelihood of on-time planting.

Reapers can also serve as the basis for a service provision business, generating income through rental services. Besides increasing sales of reaper-harvesters there is an urgent need to understanding the barriers in getting reaper service providers to extend services to more farmers. CSISA estimates that currently each 2-wheel tractor reaper is only harvesting five hectares per season, yet the reaper is easily capable of harvesting at least double that area.

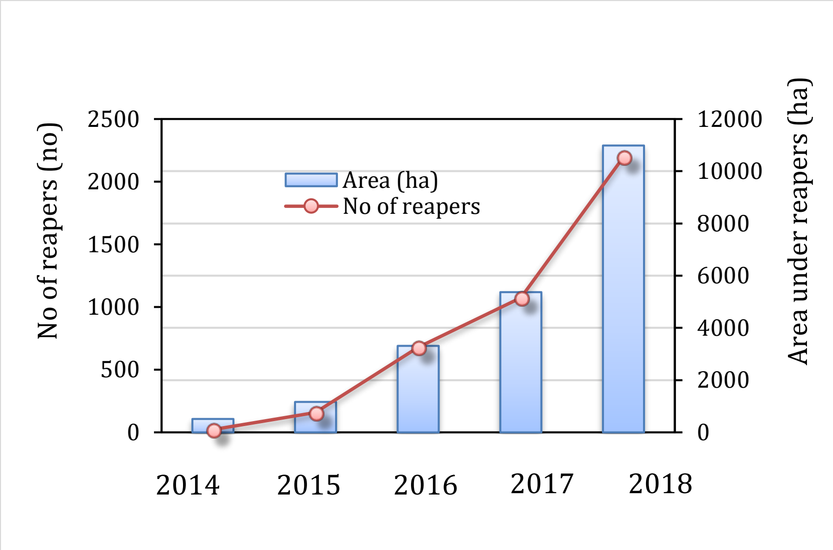

FIGURE 15. ESTIMATED REAPER NUMBER AND TOTAL AREA HARVESTED FOR RICE AND WHEAT

Demand for precision land leveling increases in Nepal Terai

A small number of farmers in the Terai plain region in Nepal are saving irrigation water and increasing yields with the use of the laser land leveler (LLL). The laser land leveler allows water to be distributed evenly within fields, increasing crop growth, resource recovery, and water-use efficiency. However, the high cost of equipment poses a barrier to scaling – even through service providers.

CSISA introduced laser land leveling technology in the central Terai in 2010. Scientists worked with farmers on technology demonstrations, participatory evaluations and awareness-raising campaigns. CSISA also provided operational and business development training to potential service providers. Workshops were organized among manufactures from India, local traders, government personnel and key farmers to discuss its scope for market development and for scaling-out the technology in the region.

Presently, the number of laser land leveler service providers has increased to 27 in the (Figure 16), and there are now five sales outlets for LLL across the Terai from a base of zero in 2013. Similarly, the Nepal government is supporting land leveling by providing a subsidy for LLL purchases and raising awareness on the importance of leveling land.

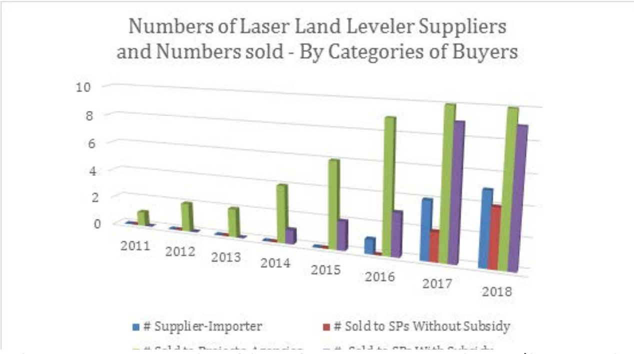

FIGURE 16. NUMBER OF LASER LAND LEVELER IMPORTER/SUPPLIERS AND UNITS SOLD IN NEPAL OVER EIGHT YEARS (2011-2018)

Farmers' willingness to pay for laser land leveling services in western Terai

To understand farmers' willingness to pay for laser land leveling services towards the goal of market development, CSISA conducted a scoping study on the adoption of laser land leveling technology in the western Terai. The study characterized interest in using laser land leveling services if services were available as a chargeable rental service. We used the semi-bound dichotomous choice model by taking the average per-hour charge for laser land leveling services (US$ 1,500 per hour) practiced by innovative service providers in the central Terai. The individual willingness to pay for LLL services for each of the farms was further derived by predicting it from interval regression. Results showed that farmers' willingness to pay for LLL services ranges from US$ 5 to 33 per hour. Furthermore, we observed a heterogeneous demand for LLL services across different farming strata. With an average willingness to pay of US$ 15.50 for per hour of LLL services, the predicted willingness to pay for LLL services for the largest 25% of farmers (landholding ≥ 1.82 ha) was significantly higher (US$ 22 per hour of service) than the lowest 25% of farmers (landholding < 0.24 ha) whose average willingness to pay for LLL services was US$ 11.40 per hour of LLL service (Figure 17). This study showed that farm size is the most important factor that derives the farmers' willingness to pay for laser land leveling services and gives guidance on the market potential in different parts of the Terai for the private sector and well as insights into how government support programs can be efficiently targeted to ensure inclusive access to this technology.

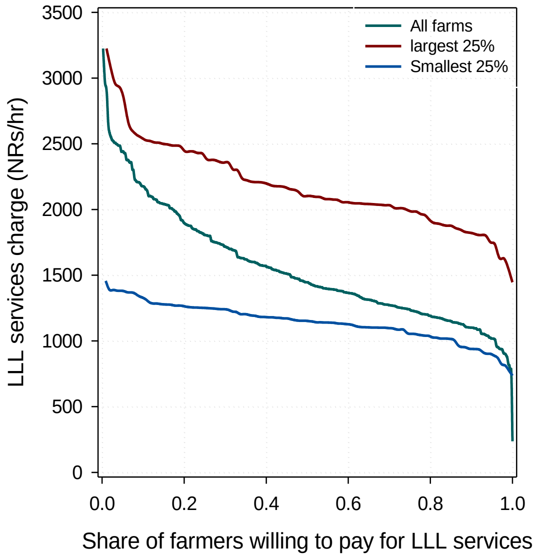

FIGURE 17. SHARE OF FARMERS WILLING TO PAY FOR LLL SERVICES

Survey of mini-tiller sales and impacts in the mid-hills of Nepal

Since 2012, CSISA has played significant role in introducing and scaling the mini-tiller, a small 5–9 horse power tractor particularly useful for the mid-hills, through field demonstrations, awareness-raising programs for public and private partners, and through market development. Currently, more than 10,000 units have already been sold across the country. To understand the impact of the adoption of a mini-tiller on farm income and the service economy, CSISA recently conducted a survey in collaboration with the Agri-engineering Directorate and the Nepal Agriculture Machinery Entrepreneurs Association (NAMEA) in six mid-hill districts.

Mini-tillers reduce the drudgery associated with agriculture production in the mid-hills of Nepal: Traditionally, bullocks and manual laborers were the only sources of tillage in the mid-hills of Nepal. A shortage of agricultural labor, mainly due to youth migration, has significantly affected agriculture production in the hills. Survey results (n = 1,004 households) indicate that 69% of farms perceive that that timely availability of agricultural labor is the major production constraint in the hills.

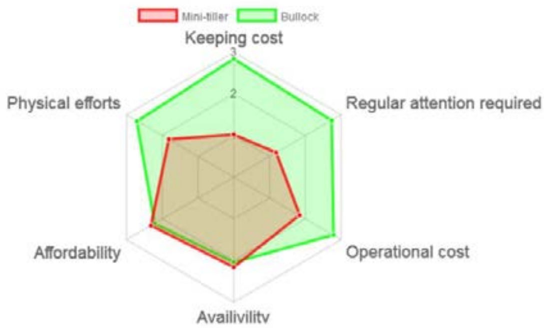

FIGURE 18. KEY CONSIDERATIONS FOR BULLOCKS VERSUS THE MINI-TILLER IN MID-HILLS. LOWER VALUES INDICATE MORE FAVORABLE PERCEPTIONS OF FARMERS.

Labor shortages affect the timeliness of crop management activities and the adoption of the mini-tiller can help overcome labor shortage problems, particularly for tillage. Compared to the mini-tiller, the cost of raising and keeping bullocks is much higher because they require feed, concentrates, fodder and labor. Although bullocks provide farmyard manure that is useful for increasing crop productivity, the daily care of raising bullocks involves significant drudgery for farmers, particularly due to the amount of time involved in collecting grasses and fodders. Our survey was conducted to assess the impact of mini-tillers in six mid-hill districts and shows that the mini-tiller substantially reduced or eliminated the costs of keeping bullocks, and reduced or eliminated the drudgery of maintaining them, thereby reducing the operational cost of farming and reducing the attention required to keep bullocks (Figure 18).

Impact of MT adoption on crop establishment cost and crop productivity: Our survey results showed that in the mid-hills, the mini-tiller is primarily used for tillage, while <1% of farmers also are using it for pumping irrigation water and transportation (using a small trailer attachment). Tillage and crop establishment costs were significantly lower for MT adopters compared with bullocks: savings of US$ 108/ha for rice, US$ 45/ha for maize, US$ 40/ha for wheat, and US$ 37/ha for vegetables.

Initial analysis showed that farm households that adopted mini-tiller tillage (through purchase or rental) produced higher yields for both cereals and fresh vegetables compared to non-adopters. On average, adopter households increased their productivity by 0.4 to 0.5 t/ha for major cereals and by 4 t/ha for fresh vegetables (Table 7). Increased crop productivity with mini-tiller adoption could be associated with timely crop establishment. Further analysis is on-going and more details will be presented in the next annual report.

Table 7: Impact of mini-tiller on tillage cost and crop productivity of major cereals (rice, wheat and maize) and fresh vegetables in study areas

Crops	Adopters	Non-adopters	Difference	*t*-value
Rice (N= 302 Adopter, 322 Non-adopter)				
Tillage cost (US$/ha)	132	240	108	12.97***
Grain yield (kg/ha)	5518	4989	529	-3.36***
Maize (N= 276 Adopter, 466 Non-adopter)				
Tillage cost (US$/ha)	118	163	45	5.80***
Grain yield (kg/ha)	3436	2989	446	-2.85***
Wheat (N= 106 Adopter, 199 Non-adopter)				
Tillage cost (US$/ha)	130	170	40	2.24**
Grain yield (kg/ha)	2201	1942	258	-2.07**
Fresh vegetables (N= 203 Adopter, 201 Non-adopter)				
Tillage cost (US$/ha)	146	183	37	3.02***
Production (tons/ha)	13.58	9.47	4.10	-5.16***

*** Statistically significant at 1% level, exchange rate US$ 1 = 100 NRs

Does the mini-tiller attract youth to agriculture in the hills? A huge number of Nepalese workers are migrating abroad in search of better employment opportunities, resulting in acute labor shortages in agriculture. CSISA is strengthening service provision opportunities and, through surveys, attempting to document the income-generating potential of different mechanization platforms and services to help further enthuse the emergence of more entrepreneurs. Out of the 254 mini-tiller owners surveyed, 26% are providing services for tillage to the neighboring farms. On average, each owner serviced 9 neighboring farms with an average area of 1.8 ha during the surveyed year, excluding their own land. The average rental service charge for tillage was US$ 5.5/hr and service providers were earning more than US$ 200/ha/year in additional income. The unit cost of the mini-tiller is around US$ 550, making the payback period less than three years. Low investment cost, short payback period and the chance to generate extra income from rental services makes the mini-tiller potentially important for rural entrepreneurship development in hilly areas of Nepal. Also, CSISA research also shows that most of the mini-tillers procured by farmers were subsidized (70%) either by government programs or development organizations. Interestingly, farmers who purchased a mini-tiller at full cost were more likely to be involved in providing services to other farms than the farmers who purchased or obtained a mini-tiller through a partial or complete subsidy.

Problems associated with mini-tiller adoption: Service providers reported that mini-tillers often vibrate too much vibration during tillage. Our survey results show that 53% of mini-tiller adopters reported vibration coming from the mini-tiller during tillage as the major constraint of mini-tiller adoption. Other problems adopters faced included wear and tear of spare parts and unavailability of spare parts locally. On average each mini-tiller owner spent US$ 67.50 (NRs 6,748) for repair and maintenance annually. Only 8% of mini-tillers owners reported that they obtained mini-tiller repair and maintenance training and 84% responded that the training was useful. CIMMYT and its partners have provided repair and maintenance training to farmers as part of the earthquake recovery support program, yet most farmers responded that they have problems accessing repair and maintenance services locally.

Agricultural Machinery Testing and Research Center, Nawalpur

The CSISA-supported Agricultural Machinery Testing and Research Center (AMTRC), co-located at the National Oil Research Center in Nawalpur, Sarlahi District, and run by NARC, was inaugurated in February 2018. With approximately US$ 145K USD provided by CSISA for machinery procurement, the center has built a new Dynamometer Testing Center and rehabilitated an older office and quarters that were given to AMTRC by the Oil Research Farm. In April, NARC also provided a co-investment of US$ 85,000 to compete the first round of building construction. CSISA provided an additional US$ 20,000 sub-grant to the center to jumpstart the testing of select agricultural machinery. The AMTRC had been chosen by the United Nations Center for Sustainable Agricultural Mechanization (UN-CSAM, www.un-csam.org) to be one of five member countries' machinery testing centers to participate in a needs assessment from an outside team of senior agricultural engineers. AMTRC staff will also receive advanced training on machinery testing protocols. Depending on the outcomes of the needs assessment, AMTRC could qualify for further investment by UN-CSAM for increasing AMTRCs testing capacity.

Agricultural Mechanization Forum with PMAMP and DOA

Another in a recent series of CSISA-sponsored thematic meetings through our partnership with the PMAMP was held on 'Mechanization for Sustainable Intensification of Nepalese Agriculture in Kathmandu on February 14-15, 2018. Participants hailed from various governmental and non-governmental, research and educational, finance and banking, and private organizations. The objective was to review the current knowledge of, and practices in, machinery value chains in Nepal and begin to develop a strategic roadmap for scaling innovations. Some initial activities were identified for fast tracking such as (1) planning for trainings of trainers and local service providers by DAE, NARC, and CSISA and private sector suppliers for the reaper-harvester, laser land leveler and direct seeded rice with Rice and Wheat Super Zones and (2) similar activities on the promotion of maize planters and power-weeders for Maize Super Zone farmers for spring and summer maize.

Design Sprint update

Dharti Agro and Khedut Agro have now have established dealers in Nepal and also have begun marketing the improved seeders that emerged from the CSISA-support collaborative design sprint that was devised to overcome long-standing design issues that were limiting sales. Dharti has now 10 pieces of 4-wheel tractor and two pieces of 2-wheel tractor seeders in stock with their dealer (Kubier and Sons in Itihari) and Khedut not only has stock but also has recently sold 15 4-wheel tractor zero till drills to the FAO's climate change project in Nepal.

CSISA mechanization video series and farmer field days

CSISA Nepal released four short videos highlighting the value mechanization and service provision in Nepal. Featuring farmers who have adopted technologies such as seed drills, power tillers, mini tillers and reapers, the videos highlight that mechanization can save time and cost and reduce drudgery. They also point out that extra income can be made from becoming a service provider, and that these opportunities to earn extra income can help reduce incentives for Nepal's youth to go abroad for work.

Sutra Media Works (the filmmaker) and CSISA hosted four video showings in the field so that farmers, potential service providers, self-help groups and Nepal government representatives could see the films, ask follow-up questions and discuss locally relevant issues raised by the videos. Held in Bardiya, Dang, Kailali and Kanchanpur for 296 attendees (including 72 women), the films were well received and the discussion participants identified the following preconditions for mechanization to spread broadly: (1) increased awareness of agricultural technologies at the local level (i.e. demand generation), (2) technical training on how to use the equipment, (3) spares and repairs for fixing machines, and (4) mechanisms to bring the cost of technology and services into reach.

Banking Sector Policy Changes and Financing for Agri-Mechanization

In the past three years, CSISA has held multiple rounds of meetings with banks and micro-financing institutes (including USAID DCA partner Laxmi Bank) about the unmet need for financing agricultural machinery in Nepal. Until recently, there had been little or no movement by the banks to connect with the agri-machinery industry, outside of financing 4-wheel tractor sales. Approximate 1.5 years ago, the Government of Nepal announced that the 10% of the funds that commercial banks must lend to the rural sector could no longer be channeled through rural development banks but had to be directly loaned from the commercial banks themselves. There was also a warning from the government that there will be an increase in the penalty for not meeting the target, which some banks had elected to pay rather than go through the extra cost of managing loans to rural clients.

These changes in the policy environment have reignited interest within the banking sector in agri-machinery loans. One recent outcome was the bank tie-up between Nepal-Bangladesh Bank and BTL Limited for the financing of tractors and attachments. A second has been that Laxmi Bank has a new loan product arrangement with SKT Nepal Pvt. Ltd. to finance agro equipment end users via selected dealers of SKT Nepal that is backed by dealer's buy back guarantee and a corporate guarantee of SKT Nepal. Financing is restricted to 70% of the invoice value, with the loan size ranging from NRs 40,000 per invoice and a maximum of NRs 500,000 per borrower. Laxmi Bank anticipates building a total loan portfolio of approximately NRs 20 million under this scheme at the piloting phase. Given the importance of finance for overall growth of the mechanization sub-sector, CSISA will continue to facilitate relationships between banks and our private sector partners like SKT and BTL.

C.2 Managing risk by coping with climate extremes

C.2.1 Coping with a weak and variable monsoon and avoiding *kharif* fallows

Understanding and coping with monsoon variability

Rice is grown in all districts of Nepal but more than 70% of total rice production comes from the Terai region. Since most systems are rainfed, production largely depends upon the onset, distribution, and cessation of monsoon rainfall.

To understand rainfall variability and its effects on rice production in the Terai and to understand coping mechanisms under both drought and flood conditions, long-term (1976–2014) rainfall and productivity trend data from 21 Terai districts were assessed.

Results underscore the complex relationships between season rainfall and yield outcomes, but also clearly show that the most extreme reductions in yield (> 25% deviation) occur when precipitation falls below 1,700 mm (Figure 19). Machine learning approaches are now being used to disentangle the complex relationships between climate and rice yields in Nepal, and full results will be presented in the annual report.

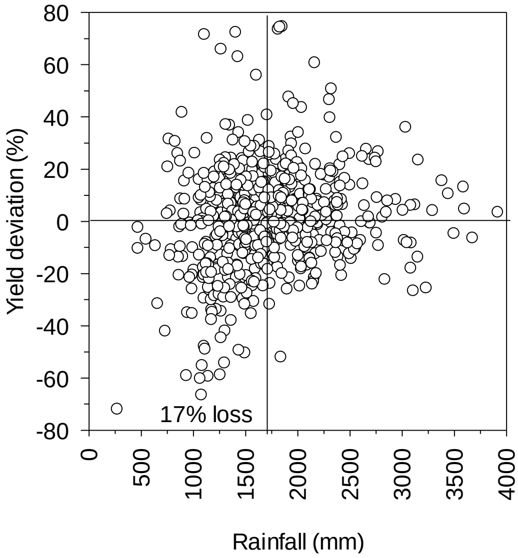

FIGURE 19. RELATIONSHIP BETWEEN RAINFALL AMOUNT DURING MAY-OCTOBER (RICE GROWING SEASON) AND THE YIELD DEVIATION

C.2.1 Coping with a weak and variable monsoon and avoiding *kharif* fallows

Water resources utilization for resilience and higher yields

CSISA's yield and production practice survey for the 2016 rice crop confirms the importance of supplemental irrigation for reducing risks and achieving high and stable crop yields. Across the Terai districts where the survey was implemented (total of more than > 1,050 households), farmers who irrigated three or four times had rice yields that averaged approximately 4.5 t/ha, whereas farmers who did not irrigate achieved yields of 3.0 t/ha, indicating that water stress in even a 'good' monsoon year reduces rice yield potential by 33%.

Past and ongoing efforts to expand the use of irrigation in Nepal for staple crop production have focused primary on assuring supply by supporting the expansion of infrastructure such as tube wells for groundwater pumping.

A long-term (1977–2013) simulation study was conducted to explore the yield of transplanted rice under irrigated and rainfed conditions in three FtF districts (Kanchanpur, Banke and Rupandehi) using the ORYZA3 model. The simulation study showed a declining trend of rice grain yield over 35 years (1977–2013), in which, compared to the initial 5 years (1977–1982), yield potential declined by 0.6 t/ha (12%) under rainfed conditions (Figure 20). However, in the same period with supplementary irrigation of 50 mm at -10 kPa soil metric potential, rice yield increased by 0.92 t/ha (15%). This simulation study suggests that increasing access to irrigation facilities for transplanted rice farmers is the best strategy to cope with monsoon variability.

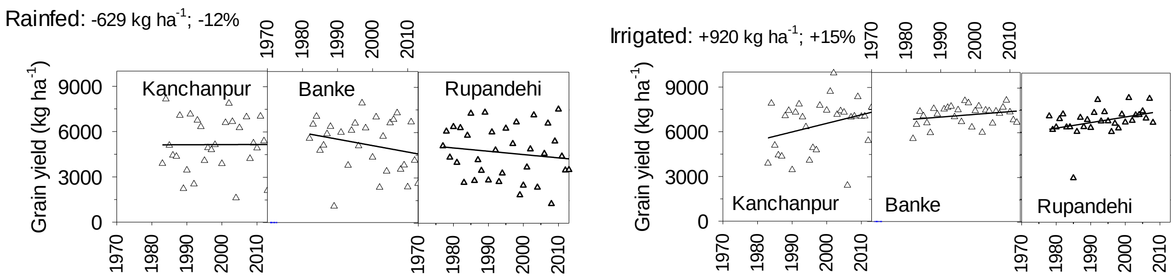

FIGURE 20. THE LONG-TERM SIMULATED YIELD OF TRANSPLANTED RICE UNDER RAINFED AND IRRIGATED CONDITIONS

Through CSISA's surveys and stakeholder engagements, it has become clear that many farmers who insufficiently irrigate rice do, in fact, have access to irrigation water but choose not to use it. To change this scenario and increase systems resilience, food security, and profitability, CSISA has partnered with the Water Resources Management Group at Wageningen University (*graduate student Anton Urfels*) to characterize farmer decision process around irrigation use in rice. Case studies were developed for Banke, Rupandehi and Kailali Districts using semi-structured interviews, household surveys, and ethnographic decision-tree models.

Our results indicate that irrigation is constrained by many of the same factors across the entire area, but with varying degrees of importance. The most influential factors associated with lower irrigation application rates in rice include: 1) 'loss aversion'-induced delays (e.g. concern that rains will eventually come, eroding the value of applied irrigation – a core issue in all districts), 2) lack of reliable electricity (Banke), 3) shortages of pumpsets (all), 4) turn-taking for shared tubewells (Rupandehi), 5) financial constraints (Kailali), and 6) pump maintenance-induced delays (Rupandehi, Kailali).

Efforts to encourage more optimal use of irrigation infrastructure will fundamentally require improvements in decision support tools for irrigation scheduling to address loss aversion. In Rupandehi, increasing tube well density is likely to stimulate informal water markets to provide more benefits by driving down rental delays. In Banke, the large number of existing agricultural electricity connections and shallow tubewells renders a reliable electricity supply a worthy focus point for improving irrigation utilization in the driest of the three districts. In Kailali, cash constraints are of larger importance. Bringing down water prices through improved pump system design and provision of credit are promising entry-points.

Challenges faced during the reporting period

1. Evolving process of political devolution:
    - Nepal recently entered into the complicated effort of building a federated structure with more regional autonomy. One result is that the agricultural budget that used to be with the District Agriculture Development Offices has been diverted to new, local administrative units. As there is no clear-cut breakdown of local budget by sector, many agricultural development support programs have been deferred or otherwise delayed.
    - Also, as the Department of Agriculture and the many of its district-level Agricultural Development Offices are mostly concentrating on transitioning to the new provincial republican structure, CSISA's collaborative work with District Agriculture Development Offices (DADOs) and Agriculture Service Centres has been negatively affected. For example, the dissemination of better-bet agronomic messages, supporting the development of the service economy and stronger agro-machinery markets has slowed down.
2. Funding uncertainty
    - In September 2017, it became clear that FY18 funds for this project were expected to be delayed and/or greatly reduced.
    - At reporting time, seven months into FY18, funding has neither been confirmed nor disbursed, limiting our ability to make commitments to staff and/or partners.
    - In response to funding uncertainty and delays, CSISA has had to reduce its staff strength by around 75% as we conserve funds. Without clarity on additional funding, we will unable to further renew additional staff contracts.

D. Policy Reform

D.1 Seed Systems

Bangladesh

Activities around seed system policy reforms have been phased down in this reporting period due to transitions in IFPRI CSISA leadership and larger project-related factors. However, CSISA continues to maintain close relationships with partners on the seed systems front in Bangladesh, including IFPRI's Bangladesh Policy Research and Strategy Support Program and Agricultural Policy Support Unit, the main CGIAR centers with offices in Dhaka, the national research system, and the donor community, and is positioned to leverage these relationships to pursue additional activities around seed systems policy research if there is sufficient interest and funding to support these activities.

Nepal

CSISA entered into a collaboration with the USAID-supported Nepal Seed and Fertilizer project (NSAF), led by CIMMYT, to determine the demand and supply gaps required to bring about a systemic policy change in varietal turnover. To assess farmers' demand for quality and timely availability of seed, CSISA had initiated discussions to field a discrete choice experiment among farmers in Nepal to better assess the specific varietal traits that farmers desire in cereals seeds. The objective was to allow CSISA to have a better understanding of ground-level issues, and provide a basis of evidence on which to advise the Government of Nepal on policy and regulatory options under the Nepal Seed Vision 2020 as the Nepal government's intention is to reduce the subsidy burden on the exchequer by replacing universal subsidies with a targeted voucher system. However, activities in this area have been suspended in light of uncertainty around funding and transitions within the IFPRI CSISA leadership.

D.2 Scale-appropriate mechanization

Bangladesh

CSISA had engaged in determining the potential impact and tradeoffs associated with the Government of Bangladesh's various policies to support and protect domestic agricultural equipment manufacturers, such as customs duties and tariffs, credit facilities, and other support mechanisms. CSISA had also characterized the status of the agricultural machine industry and the dispersion of agricultural machines throughout Bangladesh, including the structure of the aforementioned trade barriers on agricultural equipment. This task also attempted to understand the sensitivity of supply and demand to price changes, and changes in government revenue as a result of changes to trade policies. During the exercise, several important data gaps were identified that restricted our ability to infer the complete picture – such as administrative data on specific machines and data on supply and demand elasticities for relevant agricultural machines. It became apparent that a significant investment of staff time and resources would be required to complete the analysis. Continued work on this activity proved difficult for CSISA considering the uncertainty around project funding and CSISA's inability to continue to support in-country staff during the reporting period.

The need for understanding gender dynamics in emerging markets for agricultural machinery resulted in a collaborative partnership between CSISA, GCAN (a Feed the Future Initiative) and CSISA-MI. This partnership aimed to jointly generate evidence that sheds light on gendered differences in women's and men's involvement in emerging markets of reaper-harvester machinery services in the Feed the Future Zone in Bangladesh. Results from this study point towards the fact that many technical, economic, and cultural barriers constrain women's full participation in reaping the benefits from these machinery, but there is potential in reducing these gaps by prioritizing joint learning, collective hiring and lowering the costs of service provision. With frequent migration of men out of rural areas to secure more remunerative employment, women farmers represent a relatively untapped market of latent demand if access to these services is enhanced. At the same time, encouraging women to turn into service providers has immense potential in providing them with potential business opportunities and raising their income-generating capacities.

Nepal

Due to funding uncertainty, efforts in this direction have been halted under CSISA, but our continued interest in the area has resulted in IFPRI's participation in other USAID potential grants that allow us to engage in experiments around scale-appropriate mechanization in Nepal.

D.3 Soil fertility management and fertilizer markets

Bangladesh

In both Bangladesh and Nepal, there are legitimate concerns about fertilizers being smuggled across the border from India and subsequently sold on the black or grey markets. The government of India has introduced a fertilizer monitoring system that is meant to track fertilizer supplies from the manufacturer to the retailer and ultimately to the end user, which has the expressed intent of eliminating diversions of fertilizer stocks to Bangladesh and Nepal. CSISA is closely following the policy landscape on both sides of the border to determine the impact of such a policy on the availability of fertilizer in Bangladesh, particularly in the border areas. The delayed implementation of India's Aadhar-enabled fertilizer management system has impeded CSISA's efforts to qualitatively assess the impacts on fertilizer supplies in Bangladesh, as has the funding scenario.

Nepal

CSISA's collaboration with NSAF continued into in the current reporting period, allowing us to leverage project activities to jointly expand our knowledge base and insights on the key policy concerns of the Nepalese government around the establishment of strong internal manufacturing systems to support the demand for key agricultural inputs, a portion of which is currently being met by grey markets around the India-Nepal border. Recently compiled data from the NSAF project's baseline survey provide some insights into this phenomenon as well as the demand-supply gaps in effective nutrient application behavior amongst the farmers in Nepal. CSISA has undertaken a comprehensive analysis of these data to identify the price variants and other bottlenecks in the availability of key inputs such as Urea and DAP and employed the evidence to design a structured willingness to pay experiment with farmers in Nepal during the April – September 2018 semi-annual reporting period. The experiment is designed to unearth latent demand of quality and timely availability of fertilizers using modern experimental valuation techniques. Using this technique, CSISA will be able to demonstrate the differential valuation between the product (key agricultural inputs) and the constraints to access the product for the end users. Data collected as part of this activity will yield generate results and estimates that can be used to study farmer behavior with respect to key input usage in their *kharif* 2018 cultivation. Given the Nepal government's focus on reducing dependence on Indian fertilizers smuggled across the border (e.g., by encouraging organic fertilizer usage), it is imperative to fill the current knowledge gap around demand side requirements (including product and access) of key agricultural inputs that impede yield maximization of smallholder farmers.

D.4 Agricultural risk management

Bangladesh

CSISA has been evaluating alternatives for providing risk management solutions to smallholder farmers in Bangladesh, specifically stress-tolerant rice cultivars developed under the Stress-Tolerant Rice for Africa and South Asia project, and index insurance. In this reporting period, CSISA has been able to generate evidence to support efforts for increasing the scope and reach of agricultural risk management throughout the region.

First, CSISA generated the first field-level evidence on the efficacy of an innovative risk management tool that bundles a novel index insurance product with a yield-enhancing (specifically, reducing yield variability) stress-tolerant rice variety. The bundled risk management product aims to address risks related to deficient rainfall during the summer monsoon season in Bangladesh. Index insurance is generally less expensive to administer, is less prone to informational asymmetries such as adverse selection and moral hazard, and typically entails lower reinsurance costs. Consequently, it is typically considerably less expensive than conventional crop insurance. When specially calibrated to complement the performance profile of the drought-tolerant rice variety, the bundled product can provide monotonically increasing (or at least non-decreasing) benefits, since the insurance component would still provide benefits beyond the drought stress level at which the relative benefits of the drought-tolerant variety begin to decline. Overall, we find that when bundled with index insurance, farmer's valuation of the variety increases. For insurance, farmer's value insurance on its own, but when bundled with drought-tolerant rice variety, their valuation for the insurance component (as well as for the overall bundled product) increases as well. Overall, our results suggest that bundling drought-tolerant rice with index insurance may provide a mechanism for managing drought risk, and may result in increased demand for both the rice variety as well as the index insurance, while simultaneously reducing the cost of the complementary index insurance component. Results from this study form the basis for a manuscript that has recently been accepted for publication in *Economic Development and Cultural Change*.

Second, through a multi-year randomized controlled trial, CSISA was able to assess the demand for and effectiveness of a hybrid index insurance product designed to help smallholder farmers in Bangladesh manage crop production risk during the monsoon season. While index insurance confers some obvious advantages over the conventional indemnity based crop insurance, experiences in many countries thus far suggests that insurance programs will likely entail government interventions such as subsidies, at least in the short-run to encourage uptake. This study compared the relative effectiveness of two such government interventions: an upfront discount or a rebate returned to the farmer at a later date. While most farmers would prefer the discount, there is evidence that some farmers prefer the assurances of a subsequent payment (the rebate) even if the insurance does not pay out. The price elasticity of demand implied by the results suggests that there would be a need for a 15 percent discount or 33 percent rebate relative to the actuarially fair cost of insurance to ensure sufficient insurance uptake. When assessing the impacts of the index insurance product on farmers' productive behavior and agricultural outcomes, the study found that the hybrid index insurance product generated both ex ante risk management effects as well as ex post income effects. Purchasing encouraged farmers to take on greater risk exposure during the monsoon season, particularly through expanding area under higher-value crops and through investments in high-risk, high-return agricultural inputs such as fertilizers and irrigation (by 30 percent and 24 percent, respectively). The results also suggest that insurance has positive effects on agricultural production during the subsequent dry season, even though the insurance was not meant to provide any risk mitigation during this season. This effect may be principally due to increased liquidity following the receipt of an insurance payout. Insured farmers increased expenditures on fertilizers and seeds by 10 and 28 percent, respectively, resulting in an 8 percent increase in rice production.

In December 2017, CSISA co-organized a regional dialogue on agricultural risk management in Dhaka. The event was conducted in partnership with the CGIAR research programs on Policies, Institutions and Markets (PIM) and Climate Change, Agriculture, and Food Security (CCAFS). The goal of the dialogue was to provide a platform whereby experiences and ideas can be shared among various stakeholders and across disciplinary and geographic boundaries, all for the enhancement of rural livelihoods in South Asia, with a particular focus on risk management. There is considerable interest within the international development community in mitigating these risks through insurance as became evident from the policy dialogue. Policy makers, practitioners, and researchers from Bangladesh, India, and Nepal convened to share their experiences with implementing agricultural insurance across the region and to learn about the latest agricultural research on this subject. While insurance has been around for a very long time, many of its more traditional forms have suffered from low demand and asymmetric information between insured and insurer, giving rise to adverse selection and moral hazard. The agricultural research community has responded to these challenges by identifying and developing research-based innovations for agricultural insurance, such as index-based insurance programs that can minimize the severity of adverse selection and moral hazard; the use of cutting edge remote sensing and information technologies; and the bundling of insurance with novel "climate-smart" agricultural technologies and practices (CSA) that are more resilient to adverse weather conditions than traditional technologies and practices, thus serving an important risk management function in their own right. The discussions also focused on determining region-specific approaches to managing crop insurance, in light of varying socio-political factors within the participating countries (India, Nepal and Bangladesh). A platform was thus created, as a result of this convening that allows CSISA to continue to generate more evidence and inform policy on the tried and tested potential methods of risk reduction.

Nepal

The aforementioned regional dialogue hosted in Dhaka in December 2017 provided CSISA researchers an opportunity to learn from policymakers and practitioners in Nepal about the specific challenges that have been encountered in their efforts to introduce agricultural insurance in Nepal, while also sharing examples from the experiences of other countries in the region and providing evidence-based policy solutions based on small-scale pilot programs. Owing to funding uncertainty, no further activities have been undertaken with respect to agricultural risk management in Nepal.

Engagement with Missions, FTF partners and project sub-contractors

USAID Missions

In Bangladesh, the CSISA Phase III Bangladesh country coordinator regularly updates the USAID/Bangladesh Mission staff under the Office of Economic Growth with regards to ongoing activities. CSISA is also regularly consulted by the Mission for information on cereal based cropping systems, agricultural mechanization, and appropriate agricultural development investments. Notable consultations include requests for information and ideas on improving gender mainstreaming in agricultural development, in addition to solicitation of ideas for future investments. Most recently and at the Mission's request CSISA Phase III participated in a field visit to Bangladesh and project sharing program for Dr. Gary Lindon, the Acting Deputy Assistant to the USAID Administrator.

CSISA engaged with the Nepal mission in the following core areas in FY18:

- Provided technical advice and support to the KISAN II project (USAID-Nepal's flagship FtF program) on staple crop management.
- Shared technical insights into challenges and opportunities confronting the sustainable intensification of lentil production in Nepal to the USAID-funded projects, i.e., 'Nepal Seed and Fertilizer' (NSAF) and KISAN II.

FTF partners

CSISA Phase III also directly collaborates with the following FtF projects:

- **Agricultural Inputs Project (AIP):** This CNFA-led project works to improve the knowledge of and access to quality agricultural inputs for farmers in the Feed the Future zone of Bangladesh. Phase III collaborates with AIP and the Agricultural Input Retailer Network to scale-up farmers' access to information on better-bet agronomy and integrated weed management. Details on AIP can be found here: https://www.cnfa.org/program/agro-inputs-project/
- **Rice Value Chain (RVC) Project:** The IRRI-led RVC project is a 15-month activity starting on October 1, 2015 and ending on the December 31, 2016. It builds on the lessons learned from the, Cereal Systems Initiative for Southeast Asia in Bangladesh, and supports the private sector improve the efficiency of the rice value chain. The project will work out of hubs based in Jessore, Khulna, Barisal and Faridpur. Because of RVC's closure at the end of 2016, CSISA Phase-III will build on the project's activities and inherit staff and partnerships to continue to scale-out farmers' use of premium quality rice varieties in the FtF zone.
- **Cereal Systems Initiative for South Asia – Mechanization and Irrigation (CSISA-MI) project**: CSISA-MI emerged out of CSISA's ongoing efforts in the USAID/Bangladesh Mission-funded CSISA expansion project (2010–15), and during CSISA Phase II. It continues to be strategically aligned with the broader CSISA Phase III program in Bangladesh, and is led by CIMMYT in partnership with International Development Enterprises (iDE). CSISA-MI is a five- year project (July 2013 – September 2018) that focuses on unlocking agricultural productivity through increased adoption of agricultural mechanization technologies and services. The CSISA-MI Project Leader has a position on the CSISA Phase III technical coordination committee. The Phase III Bangladesh Country Coordinator also maintains a position on the leadership committee of CSISA-MI.

- Although it does not fall under the FtF program, CSISA wheat blast research activities on disease forecasting and modeling are also strategically aligned with the USAID-Washington funded **Climate Services for Resilient Development (CSRD) project**, which falls under the Global Climate Change Office Bureau for Economic Growth - Education and Environment. Strategic alignment with CSISA is assured as the CSRD Project Leader is also the CSISA Phase III Bangladesh Country Coordinator.
- The **Nepal Seed and Fertilizer (NSAF)** project, a $15 m USAID-Nepal initiative, was a direct outshoot of progress made by CSISA on seed systems and integration soil fertility management. CSISA staff deeply collaborate with NSAF on scientific and operational matters. The lead of CSISA, Andrew McDonald, acts as the senior advisor for NSAF.
- **The KISAN project**, part of USAID's global Feed the Future initiative, is a US$ 20 million five-year program working to advance food security objectives by increasing agricultural productivity. KISAN works collaboratively with CSISA by utilizing technical and extension materials and advice to improve the uptake of better-bet sustainable agriculture production and post-harvest practices and technologies for targeted cereals. KISAN has a reach of hundreds of thousands of farmers, who have been exposed to CSISA information, materials, and technologies through this partnership.

During the reporting period, CSISA and KISAN have:

- ✓ Produced accessible guides for **better bet agronomy for rice and maize** – information that is generally not available to smallholders**.** KISAN has reproduced these guides with their own resources and they provide the backbone of their technical training programs for maize and rice, the two core staple crop value chains for the project.
- ✓ Developed a factsheet on *Stemphylium* management for lentil and provided training to technicians from DADOs, KISAN, seed companies and some key farmers in different districts with the objective to disseminate the information to additional farmers.

Project Sub-Contractors

CSISA Phase III maintains three sub-contractual partners in Bangladesh that are essential in scaling-out CSISA supported technologies and for reaching farmers at large. This is particularly important as CSISA is coordinated through a partnership of three research institutions. It is only by working with development partners that the knowledge products produced through the CGIAR's research can be effectively deployed in farmers' fields. CSISA therefore strategically vets and selects partners based on their philosophical alignment with the CSISA approach and ability to generate impact at scale. Current partnerships include the following:

- International Development Enterprises (iDE): This sub-contract extended through 2018 but was cut when USAID FY18 funding became uncertain. The purpose of iDE's involvement in CSISA-III was to leverage iDE's existing work in CSISA-MI to contribute to the agricultural machinery commercialization objectives of CSISA-III. Specifically, iDE built upon its relationships with private sector and financial sector partners to support the commercialization of target technologies – power tiller operated seeder and reaper– first in Dinajpur District and then in other districts of Rangpur Division. More about iDE can be found here: http://www.ide-bangladesh.org/
- Agricultural Advisory Society (AAS): The purpose of the sub-agreement is to increase knowledge, skills, and practice of farmers on the quality rice seedlings production

through video shows and training on healthy rice seedlings production in seven FTF districts within two CSISA hubs (Jessore and Faridpur) in the southwestern region. The sub-grant's target output is the development of awareness and motivation on healthy rice seedlings production of 24,000 interested farmers through video shows and training on the healthy rice seedlings production at 240 communities in seven FTF districts within Jessore and Faridpur hubs. More about AAS can be found here: http://aas-bd.org/

- Agricultural Input Retailers' Network (AIRN): AIRN formed as a result of CNFA led efforts in the above-described Agricultural Inputs Project. Partnering with CSISA, AIRN is training 800 inputs dealers on the principles and practices of integrated weed management in Faridpur and Jessore Hubs. More about AIRN can be found here: http://www.aipbd.org/airn/airn/
- The Bangladesh Research Institute (BRRI): Under this agreement, BRRI assists with (1) implementation of on-farm trials of new Premium Quality Rice (PQR) varieties in 6 Upazilas within 3 hubs of CSISA to identify best-bet premium quality varieties in terms of yield and farers', millers', and traders' preferences, (2) on-farm performance evaluations of integrated weed management options to increase yield and profit in farmers' fields, (3) on-station trials to develop/ fine tune mat nursery method of raising rice seedlings for manual transplanting, and (4) Organize additional on-farm trials and collect necessary crop cut data as required. More information is available online about BRRI can be found here: http://www.brri.gov.bd/index.php?lang=en

Appendix 1 – Key Staff

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Appendix 2 – Project subcontractors and key partners

BANGLADESH				
PARTNER	**PARTNERSHIP OBJECTIVE**	**ALIGNMENT WITH THEMES**	**LEVERAGING OPPORTUNITY**	**STATUS OF PARTNERSHIP**
Government of Bangladesh				
Bangladesh Agricultural Research Institute (BARI)	Development, validation, and refinement of technologies and new research methods, boosting scaling capacity	Innovation towards impact	With a network of regional research stations and strong input into the development of extension materials, approaches, and policy, and with integration in the Ministry of Agriculture, BARI provides leveraging opportunities to mainstream sustainable intensification innovations into the Government of Bangladesh NARES system.	CIMMYT working to prepare an amendment for this sub-grant to refocus activities on wheat blast and early wheat sowing research in light of funding cuts and delays to CSISA from USAID.
Bangladesh Rice Research Institute (BRRI)	Development, validation, and refinement of technologies and new research methods, boosting scaling capacity	Innovation towards impact	With a network of regional research stations and strong input into the development of extension materials, approaches, and policy, and with integration in the Ministry of Agriculture, BRRI also provides leveraging opportunities to mainstream sustainable intensification innovations in the Government of Bangladesh NARES system.	IRRI maintains a formal partnership MoU with BRRI. BRRI has collaborated with CSISA in Phase II and CSISA has continued the partnership until the recent fund crisis. Further funding for BRRI's research partnership is on hold until there is clarification on funding levels and time-frames from USAID.

Department of Agricultural Extension (DAE)	Extension and scaling	Achieving impact at scale	DAE boasts over 5,000 field extension agents throughout Bangladesh. In CSISA Phase II and CSISA-BD, DAE collaborated with activities within Bangladesh's Feed the Future zone, and in Dinajpur hub. By sensitizing DAE agents to sustainable intensification technologies and approaches, large opportunities for improved reach and awareness raising among farmers are possible, with sustainability aims for messaging after Phase III is completed.	CSISA continues to collaborate with DAE on an informal and synergistic basis, despite funding cuts. The volume of activities however have been reduced due to the project's inability to support large field campaigns and collaborative metings with DAE.
Agricultural Information Services (AIS)	Production of extension materials for DAE use	Achieving impact at scale	AIS produces extension materials and media that are used by DAE. Strategic partnerships with AIS facilitate the integration of sustainable intensification principles into extension materials and messaging.	Collaboration continues on an informal basis.
Bangladesh Television (BTV)	Large-scale public showings of training videos and materials on national television	Achieving impact at scale	In CSISA Phase II, and CSISA-BD, work with BTV resulted in millions of television viewers being exposed to messaging on improved crop management and scale-appropriate machinery on the weekly farm oriented program Mati-o-Manush (MoM)	CSISA continues to collaborate with BTV to produce select educational video programming.
Bangladesh Private Sector				
Janata Engineering	Development and sales of scale-appropriate machinery	Achieving impact at scale	Domestic production and import of sustainable intensification scale-appropriate machinery and sales through the private sector	Established relationship with commercial Joint Venture Agreement (JVA). The JVA however was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID.
Metal Pvt. Ltd	Development and sales of scale-appropriate machinery	Achieving impact at scale	Domestic production and import of sustainable intensification scale-appropriate machineries and sales through the private sector	Established relationship with commercial Joint Venture Agreement (JVA). The JVA however was

				terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID.
Rangpur Foundry Limited (RFL)	Development and sales of scale-appropriate machinery	Achieving impact at scale	Import of sustainable intensification scale-appropriate machineries and sales through the private sector	Established relationship with commercial Joint Venture Agreement (JVA). The JVA however was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID.
Advanced Chemical Industries	Sales of scale-appropriate machinery, fungicides, weed control products and seed. IRRI is working with ACI to produce a range of hybrid and open-pollinated rice seeds	Achieving impact at scale	Import of sustainable intensification scale-appropriate machineries and sales through the private sector. Along with a range of chemical and cereal seed products.	Established relationship with commercial Joint Venture Agreement (JVA). The JVA however was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID.
Bangladesh projects				
Agricultural Extension Project (AEP)	Coordination assistance for interactions with DAE/AIS, capacity development of DAE Extension Agents in scaling and new extension methods	Achieving impact at scale	AEP works closely with DAE and AIS and assists in coordination of both bodies to align to CSISA's objectives. In addition AEP is working with 6,000 farmer groups in the areas where CSISA III is operating.	Established and ongoing working arrangement, though without formal agreement of fund transfers.
Women's Empowerment Project (WEP)	WEP identifies and facilitates linkages to women entrepreneurs	Systemic change towards impact	WEP works with both the Women's Ministry and DAE and will identify women who interested in adopting CSISA technologies. WEP will serve an important role in healthy rice seedling enterprises.	CSISA was in the process of developing a working relationship with WEP, although these activities have been placed on hold

				due to funding uncertainties from USAID.
NGOs				
iDE Co-implementer and project subcontractor	Development of business models, facilitation of private sector partners in scale-appropriate machinery scaling	Achieving impact at scale; Innovation towards impact	Value chain and market development NGO responsible for business modeling and joint venture agreements with the private sector partners listed above	Formal CSISA-MI and CSISA Phase III partner. Subcontracts under CSISA-MI and CSISA III were formalized in 2018-18. The CSISA III subcontract for $400,000 over four years was however suspended due funding uncertainties and fund transfer delays to CSISA from USAID.
Agricultural Advisory Society (AAS) Project subcontractor	Facilitates village screenings of training films and conducts follow-up studies	Achieving impact at scale	Working with AAS in Phase II and CSISA-BD, we were successful in reaching 110,000 farmers in village training video screenings accompanied by question and answer sessions to raise awareness among farmers on scale-appropriate machinery and associated crop management practices.	Plans for further sub-contracts to AAS in 2017-18 have been suspended due funding uncertainties and fund transfer delays to CSISA from USAID.
Agro-Input Retailers Network (AIRN) Project subcontractor	Trains input dealers & retailers	Achieving impact at scale	Will train 800 advanced retailers in integrated weed management in Southern Bangladesh by Feb 2017.	Plans for further sub-contracts to AIRN in 2017-18 have been suspended due funding uncertainties and fund transfer delays to CSISA from USAID.
Universities				

Wageningen University	Strategic research on farmer decision making processes and fallows intensification	Innovation towards impact	Strategic high-end research capacity to assist in the analysis of farmer decision-making processes with respect to intensification decisions	Formal established working relationship with CIMMYT; this relationship entails research deliverables in support of CSISA Phase III
Georgia Tech University	Technical support for the development of scale appropriate machinery	Innovation towards impact	Laboratory facilities for rapid prototyping of machinery innovations and technical support on testing in collaboration with BARI	Established yet informal relationship in co-support of CSISA III, with ongoing collaboration
Bangladesh Agricultural University	Bangladesh's largest and first agricultural university	Innovation towards impact	Bangladesh's largest agricultural university, with influence over the next generation of young scientists, many of whom go on to work in BARI, BRRI, and the DAE	Relationship with Phase III in process of establishment. Relationship is envisioned to be informal
Bangabandu Sheik Mujibur Rahman Agriculture University (BSMRAU)	Strategic partnership in wheat blast research, and in advancing methods of crop cut surveys	Innovation towards impact	BSMRAU scientists have formally collaborated with CSISA-BD and CSISA Phase II on the basis of individual sub-contracts to co-support research efforts in crop cuts and accompanying diagnostic surveys. Additional informal collaboration in geospatial analysis and remote sensing in support of wheat blast development and spread is ongoing.	Sub-contracts to BSMRAU have been suspended due funding uncertainties and fund transfer delays to CSISA from USAID.

NEPAL				
PARTNER	**PARTNERSHIP OBJECTIVE**	**ALIGNMENT WITH THEMES**	**LEVERAGING OPPORTUNITY**	**STATUS OF PARTNERSHIP**
Government of Nepal				
Ministry of Agricultural Development	Technical guidance for GoN investments in agricultural development	All	New Agriculture Development Strategy approved by GoN in Fall of 2015. CSISA acts as a technical partner to shape the loan and investment programs associated with ADS, which may exceed $100 m USD.	Active and sanctioned by CIMMYT's host country agreement
Department of Food Technology and Quality Control	Strategic and applied research on maize quality	Innovations Towards Impact	DFTQC is responsible for providing the laboratory-based facility to verify the quality of the grain grown and stored under different environment.	Active and long-standing

(DFTQC)				
Nepal Agricultural Research Council (NARC)	Strategic and applied research on SI technologies	Innovation towards impact	NARC is responsible for providing the science basis of all state recommendations; their endorsement and ownership of emerging sustainable intensification technologies is essential.	Active and long-standing
Department of Agriculture (DoA)	Front line extension and support to farmers, service providers, and private sector	Achieving impact at scale	DoA has staff at the district level across Nepal and considerable budgets to support programming; CSISA assist in improving the quality of extension messaging and works to deepen linkages to private sector.	Active and long-standing
Nepali private sector				
Machinery importers (BTL, SK Traders, Dahal, etc.)	Introduction and market development for scale-appropriate machinery	Achieving impact at scale	Rapid expansion of investment in scale-appropriate machinery and support for emerging service provision markets.	Active and long-standing
NIMBUS	Introduction and market development for new crop varieties and hybrids	Achieving impact at scale	Registration and market development for hybrids in the Feed the Future zone from a base of zero in 2015.	Active since 2015
NGO				
NAMEA	Trade association formed with the help of CIMMYT to create an enabling environment and policy dialogue for scale-appropriate mechanization in Nepal	Systemic change towards impact	Important voice for private sector with GoN as the Agriculture Development Strategy support programs take shape.	Active since 2014
SEAN	Trade association strengthened with the help of CSISA to create an enabling environment and policy dialogue for seed system strengthening /	Systemic change towards impact	Important voice for private sector with GoN as the ADS support programs take shape.	Active and long-standing

	SMEs in Nepal			
Universities				
University of Illinois	Strategic research and landscape diagnostics to uncover patterns of spatial variability in crop performance and the contributing factors for yields gaps in Nepal cereal crops	Innovation towards impact	Collaboration with advanced research institution increases the quality of science conducted in Nepal; national partners learn new research methods and contribute to the formulation of new research questions.	Active
University of Nebraska	Opportunities for agronomic practices to conserve water, reduce risk, and enhance yields in maize-based systems in the hills of Nepal	Innovation towards impact	Collaboration with advanced research institution increases the quality of science conducted in Nepal; national partners learn new research methods and contribute to the formulation of new research questions.	Active
Wageningen University	Role of livestock and value chains in farmer willingness to invest in maize intensification	Innovation towards impact	Collaboration with advanced research institution increases the quality of science conducted in Nepal; national partners learn new research methods and contribute to the formulation of new research questions.	Active
Projects				
Building Resilience and Adaptation to Climate Extremes and Disaster (BRACED)-DFID	Opportunistic partnership to take advantage of value chains, entrepreneurial skills and collections centers created by BRACED partners	Achieving impact at scale	DFID-UK funded BRACED project has priority on 'Developing Climate Resilient Livelihoods for local communities through public-private partnership for 500,000 poor people in western Nepal that suffer from climate extremes and disasters'. CSISA is taking advantage to disseminate the better-bet technology, farm mechanization at scale through the BRACED networking	Active for 2+ year

Knowledge-based Integrated Sustainable Agriculture and Nutrition (KISAN)	Strategic partnership to co-support on the large scale deployment of extension information and technologies	Achieving impact at scale	The KISAN project, part of USAID's global Feed the Future (FTF) initiative, is a US$ 20 million five-year program working to advance food security objectives by increasing agricultural productivity. KISAN works collaboratively with CSISA by utilizing technical and extension materials, and advice, to Improve the uptake of better-bet sustainable agriculture production and post-harvest practices and technologies for targeted cereals. KISAN has a reach of hundreds of thousands of farmers, who have been exposed to CSISA information, materials, and technologies through this partnership.	Active for 3+
High-value Agriculture Project (HVAP) - IFAD	Opportunistic partnership to take advantage of value chains and entrepreneurial skills created by HVAP, including among women farmers	Achieving impact at scale	HVAP has worked on literacy, numeracy, and value chain strengthening for high value commodities like vegetables. CSISA is taking advantage of the social and market capital created by HVAP to introduce and expand commercial maize production in the mid-hills.	New
Nepal Seed and Fertilizer Project (NSAF) -USAID	Strategic partnership to co-support on the large scale deployment of extension information and technologies	Achieving impact at scale	USAID-Nepal funded NSAF (Nepal Seed and Fertilizer, $15 m from 2016–2021) project, an initiative with a focus that spans the applied science-to-development continuum, inclusive of market facilitation efforts to expand private sector-led fertilizer sales. CSISA is taking advantage to disseminate the better-bet technology at scale through the NSAF networking	Active