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The U.S. Government's Global Hunger & Food Security Initiative

Cereal Systems Initiative for South Asia Phase III

CSISA

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Building Resilience in South Asia's Cereal System

Funded by

USAID FROM THE AMERICAN PEOPLE

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Partners

CIMMYT

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IRRI

CSISA COVID-19 Resilience Activity Partners

IWMI International Water Management Institute

iDE

Table of Contents

Abbreviations

2WT	Two-wheel tractor
4WT	Four-wheel tractor
AAS	Agricultural Advisory Society
ACCL	Auto Crop Care Limited
AEZ	Agro-ecological zones
AICC	Agriculture Information and Communication Centre
AIRN	Agriculture Inputs Retailers' Network
AIS	Agricultural Information Services
AKC	Agriculture Knowledge Center
AMPP	Agricultural Mechanization Promotion Policy
BADC	Bangladesh Agriculture Development Corporation
BARI	Bangladesh Agriculture Research Institute
BHEARD	Borlaug Higher Education for Agricultural Research and Development
BIID	Bangladesh Institute for ICTs in Development
BIF	Broad implementation framework
BMD	Bangladesh Meteorological Department
BRRI	Bangladesh Rice Research Institute
BWMRI	Bangladesh Wheat and Maize Research Institute
CCAFS	Climate Change, Agriculture and Food Security
CERVA	Centre of Excellence in Rice Value Addition
CEs	Choice experiments
CGIAR	*formerly the* Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CSISA	Cereal Systems Initiative for South Asia
CSISA-MI	CSISA-Mechanization and Irrigation
CSRD	Climate Services for Resilient Development
DAE	Department of Agricultural Extension
DAT	Days after treatment
DSR	Direct-seeded rice
EWS	Early wheat sowing (or) early warning system
FAW	Fall armyworm
FtF	Feed the Future
FY	Fiscal year
GoN	Government of Nepal
HRS	Healthy rice seedlings
HSD	Honestly significant difference (test)

IARI	Indian Agricultural Research Institute
ICRISAT	International Center for Research in the Semi-Arid Tropics
iDE	International Development Enterprises
IFPRI	International Food Policy Research Institute
IIDS	Institute for Integrated Development Studies
ILN	Innovation Lab for Nutrition
IPM	Integrated pest management
IRRI	International Rice Research Institute
IVR	Interactive voice response
IWM	Integrated weed management
KISAN	Knowledge-Based Integrated Sustainable Agriculture in Nepal
LSB	Lentil *Stemphylium* blight disease
ML	Machine learning
MoALD	Ministry of Agriculture and Livestock Development
MoLMAC	Ministry of Land Management, Agriculture and Cooperative
MoP	Muriate of potash
Mt	Metric tons
NAMEA	Nepal Agricultural Machinery Entrepreneurs' Association
NARC	Nepal Agricultural Research Council
NARES	National agricultural research and extension systems
NDVI	Normalized difference vegetative index
NMRP	National Maize Research Program
ODK	Open Data Kit
OPTs	Nutrient omission plot trials
OPVs	Open-pollinated varieties
NPR	Nepali rupees
NSAF	Nepal Seed and Fertilizer project
PERSUAP	Pesticide Evaluation Report and Safer Use Action Plan
PMAMP	Prime Minister Agriculture Modernization Project
PQR	premium quality rice
PRS	Pulses Research Center
PTOS	Power-tiller operated seeder
RDC	Rice and Diversified Crops Activity
RY	Relative yield
SAAOs	Sub Assistant Agricultural Officers
SRFSI	Sustainable and Resilient Farming Systems Intensification in the Eastern Gangetic Plains
USAID	United States Agency for International Development
UPF	University of Passo Fundo
USG	Urea super granules
WTP	Willingness to pay

Executive Summary

With the support of USAID and the Bill and Melinda Gates Foundation, the Cereal Systems Initiative for South Asia (CSISA) was established in 2009 with the goal of increasing the productivity and resilience of millions of farmers by the end of 2020. CSISA is led by the International Maize and Wheat Improvement Center (CIMMYT) and is implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI) in addition to numerous public and private sector partners. CSISA is about bridging the divide between research and impact. In rural Bangladesh, India and Nepal, CSISA:

- works to increase the adoption of resource-conserving and climate-resilient agricultural technologies, and improve farmers' access to market information and enterprise development;
- supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills;
- collaborates with numerous strategic public, civil society and private-sector partners, aligning them in synergy with regional and national efforts

The project has over time developed into a more comprehensive research for development program with many additional and synergistic investments by USAID/Washington, the USAID's Missions in Nepal and Bangladesh, and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), in addition to Michigan State University's Borlaug Higher Education for Agricultural Research and Development (BHEARD) program, to deepen the scope and impact of CSISA's work. This report focuses on the current third phase (2015–2021, CSISA III) of the 'base' or 'original' set of CSISA investments.[2] The third phase focuses on USAID's support to activities in Nepal and Bangladesh where CSISA is supporting partners in the public and private sectors to better contribute to sustained change by addressing systemic weaknesses. By addressing these areas and fostering new connections and collaborative efforts across the innovation system, CSISA is seeking to mainstream elements of its approach and to ensure a successful exit at the termination of Phase III.

This report provides updates on activities in Nepal and Bangladesh from October 1, 2019 through September 30th, 2020. CSISA had a highly productive first half of the reporting period, with many of the outputs described below having already been reported in the October 1- March 31 period. During the reporting period, **45,039 people and 114 small and medium-scale firms** participated in agricultural development activities facilitated by CSISA across the **27 research and scaling actions** taken by the project. **70,018 farmers** applied improved management practices and technologies on **30,669 ha** as a result of CSISA's work. In addition to these impact indicators, the CSISA team worked tirelessly to foster an enabling environment to achieve sustainable intensification at scale in South Asia.

The COVID-19 crisis struck South Asia in late March of 2020 and rendered the second half of the reporting period, the most challenging faced by CSISA during its 11 year history. Although the Project had encountered problems in the past – for example during large-scale political instability and nation-wide general strikes and violence in both Nepal and Bangladesh, lockdowns and social distancing measures caused considerable problems from March forward. Although both countries are not at this time on lockdown, the situation remains very unpredictable. The lack of quality reliable data on case numbers means that project programming responsibilities have to be made despite considerable uncertainties. Given these challenges, many of the activities planned for the second half of the reporting period had to be cancelled, postponed, or moved to virtual format. However, CSISA has also been able to partner with USAID to rapidly and effectively respond to the COVID-19 crisis, through the generation of crucial research information on the implications of the crisis on farming communities and agricultural systems, in addition to a new buy-in from the USAID Mission in Nepal to support a sub-Activity on COVID-19 Resilience in Nepal.

[2] CSISA III is primarily referred to as 'the project' throughout this report

The passages below highlight key accomplishments, as well as challenges during the 2019-20 reporting period.

Bangladesh Highlights

- **Agvisely – an agro-meteorological advisory tool endorsed and released in Bangladesh:** In partnership with the Department of Agricultural Extension (DAE) and the Bangladesh Meteorological Department (BMD), the project worked to establish Agvisely, interactive, map-based agro-meteorological bulletin and an accompanying mobile phone app that provides numerical weather forecasting model predictions with easy-to-understand crop-specific management advisories. Following workshops in October and November of 2019, Agvisely was endorsed by the Government of Bangladesh for use as an official advisory tool for farmers, with DAE, BMD and BWMRI all linking their websites to Agvisely and training their staff in the use of this tool. Agvisely is an automatic climate service advisory system for Bangladesh's major field crops. A database of climate information service advisories covers the different phenological stages of eight crops. Each stage has specific threshold temperature and rainfall threshold above or below which crop stresses occur. Agvisely contains advisories for these stages that are to be triggered for different values of temperature and rainfall that may arise within the following five day periods. In addition to providing real-time crop advisories depending on the next five day weather forecast, Agvisely provides temperature and rainfall forecasts for each of Bangladesh's 491 sub-districts. During the reporting period, CSISA worked to train DAE field agents in use of the advisories provided by Agvisely. Nearly 1,000 extension field agents, each responsible for 2,000-5,000 farmers, are now enrolled in the system. Before the end of the 2020-21 winter cropping season in Bangladesh, CSISA is aiming to increase enrollment to 8,000 extension officers and leaders of farmers' groups.
- **With CSISA support, the Fighting Fall Armyworm in Bangladesh project has launched:** In September of 2019, with support from USAID/Washington and endorsement by the USAID Mission in Bangladesh, the Michigan State University's Borlaug Higher Education for Agricultural Research and Development (BHEARD) made a synergistic investment in the 'Fighting FAW' project' that was designed to leverage CSISA's established technical staff and network of partners to take an integrated pest management (IPM) approach that can be sustainably implemented by resource-constrained farmers. This synergistic project tackles these issues by generating evidence and developing educational strategies to facilitate FAW IPM training for the public and private sector, while also addressing institutional issues needed for efficient FAW response. With co-financing from CSISA, this activity conducted a series of intensive three-day field trainings on integrated FAW management for 254 Department of Agricultural Extension (DAE) Agents in October – November of 2019. Follow-up surveys with extension agents indicated that this group conveyed IPM advice to farmers for controlling FAW in during their regular rounds of meeting with farmers and in farmers' groups and clubs. Monitoring and evaluation data indicate that IPM was extended to 74,132 farmers, among which 22% were women. In addition, a video produced by Michigan State University, USAID and CIMMYT on FAW management was shown to over 130,000 farmers throughout much of the maize growing areas in Bangladesh in village and road-side video shows during the reporting period. With direct financing by CSISA, a total of 1,047 agricultural input retailers from nine districts were trained on FAW management principles so they can more effectively advise their customers. Monitoring data indicate that these agricultural

input dealers went on to advise more than 52,000 farmers with improved FAW management advice. This was all accomplished prior to the onset of COVID-19 lockdown; however, since this period, activities were largely suspended.

- **Boosting crop health with health rice seedlings:** During the winter *'boro'* rice season in Bangladesh, mass media campaigns were deployed showing videos on HRS raising methods to farmers 1,080 villages CSISA's working areas. Prior to the onset of the COVID-19 Crisis, a total of 132,358 farmers participated in the video shows, which doubled as informal question and answer sessions and trainings, out of which 25,169 participants (19%) were female . At the same time, the project distributed 72,740 leaflets through DAE staff, agricultural input dealers, and lead farmers to the farmers of project working locations. All activities related to healthy rice seedlings were however suspended from late March forward.
- **Wheat blast early warning system validated and endorsed by the Government of Bangladesh:** On December 5th of 2019, the Bangladesh Wheat and Maize Research Institute (BWMRI), DAE, and BMD all endorsed the institute use of 'the Wheat Blast Disease Early Warning System' (Available at: www.beattheblastews.net) developed by CSISA and the USAID supported Climate Services for Resilient Development (CSRD) in South Asia projects. By February 2020, over 800 DAE field officer extension staff had been trained on use of the system and began receiving alerts by email 5 days in advance if their designated working areas were predicted to be at risk of a wheat blast outbreak. Each extension officer in Bangladesh is responsible for between 2,000–5,000 farmers. This underscores the potential to reach farmers with relevant climate information services in the form of wheat blast disease outbreak warnings and advisories now that the government has endorsed use of the early warning system.
- **Expanding impactful research partnerships:** During the reporting period, CSISA launched new research partnerships with the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) focused on big data analytics and climate smart agriculture, and with Tufts University's Nutrition Innovation Lab. The latter is focused on modeling the potential nutrition implications of agricultural development interventions in Bangladesh's Feed the Future Zone. In addition, CSISA continued to roll-out interactive voice response telephone services to assist mung bean farmers to avoid extreme rainfall event induced crop losses in partnership with DAE and the Bangladesh Institute for ITC in Development.
- **Enabling public and private collaboration on weed management:** Prior to the COVID-19 pandemic, CSISA organized a national level consultation workshop on integrated weed management on 10 October 2020 in Dhaka, Bangladesh. National agricultural research and extension systems (NARES) partners, NGOs, herbicide companies, input dealers and private entrepreneurs participated in the workshop, which focused on presenting CSISA's research results and coordinating participants to identify and build business models that can assist in expanded use of appropriate weed control predicts. CSISA also launched first-of-a-kind research trials with the Bangladesh Rice Research Institute (BRRI) on weed competitive rice cultivars in Bangladesh. All activities related to integrated weed management, exempting field trials located on research stations, however had to be cancelled in the second half of the reporting period due to the threat posed by COVID-19.

Nepal Highlights

- **New insights on constraints to appropriate scale mechanization:** During the reporting period, CSISA collaborated with the Australian Center for International Agricultural Research (ACIAR) funded Sustainable and Resilient Farming Systems for the Indo-Gangetic Plains project to develop a conceptual framework for the stepwise phased process of technology adoption among smallholder farmers. A survey of 1,500 farmers was deployed using the framework as a system to guide a series of questions on the adoption of laser land levelers, four-wheel tractor seed-drills, two-wheel tractor seed drills, spreaders, self-propelled reapers, two-wheel tractors attached reapers, four wheel tractor attached reapers, combine harvesters, and wheat residue collector machinery. The study indicated that governmental subsidies used to incentivize for the purchase of agricultural machinery appears to be at the center of nationally led efforts to mechanize Nepal's agricultural systems including the seed drills used for directly sown rice (DSR). However, this does not appear to have led to substantial purchase of machinery. The primary reason for non-use across all studied technologies is a lack of service providers, which was above 1 in 3 for six of the nine technologies, and nearly one in two for the laser land leveler and combine harvester. This highlights a need to address machine availability that is not occurring through the current subsidy program. The study suggested that increasing machinery service provision models such as custom hiring centers and individual service provisions in mechanization could close the availability and accessibility and other information gap that will help to increase the level of machines in Nepal, including for the seed drills used for DSR.

- **Launching into livestock support:** During the reporting period, and despite challenges caused by the COVID-19 Pandemic, CSISA assisted 185 farmers of the Susheli Dairy Cooperative Ltd. to develop business models for expansion of their dairy sales business. CSISA also worked with the cooperative to boost financial literacy through focused trainings, and facilitated linkages between the cooperative and the Agriculture Development Bank, Rajapur Branch, the cooperative and Shikhar Insurance Company Ltd., Guleria Branch. As a result, Susheli's farmers received a subsidized loan amount of NPR 1,000,000 at 6.24% annual interest rate from the Nepal ADB, Rajapur Branch and following enrollment of insurance for an amount of NPR 1,800,000 from Shikhar Insurance. The cooperative is now using these funds to purchase pasteurizing equipment. Susheli also subsequently distributed an additional NPR 400,000 loan amount to five member farmers (NPR 80,000 per farmer) for purchase of improved breeds of buffalos and cows.
- **Forgoing the fallow with mung beans and aligned value chain facilitation:** In parts of the Terai, about 70% of cropland remains fallow after harvesting winter season crops such as wheat, lentil, rapeseed and vegetables and before transplanting rice for about two to three months. This period is characterized as dry season, high out-migration of male to India for season jobs, and relatively free time for household laborers. This fallow land can be capitalized to improve cropping system productivity and household nutrition by introducing the nutritious (24% protein), short duration (70-80 days), and relatively drought tolerant leguminous crops such as mung bean. CSISA has been engaging with the MoLMAC of Sudurpashchim Province, in Dhangadhi, to support in planning, monitoring, training and to create strategic opportunities for scaling agricultural machineries, to expand mung bean as an option to intensify cropping, and in technical advice for improved agronomic practices. In 2019, with technical support from CSISA the Ministry of Land Management Agriculture and Cooperative (MoLMAC) of Sudurpashchim province invested USD $200,000 of governmental funds to encourage farmers to grow mung bean after wheat, an action that permitted farmers to enter into triple cropping by replacing fallows after wheat in a rice-wheat rotation. Through this program, mung bean was planted on 264 ha across Kailali and Kanchanpur districts that had previously fallowed had been cropped to mung bean. Subsequent studies indicate that 270 tons of mung bean were produced by famers. During the reporting

period, a mung bean action plan 2020 was developed convening 55 public and private sector mung bean value chain actors. In addition, 15 machinery service providers (seed drill operated) were linked in the mung bean production area. In 2020, the Project estimated that a total of 15 tons of mung bean seed were supplied in the aforementioned districts through commercial supply chains (9 tons from seed companies and agrovets, and from government subsidy schemes, 6 tons through PMAMP). In total, this aided in establishing around 600 ha of mung bean in the FtF Zone. Due to the COVID-19 pandemic, it was however not possible to organize field-level trainings for new mung bean farmers to learn about plant protection measures towards the crop flowering period. Despite these challenges, CSISA still facilitated support for new mung bean farmers. Through links facilitated by CSISA, local food preparing companies and hotels in Kailali Kanchanpur, purchased mung bean at Rs. 100/kg. Bishwas Agriculture Cooperatives Ltd. facilitated the collection and marketing of mung bean grain to these and other buyers. In addition, two seed companies that widely partner with CSISA (Gate Nepal and Panchashakti) produced 3 tons of mung bean seed during the reporting period. CSISA also supported Poshan Foods to develop a five year business strategy based on mung bean processing. This was subsequently submitted to the Bank of Kathmandu so Poshan Foods can access appropriate agricultural loans at low interest.

Policy Research and Reform Highlights

- **Assessing varietal turnover gaps:** Private companies dominate the market for hybrid seeds in Nepal. Nepali seed companies face tough competition from companies and varieties registered in India. There is a vibrant market for Indian seed varieties that come to Nepal without any regulatory clearances. Limited production of breeder and the foundation seeds is a major constraint to the rapid adoption of improved varieties of seeds. The Indian Agricultural Research Institute (IARI) has set up a business incubation center to foster partnerships with small and medium-sized seed companies and startups to propagate and market newly released varieties of rice and wheat seeds. To this end, CSISA is now engaging with the IARI incubation center to understand if a similar public-private model can be replicated in Nepal. CSISA is also repairing an inventory of new open-pollinated varieties (OPVs) and hybrid seeds of rice, maize, wheat, and lentils registered in the last 15 years. The project is also collecting information on time, costs, and procedures involved in the registration of new varieties of seeds. Analysis of primary survey data will map the penetration of the relatively new varieties of seeds in different parts of Nepal and assess the average age, measured in years since the registration of the variety, of the varieties of seeds of cereals and lentils grown in the FtF districts of Nepal.
- **Examining risks and extension options for Fall Armyworm mitigation in Bangladesh and Nepal:** A new policy research stream launched during the reporting period concerns Fall Armyworm. The objective is to test the effectiveness of video-mediated extension approaches *vis-à-vis* traditional extension approaches such as leaflets and face-to-face interaction. The information, education, and communication materials developed so far on the subject have certain information gaps in terms of communicating to farmers on the preventive and control measures that are to be adopted along with aspects such as type of pesticide and method of spraying. Therefore, to bridge this gap, this experiment seeks to develop a comprehensive video that covers all relevant aspects of FAW and provides information on the complete package of practices for managing FAW. During the baseline survey, over 80% farmer respondents reported some awareness about Fall Army Worm. Only 14% reported experiencing FAW attack during summer maize cropping in 2019. In the 2020 summer season, the majority of the respondents (>80%) reported experiencing FAW

attack on their summer maize. Of the farmers who reported FAW attack, 68% report lower yield of maize as an outcome of the attack. Increased input costs and time requirement were also reported by over 47% respondents. Agrovets (agricultural input retailers) emerged as the most relied upon source of information for over 53% of respondents before Nepal's COVID-19 lockdown, followed by the use of social networks or other farmers, and their own knowledge/past experience. After the lockdown, farmers increasingly relied on their own social networks and mass media for agricultural information, along with a decrease in farmers' reliance over agrovets. Female respondents reported higher reliance on other farmers while more male farmers reported agrovets and governmental agencies as sources of information after the lockdown. Over 25% respondents were not able to contact agrovets for any advice/requirement since the lockdown up to June. The change in the information sources and availability of timely and quality extension services impacted farming activities. Around 29% of the respondents reported that the overall quality of agriculture information had worsened, while 35.17% respondents shared that their farm suffered due to their inability to access timely information.

Impact Evaluation

- In the first half of 2020, CSISA launched an impact evaluation study in Nepal to understand and measure changes in farmer livelihoods due to the technological and institutional interventions facilitated by CSISA. The main research questions are aimed at (1) estimating the farm-level reach and adoption of CSISA-interventions in Nepal, and (2) documenting the impact of CSISA technologies on farm profitability, farmer income and livelihoods of both men and women. The empirical evaluation covers eight districts of Nepal's Terai region. 44,004 households were surveyed in February – March of 2020. Initial results show very high rates of population-level adoption of lentil with appropriate varieties and management practices, early wheat sowing, integrated weed management, irrigation, and mechanized harvesting. During the second half of the reporting period, the third phase of the Impact Assessment had to be indefinitely postponed due to the COVID-19 pandemic. The impact evaluation team therefore focused on further analysis of existing data, with a focus on social inclusion and adoption dynamics for crops and technologies among different castes and ethnic groups in Nepal, in addition to the gendered differences in adoption patterns. Outputs from this analysis are detailed in this report.

The CSISA COVID-19 Resilience Activity

- **Background:** Although Coronavirus (COVID-19) is a public health crisis, its global economic effects are severe and will be long-lasting. While much of the immediate response to the crisis has focused on implementing measures to contain spread and mitigate the disease's health impacts, substantial secondary shocks the economies of developing nations hare occurring and can be expected. As many South Asian nations are agriculturally dependent, the implications for agriculture and food systems are dire. The poor – particularly smallholder farmers with limited risk bearing and investment capacity in areas with high COVID-19 caseloads – are expected to suffer disproportionally. In Nepal, many rural farm households – which are frequently headed by women affected by previous rural out-migration – are already suffering from the collapse of remittances normally used to purchase inputs and hire farm labor for time-sensitive agricultural tasks. Conversely, more than 3.5 million Nepalis are estimated to typically work abroad, many in India. Although absolute numbers of migrants who have been forced to return to Nepal due to COVID-19 restrictions, large populations of young men are currently returning or have already returned, Many are now looking for gainful employment within Nepal's borders. Job opportunities will however be challenged by on-and-off periodic lockdowns, social distancing policies, and associated mobility restrictions. With a new investment in the Cereal Systems Initiative in South Asia (CSISA) program, the USAID Mission in Nepal is supporting the project to rapidly and effectively respond to the threats posed by the COVID-19 crisis that undermine the recovery and sustained resilience of farmers in the FtF Zone of Nepal. Activities involve two inter-linked Objectives that address CSISA's strengths in core areas needed to assist in COVID-19 response and recovery over an18 month period (From July 2020- December 2021). The ultimate goal of the CSISA COVID-19 Resilience Activity is to develop mechanisms to support longer-term resilience among smallholder farmers and the private sector – with emphasis empowering youth and overcoming challenges faced by women headed farm households. At the same time, the Activity is assisting in efforts to increase smallholder farmers' understanding of, and capacity to protect themselves, from COVID-19.

- **Partnerships to build resilience out of the COVID-19 shock:** From June to October of 2020, CSISA commenced COVID-19 Resilience activities by bringing new partners into the CSISA program in Nepal, namely International Development Enterprises (iDE), the International Water Management Institute (IWMI), Cornell University, and the Texas A&M University led Innovation Lab for Small Scale Irrigation. In partnership with CSISA staff, iDE is assisting assist in business demand creation and access to finance, with a focus on the agricultural machinery services sector and the creation of opportunities for returned migrants to purchase machinery and become entrepreneurial agricultural machinery service providers to smallholder farmers. IWMI, Cornell University and Texas A&M University conversely are assisting CSISA in the development of a 10-year framework for sustainable irrigation development in the FtF zone of Nepal, with emphasis on identifying opportunities for irrigation that can be seized in communities with large numbers of returned migrants.

Lauxman Ayal, a pathologist with the Nepal Agricultural Research Council, collaborates with CSISA in evaluation of predictive models for lentil *Stemphylium* leaf blight. Here he provides background to lentil production and management of diseases in the Terai of Nepal during a visit from USAID/Washington and USAID/Nepal staff in March of 2020.

Context, Approach and Theory of Change

Ever since the food price crisis of 2007–2008, agricultural research and development in the developing world has received considerable public, private sector, and donor investment. In South Asia, attention has shifted to focus on the impoverished areas of the Eastern Indo-Gangetic Plains – particularly Nepal and Bangladesh – where cereals feed well over half a billion people. Nevertheless, investments in agriculture have been less adept at supporting transformative change than many development planners had hoped. While progress has been made on addressing some of the systemic weaknesses that contribute to low rates of rural development, many key problems persist:

- **Research organizations** narrowly construe their mandates and are only partially oriented towards farmers and the private sector as clients of research outputs.
- **Resilient** agronomic practices and livelihood strategies are insufficiently considered in comparison to technical interventions for yield improvements.
- **Agricultural extension** primarily focuses on single technologies or generalized 'packages of practices', which are not underpinned by rigorous or participatory field evaluations that lead towards the better targeting of development interventions.
- **Livelihood** initiatives do a commendable job of reaching underserved communities, including women farmers, but rarely have the technical competence to extend their reach.
- The **private sector** – although learning quickly – lacks strategic experience in the emerging markets in the region along with the types of locational intelligence that can steer engagement and support smallholder farmers' access to new technologies.
- **Small entrepreneurs** generally lack access to support services, both for business development and technical improvements in their attempts to serve clients and generate revenue.
- Progressive **policies** ostensibly support farmers, but often impede private investment.
- There is mostly only limited **cooperation across organizations** in the agricultural research-for-development space. This limits opportunities to leverage skills and harness synergies for development impact.
- Activities at addressing **social equity and gender inclusiveness** are unfortunately more transactional and may lack depth. Initiatives to address social equity and justice in agriculture require integrated sets of action, adequate planning, and adaptive management.

Agricultural research and development efforts are complicated by the risks inherent in cropping in areas where weather patterns are erratic, water resources are poorly developed or irrigation is costly, heat stress is a binding constraint, and timely field operations are frequently compromised by rapidly declining diminishing supply and increasing costs for rural labor, due in large part by the out-migration of men to urban areas or abroad as they seek more remunerative employment. Despite these challenges, there is considerable promise that the many individual strengths within the innovation system[3] in South Asia can be marshaled and coordinated to spur and sustain transformative change.

[3] Innovation systems can be understood as networks of business, organizations and people – including farmers, researchers, extension agents, policy makers and entrepreneurs – that, through the sum of their actions bring new technologies, innovations, products processes or policies into use. Efforts to coordinate these groups and actors can accelerate the rate of uptake of technological innovation that can improve the impact of development interventions. CSISA plays a coordinating and facilitating role in South Asia as an agricultural innovation system broker.

With support from the Bill & Melinda Gates Foundation and the 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. The project has developed into a program of investments in Bangladesh, India, and Nepal with a number of synergistic side-investments provided mainly by USAID's Missions in Bangladesh and Nepal (Figure 1).

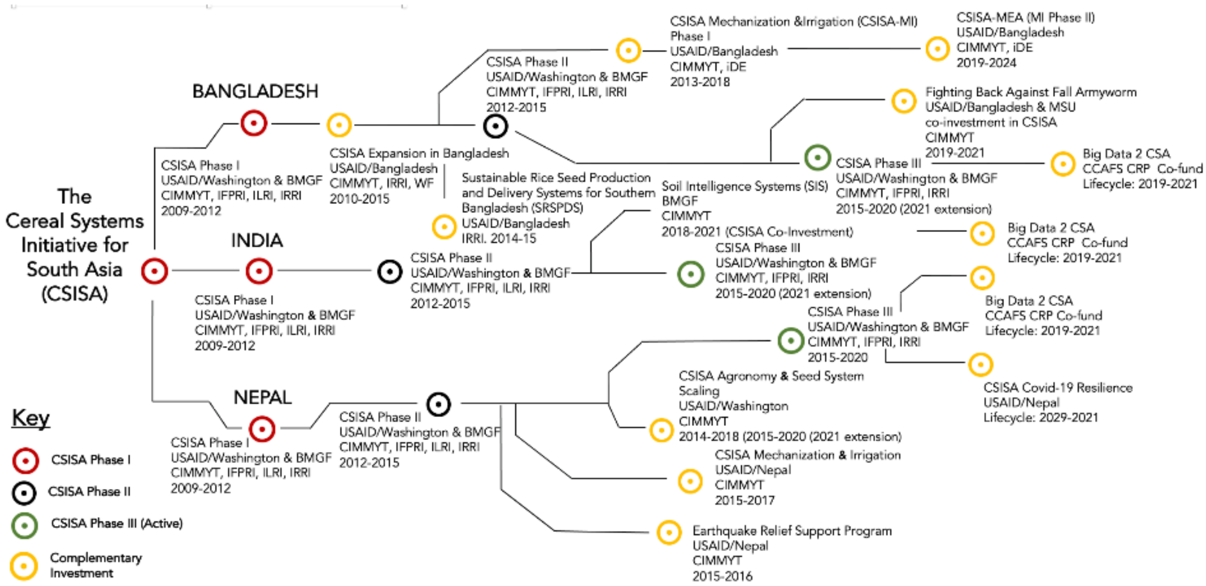

Figure 1: Evolution of USAID and Bill and Melinda Gates Foundation (BMGF) investments in the overall CSISA program in Nepal, Bangladesh and India since 2009 indicating core CGIAR and INGO partners, including new investments in the CSISA Mechanization and Irrigation project in Bangladesh.

CSISA works with technologies and management practices that can be categorized as those falling under the rubric of 'sustainable intensification', to enhance the productivity of cereal-based cropping systems, increase farm incomes, and reduce agriculture's environmental footprint.[4] As a science-driven and research into impact-oriented initiative, the project is positioned at the intersection of a diverse set of partners in the public and private sectors, occupying the crucial middle-ground where research meets development. As such, while most project team members are scientists, each is committed to developing and assuring pathways by which research products and technologies can be pushed into real-world use an impact by farmers. The project generates data and evidence on improving crop production and identifying more sustainable means of growing crops, and then scales them out to partners in the public and private sector to raise the awareness of farmers and other stakeholders on these options. By engaging with a network of partners as an agricultural innovation systems broker, CSISA is built on the premise that transformative development typically requires not one single change, but the orchestration of several changes.

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[4] 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 outcomes around both more food and improved environmental goods and services could be achieved by a variety of means.' (Pretty, J. and Bharucha, Z.P. (2014). Sustainable intensification in agricultural systems. Annals of Botany 114: 1571–1596.)

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

1. The **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 research for development (R4D).
3. **Generating critical knowledge and research-based products** that will support technology scaling-out (among farmers and service providers) and also scaling-up (institutional systems change that sustains technology generation and availability) for durable development impacts.
4. **Improving the policy environment to support sustainable intensification** in CSISA's target geographies by (a) prioritizing scaling efforts and (b) working through national partners to address policy constraints to increase the productivity and resilience of smallholder farming systems.

The project thus carries out research and shares results on the constraints and benefits of technologies and works with partners to extend evidence-based options to farmers and stakeholders on a targeted and strategic basis.

1. Bangladesh – Achievements

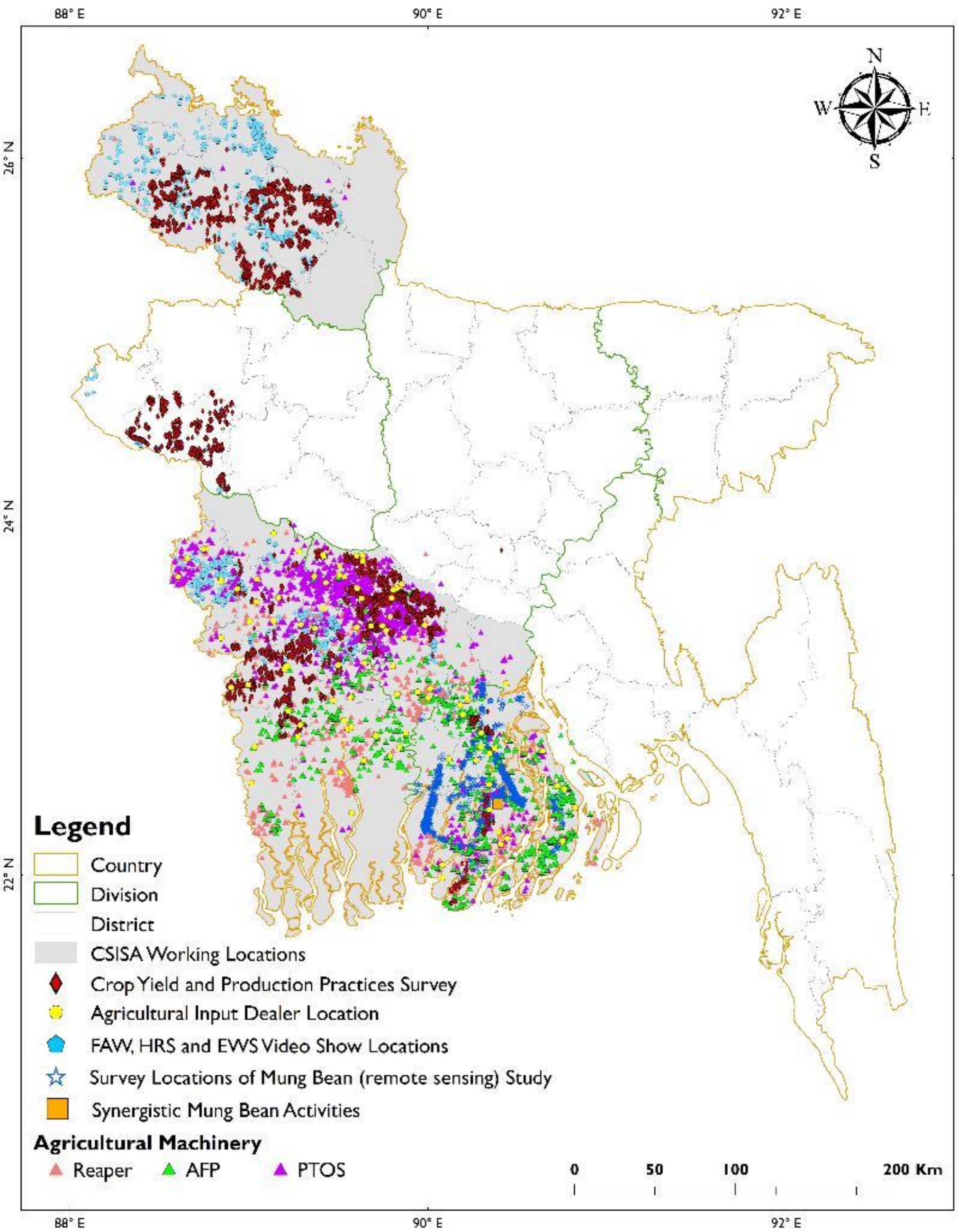


Figure 2: The CSISA project works in Bangladesh's USAID Feed the Future Zone of Influence (south western Bangladesh) and in Rangpur Division in northern Bangladesh. This map shows some of the project's activity locations and include synergistic side-investments as described in the project Theory of Change, for example in Fall Armyworm (FAW) awareness raising or crop-cut and production practice assessments led by partner organizations and supported by CCAFS, which has had spill-over effects beyond CSISA's working areas. HRS and EWS denote healthy rice seedlings and early wheat sowing, survey locations of mung bean (remote sensing) study respectively. AFP and PTOS denote axial flow pump and power tiller operated seeders, both scale-appropriate farm machinery scaled-out through CSISA's synergistic co-investment projects (in this case supported by the USAID Mission in Bangladesh) and private sector engagement. Map courtesy of: M. Hasan and M. Kamal. Synergistics mung bean activities denote areas where complementary projects have been mapped to and support CSISA. Mung bean survey locations denote areas devoted to remote sensing crop identification studies. In total, this map shows many, but not all, of the locations in which CSISA works.

A. INNOVATION TOWARD IMPACT

A1. Reducing risk to facilitate uptake of sustainable intensification practices

A1.1 Directly-sown rice to address labor and energy constraints to precision rice establishment

In South Asia, there is increased interest to shift from the most dominant agronomic method of rice production crop establishment, widely referred to puddled transplanted rice, to dry direct-seeded rice (DSR). DSR can reduce production costs and improve and environmental sustainability, though it requires large changes in management practices. DSR is established without flooding the field and through use of machine-aided sowing rather than transplanting – saves labor and water, cultivation costs, and can lower greenhouse gas emissions. While DRS has benefits, it also has important risks that limit its wide-scale adoption in South Asia, including Bangladesh. These include poor and uneven crop establishment if fields are inundated due to monsoon rain occurring during crop emergence and early establishment, increased risk of weed infestation if management is not applied carefully and a lack of suitable cultivars bred for DSR conditions. DSR may not always be well suited for all farm-environmental conditions. Soils need to be of the right texture, and farmers need to be able to very carefully manage water. Because of seedling cold injury risks during the winter '*boro*' rice season, and uncontrollable flooding in the summer '*aman*' season, CSISA has focused research on DSR mainly in the pre-monsoon '*aus*' season (usually sown in April-May and harvested in July-August – also known as kharif-1) and in select portions of the southwest of the country. This time period and these locations are more likely to be safe for DSR establishment as the risk of stand mortality caused by inundation is low during this mainly rain-free period.

The adoption of DSR however remains relatively limited Bangladesh, and as such is one of the reasons this workstream is part of 'Innovation towards impact', as it remains mainly in the research stage and work is being conducted to reduce the risks and barriers to adoption that farmers may experience. CSISA works in close partnership with the Bangladesh Rice Research Institute (BRRI), the Department of Agricultural Extension (DAE), non-government organizations (NGOs) and private sector entrepreneurs (especially seed drill owners) in the spring '*aus*' season to conduct in on-farm research that aims to (1) identify the correct environments (upland, medium land or lowland landscapes) that are more suitable for DSR in the *aus* season, (2) to quantify the impact of DSR on yield profitability as compared to farmers' predominant practices of wet tillage and manual transplanting, and to (3) identify the most suitable rice varieties compatible with DSR in the *aus* season. CSISA also makes use of on-farm trials and field days to raise awareness regarding the performance and benefit of DSR, with emphasis on increasing policy maker's understanding that DSR can be an option in the right season, location, and with the right varieties. Activities in the 2019-20 reporting period on DSR are detailed below.

Direct seeded rice performance evaluation study 1

The goal of this on-farm performance evaluation of DSR in the pre-monsoon *aus* season is to determine the comparative agronomic and economic performance of different crop establishment options to provide evidence of what landscape positions are most suitable for DSR cropping, considering establishment using both hand broadcast and machine seeding in line methods. These methods were compared to puddle transplanted rice in three 'landscape elevation' positions, including high, medium and the last *aus* season of 2019 and repeated in the *aus* 2020 as several seasons of data are required for quality data collection and for recommendation generation by NARES. Research was conducted in six farmers' fields in each of three landscape positions, totaling 18 farmers' fields in each of Jashore and Faridpur (both in the FtF zone) and in Dinajpur (in Rangpur Division of Northwestern Bangladesh) districts.

Photo 1: Discussion with farmers to select fields and farmers for DSR trials about trials and land selection in February of 2020 in Sailakupa, Jhenaidah (Photo taken by Shahidul Islam)

Each farmer's field represents one statistical replication, each accommodating two experimental factors. These are (1) combinations of three rice varieties (BRRI Dhan 83, BRRI Dhan 85 and BINA Dhan19), and (2) three crop establishment methods (machine seeding in line, hand broadcast seeding, and manual transplanting as a control).

CSISA scientists and partner scientists of BRRI jointly visited farmers' fields between 20 Feb – 15 March (Photo 1) for selection of sites. Farmers cooperated with CSISA and BRRI to implement the on-farm research during the *aus* season of 2020, despite challenges brought by COVID – 19 (Photo 2). The performance of rice varieties established using each of the three methods above were evaluated compared to conventional manual transplanting in each landscape position to quantify performance. As data were collected in *aus* of 2019, the *aus* 2020 was used to confirm results.

Photo 2: Field view of DSR BRRI dhan85, during the 2020 *aus* season in Sailakupa, Jhenaidah. The plot to the left was established by hand broadcasting seed, while the plot on the right was sown by machine (Photo taken by Asad)

During the 2020 aus season rice ice grain yields were differed significantly among study sites across landscape positions, varieties, and crop establishment methods. The highest yield was obtained in Jashore (5.6 Mt ha-1) followed by Faridpur (5.2 Mt ha-1) and Dinajpur (4.4 Mt ha-1). Across study sites, varieties and crop establishment methods, the highest rice grain yield (5.2 Mt ha^{-1}) was obtained on Medium-land followed by (5.0 Mt ha^{-1}) in both Highland and Lowland, although differences were minor and never more than 0.2 Mt ha^{-1}.

Table 1: Rice grain yields as influenced by study sites across three landscape positions, three varieties and three crop establishment methods, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh.

Study site	Mean grain yield (Mt ha^{-1})
Jashore area trial locations	5.6 a
Faridpur area trial locations	5.2 b
Dinajpur area trial locations	4.4 c

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Table 2: Rice grain yields as influenced by landscape positions across three study sites, three varieties and three crop establishment methods, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Landscape position	Mean grain yields (Mt ha^{-1})
Highland	5.0 b
Medium-land	5.2 a
Lowland	5.0 b

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Considering varieties, BRRI Dhan 83 produced the highest grain yield (5.4 Mt ha^{-1}) followed by BRRI Dhan 85 (5.2 Mt ha^{-1}) and BINA Dhan 19 (4.6 Mt ha^{-1}) across study sites, landscape positions and crop establishment methods. Machine sown direct-seeded rice and manual transplanted rice produced similar and the highest yields (5.1 - 5.2 Mt ha^{-1}) followed by hand sown direct-seeded rice (4.9 Mt ha^{-1}) across study sites, landscape positions and varieties. Again, although statistical differences were observed, they were relatively minor between treatments, ranging by 0.3 Mt ha^{-1} at most.

Table 3: Grain yields of three newly released *aus* rice varieties across three study sites, three landscape positions and three crop establishment methods, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Variety	Mean grain yields (Mt ha^{-1})
BRRI dhan83	5.4 a
BRRI dhan85	5.2 b
BINA dhan19	4.6 c

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Table 4: Rice grain yields as influenced by crop establishment methods across three study sites, three landscape positions, and three varieties, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Crop establishment method	Mean grain yields (Mt ha^{-1})
Line sown by machine	5.1 a
Hand broadcast	4.9 b
Manual transplanted	5.2 a

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

The interaction effect of landscape positions and crop establishment methods on rice grain yields across study sites and varieties was significant. The highest yields (5.4 Mt ha^{-1}) were obtained with machine sown direct-seeded rice on the medium landscape positions, and manual transplanted rice on low landscape positions, which were similar to the yield from manually transplanted rice on medium landscape positions. Hand sown direct-seeded rice produced the lowest and similar yields (4.8 - 5.0 Mt ha^{-1}) across landscape positions.

Table 5: Rice grain yields as influenced by landscape positions and crop establishment methods across three study sites, and three varieties, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Landscape position	Crop establishment methods	Mean grain yields ($Mt\ ha^{-1}$)
Highland	Line sown by machine	5.1 b
	Hand broadcast	4.8 c
	Manual transplanted	5.0 bc
Medium-land	Line sown by machine	5.4 a
	Hand broadcast	5.0 bc
	Manual transplanted	5.3 a
Lowland	Line sown by machine	4.9 bc
	Hand broadcast	4.8 bc
	Manual transplanted	5.4 a

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Labor use

In these experiments, CSISA and BRRI scientists also studied the distribution of labor used for land preparation, crop establishment and weed control. The effects of study sites, landscape positions and crop establishment methods on total number of labor used were statistically significant. Across landscape positions, varieties and crop establishment methods, the greatest amount of labor (45 person days ha^{-1}) was used in Jashore followed by Dinajpur (41 person days ha^{-1}) and Faridpur (33 person days ha^{-1}).

Table 6: Labor use as influenced by study sites across three landscape positions, three varieties and three crop establishment methods, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Study site	Mean labor use (Person day ha^{-1})
Jashore area trial locations	45 a
Dinajpur area trial locations	41 b
Faridpur area trial locations	33 c

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Considering landscapes, the he highest amount of labor was required in the highland landscape position (44 person day ha^{-1}) followed by medium and low landscape positions, respectively, which did not exhibit statistical differences at (37 person day ha^{-1}) across study sites, varieties and crop establishment methods. Manual transplanting of rice required the largest amount of labor (58 person days ha^{-1}) followed by hand broadcasting of DSR (33 person days ha^{-1}) and machine sown DSR (27 person days ha^{-1}). Overall, labor use was 43-53% lower in DSR compared to manually transplanted rice.

Economic performance

The following economic parameters were used to evaluate the economic performance of machine sown DSR compared with manual transplanted rice. (1) cost savings, quantified as the cost of transplanted rice subtracted from the cost of machine sown DSR, and also (2) added net return = yield benefit × the price of paddy + cost savings. As compared to manually transplanted rice, the median costs saved for growing machine sown DSR were the highest (USD 160 ha^{-1}) on medium landscape positions, followed by the highland landscape position (USD 156 ha^{-1}) and low landscape position (USD 142 ha^{-1}) across study sites, varieties and crop establishment methods. Added net return also followed a trend similar to cost savings. The highest median added return in machine sown DSR as compared to manually transplanted rice was found in Dinajpur (USD 237 ha^{-1}) followed by Jashore (USD 110 ha^{-1}) and Faridpur (USD 61 ha^{-1}) across landscape positions, varieties and crop establishment methods (Figure 3). In case of landscape positions the highest median added return was found on medium (USD 216 ha^{-1}) followed by Highland (USD 185 ha^{-1}) and own land landscape positions (USD 21 ha^{-1}).

Table 7: Labor use as influenced by study sites across three landscape positions, three varieties and three crop establishment methods, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Study site	Mean labor use (Person day ha^{-1})
Jashore area trial locations	45 a
Dinajpur area trial locations	41 b
Faridpur area trial locations	33 c

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Table 8: Labor use as influenced by landscape positions across three study sites, three varieties and three crop establishment methods, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Landscape position	Mean labor use (Person day ha^{-1})
Highland	44 a
Medium-land	37 b
Lowland	37 b

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Table 9: Labor use as influenced by crop establishment methods across three study sites, three landscape positions, and three varieties, *aus* season, 2020 in Sailakupa, Jhenaidah, Bangladesh

Crop establishment method	Mean labor use (Person days ha^{-1})
Line sown by machine	27 c
Hand broadcast	33 b
Manual transplanted	58 a

Note: The letters denote statistical differences at the 95% level using Tukey's HSD (honesty significant difference) test.

Summarizing preliminary results from this experiment during the 2020 *aus* season, data collected indicated that on 'high' and 'medium' landscape positions the yields of machine sown DSR were similar to the yields of manual transplanted rice, while they were 0.5 t ha^{-1} lower compared to manually transplanted rice on the lowland landscape position. The yields of hand broadcast sown DSR were the lowest on all three landscape positions. Both cost savings and added net return for growing machine sown DSR were also highest in medium landscape position followed by high landscape and low landscape positions. These preliminary results confirm most of the findings in previous *aus* season 2019. This study will be continued for one more season in *aus* 2021 to reconfirm these results, although preliminary indications appear to support the need for machine sown DSR over broadcasted DSR as an alternative to manually transplanted rice. This presents an additional set of challenges in encouraging adoption of machinery and to assure that machinery service providers to more aggressively offer DSR services to farmers, topics which CSSIA plans to address in the 2021 *aus* season in collaboration with machinery dealers and DAE.

Direct seeded rice performance evaluation study 2

This on-farm performance evaluation of rice cultivars has been designed to identify suitable and recommendable varieties for aus by farmers establishing their crop using DSR in the *aus* season. Conducted in close partnership with DAE, this research is partner-demand driven, as DAE officials are interested in having improved information and data that can be used to more efficiently recommend *aus* rice cultivars to farmers within the FtF zone. In an effort to continue these trials, which were initially established in the 2019 *aus* season, CSISA scientists and concerned DAE officials jointly visited farmers fom1 – 15 March, s in each of 3 districts and finalized an implementation plan for the study. COVID-19 lock-down however commenced in late March of 2020 for all of Bangladesh, and continued through May. Given these circumstances, neither CSISA nor DAE were able to establish these trials. What ability the Project had to implement activities were therefore focused on Performance Evaluation 1. Performance evaluation 2 is likely to be established in the 2021 season, as at least two seasons of multi-locational trials are required to draw valid agronomic conclusions.

Direct seeded rice awareness raising activities

In addition to on-farm research activities, the additional awareness raising activities are planned for the *aus* 2020. The table below summarizes these activities and indicates what was and was not possible to complete given COVID-19 restrictions.

Table 10. Direct seeded rice awareness raising activities planned, implemented, or cancelled during the reporting period.

No.	Activity type	Details	COVID-19 Status
1	Sharing meetings	During 1 – 15 March, the project organized four sharing meetings with 268 male and 60 women staff of DAE, where CSISA activities with emphasis on DSR were discussed and communicated.	Achieved as activities were conducted before lock-down
2	*Linking farmers to available subsidy programs*	The DAE currently offers farmers' rice seed in a bid to encourage *aus* cultivation. The Project actively worked with DAE and linked 215 farmers interested in DSR to access seed of BRRI Dhan 48 in the 2020 aus season.	Achieved as activities were conducted before lock-down
3	*Expanding service provision*	CSISA explored the options with existing power-tiller operated seeder (PTOS) service providers who could assist farmers with DSR establishment. Options for cooperation with authorities granting transport to machines crucial in agricultural activities are being explored, with the goal of assuring that farmers are able to establish *aus* rice with as little disruption as possible. As a result out of 215 linked with DAE seed subsidy program 77 farmers in Jheneidah district	Achieved as activities were conducted before lock-down
4	Demonstration partnerships	To raise awareness of DSR, the Project and DAE have jointly planned to implement DSR demonstrations in100 farmers' fields in Jheneidah and Magura districts. To achieve this target, CSISA and DAE jointly selected 100 farmers' fields through discussion with farmers during 1 – 15 March.	Out of the selected farmers, 77 farmers were able to establish machine sown DSR given COVID-19 lockdown and associated constraints.
5	*Training service providers*	The Project planned to work with DAE and machinery companies selling PTOS to 30 service providers interested in making business out of assisting farmers to establish *aus* DSR.	Due to COVID-19 lock-down, these activities were suspended.
6	*Field visits and field days*	Four motivational group visits and learning exchanges to DSR demonstrations for DAE staff, machinery dealers and service providers were planned in the *aus* 2020 season.	These activities were also suspended due to COVID-19 lock-down.

A1.2 Agronomic and variety recommendations to reduce the threat of wheat blast

Wheat blast is a fast-acting devastating fungal disease that threatens wheat productivity in the Americas and South Asia. In 2016, Bangladesh suffered its first severe outbreak. In 2017, with project support, the Bangladesh Maize and Wheat Research Institute (BWMRI) released a blast-resistant wheat variety (BARI Gom 33) developed from CIMMYT breeding lines in Mexico. However, there are only limited supplies of seed of this variety and wheat crops in Bangladesh and South Asia remains extremely vulnerable to blast – with the right weather conditions, outbreak could re-occur at any time. It is also estimated that it will take years to multiply sufficient seed to cover all Bangladesh's wheat areas with the resistant variety. For this reason, alternative management techniques, i.e. integrated disease management, remains crucial. The continued spread of blast in South Asia – where more than 100 million tons of wheat are consumed per year, could devastate grain markets and undermine the ability of smallholder farmers to sustain their families. Because blast is strongly driven by climate anomalies, and more humid or hot years are likely to see additional outbreaks.

Institutional adoption of the Wheat Blast Early Warning System

Starting in late 2017, the USAID funded Climate Services for Resilient Development (CSRD) in South Asia project established a collaboration with scientists at the University of Passo Fundo (UPF) and EMBRAPA in Brazil, who developed a preliminary wheat blast predictive model driven by weather data.

Photo 3: Dr. José Mauricio Fernandes (EMBRAPA/Brazil),presenting the modeling framework used for early warnings on December 5, 2019 meeting at the Bangladesh Agricultural Research Council during which the Wheat Blast Early Warning System was formally endorsed by the Government of Bangladesh. Photo by Timothy J. Krupnik)

Plans were put in place to adapt the model to Bangladesh and test it at a large scale. Scientists involved with CSRD then began to collaborate with CSISA, and together both projects released the validated model for use by DAE to advise farmers how to better and pro-actively manage the disease in 2018 and 2019.

The CSRD and CSISA team collaborated remotely with the Brazilian scientists. Finally, in December 2019 Professor Fernandes returned to Dhaka. A validation workshop was held on 5 December 2019 at the Bangladesh Agricultural Research Council. The system was officially accepted and adopted for use at the meeting by BWMRI, DAE, and BMD following intensive discussions on how the system and associated wheat blast advisories can be deployed to extension officers by email or SMS. During the reporting period, work has continued to improve the wheat blast early warning system.

As described above, the wheat blast early warning system – which can be found at www.beattheblastews.net, has been formally endorsed by the key Ministry of Agriculture line agencies responsible for its endorsement. As CSRD ended in December of 2019, CSISA has taken on the responsibility of training master trainers within DAE to understand how to use and cascade-train field extension agents on the use of the wheat blast advisories provided by the early warning system. By February 2020, over 800 DAE field officer extension staff had been trained on use of the system and began receiving alerts by email 5 days in advance if their designated working areas were predicted to be at risk of a wheat blast outbreak.

Each extension officer in Bangladesh is responsible for between 2,000–5,000 farmers. This underscores the potential to reach farmers with relevant climate information services in the form of wheat blast disease outbreak warnings and advisories now that the government has endorsed use of the early warning system. This is one of CSRD's greatest successes. The impact of this work is expected to be long-lasting with CSISA contributing to the maintenance of the system and continued trainings planned for late 2020 (when the next wheat season begins) to enroll another 4,000 extension officers and lead farmers in the system and receive automatic advisories by email and/or SMS.

Spotlight on wheat blast model validation and improvements

It is well accepted that the fungal species causing blast (*Magnaporthe oryzae*) colonizes various grass host species surrounding wheat fields. Extended periods disease-conducive factors - particularly weather conditions - favors sporulation and promotes inoculum build-up. Concomitantly, the spore density in the air dictates the infection risk. Work conducted within CSISA has helped to develop a dynamic model mimicking the life cycle of *M. oryzae* as a tool for making predictions and assisting wheat blast management. Hence, a generic disease model was parameterized to represent the life cycle of *Magnaporthe oryzae* and embedded in the early warning system (EWS). The model output simulates the cloud of disease spore density in the air. However, model validation is crucial for accepting , and then improving the model and for identifying the range of its applicability.

Table 11. Wheat blast spores observed per cubic meter over an eight hour period in multiple locations during the winter wheat growing season throughout Bangladesh.

Year	Location	Days with spores present/ Number of days observed	Highest number	Lowest number
2018	Meherpur	26/31	1.2*	0.05*
2018	Faridpur	6/32	0.8	0.5
2018	Rajshahi	20/28	0.9	0.1
2018	Dinajpur	0/26	0	0
2019	Meherpur	26/28	1.5	0.05
2019	Faridpur	12/26	0.7	0.05
2019	Rajshahi	4/26	0.5	0.1
2019	Dinajpur	0/26	0	0

To validate the wheat blast early warning system a quantification of spores of Magnaporthe oryzae present in the air was conducted by CSISA in collaboration with the Bangladesh Wheat and Maize Research Institute (BWMRI) and Embrapa Trigo, Brazil. A rotorod type of spore sampler adapted was placed in farmers 'wheat fields at Meherpur, Faridpur, Rajshahi and Dinajpur districts of Bangladesh in the wheat seasons of 2018 and also 2019. In each location, one trap was placed where the sampling arm was in 120 cm above from ground level. Each trap was calibrated to sample air by spinning two sampling rods covered with double sided sticky tapes at approximately 1130 rpm. All traps operated continuously from 8:00 AM to 4:00 PM for 25 days after heading. Sampling tapes were replaced daily and transported to the laboratory. Glass slides smeared with glycerin were prepared and spores observed under a compound microscope using 40× magnification. Unfortunately, the low number of trapped conidia in these years limited the comparison with the model output.

Alternatively, a dataset found in the literature was used[5]. In this dataset, the *M. oryzae* inoculum's seasonal availability was observed and reported during 2010 and 2011 in Dillsburg and Leesport, PA, USA. The generic disease model parameterized to represent the life cycle of Magnaporthe oryzae was applied to simulate airborne inoculum for those years and locations. Weather data from nearby weather stations (http://climate.psu.edu) were used as an input. The *M. oryzae* life cycle model output includes the spore density in the air.

The project team compared the simulated spore density in the air with the observed in 2010 and 2011 in Dillsburg and Leesport. The results are promising. Except for the location of Leesport in 2010, there was a reasonable matching between observed and simulated. A similarity index (SI) was used to evaluate model output with observed data.SI takes values between 0 and 1. An index equal to 0 indicates no match, i.e. the qualitative behavior of two time series is completely different concerning the considered feature. An index near to 1 characterizes a similar qualitative behavior between observed data and model simulations.

[5] Li, Y. 2013. Factors influencing the development of gray leaf spot of perennial ryegrass turf seasonal availability of the inoculum. PhD Dissertation, Penn State University.

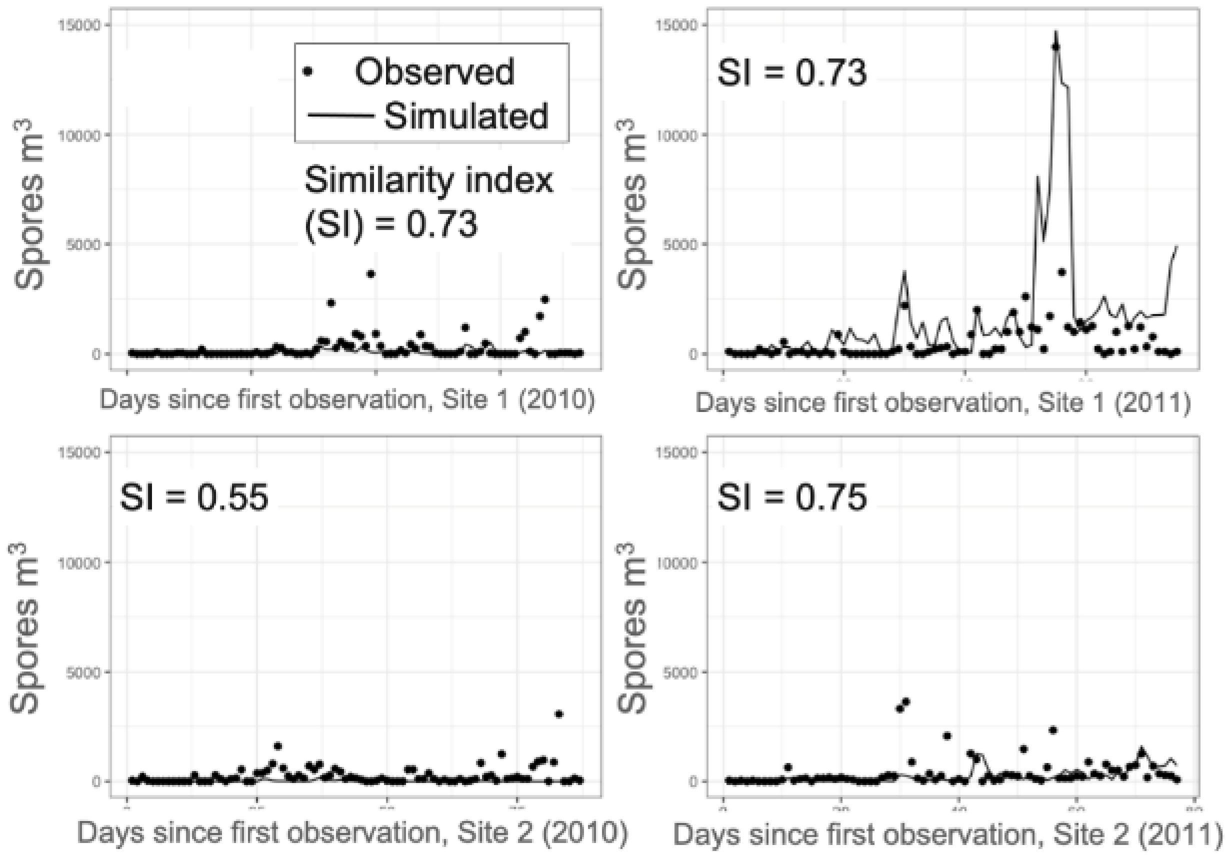


Figure 3: Illustration of the *Magnaporthe oryzae* seasonal availability data from in Dillsburg and Leesport, Pennsylvania, and simulated data constructed using the wheat blast early warning system developed by the CSISA team in collaboration with EMBRAPA in Brazil. SI=Similarity Index.

This validated dynamic model mimicking the life cycle of *M. oryzae* is an improvement on the model developed in 2018-19, and has been deployed as part of the early warning system used in Bangladesh. As such, it will be used in the 2020-21 wheat season to advise DAE if, when, and where disease outbreak could occur. DAE will therefore be prepared to widely advise farmers to take preventative action. In contrast to advisories that encourage calendar-based preventative sprays without field scouting, this data-driven approach can be used to adaptively advise farmers on how to take effective and safe preventative action through the intelligent use of fungicides for disease control. In additional simulation research, the model has also adequately described the observed epidemic and non-epidemics years in Brazil and Bangladesh.

Wheat blast surveillance

In 2016, after the first occurrence of the devastating wheat blast disease in Bangladesh at Meherpur district, CSISA started comprehensive blast monitoring and surveillance activities and were successfully done last 3 Rabi seasons across the country in collaboration with Bangladesh Wheat and Maize Research Institute (BWMRI), Department of Agricultural Extension (DAE) and Bangladesh Meteorological Department (BMD). These surveillances were conducted in seven major wheat growing districts including Meherpur, Jashore, Faridpur, Dinajpur, Rajshahi, Pabna and Barisal. Collected data from surveyed area and used to validate and improve the Wheat Blast Early Warning System, by which extension agents and farmers will be awarded about the blast disease and save their crops. Though after 2016, wheat blast disease incidence and severity appeared low in all over the country, but still the risk of outbreak remains high. Considering this risk, the surveillance activity will continue in 2020-21 wheat season.

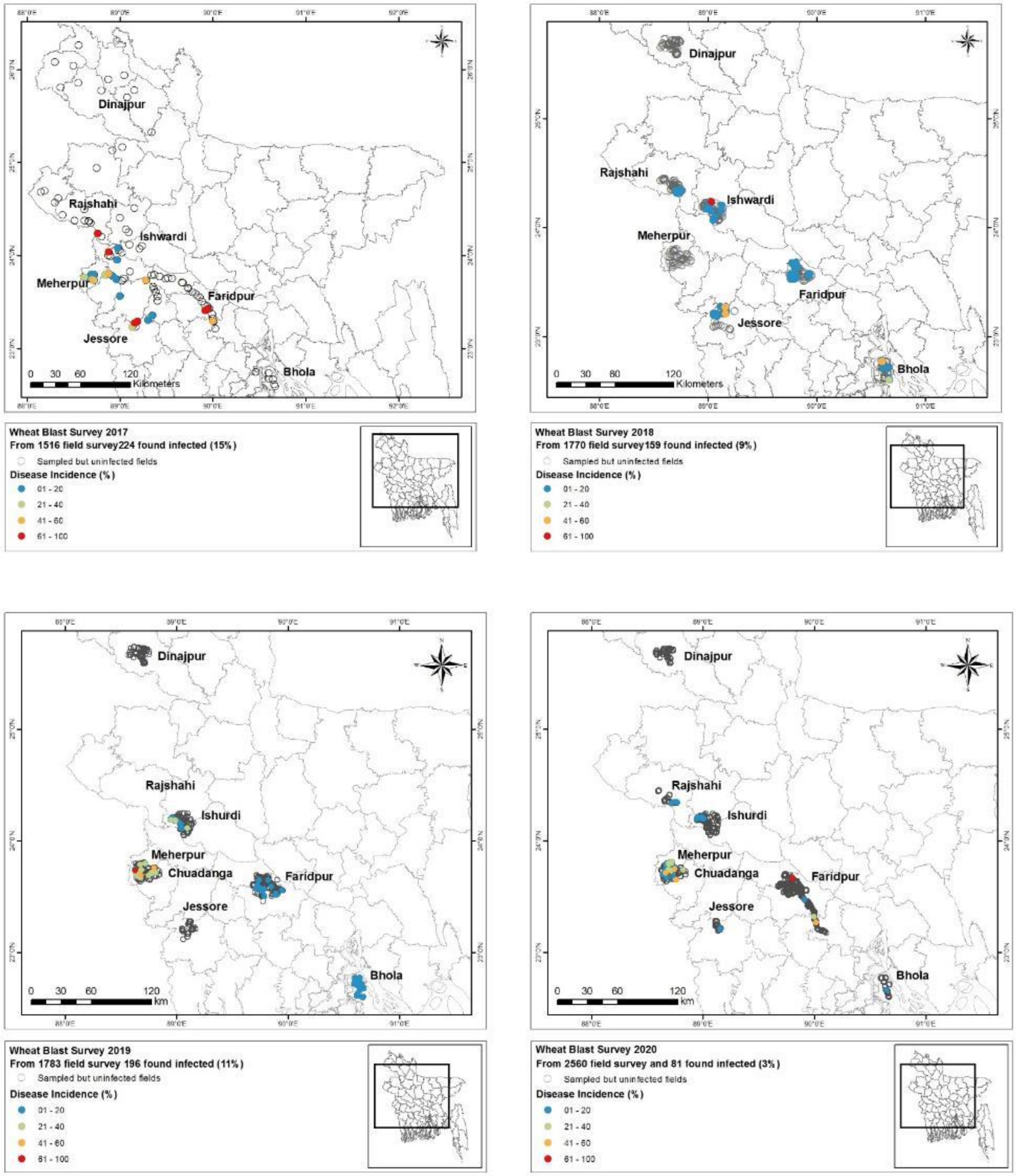


Figure 4: Wheat blast disease incidence (%) observed in sampling locations in 2017, 2018, 2019 and 2020. Map courtesy- Mustafa Kamal (GIS & Remote Sensing Analyst, CSISA).

In 2021, the surveillance and monitoring activity will remain for the existing districts. Prior to the activity, a full day training program will be organized at the end of the January in collaboration with BWMRI and DAE. BWMRI scientists will lead the training program and train enumerators to identify and collect diseases data using android based Open Data Kit (ODK). Considering previous year results, only one visit will maintained during the heading time between 20 February to 1 March 2021. During the surveillance period surveying date, field coordinates, crop growth stage, diseases incidence and diseases severity data will be recorded.

Effect of cultivar mixtures on wheat blast

After the appearance of wheat blast in Bangladesh in 2016, Bangladesh Wheat and Maize Research Institute (BWMRI) in collaboration with CIMMYT developed and release a blast tolerant and resistant variety, and recommended two lower-toxicity and PERSUAP approved fungicides for foliar sprays. Over use of spraying or over-reliance on single varieties can however over time result in fungicide resistance and evolution of the pathogen to infect even resistant varieties, respectively. In addition, genetic uniformity can render crop more vulnerable to diseases; as such, one potential and low-cost method of increasing genetic diversity in a standing crop is to mix the number of cultivars grown in a mixture.

Photo 4: Mixture trial experiment with misting irrigation system to stimulate infections under high disease pressure (Photo by Harun-Or-Rashid, CIMMYT)

There is a wide history of research that has documented how mixtures of cultivars can reduce disease incidence and severity, as well as stabilizing and in many cases increasing yield. CSISA therefore embarked on a cultivar mixture trial that was initiated in the winter wheat froing season of 2018-19 at the Regional Agricultural Research Station in Jashore in collaboration with BWMRI and BARI to identify the suitable mixture combinations to mitigate wheat blast disease and to find out to what extend fungicide can control blast under high disease pressure and favorable environment.

Photo 5: Another view of the mixture trial (Photo by Timothy J. Krupnik)

Three varieties BARI Gom 26 (blast susceptible), BARI Gom 30 (blast tolerant) and BARI Gom 33 (2NS segmented, blast resistant) were selected to test in mixtures with different seed densities. Ten sub-plot treatments- six two variety mixtures with i) 33% + 67% and ii) 67% +33% seed densities, one three variety mixture (33% + 33% + 33%) and three sole varieties were prepared and sown on 23 December 2019. The design of the experiment is a split-plot with five replications where the main plots were divided into fungicide and without-fungicide treatments.

The whole experiment and replications were surrounded by three border rows of highly blast susceptible BARI Gom 26, and were inoculated with blast spores at seven-day intervals starting from the late vegetative/early reproductive stage of the crop. The Fungicide Nativo 75WG (Trifloxystrobin 25% + Tebuconazole 50%) were sprayed five days after each inoculation in the fungicide main plots by a registered and experienced applicator with personal health and environment protection measures. During fungicide spray the no-fungicide main plots were protected from contamination by a thick plastic sheet. The whole experiment was subsequently put under mist irrigation, with misting stopped from 24 hours before to 24 hours after fungicide spraying. Beside blast, infection of Bipolaris leaf blight (BpLB) – the most common disease of wheat in Bangladesh and leaf rust (LR) to some extent – are also observed. In the 2020 season, the experiment was harvested on 26 March.

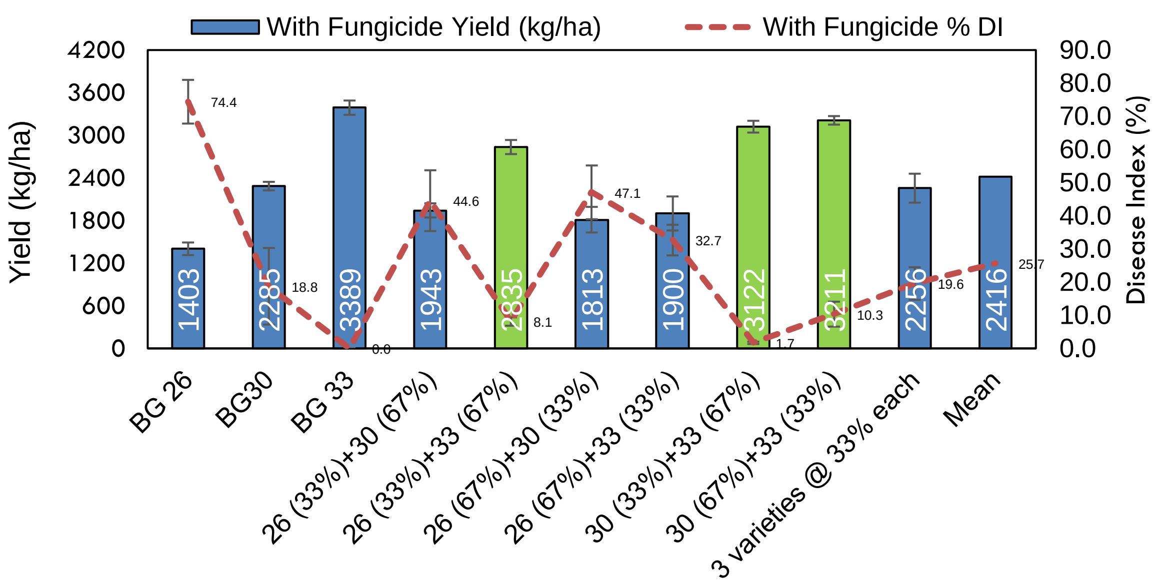


Figure 5: Performance of wheat variety mixtures and sole variety crops for yield and wheat blast disease index (DI) with fungicide spraying (Green colored mixtures were potential good yielding mixtures to control wheat blast). Three varieties BARI Gom 26 (blast susceptible), BARI Gom 30 (blast tolerant) and BARI Gom 33 (2NS segmented, blast resistant) were selected to test in mixtures with different seed densities. Ten sub-plot treatments- six two variety mixtures with i) 33% + 67% and ii) 67% +33% seed densities, one three variety mixture (33% + 33% + 33%) and three sole varieties were prepared and sown on 23 December 2019.

While blast is the main concern, Bipolaris leaf blight is the most common disease of wheat in Bangladesh, although it typically causes comparatively less damage. The experiment therefore also measured whether or not the fungicide controlled this disease. Bipolaris leaf blight data was recorded three times at Zadok growth stages 75, 80 and 85 from the flag leaves of 30 randomly tagged plants and converted to percent diseased leaf area (%DLA). Wheat blast incidence and severity percent was recorded from those randomly tagged 30 plants three times at the above three growth stages. The percent disease index (% DI) was calculated using percentage of blast incidence and severity. The results indicate that Fungicide spraying reduced the diseased leaf area in flag leaves by 66 % and the disease index for wheat blast by 18%, which in turn led to a 19 % increase in grain yield.

These results also indicate that Bipolaris leaf blight appears to be more effectively controlled with fungicides than wheat blast, although this may be due to the inoculation of blast spores in the experimental field that caused favorable conditions for disease development.

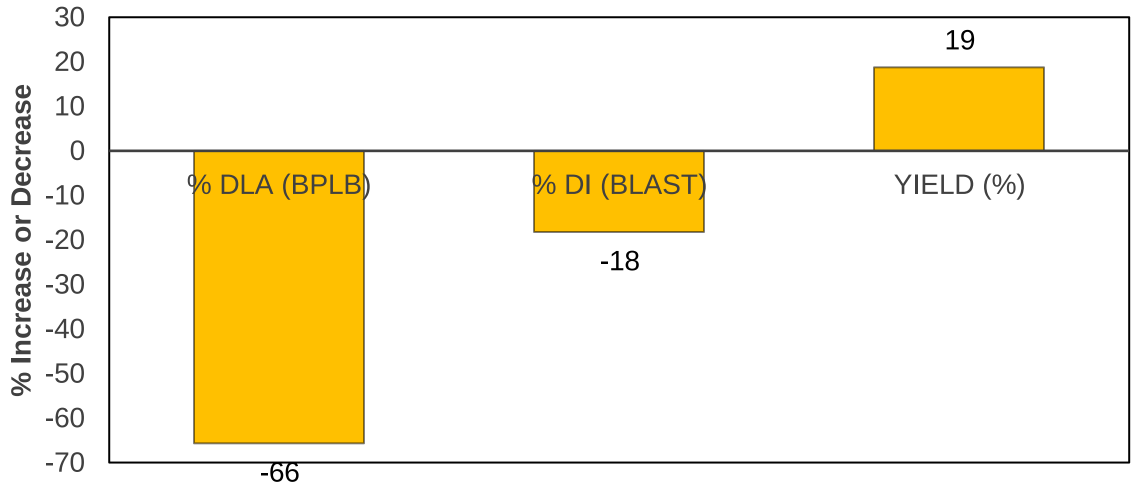


Figure 6: Change in percentage diseased leaf area (% DLA) of Bipolaris leaf blight (BpLB), and the disease index (%DI) of wheat blast & yield in response to fungicide spraying in the 2020 wheat growing season.

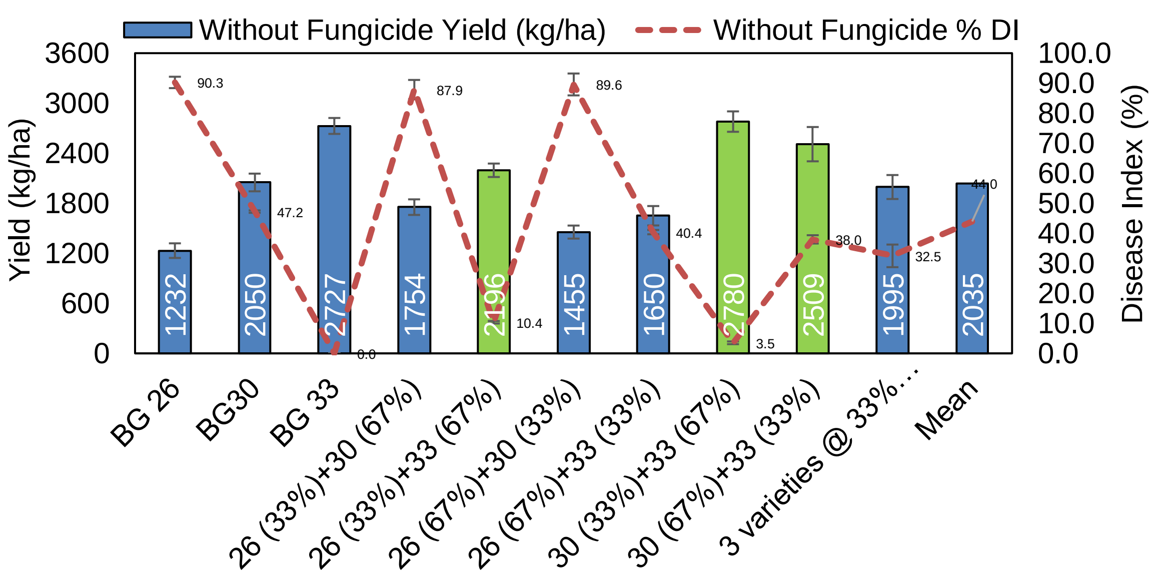


Figure 7: Performance of wheat variety mixtures and sole variety crops for yield and wheat blast disease index without fungicide spraying (Green colored mixtures were potential good yielding mixtures to control wheat blast). Three varieties BARI Gom 26 (blast susceptible), BARI Gom 30 (blast tolerant) and BARI Gom 33 (2NS segmented, blast resistant) were selected to test in mixtures with different seed densities. Ten sub-plot treatments- six two variety mixtures with i) 33% + 67% and ii) 67% +33% seed densities, one three variety mixture (33% + 33% + 33%) and three sole varieties were prepared and sown on 23 December 2019.

Additional results of interest from the 2019-20 wheat growing season are as follows. In both the with and without fungicide plots, the lowest yield and the highest level of disease was recorded in BARI Gom 26, while the he highest yield where fungicide was applied was in BARI Gom 33. In treatments in which fungicide was not administered, the highest yield was recorded with the BARI Gom 30 (33%) – BARI Gom 33 (67%) mixture, although this statistically undistinguishable from the yield of BARI Gom 33 grown in genetic monoculture.

The percent disease index in the BARI Gom 30 (33%) – BARI Gom 33 (67%) mixture was lower than the sole variety BARI Gom 30 and similar to the resistant variety BARI Gom 33, under conditions both with fungicide and without fungicide. The percent disease index was also low and yield was comparatively higher than other mixtures in the BARI Gom 30 (67%) – BARI Gom 33 (33%) and the BARI Gom 26 (33%) – BARI Gom 33 (67%) mixtures. Although this trial needs to continue at least one more year for reliable conclusions, the preliminary results indicate that BARI Gom 33 and 30 can be mixed to provide relatively good levels of disease control and yield, and as such, farmers who are unable to access a sufficient amount of BARI Gom 33, which is resistant, they may be able to mix seed before planting with the tolerant variety BARI Gom 30.

Enhancing farmers' awareness of, and demand for, wheat blast resistant seed

After appearing wheat blast in Bangladesh in 2016, CSISA has worked in regular and close collaboration with BWMRI to develop blast resistant/tolerant varieties and other mitigation technologies. As a result of CSISA's efforts and synergistic work supported by the Australian Center for International Agricultural Research (ACIAR) and the United States Department of Agriculture (USDA), a blast resistant and Zn-enriched variety, (BARI Gom 33) and a blast tolerant variety (BARI Gom 30) were approved of by the Ministry of Agriculture (MoA) and released in 2017 at the request of BWMRI. Another blast resistant variety WMRI Gom 03 (Borlaug 100, which is bread from material curated by CIMMYT in Mexico) has also been approved by MoA to release as variety in September 2020. Despite these achievements, seed stock for these varieties remains low, making availability to farmers more limited than desirable. Typically, the Bangladesh Agriculture Development Corporation (BADC) requires 4-5 years to multiply seed to reach sufficient quantities so that farmers can plant them on a large scale.

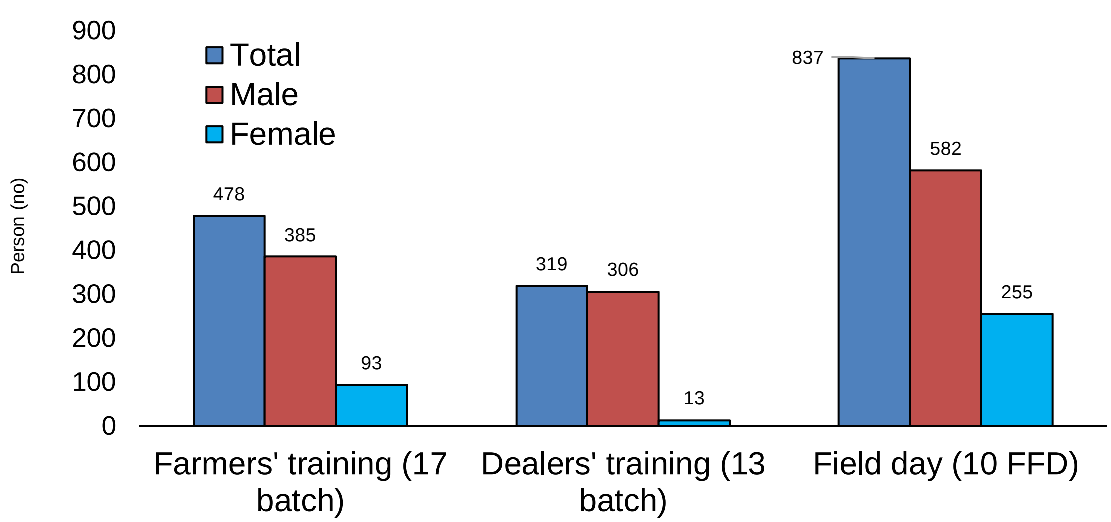


Figure 8: Farmers' and dealers' training, and field days in wheat blast resistant variety seed production demonstrations conducted during the 2019-20 winter wheat growing season. Demonstrations were conducted by CSISA in collaboration with the Bangladesh Wheat and Maize Research Institute and the Department of Agricultural Extension

In response, CSISA in collaboration with BWMRI and DAE conducted farmers participatory wheat seed production demonstrations with 144 participating farmers who grew these varieties in a summed total of over five hectares. BWMRI suppled seeds of BARI Gom 33, BARI Gom 32 and BARI Gom 30 for 75 demonstrations in Jashore, Faridpur and Dinajpur districts. CSISA, in assistance to BWMRI, trained 478 farmers including 93 women in 17 batches on seed production and preservation technologies. Most of these farmers (73%) preserved seeds for their own use, while 27% was sold as seed to neighboring farmers and dealers (Table 1). In total, more than 19 tons of seed were produced, which can be used to seed 162 ha – potentially benefitting 833 farmers considering average wheat field per farmer is around 0.19 ha. The outcomes of these effort on replanting will be reported in the 2021 semi-annual report following observations in November-December of 2020 by the CSISA monitoring and evaluation team.

Importantly, many farmers usually frequently visit to input dealers as their primary form of agricultural advice. As such, 319 input dealers were trained on how to explain viable wheat blast mitigation technologies to farmers in 13 batches. To encourage rapid dissemination information on where farmers could access blast resistant and tolerant varieties, 10 additional farmer field days were organized with 837 farmers participating, of which 30% (255) were women in March 2020. In addition, 79,310 wheat blast factsheets were distributed by DAE, agricultural input dealers, Agricultural Advisory Society (AAS, an NGO that partners with CSISA), and through government sponsored Agricultural Information Communication Centers (AICC).

Table 12. Seed preservation by demonstration farmers in Jashore, Faridpur and Dinajpur districts conducted during the 2019-20 winter wheat growing season. Demonstrations were conducted by CSISA in collaboration with the Bangladesh Wheat and Maize Research Institute and the Department of Agricultural Extension

Variety	Land (ha)	Seed (kg) used by farmers for the following purposes			
		Own use	Sold as seed	Consumed	Total seed
BARI Gom 33	4.55	13608	3708	1013	17316
BARI Gom 32	0.24	225	560	145	785
BARI Gom 30	0.36	400	820	219	1220
BARI Gom 29	0.04	40	90	25	130
Total	5.20	14273	5178	1402	19451

Some farmers – particularly those who are very poor – sell seeds they preserved after harvesting even at low prices price due to necessity of generating income for family requirements before the next wheat season comes. CSISA responded by conducting a quick survey in June of 2020. The survey was conducted by telephone due to COVID-19 movement restrictions. The research team found 20.6 ton seeds of only BARI Gom 33 have been preserved by 81 farmers of Faridpur and Jashore regions, of which 6 were female.

This is a notable achievement given the economic crisis experienced during the COVID-19 restriction period. Farmers are now are discussing with Seed Certification Agency (SCA) to test germination and vigor of these seeds. CSISA staff have also made linkages between the dealers and farmers through DAE facilitate further farmer-to-farmer linkages between those wishing to sell or purchase seed. These actions will encourage farmers to produce more seeds in future years as seed prices are much more than grain prices.

2. Adding value to extension and agricultural advisory systems

A.2.1 Strengthening the foundations of agro-advisory through knowledge organization and data integration

Building farmers' resilience with actionable climate services: National partnerships result in large-scale use of the Agvisely decision support tool

'Agvisely' is an automated climate advisory service tool for major field crops of Bangladesh developed in partnership with Department of Agricultural Extension (DAE) and Bangladesh Meteorological Weather Station (BMD) and supported by USAID. A database consists of different phenological stages of eight major crops. Each crop stage has a specific temperature and rainfall thresholds above or below which the crop is exposed to stress. The application analyzes the weather forecast data generated by the Bangladesh Meteorological Department and provides location-based agrometeorological advice through evaluating atmospheric thermal and moisture stress thresholds at different phonological stages. When the threshold is crossed, Agvisely triggers management advisories for the following five days. Agro climatic advisory services is provided across 492 sub-districts (Upazila) of the country that is authentic, localized, timely, actionable and simple to solve climate-related agricultural problems for field-level extension agents of the Department of Agricultural Extension and farmers.

Before the end of 2019, 101 extension officers were trained by CSISA on Agvisely and subsequently these officers trained over 1050 extension agents who directly provide crop advisories to the farmers. The flow of the extension activities was seriously interrupted due to Covid-19 pandemic situation. Several virtual meetings were organized with DAE field level extension agents to obtain the comments and suggestions for improvement of the app and designing and converting it into a Progressive Web Application. On 15 September 2020, DAE-CIMMYT organized a Zoom meeting attended by the Directors of different wings, all Assistant Directors (ADs) and Deputy Directors (DDs) in the presence of the Director-General of DAE. Since the advisories are up to sub-district level, the participants recommended for extensively using this app by the DAE staff to advise the farmers. In closing remarks, DG, DAE appreciated the work of CIMMYT and recommended to the use the Agvisely at the field level, and give feedback on the applications for its further upgrading.

Since then, the web app has been improved and upgraded significantly, taking all the feedback and suggestions into account. In the earlier version, the registration process was a bit complicated for the SAAOs that hindered mass signup, and now SAAOs can register the app only using their mobile phone number. After the registration process, the app can be download. An Agvisely icon will appear in the android devices so that its offline use could be possible. Besides daily temperature and rainfall data, daily humidity data will be added as a weather variable. Before the upcoming rabi season, diseases section will be added for four major crops. In achieving the goal of enrolling 8000 SAAOs before the end of March 2021, a campaign team has been formed to reach out to the SAAOs. DAE has already assigned two officers to work with the Agvisely development team so that DAE can further develop and own this in future.

Figure 9: Left: the Agvisely log. Right: Placement of Agvisely and also the Wheat Blast Early Warning System on the home page of Bangladesh's Department of Agricultural Extension.

Stempedia: Development of a weather-forecast driven early warning system for lentil crop diseases

In addition to availability of a host crop and the presence of fungal inoculum, weather conditions play a key role in causing crop disease epidemics. This is equally true for *Stemphylium* blight (SB) disease of lentil, which is caused by the fungus *Stemphylium botryosum*. The disease presents a sustained threat lentil production in South Asia, including Bangladesh and Nepal. With severe infections, farmers may experience up to 60% yield losses. Making matters worse, there are few varieties with seed widely available that are resistant to SB in South Asia.

Driven by weather conditions, such as temperature and cloudiness, the effects of SB can be severe or limited in one year compared to the other, and also in one location compared to others. The heterogeneity associated with SB therefore makes comprehensive management solutions difficult to put into practice. Farmers either abandon efforts to control SB, or conversely may apply a calendar-based application of costly foliar fungicides that are not always effective or profitable. Early warning using weather-based model(s), such as 'Stempedia' – a SB early warning system driven by weather forecast data – can be of help to the farmers in making climate-smart decisions on fungicide application to maintain productivity and resilience in the face of disease risks.

The CSRD project conducted large-scale field surveys in Bangladesh, India and Nepal during the growing season of 2017-18 and 2018-19 to record the disease status in terms of incidence and severity. The data from 2017-18 were used for Stempedia model calibration, while data from 2018-19 were used for validation. In both years, data on SB and other diseases of lentil were collected from 480 farmers' fields – five sites (Jashore, Faridpur, Magura, Meherpur and Rajbari), 32 fields each, in Bangladesh; five sites (Barh, Barhaiya, Masaurhi, Mokama and Paliganj), 32 fields each, in the State of Bihar of India; and four sites (Banke, Bardiya, Kanchanpur and Kailali), 40 fields each, in Nepal. Based on the availability of field data weather data, the CSRD project undertook five sites, three (Jashore, Faridpur and Meherpur) in Bangladesh and two (Banke and Kailali) in Nepal for Stempedia model calibration and validation. On average, the disease severity predicted by the calibrated best set of the model's parameters was very similar (mean 2.10±0.14 standard deviation) to the observed data (mean 2.10±0.11 standard deviation). Considering validation efforts, the predictions from the calibrated Stempedia model explained 84% of the observed variation in disease severity (at the $P<0.0001$ level) across the five sites. In response to this satisfactory performance, and with the closure of the CSRD project in December of 2019, CSISA took on the further development of lentil crop disease research activities with the goal of running validation field tests with national partners and working more the model into a formal weather-forecast based early warning system.

Activities conducted in the 2019-20 reporting period

During the 2019-20 reporting period, the Project concentrated on four aspects of the lentil disease modeling system: (i) development of the broad implementation framework (BIF) for the early warning system for lentil *Stemphylium* blight disease (EWS-LSB) in Bangladesh and Nepal, (ii) raising stakeholders' awareness and holding consultations on the feasibility and applicability of EWS-LSB in the Nepal and Bangladesh, (iii) analysis of the value of model-guided fungicide application in controlling lentil SB disease, and (iv) protocol design and development of a plan of action for field testing of the EWS-LSB in the 2020-21 lentil season.

Unfortunately, however, COVID-19 lock-downs completely disrupted physical meetings, face-to-face consultations, and office and field visits during the second half the reporting period. This was the case in both Bangladesh and in Nepal. The Project reached by conducting as many of these consultations as possible on Zoom; however, virtual communication systems have not been effective in implementing on-farm research activities and consultations with stakeholders unaccustomed to or without internet connectivity. Yet despite these difficulties, the Project managed to fulfill many of the planned activities without much compromising the quality. Actions that could be implemented are reported on below.

Development of the implementation framework for the early warning system for lentil Stemphylium blight disease in Bangladesh and Nepal: The BIF for EWS-LSB was presented in CSISA's 2019-20 semi-annual report. Within this framework, Bangladesh's Department of Agriculture Extension (DAE) has been positioned by to be the core agency to implement the system. DAE will create a working relationship partnering with two agencies, the Pulses Research Centre (PRC) of BARI and with Bangladesh Meteorology Department (BMD). The PRC will provide intellectual support on providing advisories relevant to the management aspects of the disease, while BMD will generate and channel location-specific weather-forecasts to drive the early warning system. CSISA is assisting in facilitating working modalities and partnerships between DAE, PRC and BMD.

The partnership will undertake four tasks including (i) the formalization of 'Stempedia' as a forecasting engine, (ii) development of the EWS-LSB including channeling location-specific weather forecast data, (iii) development of the advisory content based on the EWS-LSB, and finally (iv) the development of the advisory delivery system with farmers and agricultural inputs dealers as end-users. DAE will also undertake consultation with end-users on the advisory contents, especially on its practicality and implementation-friendliness. The National Agricultural Meteorological Advisory System, currently a part of DAE, will play a key role in providing feedback in these activities and particularly in delivering advisories to farmers. CSISA will closely work with DAE in all aspects of implementing the EWS-LSB. A similar EWS-LSB is also in the process of being developed for Nepal with the participation of the Nepal Agricultural

Research Council, the Department of Hydrology and Meteorology, and likely with the system of Agricultural Knowledge Centers and farmer cooperatives.

Participatory co-design with stakeholders in Bangladesh: Regarding awareness-consultation efforts among stakeholders on the feasibility and applicability of EWS-LSB in the implementing countries, CSISA's lead scientist working on lentil diseases, Moin Salam, conducted a meeting with Dr. Md Abdul Wohab, the then Director General of BARI, on 1 March 2020. During this meeting, BARI committed support on this initiative, which to be channeled through the PRC Directorate of BARI. CSISA staff also organized an hour-long meeting with Mr. Chandi Das Kundu, the then Director of the Field Service Wing of DAE, on 11 March 2020, where he discussed on need and applicability of the proposed EWS-LSB. Mr. Kundu, in presence of Dr. Md Akhtaruzaman, the Deputy Director of DAE of Jashore, understood the need and offered his support on implementing the system in his agency. A subsequent meeting was also held on 12 March 2020 with Mr. Shah Akramul Haque, the then Additional Director of the Field Service Wing of DAE.

Participatory co-design with stakeholders in Nepal[6]: The *Stempedia* framework was presented to Dr. Rajendra Darai and Mr. Laxman Aryal, the Coordinator and Legume Pathologist, respectively, of the Grain Legumes Research Program of the Nepal Agricultural Research Council (NARC), in Nepalgunj, Nepal, on 21 February 2020. Both offered their support for and participation in the proposed system. Moin Salam also talked with lentil farmers of Belasapur locality in Banke of Nepalgunj, Nepal, during 22-25 February 2020 in the field visits; farmers mentioned they would be benefitted from such a system. The system was presented to a team from USAID Washington and the Mission in Nepal during their field visit in Nepalgunj, Nepal on 25 February 2020.

Regional stakeholders workshop on lentil Stempedia model piloting: A Skype meeting was arranged for a workshop on piloting Stempedia model in Bangladesh and Nepal on 15 July 2020, which was attended by 21 participants from the two countries representing BARI, DAE, BMD, and Sylhet Agricultural University from Bangladesh and NARC, DHM and Ministry of Agriculture, Livestock and Irrigation (MOALI) from Nepal. Moin Salam presented the draft plan of piloting Stempedia model guided fungicide application in controlling lentil SB disease in both the countries in the 2020-21 lentil season, which was followed by a discussion.

Training to KISAN II in Nepal: With an invitation from Alexis Ellicott, Chief of Party of the Feed the Future KISAN II project in Nepal, the project delivered a virtual training to KISAN II core staff and partners, CSISA II core staff and partners, and NARC scientists on 7 September 2020. Attended by over 40 participants, Moin Salam coordinated the training on 'Towards transforming lentil into a competitive enterprise in Nepali farming systems', where the value of the Stempedia model was highlighted in sustaining the industry in the country. The project partnered NARC (Dr. Saraswati Neupane, Entomologist and Senior Scientist S-3, and Mr. Laxman Aryal, Plant Pathologist and Scientist S-1) in the training. The training clearly met a need for KISAN II staff, remarked by Ms. Ellicott.

[6] Although this reporting section is on Bangladesh, information from Nepal have been included as work on Stempedia is conducted in both countries.

Analysis of the value of the model-guided fungicide application in controlling lentil SB disease: Conventional advice given by nation is the best option for SB disease control, although in practice, farmers either typically apply too much fungicide when it is not needed, which can lower their profits, or not at all.

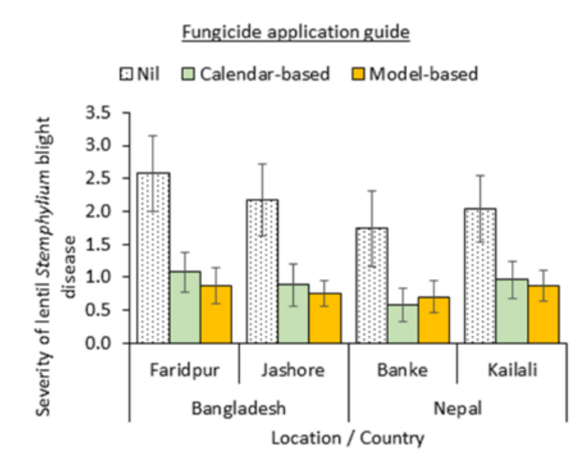


Figure 30: Status in the severity of lentil Stemphylium disease in two locations each in Bangladesh and Nepal under nil, calendar-based and model-based fungicide application – results from experimentation with Stempedia model.

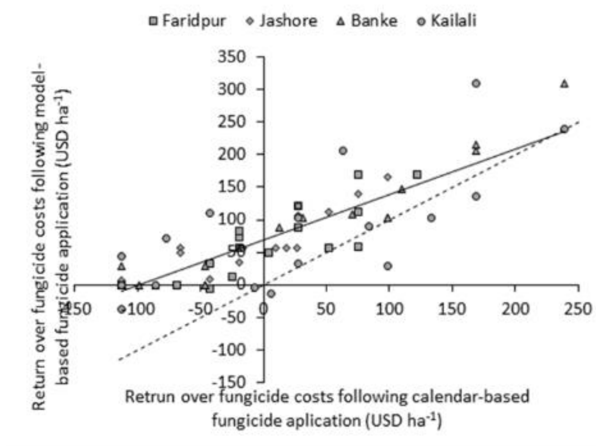


Figure 11: Economic returns comparing calendar-based and model-based fungicide application in controlling lentil Stemphylium disease - results from experimentation with Stempedia model.

In response, the Project undertook Stempedia model-based experimentation on this issue and found that (i) the severity of SB disease could be significantly reduced by fungicide application, (ii) due to uncertainty in the appearance of the disease, the control of the disease through blanket calendar-based three-applications of foliar fungicides not always effective and economic, (iii) the frequency of fungicide application can be reduced significantly, on average by half, following the guidance of Stempedia model, while reducing the disease at the same level as controlled by the calendar-based three-applications of foliar fungicides, and (iv) economically, under longer-term scenarios, when a farmer would be achieving 1 USD ha^{-1} margin over fungicide costs (includes chemical and labor costs) following calendar-based fungicide application guide, s/he would expect to achieve 1.70 USD ha^{-1} if they used the model-based fungicide application.

Plan of activities for 2020-21: During the coming 2020-21 lentil season, the CSISA will undertake field testing of Stempedia model-guided fungicide application in controlling lentil *Stemphylium* blight disease in collaboration with national research and extension system partners Bangladesh and Nepal. For its implementation, the following tasks will be undertaken.

- Formalization of partnership with (a) the On-farm Research Division (OFRD) of the Bangladesh Agricultural Research Institute (BARI) through the Director General, (b) Field service wing (FSW) of the Department of Agricultural Extension (DAE) through the Director General, (c) Weather forecasting section of Bangladesh Meteorology Department (BMD) through the Director, (d) National Grains Legume Research Programme (NGLRP) of the Nepal Agricultural Research Council (NARC) through the Executive Director, and (e) Weather forecasting section of the Department of Hydrology and Meteorology (DHM) of Nepal by 31 October 2020.

- National endorsement of Stempedia model and model-based EWS by the end of 2020 through an international webinar workshop on the value of Stempedia model and its application in guiding fungicide application in controlling lentil Stemphylium blight disease in South Asia with participants from Australia (Australian Centre for International Agricultural Research, ACIAR and the University of Western Australia, UWA), Bangladesh (BARI, BMD and DAE) and Nepal (NARC).
- Field operations during October 2020 to May 2021in 20 farmers' fields each in Faridpur, Jashore and Meherpur districts of Bangladesh, and Banke, Dang and Kailali districts of Nepal; includes farmers and fields selection, seed and fungicide procurement, field layout and seeding, field management, fungicide application, scoring of diseases and crop cut in partnership with OFRD of BARI, FSW of DAE, NGLRP of NARC.
- Forecasting system set up and development the end of 2020 through connecting to BMD and DHM for channeling weather forecast data, exploring other sources of forecast data, and setting Stempedia model for the forecast.
- Communication campaign by arranging field days each in Faridpur, Jashore and Meherpur in Bangladesh, and Banke, Dang and Kailali in Nepal during March 2021. The field days will be arranged by OFRD in Bangladesh and NGLRP in Nepal with active support from CSISA III.
- Data tabulation, cleaning, analysis, and technical report writing by the core CSISA III staff during June – September 2021.

Through these tasks, CSISA will generate a knowledge- and evidence-based product, early warning system for lentil Stemphylium blight disease (EWS-LSB) in Bangladesh and Nepal. Following a final endorsement workshop anticipated within the next reporting period, EWS-LSB will be scaling-out among farmers and service providers (input dealers in Bangladesh and Agrovets in Nepal). It will also scaling-up BARI and NARC institutional systems in sustaining disease management systems by looking into a new dimension of disease management system generation and practical and financially viable technologies.

A.2.2 Building precision nutrient management approaches around scaling pathways

This activity was scaled back by CSISA after funding shortfalls and delays experienced in 2017 and 2018 that resulted in the departure of scientific staff leading research. Since this period, only limited work on precision nutrient management has been conducted in Bangladesh. As such and as indicated in the semi-annual report, major activities were undertaken in this work package during the 2019-20 reporting period, aside from the production of a scientific manuscript titled 'Modeling of heterogeneity of nutrient limiting yield: implications for precision nutrient management of maize in the eastern Indo-Gangetic Plains'. The abstract for this paper is as follows:

Inadequate knowledge of factors affecting maize yield to nutrient limitations or sufficiency in the eastern Indo-Gangetic Plains has constrained efforts to develop precision nutrient management recommendations that aim to reduce input costs, and increase yield and profits with less environmental footprints. We used data from nutrient omission plot trials (NOPTs) conducted in 324 farmers' fields across ten agro-ecological zones (AEZs) of Bangladesh during winter, rabi seasons of 2011-2012 and 2012-2013 to explain maize yield variability and identify variables controlling nutrient limited yields in those AEZs. An Additive

Main Effect and Multiplicative Interaction (AMMI) model was used to explain maize yield variability to nutrient addition,. and then interpretable machine learning (ML) algorithms to rank management, soil, and remotely sensed variables controlling N-, P-, K- and Zn-limiting yields relative to NPKZn fertilization in different AEZs. Mean yields in the non-limiting nutrient 'sufficiency' plots were highest in the Active Ganges Floodplain (AEZ 10) and Young Brahmaputra and Jamuna Floodplain (AEZ 8) in the first and second year, respectively, and were consistently lower in Old Meghna Estuarine Floodplain (AEZ 19). Nutrient omission treatments explained ~ 60% of yield variation in both years; AEZ explained 30 and 32%; while the $AEZ \times NOPT$ interaction explained 8.4 and 7.3% of the variation in the first and second year, respectively. Ranges for yield response to N, P, K and Zn fertilization across AEZs were 2.90–6.35, 0.50–3.60, -0.10–2.40, and -0.40–1.00 t ha^{-1}, respectively. The estimated expected yield response to N, P, K and Zn under medium-fertility conditions were 6.8, 2.9, 1.3 and 1.4 t ha^{-1}. Relative yield (RY) which represents the soil indigenous nutrient supply (INS) capacity ranged 0.15–1.00, 0.41–1.21, 0.17–1.37, and 0.6–1.56 for relative yield of N (RY_N), P (RY_P), K (RY_K), and Zn (RY_{Zn}), respectively. Among the 42 ML models, the root means squared errors (RMSEs) of the best model were 0.122, 0.105. 0.123, and 0.104 for RY_N, RY_P, RY_K, and RY_{Zn} respectively The permutation-based feature importance technique identified soil pH as the most important variable controlling RY_N while the variabilities of RY_P and RY_K largely depends on the characteristics of AEZ. Flooding land type was associated with RY_{Zn}. To develop more precise nutrient guidelines for maize in the eastern IGP, further research is required by updating the databases cataloging variability in land types, soil characteristics, and INS will need to be combined with information on farmers' crop management practices and robust attainable yield estimates.

A.2.3 Aiding the Fight Against Fall Armyworm in Bangladesh

The fall armyworm *Spodoptera fruigiperda*, is a global threat to farmers, especially to maize farmers. It first appeared in South Asia in India in mid-2018 and by November 2018 had arrived in Bangladesh. Damaged maize was found in several districts, including CSISA working areas in the FtF zone. Further details on the biology and ecology of Fall Armyworm (FAW) are given in CSISA's 2018/19 semi-annual report.

In September of 2019, with support from USAID/Washington and endorsement by the USAID Mission in Bangladesh, the Michigan State University's Borlaug Higher Education for Agricultural Research and Development (BHEARD) made a synergistic investment in the 'Fighting FAW' project' that was designed to leverage CSISA's established technical staff and network of partners to takes an integrated pest management (IPM) approach that can be sustainably implemented by resource-constrained farmers. This synergistic project tackles these issues by generating evidence and developing educational strategies to facilitate FAW IPM training for the public and private sector, while also addressing institutional issues needed for efficient FAW response. Key outcomes for shared activities from the Fighting FAW project – which also shares staff and leverages complementary co-investment by CSISA – are described below[7].

[7] Note that some of the text shown here mirrors the executive summary submitted to Michigan State's BHEARD and USAID/Bangladesh in the 2019-20 Annual Report for the Fighting Back Against Fall Armyworm (FAW) in Bangladesh project, submitted on April 24 of 2020. The text is repeated here as the Fighting FAW project is considered as a co-investment in the CSISA program and as such activities are aligned and reported on here.

- CSISA supported the USAID Mission funded Fighting FAW project and conducted a series of intensive three-day field trainings on integrated FAW management for 254 Department of Agricultural Extension (DAE) Agents in October – November of 2019. Follow-up surveys with extension agents indicated that this group conveyed IPM advice to farmers for controlling FAW in during their regular rounds of meeting with farmers and in farmers' groups and clubs. Monitoring and evaluation data indicate that IPM was extended to 74,132 farmers, among whom 22% were women.
- Surveys also clarified that the trainings were extremely effective. A total of 239 DAE Sub-Assistant Agricultural Officers (SAAOs) set up and maintained pheromone traps in demonstration FAW IPM plots in farmers' fields after the training. In addition to regular and informal passing of information to farmers during extension visits, 129 SAAOs also pro-actively and independently arranged formal farmer field days. During these field days they discussed conservation biological control and demonstrated how most safely apply insecticide and maintain spray refuges to maintain natural enemy presence in fields. 216 SAAOs scouted fields and advised farmers to *not* apply pesticides three times more frequently than they did, indicative of success of the trainings that focused on reducing unnecessary pesticide spraying. During the reporting period, the Activity supported Bangladesh's FAW Task Force by printing 100,000 copies of the nationally endorsed FAW integrated Pest Management (FAW) fact sheet that were widely distributed by public agencies and the private sector throughout Bangladesh.
- In the second half of the reporting period, CSISA and the Fighting FAW project completed the production of two additional Bangla language videos to raise awareness on FAW IPM. The video "*Best practices to manage Fall Armyworm*" provides information on the advent of the FAW migration to Bangladesh, its pest status, and how farmers can use monitoring and scouting procedures, as well as methods to identify and understand FAW and its basic biology and IPM methods. The second video, "*Jamal conquered his dream through maize farming*," is an informational training video filmed in the format of an entertaining fictional drama. Due to restrictions imposed by COVID-19, in-person screenings of these videos is however not possible. Rather, the Activity has begun working with cable television stations in their dissemination. Through October 2020-January 2021, cable television operators in195 sub-districts in 25 maize growing districts will begin airing the videos in accordance with the time during which maize tends to be sown by farmers.

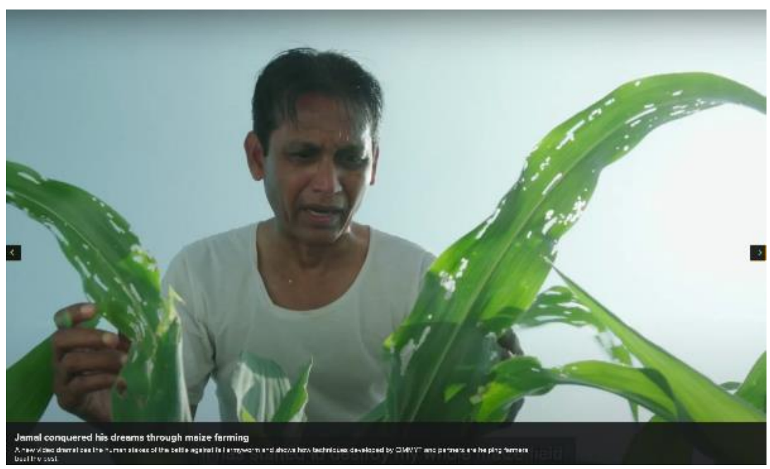


Photo 6: ***Screen shot from the "Best practices to manage the Fall Armyworm" video produced by the Activity placed prominently on the CIMMYT homepage.***

- Through synergistic activities in the CSISA Project, a video produced by Michigan State University's Scientific Animations Without Borders (SAWBO), USAID and CIMMYT on FAW management was shown to over 130,000 farmers 21% of whom were women – throughout much of the maize growing areas in Bangladesh in village and road-side video shows during. These showings doubled as an opportunity for light training as farmers were encouraged to ask questions with answers provided by subject experts associated with CSISA in between runs of the video. In addition, these activities galvanized support for use of the SAWBO video, with the Government of Bangladesh electing to post the SAWBO video on FAW management on all governmental websites, shown prominently alongside other videos highlighting health topics such as dengue and COVID. This can viewed on [this link](#).

- In late 2019, the Fighting FAW activity has developed an app – the [Bangladesh Fall Armyworm Monitor](#) – that is custom designed based on the requests of the National FAW Task Force and DAE in particular, to monitor the FAW population in the 9 major and 16 minor maize growing districts. Extension agents collected data on FAW populations and damage to maize from 777 fields weekly from across Bangladesh, with all data uploaded and analyzed automatically in a dashboard format to enable policy makers and extension staff to make better decisions and advise farmers more appropriately. This is the first time that digital tools were used for large-scale surveillance of pests in Bangladesh, and widely seen as a major contribution of the project. The monitoring tool has also been expanded to Myanmar through an investment from the CGIAR Research Program on MAIZE. In addition,

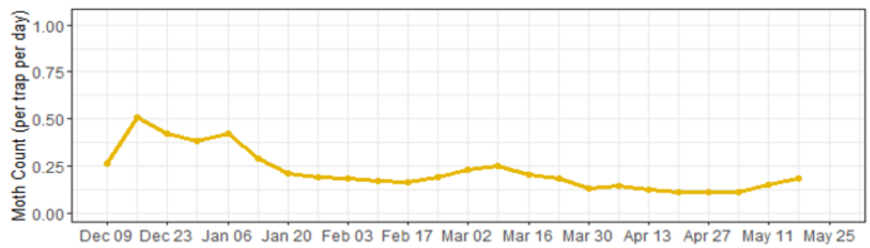


Figure 12: National level aggregated moth count data (per trap per day). Data were data collected from 777 fields in Bangladesh during the 2019-20 winter maize growing season.

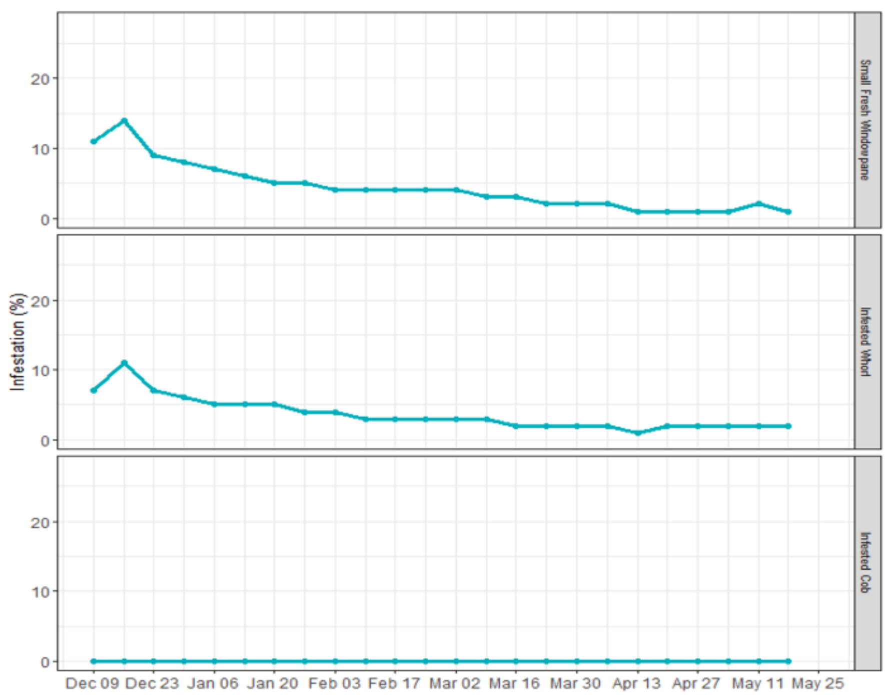


Figure 13: National level aggregated FAW infestation data. Data were data collected from 777 fields in Bangladesh during the 2019-20 winter maize growing season.

partnerships with the Bangladesh Agricultural Research Institute and Bangladesh Rice Research Institute enabled similar monitoring in cabbage, tobacco, rice and tomato crops.

- Combining resources with CSISA, Fighting FAW project to has embarked on an ambitious set of research support activities targeting FAW to better understand how farmers across Bangladesh responded and managed damage in their fields, while also initiating cooperative research with the Bangladesh Agricultural Research Institute (BARI), Bangladesh Wheat and Maize Research Institute (BWMRI), and the Bangladesh Rice Research Institute (BRRI). Research topics respond to key expert-defined needs for FAW studies in Bangladesh and include: Screening studies to evaluate the effectiveness of new pest control materials (led by BARI), FAW severity, incidence and management surveys to inform mitigation (led by CIMMYT with BWMRI and DAE), studies to characterize natural enemies of FAW in Bangladesh (led by BARI), intercropping and agroecological management of FAW (led by BWMRI) and FAW digestibility of rice to assess risk damage to an alternative host (led by BRRI).

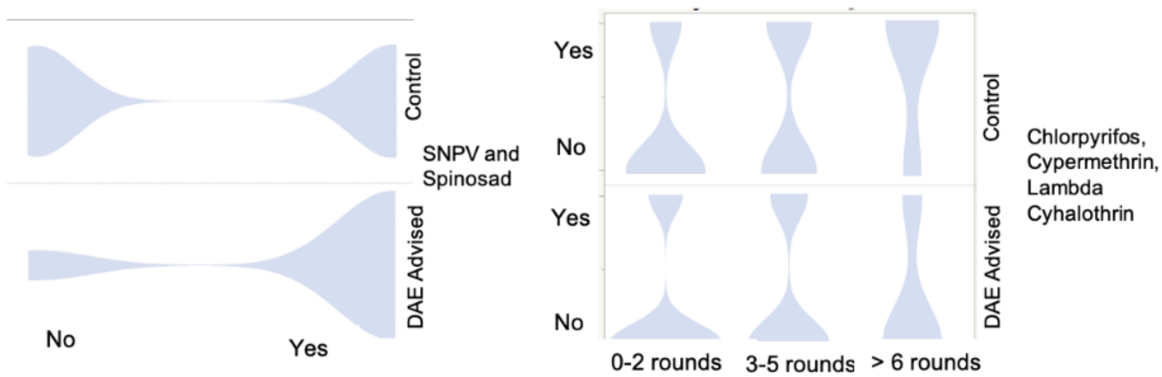


Figure 14: For farmers who did apply pesticides as reported in the survey, these graphs depict farmers' spraying behavior of new pest control substances - Spodoptera Nuclear polyhedrosis Virus (SNPV) and Spinosad in the left panel, and spraying of more toxic and non-effective chemicals such as Chlorpyrifos, Cypermethrin, Lambda Cyhalothrin among participating in the FAW monitoring program who had contact with and were advised by DAE and the control sample. .

- CSISA worked with the Fighting FAW project synergistically to assist in the development of technical materials and a rapid one-day awareness raising training for agricultural input dealers in 10 major maize growing districts of Bangladesh from January to February of 2020. These trainings were deployed by partnering with the Agricultural Input Retailer Network (AIRN) in Bangladesh. A total of 1,047 retailers from nine districts participated in these hands-on trainings. Each of the retailers trained by the AIRN master trainers reached at least 50 farmers with information on FAW management. Extrapolating these results, more than 52,000 farmers were able to access enhanced advice on FAW management through trained dealers. In addition, agricultural input dealers distributed 109,000 infographics on FAW.

- CSISA supported the Fighting FAW project to facilitated a one and half day long training program for pest control product companies on 20-21 November of 2019. This training program was arranged during 20-21 November 2019 at Hotel Shahid, Chuadanga. A total of 30 participants participated in the training program. All of the participating companies followed-up after the trainings and further extended information to their staff, dealers, and farmers, in addition to investments in low-toxicity and biological pesticides.

B. SYSTEMIC CHANGE TOWARD IMPACT

B1. Partnerships for inclusive growth around commercial pockets and neglected niches

B1.1 Deployment of better-bet agronomic messaging through input dealer networks and development partners

The adoption of science-based agronomic management practices by farmers can reduce yield gaps and increase the productivity and profit of crops in farmers' fields. Communicating and providing advice on appropriate and proven agronomic practices to farmers through easily understandable extension materials is an important way of scaling out these practices among farmers. In 2016/17, the project produced a video on raising healthy rice seedlings and early wheat sowing, leaflets and booklets on healthy rice seedlings, mung bean cultivation and early wheat sowing and a fact sheet on wheat blast mitigation. These materials are updated annually and supplemented by new extension materials Since then, the project continued to use these materials to deploy recommendations on appropriate agronomic practices to smallholder farmers in partnership with the DAE the Agriculture Information and Communication Centre (AICC), the Agriculture Information Service (AIS), AAS, and AIRN.

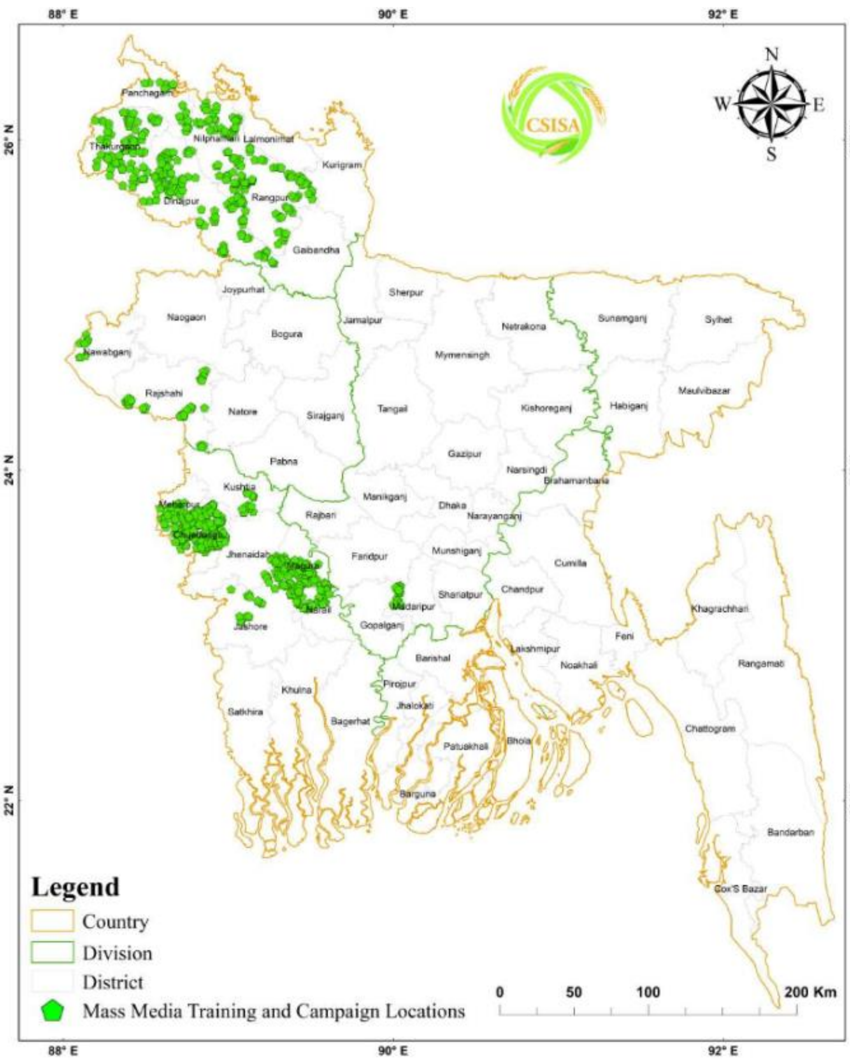


Figure 15: Healthy rice seedling mass media video show and informal trainings took place in 1,080 villages across CSISA's working areas – with some additional spill over into new locations – during the reporting period. Map courtesy of Mustafa Kamal.

Healthy rice seedlings for higher yields: Information reaches more than 130,000 farmers

Despite being primarily a rice growing country, many farmers in Bangladesh remain relatively unaware of the simple techniques that can be used to raise healthy rice seedlings (HRS). Similarly, they often lack understanding of the basis for HRS practices in reducing transplanting shock and encouraging early vigorous growth that can increase yield by 7 – 10% compared conventionally grown and transplanted seedlings. In response to these problems, the CSISA project has been working to increase farmers' awareness about the benefits of young HRS as well as increase farmers' capacity to raise HRS through the distribution of leaflets and showing the video on raising HRS to farmers, facilitating preparation of community seed bed, and providing HRS training to DAE officers and seedling entrepreneurs. HRS training to DAE officers and seedling entrepreneurs.

However, with the outbreak of COVID-19 in Bangladesh, all the awareness raising activities except community seed bed preparation on HRS were suspended since March 2020. All the activities reported in this report were accomplished before March 2020 during the winter *boro* season from 2019-20. As an exemption, community seed bed preparation was accomplished in both the *boro* season of 2019-20 and summer *aman* season of 2020. During the reporting period mass media campaigns were deployed showing videos on HRS raising methods to farmers in 1,080 villages in CSISA's working areas. A total of 132,358 farmers participated in the video shows prior to the development of COVID19, which doubled as informal question and answer sessions and trainings, out of which 25,169 participants (19%) were female. At the same time, the project distributed 72,740 leaflets through DAE staff, agricultural input dealers, and lead farmers to the farmers of project working locations.
Due to COVID-19, CSISA monitoring and evaluation team contacted 959 farmers in winter *boro* season 2019-20 and 450 farmers in summer *aman* season 2020 through telephone calls. A total of 566 and 416 farmers responded regarding their dealing management practices for the *boro* and *aman* season, respectively. Farmers responded to a series of structured questions on their retention and use of knowledge gained through the CSISA-led mass media campaign to determine the farmers' adoption status of HRS raising practices. Each of the farmers surveyed had been registered as having viewed the HRS videos during the mass media campaign, and were registered as having received HRS leaflets from the Project.

Table 13. Adoption of management practices for raising healthy rice seedling by rice farmers in winter boro season 2019-20 and summer aman season 2020 as observed in farmer survey through phone call.

Management practices for raising healthy rice seedlings	Percent of farmer adopter	
	Boro season 2019-20 (*n* = 566)	*Aman* 2020 (*n* = 416)
Seed bed prepared in a location for maximum solar insolation	47	77
Seed bed soil texture either loam or clay loam soil	32	58
Used certified seeds	48	59
Practiced seed germination test	29	61
Identified non-viable seed through water flotation methods	7	48
Used fungicides for seed treatment	3	13
Practiced recommended seed rate (3-3.5 kg/decimal) in seedbeds	9	13
Used raise seedbed with drainage channels	46	60
Used young seedling (<30 days old seedlings in *aman* season and 30 – 40 days old seedlings in *boro* season)	64	46

In both the *boro* and *aman* seasons, sustained adoption of HRS agronomic practices were observed among surveyed rice farmers. In the *boro* season, 52% of respondents utilized methods to improve their seed bed preparation and management. This was up from 20% in the previous season. Additionally, 78% of the farmers interviewed indicated that they will continue to make use of HRS methods in subsequent seasons. The results also indicated that 64% of the surveyed rice farmers used rice seedlings of recommended age, and that 48% had begun using certified seeds following their interactions with the mass media campaigns . In the *aman* season, survey results indicated that 46% of the surveyed rice farmers used rice seedlings of recommended age, and that 59% had begun using certified seeds following their interactions with the mass media campaigns.

During the reporting year, the CSISA project also organized linkage meetings to facilitate awareness of HRS techniques. One linkage meeting was held at a District level during the reporting period with 37 senior DAE staff attending. Five meetings were held at the sub-District level involving DAE staff and lead farmers. The project also provided training on HRS techniques to 106 DAE staff (16% women extension officers), 69 seedling entrepreneurs, and prepared 28 community seedbeds involving 326 farmers in the FtF zone.

Distribution of learning materials to farmers, extension staff, and the private sector

During the reporting period, CSISA printed and leveraged its broad partner network in both the public and private sector to distribute various types of educational technical learning materials. The ultimate goal if these actions were was to disseminate key technical messages for the farmer and assist them by raising their awareness and use of appropriate agronomic techniques.

Table 14. Distribution of extension information through public and private sector partners in Bangladesh during the 2019-20 reporting period.

Extension material name	Quantity distributed	Which partner assisted in distribution of these materials?
Leaflet on Healthy Rice Seedlings (Bangla)	100,000	District and sub-district level DAE Offices, SAAOs, AIRN/dealers, AAS, civil society partners and lead farmers
Leaflet on Early Wheat Sowing (EWS) infographics	100,000	As above
Wheat Blast Fact Sheet	80,130	As above
Leaflet on wheat blast disease control (Bangla)	100,000	District and sub-district level DAE Offices, SAAOs, AIRN/dealers, AAS, civil society partners and lead farmers
What is wheat blast and how to control it? (Bangla)	100,000	District and sub-district level DAE Offices, SAAOs,
What is wheat blast and how to control it? (Bangla)	100,000	AIRN/dealers, AAS, civil society partners and lead farmers District and sub-district level DAE Offices, SAAOs, AAS, civil and lead farmers
What is wheat blast and how to control it? (Bangla and English)	25,000	DAE officers
Pocket booklet on easy to use methods to improve Mung bean (Bangla & English)	500	District and sub-district level DAE Offices, SAAOs, AAS, civil and lead farmers
Pocket booklet on grow vegetables with hybrid Maize (Bangla & English)	4,000	District and sub-district level DAE Offices, SAAOs, AAS, civil and lead farmers
Fall armyworm Bangla Infographics	398,000	Bayer Crop Science Limited, Auto Crop Care Limited (ACCL), Petrochem Bangladesh Limited, NAAFCO, Supreme Seed Company Limited, Xplore Business Limited, Konika, Agro Input Retailers' Network (AIRN), Agricultural Advisory Services (AAS), Abt/BNA and US Trade Fair
EWS Festoons	150	DAE
EWS Stickers	3,000	DAE offices, agricultural input dealers
EWS Banners	200	DAE offices, market places

During the reporting period, mass media campaigns led by CSISA and the NGO Agricultural Advisory Society had considerable impact among the farmers': A total of 599 video shows (EWS, HRS, FAW) were conducted before the COVID-19 outbreak, where a total of 55,675 participants were attended in video shows (10,082 women and 45,593 men) show. The project played a vital role to strengthen the public & private partnership' approach and took some collaborative efforts between CIMMYT-DAE-BWMRI-AAS-AIRN-AICC-AIS.

B1.2 Rice-fallows development and intensified cropping patterns

Since the inception of the third phase, the project has focused work in Southern Bangladesh to assess ways in which dry season fallow land – which represents an enormous resource for increasing the productivity of farming systems in the FtF zone– can be reliably brought into production using management practices that rely on approaches aligned with Sustainable Intensification Goals.

To accomplish this, the project conducts strategic research on pathways and approaches to encourage fallow land intensification, starting with the development of a thorough understanding of trajectories of farming systems change within the region. Understanding how systems have changed and where their current trajectories are headed given biophysical and social constraints that farmers face is crucial to inform development planners and policy makers and advise on appropriate development interventions within the region. CSISA's Semi-Annual report for 2019-20 provides detail on many of the ongoing research topics in this area. This report however focuses only on those that have had significant additional focus in the second half of the 2019-20 reporting period.

Building farmers' resilience to weather shocks and replacing fallows with mung bean in Bangladesh

Figure 16. Mung bean is an increasingly popular but climate risk prone crop in southern Bangladesh. In addition to weather advisories, project efforts have also focused on the provision of basic but crucial agronomic information to farmers of this crop. These include topics such as seed selection, land preparation, fertilizer application, weeding, irrigation & drainage, pest and diseases, and safety precautions for pet management.

Background: Mung bean is a highly profitable and widely grown legume crop among the farmers in the center coast (especially Patuakhali, Barguna, and Barishal districts) of Bangladesh. Over the last five years, land area devoted to mung bean has grown by nearly 50% as farmers replace dry season land fallowing with this crop. However, during the harvesting period that starts from march and continues through early June, farmers face large yield and income losses due to heavy rain and storm events that cause pod shattering and waterlogging.

Among 159,314 IVR calls, 65% of the calls were successfully received and listened to by the farmers and mung bean traders and the rest of 35% of the call failed to reach end-users mainly because the calls were ringed out without any answer by the users and phones were switched off. It is found that most of the call listened by the farmers was around 48 seconds on average which indicates the farmers mostly listened to the weather forecasts in the IVR calls.

Also during the reporting period, a mung bean climate and market information services app for smallholder farmers called "Mugdal Sheba" was launched remotely in Zoom meeting on May 19, 2020. An in-person launch was not possible due to the COVID-19 lockdown. This app provides weather forecasts with harvesting advisory, the previous day market price of mung bean in Barguna and Patuakhali and mung bean agronomic information. Ninety three participants from various Government offices, development organizations, and universities in Bangladesh and abroad attended the workshop. The E-Krishok App where the mung bean service is integrated is available in Google Play and the link of the app is found in [this link.]

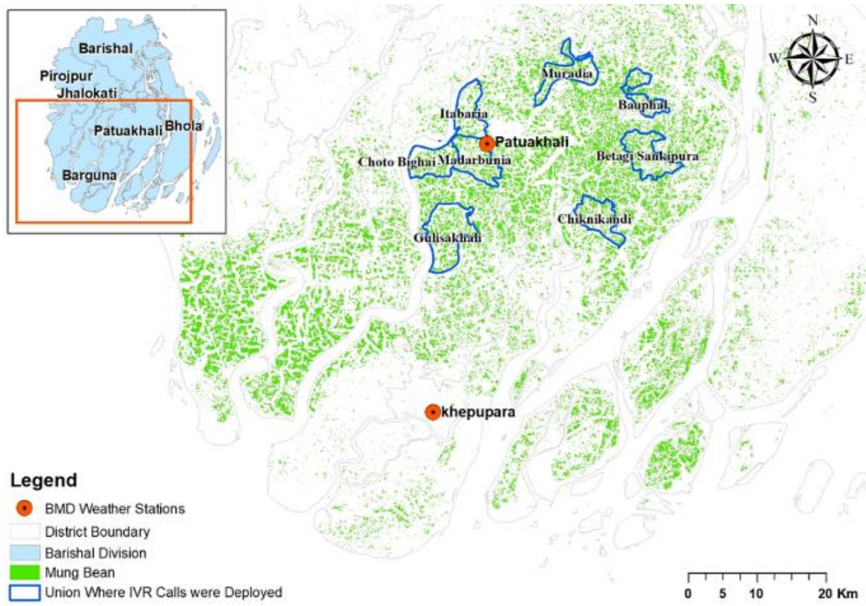


Figure 17. Map showing the eight unions where the weather and crop advisory interactive voice response calls were deployed to mung bean farmers from April 22 and June 30, 2020

In addition, a stakeholder Workshop on "Sustainable Business Models for IVR (Interactive voice response) based advisory services": The case of mung bean in costal Bangladesh" was held on June 28, 2020 on Zoom. As with other meetings in the second half of the reporting period, in person interactions were not possible due to COVID-19 related risks. The main objectives of the workshop were (i) to discuss options for a business model to sustained investment IVR advisory dissemination after project support is withdrawn, and (ii) to create dialogue among key stakeholders on ways to support business models by private companies in scaling of the advisory services in general and mung bean services in particular. More than 50 participants from various government offices including the Ministry of Post, Telecom and ICT, telecom companies such as Grameen Phone and Robi participated. CSISA is now pursuing options to bundle IVR services with paid for private company advertising for rhizobia inoculants suitable for mung bean in a public-private partnership with companies anticipated in the 2021 mung bean season.

Lastly, during the second half of the reporting period, a telephone survey of 881 mung bean farmers (775 men and 106 women) from eight locations whose phone numbers were randomly drawn from the IVR call recipient list was conducted after the mung bean season from June 25 to July 20, 2020. The survey results indicated that:

- 86% of surveyed farmers took immediate action by starting to harvest their crops with family members/labor, or opened/cut drain in the field (for ensuring drainage) or protected/moved harvest crops in response to the heavy/very heavy rain alerts with advisories. Because of taking immediate actions, on average 65% of farmers saved their crops from rainfall-induced damages and losses after receiving weather forecast and harvesting advisory.

- 7% of farmers found the market price information as very useful. Among farmers, only 18% of the farmers used the market price and traders' contact information and proactively reach out to traders to sell the mung bean directly to them. Rest of the farmers didn't like prices that the traders offered.
-
- In terms of future IVR deployment, 40% of farmers would like to get weather forecasts and management advice only, 35% would like to get at least the mung bean market price along with the weather forecast and the rest of the farmers wanted all three services together for the next season which indicates a high demand for weather forecasts during the mung bean harvesting period.

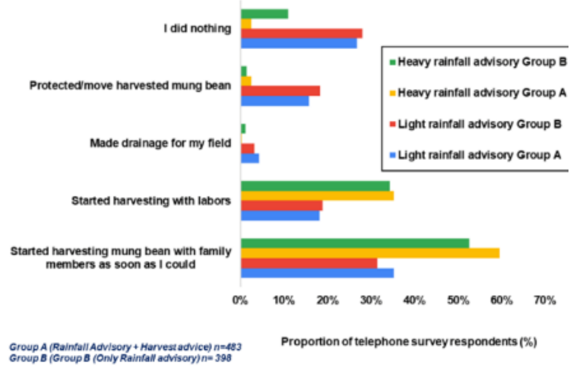


Figure 18: Response to the question 'Did receiving the voice messages from Mung bean IVR service made you to do something different in how you manage your mung bean this year' from those who received weather advisories or weather advisories combined with mung bean management advice, respectively

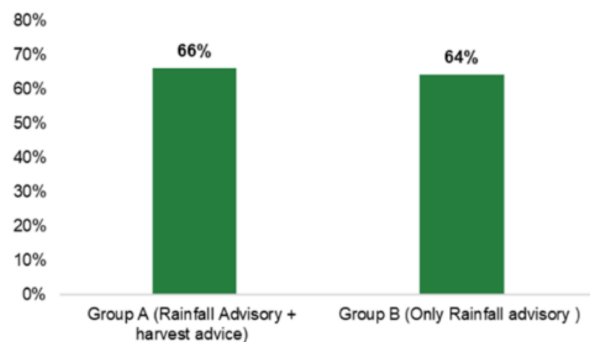
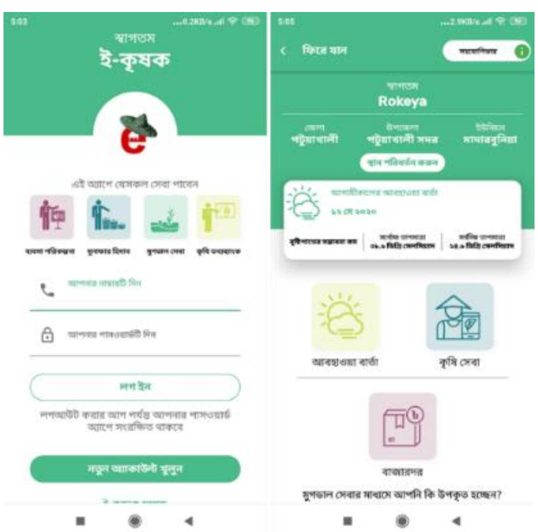


Figure 19: Response to the question 'how much of your mung bean crop do you believe you saved by harvesting early in response to the voice calls', averaged across heavy rainfall forecasts and differentiated by A and B call groups



Due to limited access to weather

Figure 20: screenshots of the Mungdhal Sheba android app interface. The E-Krishok App where the mung bean service is integrated is available in Google Play and the link of the app is found in this link.

Plans for the remaining months of 2020: With high demand for weather forecasts, there is scope of expanding the IVR services to at least 10,000 mung bean farmers in Patuakhali and Barguna districts in the next season. Currently, there are around 388,106 farm families, 144,420 hectares of mung bean area with an average yield of 1.24 MT per ha and a total 130 unions in both districts together. In the remaining months of 2020, at first, the CSISA team is working to identify the potential area increasing the number of farmers receiving IVR calls. Currently, the forecasts used to generate the IVR based advisories are generated by BMD at a resolution of 17 km^2; CSISA scientists are working with climatologists at BMD to provide 9 km^2 gridded to achieve more accurate rainfall forecasts.

In addition, CSISA is continuing to develop plans for public-private partnerships to leverage financial investments in the IVR system, which will assist in achieving sustainability of the system in a post-project period. The latter effort is being undertaken in collaboration with the USAID/Bangladesh funded FtF Rice and Diversified Crops (RDC) Activity. Current discussions between CSISA and RDC are on-going and aimed at creating a platform for private companies invest in advertising using the IVR system, while also bundling the IVR facility with seeds inoculants. The modalities of the platform approach and bundling is expected to be finalized before the end of 2020.

Mapping mung bean with remote sensing in coastal Bangladesh

Mung bean plays an important role providing protein in the rice-based diet of the people 12 in Bangladesh. In the coastal division of Barisal in Bangladesh, average farm size is less than 0.5 ha 13 and individual fields measure about 0.10 ha. The agricultural landscape in this region is similar to other parts of South Asia that rotate winter season crops with monsoon season paddy rice production. They are densely populated and farmers cultivate nearly every square meter of land. Road infrastructure in this region is also poor, with many roads being too narrow for regular vehicles. As such, most smallholders' parcels can be accessed only by foot. This makes traditional crop monitoring surveys that aim to quantify the amount of land area under mung bean challenging; in addition, *in situ* data collection is time consuming.

Photo 7: Members of the CSISA S2-AEC sea plane used for mung bean crop field surveillance at 150-300 m height on March 25, 2019 (photo by Mustafa Kamal at takeoff station at Hazrat Shahjalal International Airport, Dhaka).'

Considering these issues, the Bangladesh Bureau of Statistics (BBS) uses two approaches to assess the extent of agricultural land under different crops. The first is based on direct observation of crops in the 78 field, though this approach is applied only to major crops, such as rice, wheat, potato and jute. For 79 minor crops, such as mung bean, lentils or grass pea (*Lathyrus sativus* L.) BBS conversely relies on household surveys. In each union, the smallest administrative district, which typically measures 32 km2 , enumerators interview five farmers. Resulting data are then aggregated to the next higher administrative unit, using data from the previous or a normal year and their local expertise. Data are then reported at the district level. This is very time consuming, and requires extrapolation to generate estimates of total cropped area, for example of mung bean as a replacement crop for fallowed land. Satellite- and aircraft-based remote sensing has been widely proposed as a viable alternative for agricultural land use 86 and crop monitoring. This research primarily aims to demonstrate a method that integrates multi-source *in situ* data for crop identification in a region where access to fields is challenging and time consuming.

This work theme responds to these difficulties using an aerial survey supported by USAID/Bangladesh's collaboration with MAF Bangladesh supported S2-AEC sea plane to conduct aerial surveys carried out on March 25, 2019. A total of 2.5 hours were required complete the entire survey, which consisted of taking photographs of mung bean fields along a flight path in coastal Bangladesh (see Figure 2) at 150-300 m height. This saved time and resources used to collect data, enabling the CSISA team to produce detail mung bean area maps that could be used to validate near real time satellite image classification. Outputs from this work have already been used to assist in targeting climate advisories for mung bean farmers.

In addition to aerial photographs, additional data were collected from on the ground using Open Data Kit (ODK), Sentinel-2 (10 m ground sampling distance) satellite image and ESRI (ArcGIS version 10.7.1) and Google earth high resolution imagery. These data were then used to create training and test data for a multitemporal segment-based classification of mung bean. Recall for mung bean was 0.98 and precision was 0.99. Hence, the accuracy metrics indicate that the random tree classifier was able to identify mung bean based on 10 m GSD data, despite of the small size of the individual fields.

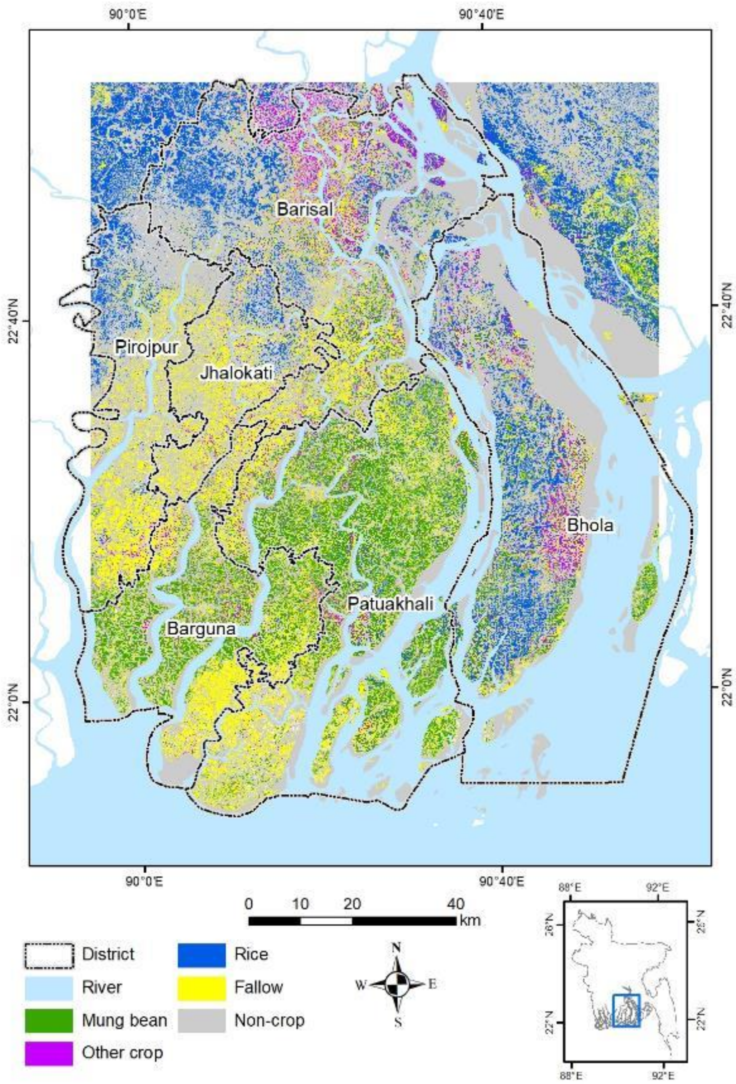


Figure 21: Classified spatial distribution of the four major crop types cultivated in the Barisal division of coastal Bangladesh during the mung bean growing season from February 6 through April 17 of 2019.

The results of this research indicate that mung bean reached an 109,416 ha in 2019, which is about 40% lower than the Department of Agricultural Extension estimates (183,480 ha), but more than four times higher than the 2019 data reported by the Bangladesh Bureau of Statistics (26,612 ha). Further analysis revealed that crop production tends be clustered in the landscape by crop type. After merging adjacent segments by crop type, the following average cluster sizes resulted: 1.62 ha for mung bean, 0.74 ha for rice, 0.68 ha for weedy fallow and 0.40 ha for the other crops category. Which justify the usage of 10 m GSD satellite data can be used for identification of some predominant crops grown in this region. The methodology being developed will serve as an example for similar studies in other regions, and opens new doors for crop surveillance and crop monitoring, and also learning and evaluation activities.

B1.3 High-value, premium quality rice (PQR) expansion in Bangladesh

The transformation of food value chains places substantial pressure on smallholder farmers in developing countries to adapt their local production practices but creates also opportunities to improve local livelihoods. For this reason, CSISA has been working to investigate the integration of smallholder farmers into emerging value chains for premium quality rice (PQR) in Bangladesh. CSISA's PQR work stream focuses on developing strategies and collaborative business planning with value chain stakeholders, as well as research to facilitate a business environment where the benefits from high value PQR products are distributed evenly across the value chain. The project works to develop producer groups to cultivate PQR, and also works to assure the supply of quality seeds to these producers by linking them to seed companies, while also linking these companies to BRRI for regular breeder seed supply. CSISA is also working to create direct linkages with millers and marketing firms, and also conducting research on introducing quality incentive pricing, while investigating the nutritional and grain quality benefits of PQR. Key activities conducted on PQR in the reporting period are detailed in the following passages.

PQR expansion and market development activities in Khulna Division: The rapid increase in labor and input costs in Bangladesh are rendering rice cultivation – especially in the winter boro season – less profitable and attractive to farmers in the FtF zone. Despite this challenging trend, rice cultivars that have thin or small grains, and that have aromatic qualities, can fetch a higher market price than the bold and medium-grain types. Some of the most commonly cultivated non-aromatic, non-premium rice varieties in the south-western corner of Bangladesh include Gutiswarna, BINA dhan-7, and BRRI dhan49 in the wet season (*aman*), and Suballaot and BRRI dhan28 in the dry season (*boro*); fetches lower market price than PQR varieties, regardless of the season. Nevertheless, the cultivation of these varieties are stymied by the slightly lower yield of some of these varieties, although farmers can earn more though sales of PQR compared to conventional rice varieties. By introducing promising new PRQ verities and advising extension services and farmers on appropriate agronomic management, CSISA addresses the yield gap while also developing business linkages with seed companies, millers and marketing firms. The onset of COVID-19 lock-downs and movement restrictions have however created some set-backs in the Project's efforts reach out to stakeholders and aggressively pursue activities, although progress in Khulna division was nonetheless promising it the reporting period.

During the 2019-20 winter *boro* rice producing period, the CSISA project worked to develop PQR producer groups with 83 farmers in Jashore district (69 men and 14 women). Another 73 farmers (59 male and 17 female) were engaged in PWR production groups in Faridpur district. 350 kg seeds of BRRI Dhan 50 and 622 kg of BRRI Dhan 87 seeds were distributed in Jashore and Faridpur, respectively. 155kg seeds of BRRI Dhan 75 seeds were also distributed to mobilize to supply to these producer groups. CSISA also convenient discussions with agricultural machinery service providers operating rice combines. These service providers met with and serviced these farmer groups. Yields achieved with BRRI Dhan 50 in Jashore were 6.72 tons per ha, although lock-downs and losses of markets during the height of COVID-19 restrictions reduced their ability to fully market harvested grain.

In the subsequent 2020 monsoon *aman* rice season, the same PQR producer groups cultivated BRRI Dhan 75 and BRRI Dhan 87, with seed supplied through market linkages to seed companies facilitated by CSISA. As a first step, five seed companies prominent in the area were selected, including (i) Uzirpur Organic Multipurpose Cooperative Society Ltd (Narail district),(ii) Modern Agro Private Ltd. (Chuadanga district), (iii) One X Crop Care Square Seed (Meherpur district), (iv) Krishi Unnayan Kendra (Monirumpur district), and (v) Friend Seed (Maheshpur and Jhenaidah districts). Following interactions with the CSISA team, they provided with 200 kg seed of BRRI Dhan 87 aim to cover 7 ha land with 50 farmers in order to demonstrate the viability of their seed. The crop has yet to be harvested at the time of reporting.

In 2020-21 season, CSISA will link these seed companies with BRRI for long term access to breeder seeds so quality seed can be continuously made available to these and other PQR producer. In addition to these efforts, 23 farmers from Vojgati village under Monirumpur, Augmundia and Syamnagar under Jheneidah Sadar Upazila, Bollovpur under Shailakupa Upazila cultivated 2.5 hectares of BRRI Dhan 87, which they plan to sell as seed to other producer groups. In addition, the project kick-started seed supply of BRRI Dhan 75 by supplying nine farmer groups under Narail Sadar, Jheneidah Sadar, Sharsha, Jhikargacha and Shailakupa Upazilas who cultivated this variety on 15.12 ha of land. These producer groups will also be linked to the above mentioned companies for continuous seed supply in the coming seasons.

PQR expansion and market development activities in Rangpur Division: Dinajpur District within Rangpur Division is famous for rice trading, but predominantly for coarse grain, which makes up about 98% of winter season *boro* rice area. Small-scale cultivation of PRQ rice cultivars BRRI Dhan 34 and some local PQR varieties like *Kataribhog*, *ZiraKatari*, *Kalozira*, and *Badshabhog* are grown during the summer *aman* season (aman), though yields are low. CSISA has worked to encourage the expansion of the PQR variety BRRI Dhan 50 in the *boro* season of 2019-20 by creating 20 farmers' groups (consisting of 510 men and 90 women) with the help of both public and private sector partners. Facilitating marketing of this PQR variety by engaging with two auto rice millers in the region increased confidence among the smallholders. Though initial facilitation of seed provisioning to the selected farmers through BRRI with presence and advice of millers also created a confidence amongst millers, CSISA's future strategy is to facilitate breeder seed supply directly from BRRI to seed companies, through which supply of quality PQR seeds to farmers can be better assured on a commercial basis in the post-project period. Four seed companies have been provisionally identified for this purpose; CSISA is currently working to secure partners agreement with them. CSISA also is in discussion with seed companies to transform some of the PQR producer groups into PQR seed producer groups with contracts offered by companies to produce seed for commercial sale.

Photo 8: Mechanical harvesting of PQR rice (BRRI dhan50) for ensuring quality grain harvesting at Barinagar, Jashore Sadar (Photo by Sabuz Biswas)

In 2019-20, to kick start farmers' interest in this new rice variety, CSISA provided 500 kg of high-quality BRRI Dhan 50 seed to selected farmers, who were also engaged in training on how to best cultivate BRRI this variety. Trainings were led by CSISA and DAE, with the presence and advice from rice millers. The 600 farmers who participated in the BRRI Dhan 50 kick-start established 20 community based seedbeds to raise seedlings. Soon thereafter, the project organized 17 batches of PQR linkage meetings with PQR traders and farmers between 22 and 27 February 2020, with 425 farmers (350 men and 75 women) participating. During these meetings, the Project facilitated business deals between farmers and traders who organized themselves to collect grain after harvest. CSISA staff also organized informal meetings to engage PQR farmers with traders and millers in Dinajpur, Thakurgaon and Nilphamari Districts. Among the millers who participated in these market demand-creation meetings, PRAN Agro, Avijat Group, A K Das trading and Dui Bhai Auto Rice Mill ltd. have now begun to actively market BRRI Dhan 50 from these Districts as '*Banglamati*') throughout Bangladesh. Prior to this intervention, millers from these companies were exclusively sourcing PQR grain from southern Bangladesh as they faced challenges in finding farmers selling this variety in Rangpur decision.

To achieve this outcome, the Project worked carefully with these companies to develop business plans that detailed how it is possible to lower transportation and transactions costs, hence saving their time and money while assuring the supply of high-quality grain from more localized markets. These companies have also provisionally agreed to make a 1:1 co-investment in supporting future like market linkage in the second half of the reporting period, but due to COVID-19 lock-downs this activity has had to be temporarily suspended. Similarly, the project will train millers to increase their awareness of improved cultivation practices so they can extend them to farmers, while also working to encourage millers to invest in combine harvesting services so farmers from which they purchase grain from can have their fields rapidly harvested before seed shattering or lodging losses could compromise production. Details of season wise achievement is as follows:

The winter Boro 2019-20 season:

- 500 farmers were involved with PQR (BRRI Dhan 50) production through 20 farmers' groups formed with the assistance of CSISA.
- The DAE, CSISA, and millers provided hands-on training on PQR production technologies and PQR marketing.
- After receiving training, farmer producer groups grew healthy rice seedling through community seedbed, timely seedling transplanting, and followed best agronomic practices with a technical backstop from CSISA hub.
- Two leading private Auto Rice mill companies were shortlisted from a list of Auto rice Mills in the region (Avijat Group (Shamsul Haque Auto Rice Mill) in Nilphamari, another one was Dui Bhai auto rice Mill in Thakurgaon) for further collaboration in direct sourcing of PQR, potentially on contract, with farmer's groups.
- Despite COVID-10 restrictions, the total production of PQR through these groups was about 550 tons.
- CSISA facilitated the selling of PQR to these companies through collection points with predominantly spot payment with an additional premium of 5 to 7 Tk/kg (price: 27 BDT/kg for BRRI Dhan 50, whereas prices are only 20-22 BDT/kg for coarse grain).

The summer Aman 2020 season:

- Despite challenges from COVID-19 restrictions, 401 (17 groups) farmers produced PQR varieties (BRRI Dhan 75 and BRRI Dhan 87).
- J.R Agro, a private seed company was encouraged by CSISA to work with these producer groups; they subsequently supplied 400 kg seeds (150 kg breeder and 250 kg foundation seed) to PQR farmers groups for seed production. This was done free of cost so farmers could gain trust in their seed, and to develop a wider client base in future seasons.
- PQR seeds produced by these groups will be purchased by the seed company. Harvest is beginning at the time of reporting.

- The seed company Srizon Ago has also expressed interest in similar arrangements, which CSISA is now working to facilitate in Rangpur division.

Photo 9: Member of a premium quality rice group in a field planted to BRRI Dhan 50 (Photo by Alanuzzaman Kurishi).

Assessing and advising on PQR grain quality and nutrition: A value chain study

The sustainability of PQR primarily relies on developing business opportunities for a quality value chain. Stating that, the rapid increasing of demand for premium quality can be meet either by upgrading domestic PQR or importing from international markets. In this regard, understanding the current PQR value chain system – conformity of quality traits, constraints that faced by value chain actors, and potential investment requirements to upgrade the value chain to meet the "quality" demands, are the central in importance. CSISA also studies the production optimization and supply chain linkages of PQR at the producer level so that smallholders are not left out in this transformed food value chain. During the reporting period, CSISA worked to estimate the agronomic contributions to the productivity and supply of PQR and test if value chain investments can incentivize farmers to adopt PQR alongside yield-enhancing and improved crop management practices, thereby enabling a pathway by which farmers are more able to participate in the benefits of PQR market development.

Decision choice experiments: CSISA is making use of decision choice experiments (CEs) to test if an improvement in PQR value chain (quality, traceability, supply, etc.) could lead to improved investments by different market actors and consumers' willingness to pay for such products. The study is being administered to PQR producers, millers, retailers and urban consumers in Mymensingh, Khulna and Dinajpur in Bangladesh. During the reporting period, COVID-19 forced a stop of three months from April to June, although CEs could still be completed with farmers and millers. Currently, this work is resumed and well underway, although many activities had to be put on hold due to the COVID-19 crisis. Detailed surveys with retailers and consumers are planned to start in November, with the value chain surveys expected to be completed by April 2021.

Hypothetical intensification pathway choice experiments:

In the above research, after eliciting preferences for PQR cultivation, an intensification experiment is administered with producers. In this experiment, farmers are asked hypothetically to allocate their land for different varieties (PQR and non-PQR). A lab-to-field experiment is designed to understand farmers' investment behavior on intensified cultivation of PQR. Based on rice monitoring survey data from 2017, input oriented technical efficiency of PQR and non-PQR varieties are estimated using stochastic frontier models. Four efficiency classes are identified with various levels of input use and productivity. According to farmer's investment choice on inputs such as seed, fertilizer, pesticides, irrigation, labor and other costs, separate productivity and efficiency classes were assigned. Those who are below optimal efficiency (<85% with an average efficiency of 90% in the class), have multiple options to reach a higher efficiency level and higher pay-outs. That is, the net revenue and pay-out from the experiment depends on farmers' decisions on how to optimally intensify their crop production system. This revised investment is compared with their actual production behavior in the previous season[8]. The detailed experimental protocol was submitted to 3ie for evaluation and is available upon request.

Photo 10: PQR survey with producers after the lock down following COVID precautions such as wearing mask, distance, temperature check, frequent washing etc. (Photo by Prakashan Chellattan)

The intensification experiment is being conducted at 142 randomly selected villages (Sherpur district – 32, Jheneidah district – 38 and Dinajpur district - 72). These are regions famous both premium quality rice cultivation and traditional rice varieties. Enumerator training for the producer and miller survey instruments and choice experiment was held in Dhaka at the IRRI Bangladesh office from 29th September 2019 to 5th October 2019. This included a field visit and piloting to test the survey questionnaires on 4th October 2019. After this training enumerators completed the baseline census of 72 villages in Dinajpur, 36 villages in Jheneidah and 32 villages in Sherpur. Using the baseline, a representative sample of millers and farmers were selected. A second training was held from 23rd December to 26th December and the choice experiment was tested in the field in Gocha village, Rajshahi district on 25th December 2019. After the second training, enumerators started implementing the survey and choice experiments in Dinajpur. The experiment started in February 2020, but had to be temporarily suspended for three

[8] Ideally a follow up survey with the real farm investment and analyse their technical and input allocation efficiency to understand the long term impacts of this experimental game is desirable. Given the budgetary limitation, we confine the work by comparing with their previous season farm investments, and later we will explore the potential to do a follow up survey.

months due to COVID-19 lockdown in Bangladesh, though activities resumed in July. The survey and experiment were completed on 10th October 2020. The data cleaning is in progress the initial results are anticipated by the end of this year. Survey and choice experiments of consumers and retailers will start from November 2020 and are expected to conclude in the second quarter of 2021 if COVID-19 restrictions are not reimpose. The plan is to virtually train enumerators on the new survey instruments in November 2020 due to travel restrictions, and assure that all enumerators practice social distancing and use personal protective equipment.

Nutritional and grain quality assessment of premium quality rice as a function of processing, value chain handling, and cooking technique:

Grain samples from different nodes of the PQR value chain are being used by CSISA to develop a comprehensive assessment of nutritional and grain quality as a function of production, processing, value chain handling, and cooking techniques. The sample collection is integrated with value chain surveys, and at the first stage samples from producers and millers are randomly chosen and taken from harvested grain stocks (employing a standard protocol of sampling of respondents as well as grain from each respondent). Samples will be used to trace the fluctuations in grain quality and nutritional attributes of selected rice varieties as they move along the rice value chain. Comprehensive grain quality profiling will be undertaken at the Centre of Excellence in Rice Value Addition (CERVA) at IRRI's South Asia Regional Centre in Varanasi.

The first step in this activity encompass collecting grain samples and then properly barcoding and shipping samples to CERVA. This process required phytosanitary certificate and import permits from the Indian Council of Agricultural Research. After receipt of permits, grain samples are sanitized and shipped to India in four to five batches. The first set of 487 rice samples from Bangladesh was received at CERVA on 21st August 2021. There has been a substantial delay due to the COVID-19 outbreak. However since survey activities have resumed in July 2020, more samples have been collected and they will be exported to CERVA in four to five batches in the coming months. Initial sorting and weighing of sample packets has been completed. The individual sample weights ranged from 11g to 401g. A total of 15 samples weighed >300g each, 118 samples weighed between 200g -300g each, 260 samples weighed between 100g to 199g each and 94 samples weighed <100g each.

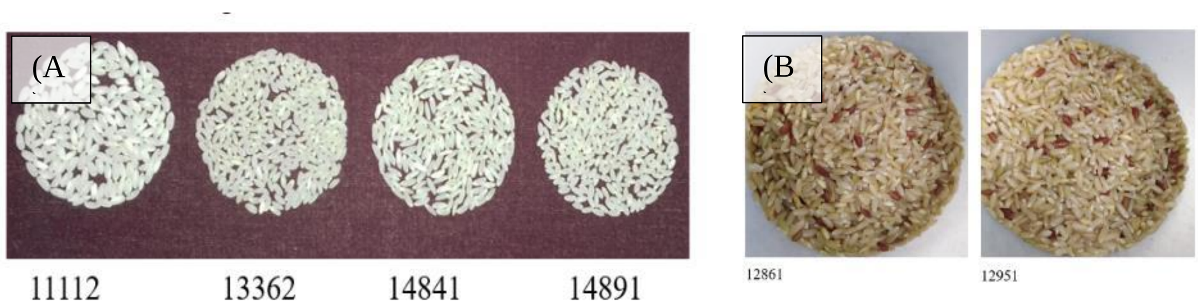


Figure 22. Images of (a) milled and (b) hulled premium quality rice variety samples received from Bangladesh.

The grain quality analyses have been commenced. Moisture content measurement is completed for all 487 samples, while de-husking is completed for 210 samples. Milling quality evaluation is in progress with various parameters such as the hulling % of 210 samples, milling % of 151 samples and the head rice recovery (HRR) of 55 samples completed. Milling of the samples revealed varying grain size and shapes as shown in Figure 24.a. However, the quantitative measurements for the physical appearance traits are yet to be carried out so as to allow the classification of the samples into grain size and shape classes. Some of the samples analyzed so far clearly revealed physical mixture of grains as shown below.

The moisture content, hulling percent, milling percent and head rice recovery percent of the 55 samples are shown in the next figure. The hulling % ranged from 69.66% to 81.38%, the milling % from 61.60% to 76.64% and the head recovery from 56.65% to 75.64%. The moisture content ranged from 13.90% to 15.80%. Correlation analyses on these 55 samples revealed a strong positive correlation of head rice recovery with the milling % (*r* = 0.802), while no strong correlation of head rice recovery was observed with the moisture content (*r* =0.261). Nutrient (Fe and Zn) analysis will be performed in the next stage.

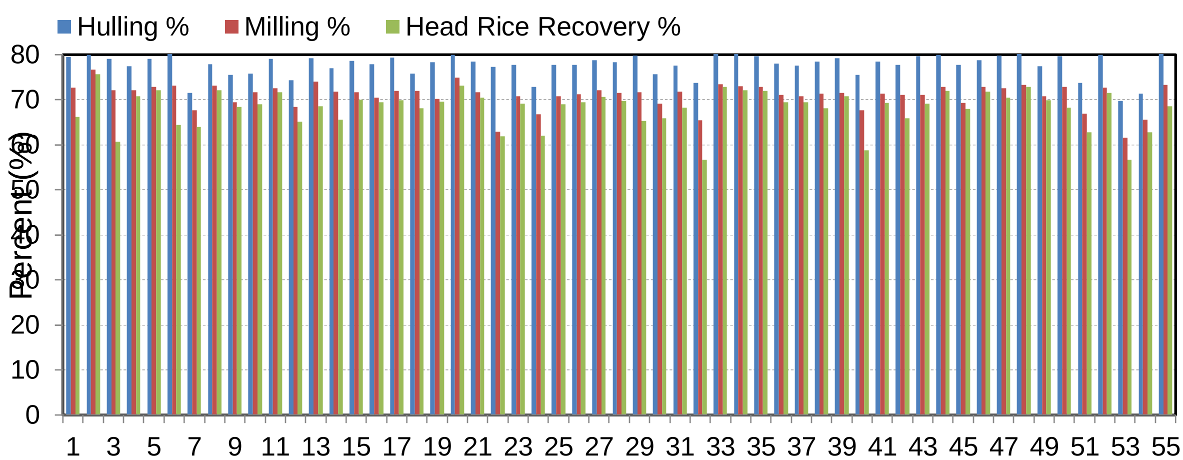


Figure 23. Variability in Milling quality parameters of a sub set of rice samples received from Bangladesh

The partners involved in the conducting the survey and the choice experiment in Dinajpur, Sherpur and Jheneidah is AVA Development Society. In the second half of the study, and contingent on COVID-19 restrictions being lifted, the project will engage with retailers and consumers.

Through the work packages described above, CSISA will be uniquely positioned in South Asia provide strategic investment requirement advice *viz-a-viz* the market potential for PQR, such that an appropriate level of investments by various stakeholders can be designed and pitched to the private sector and interested policy makers. Furthermore, the incentive for farmers to produce efficiently will be captured and developmental programs would able to implement targeted efforts for improved PQR. In the final stage – planned for 2021 – CSISA's work will be linked with large scale rice trading firms and design an exclusive production, processing and marketing plan for PQR to target both domestic and international markets.

B2. Bringing participatory science and technology evaluations to the landscape and back again

B2.1 Increasing the capacity of the National Agriculture Research and Extension System to conduct participatory science and technology evaluations

This CSISA workstream suffered set-backs and delays that resulted from the uncertainty in project funding as described in the Executive Summary and Challenges sections of this report. Despite these issues, CSISA however was able to attract additional synergistic and complementary funding from the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) to work with national partners – most notably the Department of Agricultural Extension – to collect crop cut data and management practice information from farmers at a large scale that will be used to characterize the challenges farmers face and to identify, using novel machine learning and data mining analytics, new methods and ways that famers can increase productivity and resilience while reducing their environmental impact.

Big data and large-scale agronomy diagnostics: Bangladesh's Department of Agricultural Extension embraces research to improve advice for farmers

Photo 11: Group exercise of Sub Assistant Agricultural Officers (SAAOs) of DAE on data collection using internet enabled tablets in surveys, Rangpur (Photo: Alanuzzaman Kurishi)

In synergistic action with the CCAFS activities described above, CSISA has been working to coach DAE to conduct thousands of cop cuts and production practice surveys for *boro* and *aman* rice, and also wheat Crop cuts and surveys are executed by the Sub-Assistant Agriculture Officers (SAAOs). This activity comes from the expressed interest of DAE in modernizing and refining their crop-cut data collection system to include collection and analysis of data that can be used to most appropriately advise farmers. As part of this data-driven initiative and DAE's own project programming, DAE has equipped more than 6,000 internet-enabled Android phones and tablets that are now used by SAAOs all over Bangladesh. CSISA and the CCAFS project described above are collaborating to develop a system that provides a robust platform upon which improved surveys, cloud-based analysis, and dashboard representation of research results can be built on these efforts. In 2019, 125 SAAOs were trained on the digital survey tool, Open Data Kit (ODK), using android devices to implement surveys and crop cuts with farmers. In 2019 and 2019-20 season, a total of 12,889 crop cut and crop production management surveys were conducted by DAE, with all resulting data supplied to CSISA (Table 1). All data were entered with internet enabled tablets using ODK platform and sent to CSISA server for semi-automated analysis. In collaboration with DAE, the CSISA and CCAFS team also developed a monitoring tool (Bigdata-Monitor) to check incoming data and minimize data errors though near-real time advising of DAE staff doing surveys.

Table 15: Crop cut and production management surveys implemented by DAE in various seasons in Bangladesh

Season	Crops	Number of Crop cuts planned by DAE	Number of surveys planned by DAE	Total achieved DAE	Achieved (%)
2019	Aman rice	2,972	1,300	4,272	95
2019-20	Wheat	2,712	1,449	4,161	92
2019-20	Boro rice	2,947	1,509	4,456	99
Total		*8,631*	*4,258*	*12,889*	*95%*

On 29 April 2020, a virtual coordination zoom meeting held on Big-Data CSA with DAE. Assistant Directors (ADs) and Deputy Directors (DDs) of DAE form Jashore, Faridpur, Rajshahi, Dinajpur and Rangpur participated in that meeting. They were trained on these crop cut and management survey monitoring tools. They were also provided with an overview of the analytical results and approaches to developing customized advisories that can be deployed by the field level extension agents. Due to the COVID-i9 pandemic, the CSISA team also developed short training videos on ODK crop cut data entry and provided them to DAE through google link and messenger. In addition, COVID-19 safety instructions were provided to DAE so that they can follow them during crop cut and data entry.

Photo 12: Orientation on crop cut and production practice survey using internet enabled tablets in Rajshahi region (Photo: Maruf Hossen Shanto)

In terms of analytics, the quality of the incoming data was checked with a web-based dashboard and for some data points rechecked with the extension agents to reduce errors. After the completion of the surveys, all data were exported from CSISA server for additional cleaning. Box and Whisker methods and Robust Mahalanobis Distance method were used for detecting outliers. After detecting the outliers, the data were replaced with a method called 'Multiple imputations by chained equations (MICE)'. The cleaned primary data sets are then merged with secondary datasets for enhanced analysis, such as soil data, weather/environmental data and remote sensing data. Greenhouse gas emissions are also being simulated calculated using the Mitigation Options Tool (CCAFS-MOT).The ultimate goal of these efforts is to understand options for how farmers can maximum productivity and profitability while lowering greenhouse gas emissions to generate advisories for best practices in agricultural management that can be deployed by DAE as part of their regular extension advising.

Innovative modeling and ex-ante research on integrated farm and household nutrition systems through collaboration with the Nutrition Innovation Lab

Background: Many large-scale policy and development initiatives, including those funded by USAID, DFID and the EC, as well as the Government of Bangladesh, invest in agricultural interventions based on assumed linkages between increased agricultural productivity and improved nutrition of households. But different farm and livelihood system types can vary considerably in their capability to provide food-derived energy, vitamins, and nutrients to households and there is a critical need of generating knowledge to guide nutritionally-sensitive agricultural development investments. Towards this end, an innovative 'AgSyst2N: Linking Agricultural Systems to Nutrition" decision support model is being developed as a part of the CSISA project that is designed to assist in assessing how agricultural interventions lead to nutritional outcomes i.e. supply of sufficient energy, protein, zinc, iron, and vitamin A to men, women, and children within households and as a function of differing farm types.

Activities: AgSyst2N: Linking Agricultural Systems to Nutrition' is being developed through a partnership with the Feed the Future Innovation Lab (Friedman School of Nutrition Science and Policy) for Nutrition (Team: Dr. Patrick Webb and Dr. Robin Shrestha, Dr. Shibani Ghosh, Dr. Katherine Heneveld), Tufts University. This collaboration lays in the intersection between nutrition and agronomic and food security perspectives to understand, assess and ultimately improve the links between agricultural systems and nutrition in smallholders in Southern Bangladesh. This research builds on an existing dataset from a comprehensive household survey by the Innovation Lab for Nutrition (INL) of 3,000 farm households (with detailed food production and consumption data from male member/household heads, mother/female caregivers (15-49 years and children under 5 years) across Dhaka, Barisal, and Khulna divisions in Bangladesh covering the 102 unions of the FtF zone baseline survey.

Based on the BAHRN survey data, the CSISA and ILN team conducted research aimed at the identification of farming and livelihood system types based in the study area using a multivariate analysis of major structural characteristics (owned and common land available for farming, crops produced as well as the fishpond size and livestock herd) and functional characteristics (agricultural production for self-consumption and for markets, off farm work, migration and remittances). This work is now completed. The figures below show a schematic representation of four of the six main farm types identified in the region based on this analytical work. These farm types will form the basis of the assessment of the differentiated impacts of simulated interventions that will be identified in consultation with the USAID Mission in Bangladesh, with emphasis on examining the implications of different interventions on nutrition and food security. As such, this work is of considerable importance for targeting and tailoring alternative development interventions for greater efficiency and social equity.

The second step in assessing the contribution of current agronomic practices and alternative agricultural development interventions is to depict the nutritional profile in each household in terms of their ability to produce or buy sufficient nutritious food a healthy life. For this, the CSISA and ILN team are currently developing a model to quantify the net production and purchases of eleven macro and micronutrients (energy, protein, zinc, iron, and vitamins). This mode will be matched with farm household family nutritional requirements in terms of age and gender composition of farm household members.

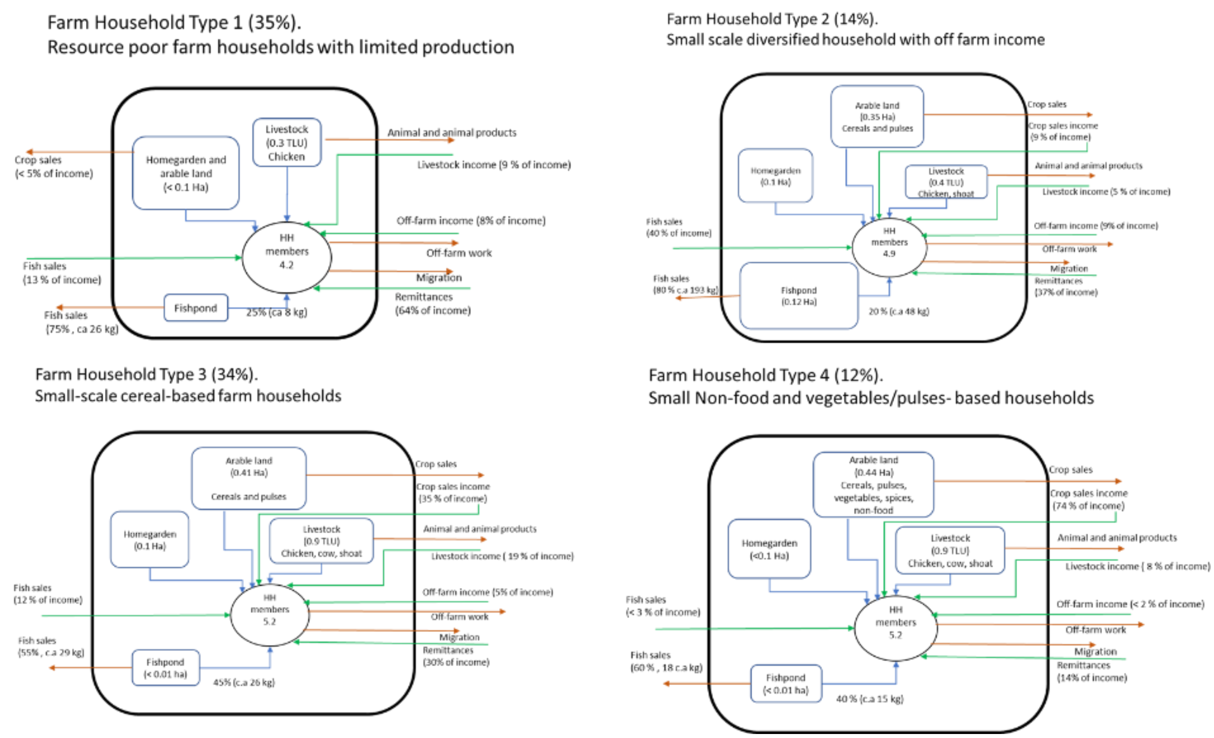


Figure 24. Schematic representation of four distinct farming systems in the FtF zone of Southern Bangladesh. These farm types will form the basis of the assessment of the differentiated impacts of simulated interventions that will be identified in consultation with the USAID Mission in Bangladesh, with emphasis on examining the implications of different interventions on nutrition and food security. As such, this work is of considerable importance for targeting and tailoring alternative development interventions for greater efficiency and social equity.

Preliminary analyses of nutrient production and demand in identified farm household types are in progress and expected to be ready by the end of November 2020. Some methodological challenges such as the need to harmonize, on a temporal scale, the production and consumption patterns of farm households (i.e. a seven-day recall on consumed food items vs a yearly production, consumption and marketing of main crop, livestock and fish products) are being worked through. We are currently exploring the consistency of the nutrient consumption pattern and the existence of nutrient consumption types that can generalize the on a temporal scale to mitigate the issue. The nutrient composition of some crop, livestock and fish products as well as processed purchased food items also need to be added to our database and work is on progress in this regard.

The third and final step is to assess, the potential effect of different interventions, for different farm household types, on their food and nutritional security by using different coefficients in the production-consumption balance model. Schematic representation of the model is given below. The expected scenarios are for example, what would be the effect of implementing a cropping system with higher yield on the availability of key nutrients (food based energy, protein, macro and micronutrients) for the household? What would be the potential effect of diversifying the crop, livestock and fish production on the nutritional and food security of different farm household? Would any of these SI alternatives have the same effect across unions, districts and types of farm households? Can we identify types of farm household, in specific settings, to better target interventions for improved food and nutritional security? These and other scenario analyses would certainly contribute for better efficiency of development interventions for FtF in Southern Bangladesh. The CSISA and INL to have a model ready for such *ex-ante* assessment at the end of 2020 or early 2021. The COVID-19 scenario did not affect the progress of this work as it was being done based on an existing dataset and following remote work modalities.

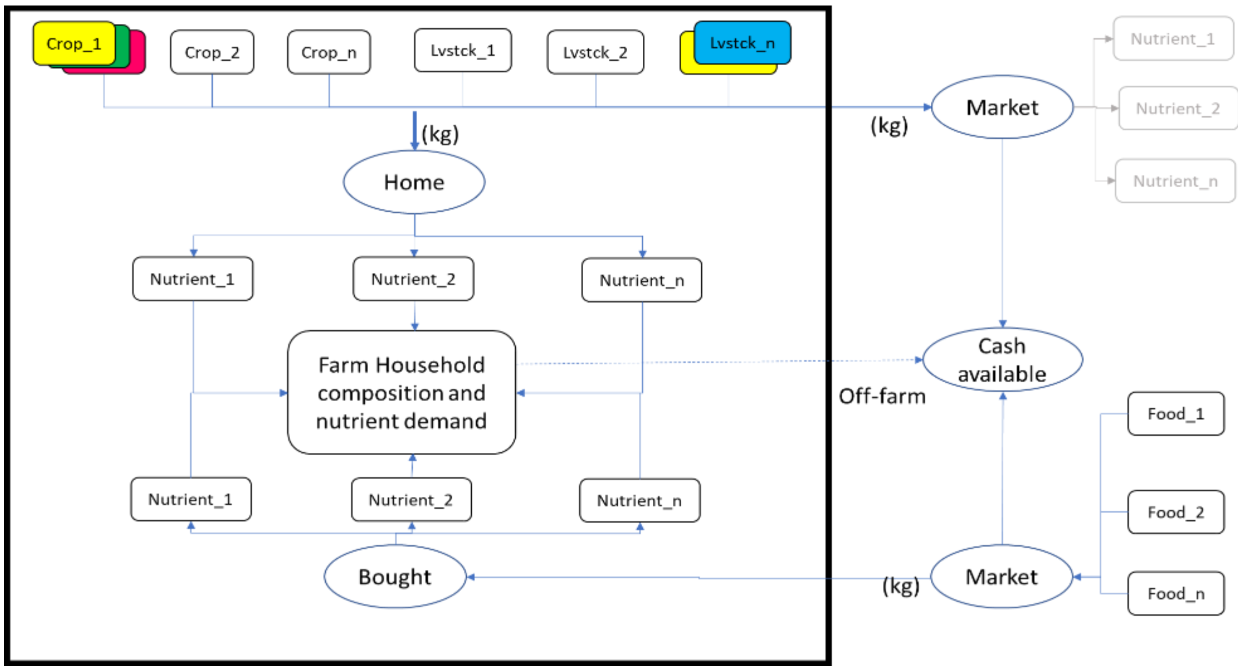


Figure 25. Schematic representation of the model to assess the role of different agricultural activities in the nutrition and food security of each farm household in Southern Bangladesh and the assessment of scenarios related to SI intervention.

C. ACHIEVING IMPACT AT SCALE

C1. Growing the input and service economy for sustainable intensification technologies

C1.1 Integrated weed management to facilitate sustainable intensification transitions in rice

Since 2016, CISA has played a catalytic role to develop and raise awareness among Bangladeshi farmers regarding the multiple benefits of adopting integrated weed management (IWM). Some of the principles of IWM include:

1. Carefully monitor your fields, identify the problems, select appropriate control measures, and take action to minimize the economic impact of weeds on the crop
2. Work to prevent weeds from establishing or multiplying, with emphasis on controlling the production and spread of weed seeds or weed parts that reproduce vegetative
3. Consider and integrate cultural, mechanical/physical, biological (including use of weed competitive cultivars) and chemical control options as needed
4. Where possible, reduce and minimize the use of herbicides, particularly highly toxic ones

The project in collaboration with the Bangladesh Rice Research Institute (BRRI) identified the most effective and profitable options for transplanted rice through on-farm research in 2016/17 and 2017 as the careful and safe application of relatively less toxic Mefenacet + Bensulfuron methyl as pre-emergence herbicide followed by either Bispyribac-sodium or Penoxsulam as post-emergence herbicide followed by one hand weeding. Building on these research results, the Project has worked to develop awareness and market demands for these products, in close partnership with the private sector.

CSISA pioneers public-private sector partnerships in appropriate and safer weed control products

Photo 13: A national level consultation workshop was organized on 10 October 2020 in Dhaka, Bangladesh involving national agricultural research and extension systems (NARES) partners, NGOs, herbicide companies, input dealers and private entrepreneurs. (Photo by Sharif Ahmed)

Partnering with BRRI, the CSISA project identified relatively safe, efficient and profitable integrated weed management (IWM) options to control weeds in transplanted rice through on-farm research during three seasons (the 2016 *aman* season, and the *boro* season of 2016-17 and the *aman* 2017 season). Resulting IWM options consist of application of Mefenacet + Bensulfuron methyl as a pre-emergence herbicide followed by either Bispyribac-sodium or Penoxsulam as post-emergence herbicide followed by one hand weeding to reduce weed propagules and knock-back weeds before they develop strong root systems or enter their reproductive phases. Application of these options gave similar yields but reduced weed management costs by USD 44-94 ha^{-1} and increased farmers' net profits by USD 54-77 ha^{-1} compared to conventional weed management practices. These results are important because farmers' current weed management practices tend to be labor intensive and costly, involving either 2-3 manual weeding or use of pre-emergent application of pretilachlor (a relatively more toxic and also not registered by US EPA and not approved by USAID in the PERSUAP for Bangladesh), followed by two hand weeding. Additionally, based on data garnered through surveys of farmers, key knowledge gaps in integrated weed management have been identified by CSISA. These include:

1. Lack of knowledge on the selection of right herbicides,
2. Limited knowledge of when or how to apply herbicides,
3. Low knowledge of safety precautions for appropriate herbicide application.

During the reporting period, the Project has worked to encourage the market commercialization and scaling-out comparatively safe and cost-effective IWM options and practices that have been identified in survey and field experimental data.

To respond to this goal, a national level consultation workshop was organized on 10 October 2019 in Dhaka, Bangladesh. National agricultural research and extension systems (NARES) partners, NGOs, herbicide companies, input dealers and private entrepreneurs participated in the workshop, which focused on presenting CSISA's research results and coordinating participants to identify and build business models that can assist in expanded use of appropriate weed control predicts (Photo 13).

The major outcomes of this workshop include:

1. Comprehensive communication and dissemination of results from CSISA and BRRI's collaborative research on IWM to key stakeholders,
2. A database of herbicide product types and sales volumes, and in some case prices in the FtF zone, were gleamed from interactions with the private sector during the workshop ,
3. The challenges and opportunities that companies see in investments to commercialize safer and less-toxic herbicides were identified, and
4. Strong opportunities for companies to collaborate with CSISA were identified following this partnership-building workshop.

As follow up of this workshop, the Project has entered into one-to-one dialogues with herbicide companies on possible collaboration for commercialization and on-farm demonstration of safe and less-toxic herbicides particularly Mefenacet + Bensulfuron methyl, Bispyribac-sodium and Penoxsulam. As a result of these discussions, Auto Crop Care Limited (ACCL) has partnered with CSISA to conduct jointly 200 on-farm demonstrations of these new products in the project working areas in each of winter *boro* season 2019-20 and summer *aman* season 2020 (Photo 14). These agreements came along side co-supporting financially on farmer field days to increase awareness of, and sales for, demonstrated products. ACCL also donated all required post-emergence herbicides for all on-farm IWM demonstrations in winter *boro* rice season 2019-20 and summer *aman* season 2020. They also agreed to organize field days jointly with the project.

Photo 14: CSISA staff are in meeting with ACCL personnel of Dinajpur District to plan large-scale product demonstrations (Photo by Sunil Roy)

Photo 15: Farmers' training on IWM jointly organized by CSISA and ACCL, boro season 2019-20, Dinajpur (Photo by Kanailal Roy)

During the first half of the reporting period, and before COVID-19 restrictions were imposed, 200 on-farm demonstrations were successfully completed in CSISA's working areas – 100 farmers' fields in Jashore region (25 in Jashore district, 20 in Chuadanga district, 15 in Meherpur district, 40 in Jhenaidah district), 50 farmers' fields in Faridpur region (41 in Rajbari district, 9 in Faridpur district) and 50 farmers' fields in Dinajpur region (20 in Dinajpur district, 20 in Nilphamari district and 10 in Thakurgaon district) for *boro* season 2019-20 and 200 on-farm demonstration were established in *aman* season 2020. In these demonstrations, when and how to apply the herbicides in the transplanted rice fields and the efficacy of the two relatively safe, the most efficient and profitable IWM options were demonstrated and evaluated for the benefit of their uses in terms of grain yield and weed management costs compared with farmers' current weed management practices.

The two IWM options were (i) application of Mefenacet + Bensulfuron methyl as pre-emergence herbicide followed by Bispyribac-sodium as post-emergence herbicide followed by one hand weeding (IWM option 1), and (ii) application of Mefenacet + Bensulfuron methyl as pre-emergence herbicide followed by Penoxsulam as post-emergence herbicide followed by one hand weeding (IWM option 2). Farmers' current weed management practices were either 2-3 manual weeding or use of pre-emergence application of pretilachlor followed by two hand weeding. Each IWM option was demonstrated and evaluated on approximately 50% of each farmers' field in each region along with two micro-plots – one maintained weed free by hand weeding and another weedy with no weed control measure throughout the season.

Table 16: Grain yield and weed control costs of transplanted rice as influenced by weed management (IWM) options in on-farm demonstrations in Jashore, Faridpur and Dinajpur regions, boro season 2019-20.

Weed management option	Grain yield (Mt ha^{-1})			Weed management costs (USD ha^{-1})		
	Jashore	Faridpur	Dinajpur	Jashore	Faridpur	Dinajpur
IWM option 1	6.5 a	7.7 a	6.2 a	69 b	59 b	78 b
IWM option 2:	6.7 a	7.8 a	6.3 a	73 b	67 b	90 b
Farmers' current weed mgt.	6.5 a	7.5 a	6.1 a	125 a	172 a	235 a
Weed free	6.6 a	7.8 a	6.4 a	N/A	N/A	N/A
Weedy	4.4 b	5.3 b	4.5 b	N/A	N/A	N/A

Note: The letters denote statistical differences at the 95% level using Tukey's HSD test.

In the winter *boro* season of 2019-20, rice grain yields were similar in IWM option 1, IWM option 2, and farmers' practice and weed free treatments in all three regions. However, these treatment differed significantly in weed control costs, with US$ 52-56 ha^{-1}, USD 105-113 ha^{-1}, and USD 145-157 ha^{-1} lower in IWM option 1 and 2 in comparison to farmer's current weed management practice in Jashore, Faridpur, and Dinajpur, respectively. Weed competition in weedy plots resulted in 30-33% yield loss as compared to weed free plots. The rice crop in 200 on-farm IWM demonstrations in current *aman* season 2020 will be harvested in November 2020 and results will be reported in next report.

Despite challenges brought by COVID-19 restrictions in Bangladesh, the CSISA team have been continuing the dialogue with Auto Crop Care Limited (ACCL) and AIRN to engage them in making safe herbicide molecules and safety equipment available in local markets, printing and dissemination of IWM leaflets, and conducting IWM on-farm demonstrations in 2020-21 *boro* season and onward. The Project also plans to organize a national workshop involving BRRI, DAE, and private sector in mid-2021 to further sensitize the private sector and DAE for sustainable dissemination of safe herbicide molecule with proper safety guidelines and equipment and BRRI to continue research on IWM.

Raising awareness of integrated weed management options among farmers

During the reporting period, the CSISA project in partnership with DAE carried out the following activities to raise farmers' awareness on the use and benefits IWM:

- In January to March 2020, the project provided one day training on IWM for rice to 106 farmers (16% women) in Faridpur and Rajbari districts and 30 farmers in Jheneidah district.
- CSISA facilitated activities by ACCL to establish on-farm demonstrations on IWM in 100 farmers' fields in Jashore district and in 50 farmers' fields in each of Faridpur and Dinajpur districts during each of *boro* (January 2020) and *aman* season (July-August 2020).
- In January of 2020, CSISA organized a meeting with input dealers and private sector entrepreneur (total 23 participants) in Rajbari district to facilitate increased availability of power sprayers, multiple boom nozzles and safe, less-toxic herbicides.

Since the outbreak of COVID-19 in March 2020 all subsequent trainings, meetings, field days planned for the remainder of the winter *boro* and summer *aman* season were suspended due to restricted movement and to maintain safety measurements

Achieving weed competition reduction win-wins: Results from collaborations with the Bangladesh Rice Research Institute to examine rice cultivar competitiveness with weeds

Use of weed-competitive rice cultivars is an attractive low-cost strategy of an overall IWM program to reduce herbicide use and it is also easy to disseminate to farmers. Often, however, one of the trade-offs associated with weed competitive cultivars is their lower yield. However, recently evidence suggest that dual goals of high yields and weed competitiveness can be achieved feasible In Bangladesh, there is limited of information on competitive ability of currently released high yielding varieties of rice. Therefore, CSISA in partnership with BRRI has been jointly conducting both on-station and on-farm research activities since November 2018 to identify high yielding as well as weed competitive rice varieties for transplanted condition in boro and aman season.

During the reporting period,11 popular rice varieties for the summer *aman* season 2019 and 14 popular rice varieties for the winter *boro* season 2019-20 were successfully tested for their ability to compete with weeds. In *aman* season 2019 the tested rice varieties were: BRRI Dhan 23 (V1), BRRI Dhan 34 (V2), BRRI Dhan 39 (V3), BRRI Dhan 49 (V4), BRRI Shan 52 (V5), BRRI Dhan 66 (V6), BRRI Dhan70 (V7), BRRI Dhan71 (V8), BRRI Dhan72 (V9), BRRI Dhan 80 (V10) and BRRI Hybrid Dhan6 (V11). Weed density and weed biomass data at different growth stages of rice and grain yields in weed free and weedy condition were collected for each variety. Weed and yield data from the summer *aman* season 2019 are presented below. BRRI Dhan 23 was found the most weed suppressive as well as high yielding at both on-station (Gazipur) and off-station (Kapasia) sites with yield reduction due to full-season weed competition was only 17% and 28% at on-station and on-farm sites, respectively.

Photo 16: Field view of an off-station experiment on screening rice cultivars for their yield and weed competitiveness during T. aman 2020 at Tok, Kapasia (Photo by Khairul Alam Bhuiyan)

Photo 17: Field view of on-station experiment on screening rice cultivars for their yield and weed competitiveness during T. aman 2020 at BRRI Farm, Gazipur (Photo by Khairul Alam Bhuiyan)

At the on-station research site, other varieties which were found weed competitive and high yielding were BRRI dhan39, and BRRI hybrid dhan6 with yield reduction due to weed competition was 24-28% followed by BRRI dhan 34 (PQR variety) with yield reduction 34% due to weed competition. The hybrid variety was the highest yielding under weed-free conditions among all varieties and found weed competitive also. In other varieties, yield reduction due to weeds ranged from 43 to 58% and these varieties were less weed competitive. BRRI dhan 71 was also one of the highest yielding variety with similar yield to hybrid variety (6.18 t/ha), but was not weed competitive with 55% reduction in yield due to weed competition. Aman-season 2020 will be harvested in November 2020 and data will be presented in the next report.

Table 17: Mean weed infestation in weedy plot and grain yields in weedy and weed free plot of different rice varieties in transplanted aman rice during the monsoon of 2019 at the BRRI research farm, Gazipur. DAT indicates 'days after transplanting'

Variety	Weed infestation at						Grain yield (t ha-1)		
	35 DAT		50 DAT		75 DAT				
	Weed no. m^{-2}	Weed wt. ($g\ m^{-2}$)	Weed no. m-2	Weed wt. (g m-2)	Weed no. m-2	Weed wt. (g m-2)	Un-weeded	Weed free	Yield difference ($t\ ha^{-1}$)
V1	26	70.16	21	44.25	66	31.69	4.38	5.28	0.90
V2	64	116.95	74	117.38	65	84.44	3.22	4.86	1.64
V3	49	102.33	47	104.70	48	72.38	4.25	5.61	1.36
V4	74	159.63	33	394.86	31	355.56	3.20	5.66	2.45
V5	54	186.38	77	166.57	85	189.45	2.39	5.28	2.89
V6	69	141.01	56	144.44	33	175.76	2.63	5.43	2.80
V7	97	136.18	73	413.03	87	139.44	2.63	5.42	2.79
V8	102	145.72	54	139.24	93	248.09	2.78	6.18	3.41
V9	86	157.14	73	458.19	84	181.69	3.22	5.76	2.53
V10	75	141.48	78	210.21	78	158.85	2.42	5.66	3.24
V11	60	128.67	41	142.19	59	92.74	4.45	6.18	1.73

Table 18. Weed infestation in weedy plots and grain yields in weedy and weed free plots of different rice varieties in the 2019 monsoon transplanted aman rice season in farmer's fields, Kapasia, Gazipur. DAT indicates 'days after transplanting'

Variety	Weed infestation at						Grain yield (t ha-1)		
	35 DAT		50 DAT		75 DAT				
	Weed no. m^{-2}	Weed wt. ($g\ m^{-2}$)	Weed no. m^{-2}	Weed wt. ($g\ m^{-2}$)	Weed no. m^{-2}	Weed wt. ($g\ m^{-2}$)	Un-weeded	Weed free	Yield difference ($t\ ha^{-1}$)
V_1	117	94.87	121	113.71	151	102.04	3.61	5.05	1.44
V_2	165	189.31	277	325.88	294	279.60	1.60	3.41	1.81
V_3	138	162.05	229	200.83	260	213.82	2.52	4.22	1.70
V_4	322	266.69	283	331.88	351	362.64	2.71	5.59	2.87
V_5	405	493.15	348	374.55	354	320.76	2.28	4.83	2.55
V_6	403	349.52	338	387.66	463	375.77	2.51	4.39	1.88
V_7	352	287.52	387	395.90	432	328.94	2.60	4.71	2.11
V_8	371	406.86	404	438.81	351	331.60	2.55	5.51	2.96
V_9	346	253.36	356	325.47	315	396.51	3.00	5.34	2.34
V_{10}	359	416.46	399	410.18	354	376.71	2.80	4.85	2.05

In the *boro* season of 2019-20, the same 14 rice varieties used in *boro* season 2018-19 were tested at both research farm at Gazipur and off-station in Kapasia. The tested rice varieties were BRRI Dhan 17 (V1), BRRI Dhan 28 (V2), BRRI Dhan 29 (V3), BRRI Dhan 45(V4), BRRI Dhan 50 (V5), BRRI Dhan 58 (V6), BRRI Dhan 67 (V7), BRRI Dhan 81 (V8), BRRI Dhan 84 (V9), BRRI Dhan 86 (V10), BRRI Hybrid Dhan 5 (V11), Jolok (V12), SL-8H (V13), and Mollica (V14). Among them 4 varieties are hybrid varieties (V11 – V14). Preliminary weed and yield data are presented below. BRRI Dhan 17 was found the most weed suppressive as well as high yielding at both on-station (Gazipur) and on-farm (Kapasia) sites with the lowest yield reductions of 29% (1.53 Mt ha^{-1}) and 33% (1.85 Mt ha^{-1}) at on-station and off-station sites, respectively due to full-season weed competition.

Weed infestation in BRRI Dhan 17 in terms weed number and weed dry matter was also the lowest at all sampling dates in both sites. In high yielding varieties such as BRRI Dhan 50, BRRI Dhan 84, BRRI Dhan 86, and BRRI hybrid dhan5, yield reduction due to weed competition ranged from of 38 – 41% in on-station site and 41 – 43% in on-farm site due to full-season weed competition. The hybrid variety 'Jolok' was found weed competitive and high yielding in on-station site as it maintained higher yield under weedy condition with yield reduction of 32%. Both on-station and off-station experiments with the same 11 rice varieties used in *aman* season 2019 were established in current *aman* season 2020. The crop will be harvested in November 2020 and the results will be reported in next report. This study will be continued in both on-station and off-station sites in 2021.

Table 19. Weed competition in weedy plots and grain yields in weedy and weed free plots of different rice varieties transplanted in winter *boro* rice season 2019-20 in on-station field, Gazipur. DAT indicates 'days after transplanting'.

Variety	Weed infestation at						Grain yield (Mt ha^{-1})		
	35 DAT		50 DAT		75 DAT				
	Weed no. m^{-2}	Weed wt. (g m^{-2})	Weed no. m^{-2}	Weed wt. (g m^{-2})	Weed no. m^{-2}	Weed wt. (g m^{-2})	Weedy	Weed free	Yield difference
V1	56	13.07	47	20.90	13	9.68	3.64	5.17	1.53
V2	46	21.43	54	32.33	64	15.31	3.67	6.56	2.89
V3	47	18.80	52	34.22	54	18.93	4.26	6.83	2.57
V4	43	20.25	56	22.81	51	17.88	3.69	6.33	2.64
V5	61	27.33	36	27.60	44	16.32	3.72	6.30	2.59
V6	50	20.97	38	30.31	50	20.04	3.13	6.08	2.95
V7	76	23.21	47	34.35	44	22.35	3.83	6.28	2.45
V8	44	14.04	51	29.32	40	19.06	2.50	6.52	4.01
V9	60	23.40	47	29.64	31	17.92	4.22	6.82	2.61
V10	36	18.37	47	27.38	54	18.56	3.78	7.30	3.52
V11	47	18.53	50	28.90	50	19.74	4.34	7.22	2.88
V12	53	19.61	42	30.44	44	19.89	4.43	6.52	2.09
V13	56	18.07	54	26.86	58	22.35	2.80	6.59	3.79
V14	49	18.80	49	22.93	51	21.83	3.77	6.49	2.72

Identifying weed diversity and composition in farmers' rice fields

During July - November 2019, CSISA scientists studied weed diversity and composition in 120 farmers' fields across Jashore and Faridpur Districts. The major objectives of this study were to determine the effect of environmental variables, cropping systems, and weed management practices on weed species composition and diversity, and to identify the most troublesome weeds that could be focused on in subsequent IWM research. Study fields were selected based on two major rice-based practices. These included weed control by using herbicide and without herbicide. Using a structured questionnaire, farmers of the studied fields were surveyed during November 2019.

During the survey, a poster with the most common weed species in South Asia found in rice fields was shown to farmers so that they can identify the troublesome weeds (usually not controlled by the herbicide) in their rice field. In this study, the weed diversity was higher in the Jashore site compared to the Faridpur site. Between the cropping systems, weeds in the rice-wheat-Jute system were more diversified than the rice-rice system, and between the weed management options, managing weeds by using herbicide were less diversified than the without herbicide.

From the survey, it was found that the use of herbicide in managing rice weeds is increasing and farmers mostly receive (more than 95%) the herbicide related information from the local inputs dealers. Farmers usually don't use any safety protocols during the application and the common herbicide application method is broadcast granular herbicides, mixing with urea fertilizer (>95%) after 3-15 days of rice seedling transplanting.

This presents opportunities for CSISA to intervene by training agricultural input dealers, lead farmers, and DAE on safety procedures that can be passed onto farmers. Regarding herbicides, farmers responded that herbicide reduce management cost but a few weeds usually not controlled by the herbicide application and the major five troublesome weeds (not controlled by the herbicide) in both sites were *Cynodon dactylon, Paspalum dishticum, Cyperus rotundus, Echinochloa crusgalli, and Scripus maritimus*.

Photo 18: Farmers' survey to identify the current weed management gap in rice. During the survey, a farmer in Jhenaidah showing the dominant and most problematic weed species in his field. (Photo credit Md. Shariful Islam)

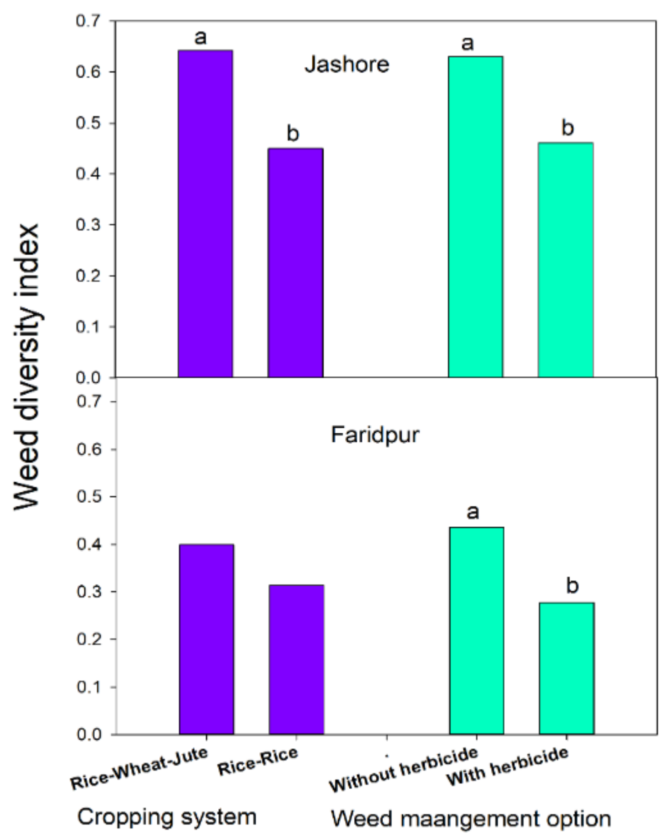


Figure 26 : Weed diversity index (Shanon diversity H´) as influenced by the cropping system and weed management option in Jashore and Faridpur sites. The Shannon diversity index value (H´) was calculated for each farmer's field as follows: H´= - Σ [pi ln(pi)], where Pi is the proportion of total individuals in the ith species in the sampling quadrat. The different letters above the bars is statistically different according to Tukey's HSD test at alpha = 0.05.

C1.2 Accelerating the emergence of mechanized solutions for sustainable intensification

C1.3 Commercial expansion of two-wheel tractor-based machinery and associated service provision models for reapers and seeders

In its first two years of its third Phase (2015 and 2016), the CSISA project worked intensively to established enabling market conditions to scale-out the use of multi-crop reapers and two-wheel tractor-based seeding equipment in northwestern Bangladesh. Activities were undertaken to complement the successful market initiatives undertaken in south Bangladesh's FtF zone through the USAID/Bangladesh Mission-funded CSISA-Mechanization and Irrigation initiative. However, activities in the Dinajpur Rangpur division had to be cancelled in 2017/18 due to budget delays and shortfalls. This resulted in the decision to cancel joint venture agreement (JVA) contracts with several private sector partners and a leading micro-finance institution.

Since this time budgetary flow to CSISA has remained uncertain, with disbursements often coming late. This has slowed project progress in some areas, including mechanization. In the third phase of CSISA in Bangladesh, clear funding flow is required as the project works strategically with private sector partners through joint venture and business agreements to expand the commercial footprint of planting and harvesting machinery. However, without certainty on fund flow, it is risky – both from the perspective of the project and from the private sector – to invest in large-scale commercialization activities. As such, mechanization activities in Rangpur division have still not been fully resumed. Staff involved in CSISA Phase III nonetheless cooperate and jointly implement the USAID Bangladesh Mission funded CSISA Manufacturing and Extension Activity (CSISA-MEA), which began in October of 2019, and is described briefly below.

CSISA III's synergistic support to the expanding CSISA Manufacturing and Extension Activity (CSISA-MEA)

Building on the successes of the CSISA-Mechanization and Irrigation (CSISA-MI) project, which emerged from the set of USAID/Washington core investments in CSISA, the Feed the Future Bangladesh Cereal Systems Initiative in South Asia Mechanization Extension Activity (CSISA MEA) began on 1st October 2019. It has three main objectives, including:

The project, after some modifications during the year now has three main intervention areas:

1. Build the capacity of the agricultural machinery manufacturing sector to produce high quality, competitively priced agricultural machinery and spare parts by providing manufacturing skills training, technical advice on manufacturing processes and machinery systems and improved access to finance.
2. Support agricultural machinery marketing companies expand new agricultural machinery technology marketing into southern Bangladesh and Cox's Bazar, improve after sales services to include training for machine operators and mechanics and spare parts supply systems. Support banks to develop improved systems for the financing of agricultural machinery purchases
3. Support firms in the agricultural machinery, production and food industry provide machinery service providers (LSPs) access to a wider range of labor saving machinery than currently available and to other services such as input supply and crop marketing services. This will allow LSPs to sell farmers

the services they need to plant through to marketing. Particular emphasis will be given to developing new or existing agricultural service provision businesses managed by women and youth

Through activities designed to meet these objectives, the activity will aim to address a number of challenges faced by the light engineering sector involved in the manufacture of agricultural machines and spare parts. These challenges were identified by a study commission by the project from the Bangladeshi company, Inspira. These include poor manufacturing processes, use of old and inefficient manufacturing equipment, limited supply of good quality materials, limited access to appropriate financial services and low levels of workforce skills.

Before the covid-19 crisis began CSISA-MEA conducted machinery demonstrations, LSP training and service provider coordination events. In the Rohingya crisis zone, CSISA-MEA also provided training to FAO staff in vegetable production and conducted vegetable and fodder crop production demonstrations. Overall from the two areas these activities resulted in resulted in 43,000 farmers (22% women) gaining access to new labor and cost saving machinery technology through machinery services provided by 1,153 local service provider entrepreneurs with 1,186 machines (63 Axial Flow Pumps, 38 mini combine harvesters, 982 Power Tiller Operated Seeders, and 97reapers). In the reporting period, dealers sold 85 different agro-machinery worth $279,000. CSISA-MEA provided training in machinery use and maintenance to 907 farmers, LSPs and mechanics (25% women, 19% youth) project.

Photo 19: CSISA-MEA distributed personal protective equipment to agricultural machinery manufacturers and light engineering workshops during the onset of the COVID-19 pandemic. (Photo by Mustafa Kamrul Hasan)

After the arrival of the COVID-19 pandemic in March of 2020, staff were confined to their homes and were unable to conduct field activities and meet partner organizations. All communication was conducted by telephone and Zoom meetings. Despite these restrictions, the project was able to complete the following:

- Telephone and on-line meetings provided support to farmers, dealers, mechanics and machinery service providers. For instance in Cox's Bazar, 379 farmers received technical support through 1,354 phone calls.
- Following publication of a request for expressions of interest, eight lead firms were selected for negotiation of agreements with the project to support Objective 1. These agreements will support these firms promote the use of new machinery technology such as mini combine harvesters, rice transplanters and jute fiber extractors. Agreements have also been signed with a bank and a non-bank financial institution to provide loans to small enterprises and machinery service providers.
- CSISA-MEA completed collection of basic data on the products manufactured and size of 443 light engineering micro, small and medium enterprises in Bogura district, Khulna division and Dhaka Division (Faridpur, Rajbari and Gopalganj districts). From this, 97 companies were selected as

- potential partners. From these, following publication of an expression of interest request, 53 MSMEs with a 1,624 workforce staff were selected as project partners in Objective 1 and 2.
- In partnership with three training service providers, a training program has been developed supporting Objective 1 and 2. This included identification of small and medium-scale farm machinery manufacturing enterprise training needs and development of training content, curriculum, lesson plans and training materials. Special curricula have been developed for metal workers (welding, lathing, bending, cutting, drilling and painting skills), foundry workers and management skills form managers.
- The three training service providers will also be supported to give on-line training and for this equipment is being purchased and training videos prepared.
- A telephone survey to determine the number of service providers owning smart phones and a baseline survey of small and medium scale manufacturing enterprise workers current skill levels was completed.

Photo 20: CSISA-MEA played a pivotal role in assisting farming communities in the Rohingya crisis impacted area on Cox's Bazar in USAID's Zone of Resilience by linking them to combine harvest service providers who aided in harvesting their *boro* winter rice paddy during lockdowns that reduced the availability of agricultural labor.

C2. Managing risk and increasing resilience by coping with climate extremes

C2.1 Coping with climate extremes in rice-wheat cropping systems

C2.2 Early wheat for combating heat stress in Bangladesh

Resilience-enhancing early wheat sowing in the last Rabi season

Wheat consumption in Bangladesh is increasing by around 10% per year. However, the country produces only about a fifth of the amount it consumes, and there is little scope to increase the area under wheat due to the decreasing area of arable land and competition with other high-value crops. Except for costly imports, Bangladesh's main option to increase national wheat availability is to boost yield; but Bangladeshi winters are warm and brief.

As a temperature sensitive crop, such warmth at the end of the season – which scientists refer to as terminal heat stress – causes reduced grain filling in wheat and lower yields. Recent research has found that for each day sown late, from, 15 -22 November seeding in Jashore (south western Bangladesh), yield reduces by around 32 kg/ha/day. In Northern Bangladesh in the north of the county (in Dinajpur region) yield loss is about 22 kg/ha/day. This yield loss is due to high temperature at grain filling stage that reduces grain weight and number/spike due to pollen sterility at temperature above 32° Cat flowering. Late sown crops also often encounter severe storms during February to early March resulting lodging and reduced grain weight. Late seeding also increases the incidence and severity of major diseases, with evidence of increased infection of leaf blight, leaf rust, and wheat blast. This workstream responds to these issues and aims to increase farmers' awareness of the importance of timely sowing to overcome climatic stress and increase resilience in wheat.

The results from previous focus groups conducted by the Project in 2016 with 300 farmers and extension personal in Dinajpur, Jashore, Faridpur and Bhola districts revealed that excessive soil moisture that prevents tillage and seeding around November 15th is the number one cause of late wheat seeding. This is followed by farmers' knowledge gaps on the benefits of early seeding, use of long duration rice varieties grown in before wheat, and the long turn-around time between rice harvest and wheat seeding. The project raised awareness of the farmers in 2019-20 wheat growing season by organizing implementation of the following activities:

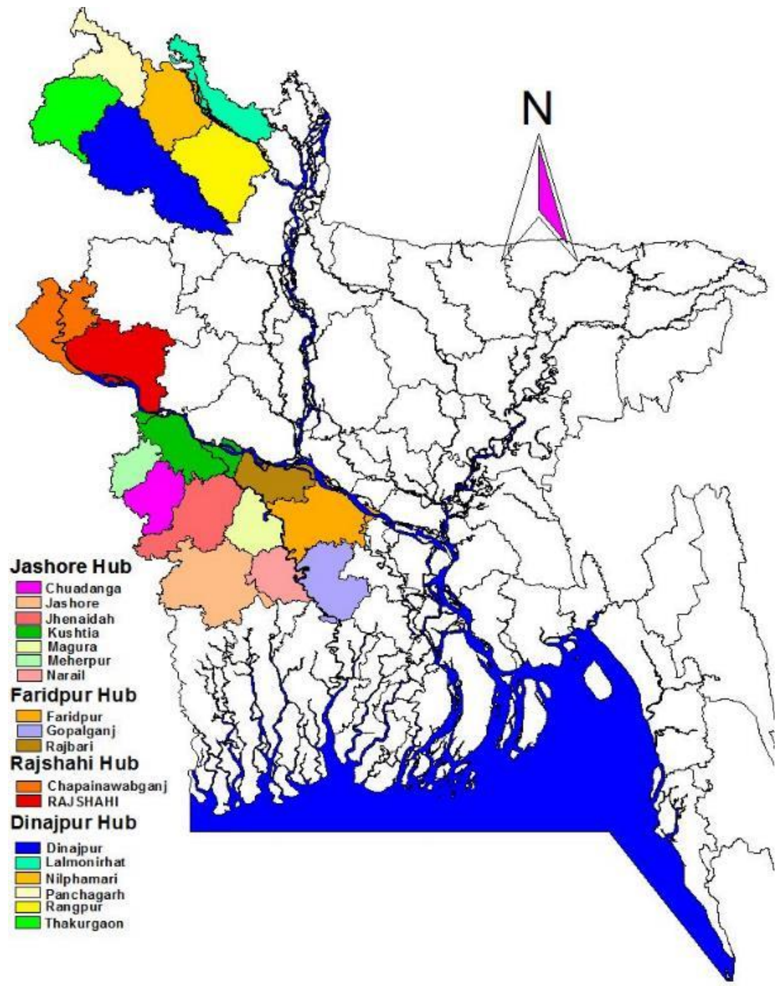


Figure 27: Districts in Bangladesh in which CSISA engaged farmers in video shows by AAS on the benefits of early wheat seeding.

- Five linkage meetings organized in November 2019 with farmers, machinery service providers, input dealers, DAE and Bangladesh Agricultural Development Corporation officials, and encourage farmers to grow short duration *aman* rice varieties before wheat, harvest rice by mechanical reaper at 80% maturity, and seed wheat by mechanical seed drill.
- A CSISA video on early wheat seeding was shown 708 times from October to November 2019 to 87,084 farmers (81% male, 19% female) of whom 40,356 were registered with signature for attendance at shows conducted in collaboration with the Project's NGO partner Agriculture Advisory Service (AAS). Many of these shows were broadcast in the evening at marketplaces to maximize visibility.

- From November to December of 2019, the project distributed 82,275 leaflets on the benefits of early wheat seeding during video shows and other CSISA events including meetings, trainings, and workshops.
- Awareness was also raised by conducting famers' rallies, hanging 200 banners, 250 festoons, and placing one billboard in collaboration with DAE that were cumulatively seen my thousands of farmers and related organizations.

Most of the CSISA's activities early wheat seeding were not affected by COVID-19 as the government of declared locked down from 26 March, 2020. By this time, most of the interventions and harvesting of wheat crop has been completed. Harvesting of some relay cropping trials and some post-harvest data however were not completed before lockdown began. Nonetheless, CSISA still managed to successfully facilitate harvesting by participating farmers and collecting post-harvest data while maintaining social distancing.

One of the agronomic methods that CSISA has worked to create awareness among farmers of is relay surface seeding of wheat into the standing rice crop before it is harvested. This saves time, and compared to the need to harvest, plough, and seed a conventional wheat crop. These actions could reduce the risk of terminal heat exposure in wheat at the send of the season. In some landscapes characterized by slightly lower than average elevation, farmers grow wheat by relay broadcast seeding it into rice before rice is harvested. This is typically is due to very high soil moisture in these fields, and the presence of late transplanted rice that has yet to be harvested during the recommended seeding time for wheat. But these areas can also be used to seed wheat early and gain the double advantage of avoiding heat stress. In these type of areas, CSISA conducted 17 relay trials with three seed rates and two new varieties.

Varieties and Seed rates	Yield (kg/ha)	Farmers' preference score (FPS)
BARI Gom 33	4094	4.45 a
BARI Gom 28	3896	2.55 b
150 kg/ha	3582 c	2.69 b
180 kg/ha	4112 b	3.91 a
210 kg/ha	4230 a	3.88 a

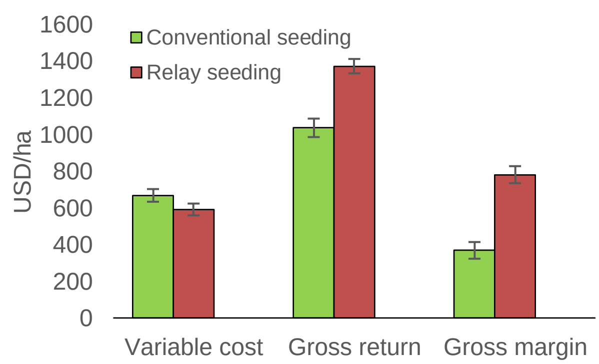


Figure 28. Yield and farmer's preference scores for varieties and seed rates (left) and comparative cost, return and gross margin of conventional and relay seeding

The performances of those relay crops were shown to 210 farmers and local DAE personnel in workshops, learning visits and farmer field days. Women and youth were invited in each of the 17 trials (170 people attended the field visits) before lockdown began on 26 March, 2020 for participatory evaluation of the varieties and seed rates in the experiments. Evaluation scoring was on a scale from 1-6, the latter indicating maximum preference. Whole plots were harvested for recording yield and yield components.

Though there was no significant yield difference between BARI Gom 33 (4,094 kg ha^{-1}) and BARI Gom 28 (3,896 kg ha^{-1}), the widely grown variety of the area, farmers preference was significantly higher for the 1st variety (4.45) than the 2nd (2.55). This higher preference was is likely due to the bold grain, long spike, blast resistance, and Zn enriched qualities of BARI Gom 33. The cost and return data indicating that variable cost in conventional seeding (667 USD ha^{-1}) was higher than relay seeding (USD ha^{-1}), but gross return was the opposite. From relay seeding the return was (1,371 USD ha^{-1}) in contrast to conventional seeding it (1,035 USD ha^{-1}). The gross margin in relay seeding was 780 USD ha^{-1} and in conventional it was 368 USD ha^{-1}.

After completion of scoring, a short focus group was organized with the participating farmers where questions asked to them were what the advantages and disadvantages of relay cropping are.

Table 20. Advantages of conventional vs. wheat relay seeding as described by farmers in focus group discussions.

Advantages	Disadvantages
1. Relay cropping allows timely seeding, and gives higher yield than the conventional late seeding 2. Relay cropping reduces production cost and increases profit 3. Relay cropping allows timely sowing of next crop, thereby increase system productivity. 4. Early seeding allows early harvest of the crop which escapes from pre-season rains and storms, lodging, diseases, in addition to heat stress.	**1.** Changes in weed flora require different weed management practices. **2.** More seeds are needed for wheat crop establishment **3.** The right amount of suitable moisture for seeding is sometimes challenging to identify

The other important management practices for early wheat seeding are ensure timely transplanting of short duration *aman* rice varieties in the summer. This allows earlier harvest of rice, and rapid establishment of wheat (which can be sown conventionally or with relay cropping). CSISA facilitated eight seed companies in partnership with DAE and BRRI to distribute starter kits totaling 2,668 kg of seeds of BRRI Dhan 75 and BRRI Dhan 87 – both relatively short duration and higher yielding varieties to 649 farmers of 35 farmers groups in Jashore, Faridpur and Dinajpur districts. At the time of writing, the crop is near mature and early wheat establishment is expected. Farmers are anticipated to keep or sell the rice variety seeds, thereby permitting an expansion of their cultivation, and earlier sowing of the subsequent wheat crop, in 2021.

To assess the impact of project interventions in this period, CSISA collected data from DAE records and also conducted a phone survey with farmers who had seen the early wheat seeding video in October through November of 2019. The data suggested that farmers whose awareness was raised by CSISA moved their wheat sowing date five days earlier in 2019/20 compared to in 2018/19. In terms of area and impact, this equates to an estimated 3,037 ha. Despite the efforts put forth this year, was still a shortfall of approximately 50% compared to the targeted area. However, the limitations to achieving the target appear to have not been related to CSISA's lack of efforts; rather, farmers faced added difficulties sowing wheat on time in the 2019-20 reporting year due to excessively late season rain and a delayed withdrawal of the monsoon, in addition to Cyclone Babul. Rain during 19 Oct to 19 December 2019 was 167.8 mm at Jashore, 83.2 mm at Faridpur and 40.6 mm at Dinajpur areas – this made it difficult for farmers to harvest rice and also to enter their fields to prepare for wheat as excessively moist soils do not permit tractors to operate effectively. In addition, wheat area of Faridpur region reduced 5.8% compared to the previous year due to low prices for wheat at the farmgate, and farmers' increasing interest in maize as compared to wheat cropping.

Detailed research on the response of new wheat varieties to different seeding dates

CSISA has collaborated with BWMRI over the last four years to evaluate the effect of late sowing on a suite of recently released wheat varieties. These varieties were shown in in optimum (Nov 15-30) as well as late (Dec 20-25) sown conditions. Experiments have been ongoing since 2017 in experiment was three locations within Bangladesh, including in the north (Dinajpur), center (Rajshahi) and south west (Jashore) of the country to evaluate the performance of these varieties under different dates of sowing. In the first two seasons, six new wheat varieties, including 'BARI Gom 26', 'BARI Gom 28', 'BARI Gom 30', 'BARI Gom 31', 'BARI Gom 32' and 'BARI Gom 33', while in third year (2019-20) seven wheat varieties (six + newly released 'WMRI Gom 1') were evaluated in five sowing dates starting from 25 November to 4 January with 10 days interval.

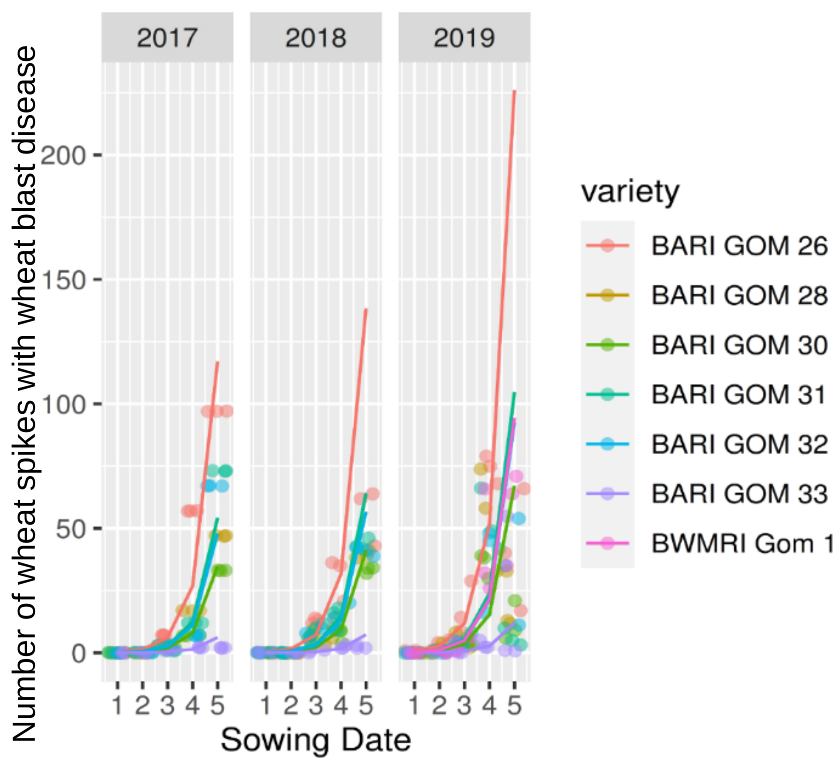


Figure 29: Number of wheat spikes observed with wheat blast infection across sites and in three years in five sowing dates starting from 25 November to 4 January at a 10 day interval.

Under the environmental condition of Dinajpur in northern Bangladesh, it was found that all the wheat varieties sown at on the earliest sowing date of (25 November) produced the maximum yield and escaped the wheat blast disease. Wheat yield of all varieties decreased when sown at late in all three locations in all three seasons of the experiments. The lowest yield was recorded on the January 4th seeding date, irrespective of years and locations. Although no disease incidence was recorded in northern Bangladesh in any of the five sowing dates in Rajshahi and Jashore, blast infection was found in the last three sowings, including 15 Dec., 25 Dec. and 04 January in first two seasons; while in third season wheat blast was recorded in all sowing conditions in Jashore and only in the last sowing date (on 4 January, 2020) in Rajshahi.

The yield of BARI Gom 30 was the highest in Dinajpur, irrespective of seeding dates. This was followed by BARI Gom 32 and BARI Gom 33. Conversely, in Rajshahi and Jashore, BARI Gom 33 performed better followed by BARI Gom 30, 'BARI Gom 31, and BARI Gom 2'. The highest wheat blast severity and incidence was recorded in BARI Gom 26 in both Rajshahi and Jashore locations and the lowest in BARI Gom 33. BARI Gom 30 and BARI Gom 32 have moderately blast tolerant traits and have a lower level of disease incidence and severity. After three years observation, the CSISA research tea, and BWMRI are provisionally able to concluded that there is remarkable variety location interaction with yield and disease incidence; as such, location- and sowing-date specific variety recommendations will be needed for optimal cropping. These results will be shared with the DAE in the next reporting period, and are anticipated to form the basis of new management recommendations that can be provided to farmers throughout Bangladesh.

2. Nepal – Achievements

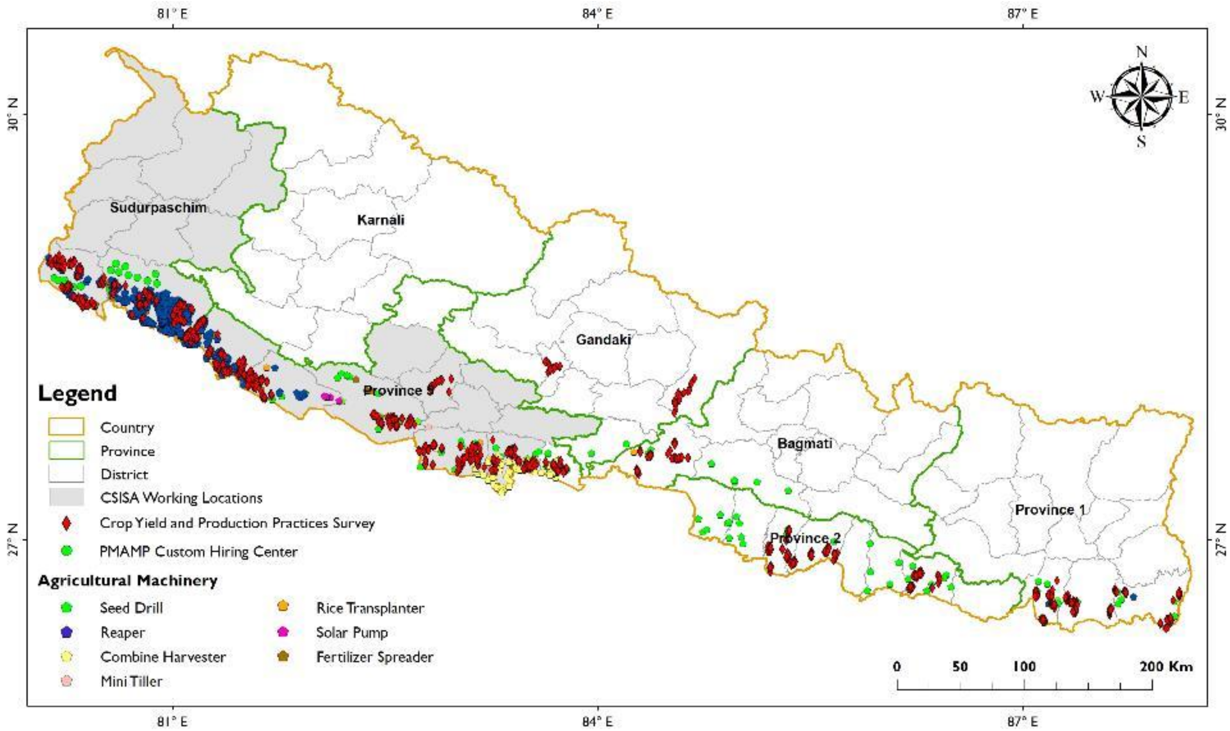


Figure 30: The CSISA project mainly works in five western Terai districts in Province 5 and the Sudurpashchim province. 9 Its secondary working area is the other Feed the Future zone districts. Note that some survey work may take place outside the CSISA working areas within the FtF Zone. Similarly, a spill-over effect of machinery service providers has been observed outside CSISA's working areas, which is partly attributable to CSISA's market and policy work in Nepal, in addition to other research for development projects.

A. INNOVATION TOWARD IMPACT

A1. Reducing risk to facilitate uptake of sustainable intensification practices

A1.1 Directly-sown rice to address labor and energy constraints to precision rice establishment

CSISA has been researching direct seed rice (DSR) as an agronomic overcome the to overcome labor shortages in Nepal that result from out-migration from rural areas. DSR is the method of rice directly sowing rice through the seed drills. In traditional rice cultivation, considerable human labor is required for nursery establishment and seedling uprooting, transplanting, weeding, harvesting and threshing. DSR conversely nearly eliminates unneeded labor use for rice establishment, freeing farmers' time and wallets

[9] Note: Nepal's Sudurpashchim province (where the project works) was previously called Province 7.

from the heavy expenditure needed for this crop. DSR also reduces water requirements in irrigated rice, and can be established with a four-wheel or two-wheel tractor attached seed drill. While there are some traditional methods of hand broadcasted DSR, which are common in some east Asian countries, in South Asia, DSR is mainly mechanized.

DSR has been prioritized in national program as well, and has been endorsed by the Nepal Agricultural Research Council (NARC). Adoption of DSR among smallholder farmers in Nepal and particularly around the FtF ZoI has however been sluggish. To identify the binding constraints associated with DSR adoption, CSISA conducted a farmer study in last quarter of 2019. While some of the preliminary results have been shared in the semi-annual report, in this annual report we provide the detailed results from the study. In addition to the DSR seed drills, this study also assessed eight other technologies in the sampling frame. The technologies that are considered in the sampling frame are shown below. Each of these technologies have been prioritized by CSISA and its partners. Moreover, by including multiple technologies in the assessment it helped us understand why some technologies are more rapidly adopted by farmers and not others are not. This information will help to improve technological up-scaling strategies in Nepal.

Photo 21: Nine mechanization technologies were investigated in this study. [A] Laser Land Leveler; [B] Four-wheel tractor seed-drills; [C] Two-wheel tractor seed drill; [D] Spreader; [E] Self-propelled reaper; [F] Two-wheel tractors attached reaper; [G] Four wheel tractor attached reaper; [H] Combine Harvester; and [I] Wheat residue collector. (Photo source: CSISA)

The stepwise conceptual and theoretical framework for this research consisted of four phases to understand reasons behind adoption and dis-adoption of the technologies. The first phase starts with farmers "exposure phase", followed by "progression phase". The third phase deals with "continuation phase" and finally ends with "utilization phase". In each phase, farmers were asked to provide the information related with access to information, utilization, and qualitative reasons if not adopted and/or dis-adopted. The figure below presents the overall status of the nine machines and stepwise framework. The result suggest that a significant information gap is limiting the adoption of seed drills and other machines in Nepal Terai. The information gap is primarily related with unawareness and unfamiliarity among most of the technologies except four-wheel tractors operated seed drills, where farmers are much more sensitized compared to other technologies. However, the dis-adoption of the four-wheel seed drills is also much higher. The details of four phases which can provide the answers why slow adoption and dis-adoption were observed are discussed in the next section.

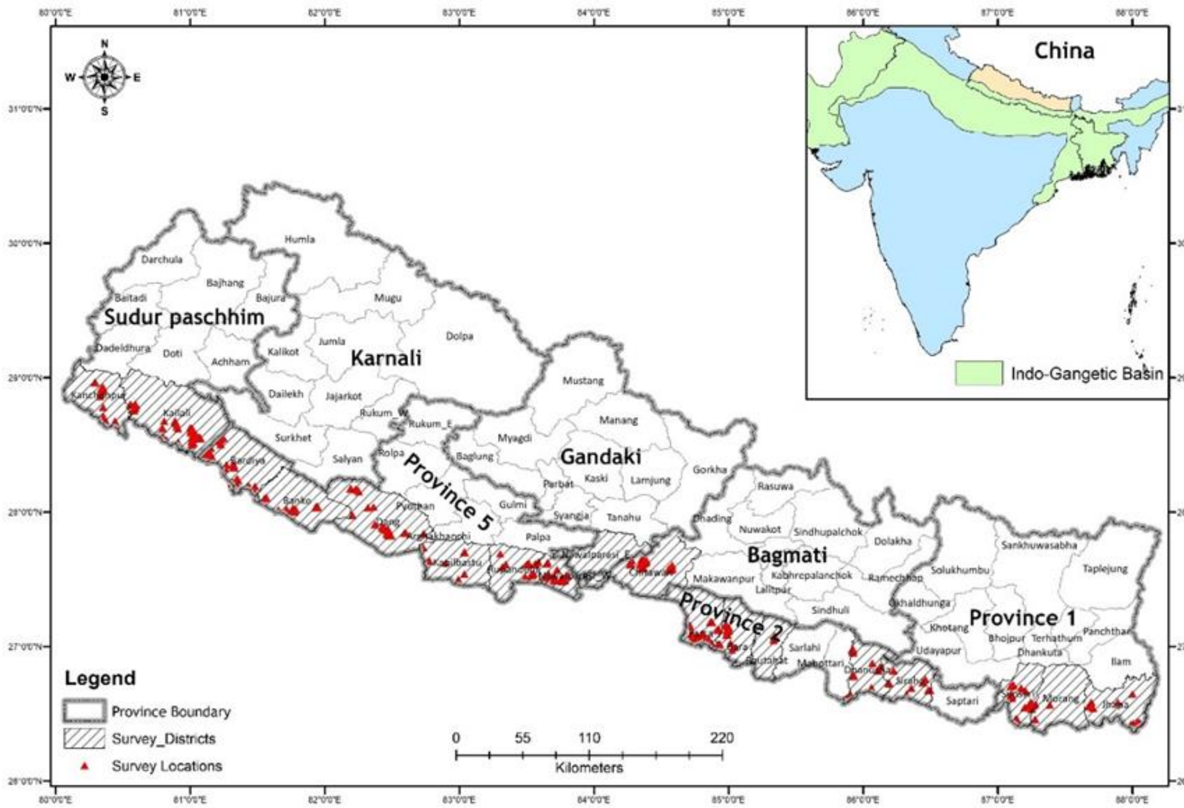


Figure 31: Map depicting the districts and location for the surveys conducted in Nepal's Terai.

Stagnation at the "exposure" phase

The exposure phase compares and quantifies farmers with insufficient information (i.e. 'Unaware' and 'Unfamiliar' stages) to those who have sufficient information of technological options (i.e. the remaining six stages) to understand if awareness is a core constraint to the adoption process. Lower exposure suggests that movement along the adoption pathway may potentially be constrained by information flows. And that means communities are not able to sufficiently obtain information, learn about potential innovations and evaluate the potential benefits of DSR and other technological options.

Overall, there appears to be substantial information gaps with five of the nine technologies evaluated in the surveys. These were observed to have a non-exposure rate above 85%. In only one case (four wheel tractor seed drills) did the majority of respondents have sufficient information to progress to evaluation. In six cases unawareness was the dominant component of the non-exposure rate, with the dominant reasons for unawareness being that the technology was not known to be in the community and this case was especially strong for 2 WT machines. The exception to this was the laser land leveler, where the primary reason for unawareness was a lack of technical support and information access. This indicates not a potential lack of motivation to seek information (where the dominant proportion is unfamiliarity), but that information systems are not assisting the closure of the exposure gap. This is consistent when household's exposure is considered across the nine technologies. 74% of households were either unaware or unfamiliar with at least six machines investigated, while 20% of households were unaware of unfamiliar with all nine. Only 2% were aware of all nine, and only 10% of households were aware of at least 3 technologies. This highlights that there are substantial information gaps that are constraining agricultural mechanization in the investigated communities.

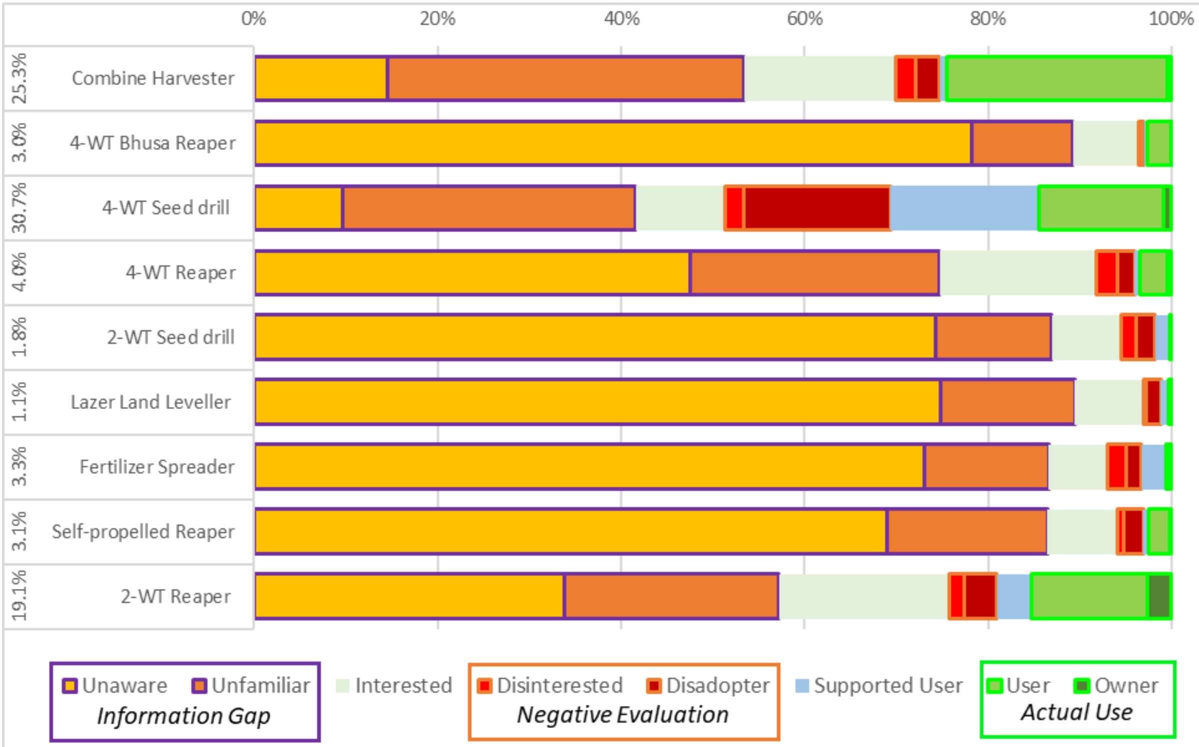


Figure 32: Full step wise framework analysis of the status of nine sustainable agricultural machines, listed in order of time since introduction.

Limitations in moving past the "progression" phase

The progression phase provides insights into what happens once exposure has occurred, and a household has enough information to make an evaluation. Results suggest the proportion of disinterest for all technologies was limited, suggesting that all machines have potential benefits to communities. The comparatively higher disinterest in the hand propelled fertilizer spreader was driven by a lack of relevance (53%), likely a reflection of preference by larger farmers to mechanize those tractor use. For the two-wheel seed drill, disinterest was driven primarily by unavailable services (37%) and a perceived lack of relevance (26%), potentially due to a preference for the four-wheel tractor seed drill for larger farmers, or hand seeding for smaller farmers. For other machines, the drivers of disinterest varied: cost and unavailability (each 33%) were drivers for the laser land leveler, perceived lack of relevance for the four-wheel seed drill (42%), and unavailable services for self-propelled reaper (33%) and bhusa reaper (33%). Cost was the main driver for both combine harvester (24%) and 2 WT reaper (24%). Counterintuitively, small land was not a driving reason for disinterest for any of the technologies, reaching a maximum of 10% for the four when tractor seed drill and only 6% for the combine harvester. The agronomic evaluations conducted by CSISA and of many of these technologies discussed in previous Annual Reports indicates that they have significant advantages; however, the fact that farmers perceive some of the technologies to lack relevance indicates that additional work must be done to raise awareness and technical understanding of these machineries.

Dis-adoption at the "continuation" phase

The continuation phase is crucial to understanding the success of a used innovation, because it reflects the rate in which a machine is successful at a particular point in time. A higher dis-adoption rate suggests issues in implementation, or in the case of aging innovations obsolescence as new innovations supersede existing technologies. Results of the nine investigated technologies suggest issues with at least six of the nine machines, which has a dis-adoption rate of at least 1 in 4. However, these tended to be concentrated in planting and fertilizing equipment and also harvesting equipment. Of all machines, only the self-propelled reaper conversely has a very substantial dis-adoption rate. As the laser land leveler, which is used periodically to level fields is not used season after season, disadoption was only considered if it had not been used at least once over the last four years, yet it still remained the machine with the highest dis-adoption rate. This was driven primarily by a lack of service providers (69%), and this was the primary driver of dis-adoption for the other planting equipment (four-wheel tractor seed drills used for DSR – 48%; two-wheel tractors seed drills - 50%, fertilizer spreader - 38%). The reason for substantial dis-adoption of the self-propeller reaper was balanced between a perceived yield penalty in use (33%) and a lack of service providers (33%). Reasons for disadoption for the remaining machines had no dominant reason, though land suitability such as waterlogged rice plots during the harvesting time was cited by farmers as a reason for combine harvest dis-adoption (34%).

"Utilization Phase"

The utilization phase is crucial to understand how an innovation is being used, sometimes not in the intended ways. For instance, a high proposition of supported users may indicate project driven adoption and the potential for steeper dis-adoption rates once incentives end. Likewise, ownership indicates a deeper commitment to the machine and indication of likely longer use, and the ability to provide services to other farmers. However, in most cases in smallholder agriculture the usual end in progression will be user, so this is the ideal category to be maximized in such analyses. Interestingly, this was not the case with harvesting equipment, which tended to have higher proportions of users, and never more than 20% subsidized use. This reflects both more limited subsidizes for harvest services and less engagement of projects in these machines. Despite this, ownership remained constrained across most technologies, with the exception of the fertilizer spreader (a low-cost technology of around US$ 35) and the two-wheel tractor attachable reaper (likely as this attachment is a cost-effective addition to an already purchased two-wheel tractor). The limited combine harvester ownership observed in the dataset despite high use in the community reflect Indian owned harvesters that cross the border during peak times, and that a substantial portion of hiring comes from migratory harvesting machine operators.

Overall the study concludes that subsidy used to incentivize for the purchase of agricultural machinery appears to be at the center of the theory of change to sustainably mechanize Nepal's agricultural systems including the seed drills used for DSR. However, this does not appear to have led to substantial purchase of machinery. The primary reason for non-use across all studied technologies is a lack of service providers, which was above 1 in 3 for six of the nine technologies, and nearly one in two for the laser land leveler and combine harvester. This highlights a need to address machine availability that is not occurring through the current subsidy program. The study suggested that increasing machinery service provision models such as custom hiring centers and individual service provisions in mechanization could close the availability and accessibility and other information gap that will help to increase the level of machines in Nepal, including for the seed drills used for DSR.

Raising awareness about direct sown rice (DSR)

As described in the research above, raising awareness is crucial for the wider dissemination of direct seeded rice (DSR). CSISA is raising awareness of the potential benefits of DSR in both spring and rainy season rice. In June of 2020, CSISA technically facilitated the USIAD/Nepal FtF Implementing Partner project KISAN II to conduct the demonstrations of DSR in Joshipur rural municipality and Bhajani municipality on 30 hectares. Due to the risk of spreading COVID-19 only 15 farmers representing different groups were however permitted into the field to observe the seeding machinery. In February of 2020, seven events of demonstration and evaluation of direct seeding rice (DSR) were completed in Bardiya in coordination with Rice Super Zone and Custom Hiring Centre on a land area of 4.1 hectares. In addition, five farmers implemented spring planted DSR on 6.5 ha by the use of seed drills and hand broadcasting methods in Bardiya district.

In addition to direct and in-person demonstrations, CSISA aired radio jingles describing the economic profitability of direct seeding rice(DSR) and the contact number of existing machinery service providers offering DSR services. This helped to reduce the movement of farmers seeking machine seed drill service providers, which aided in reducing the risk of COVID-19 infections to by reducing the need of service providers to visit multiple farmers to develop a client base. As a result of this work, DSR was established by farmers on 200 hectares. CSISA also conducted action research evaluations of DSR comparing drum seeders, two- and four-wheel tractor driven seeders, and manual broadcasting. Measurements could however not be taken due to COVID-19 national lock-downs Similarly, other field trials that were implemented by PMAMP coordinating with CSISA could not be properly harvested, representing an unfortunate loss of data in this year of the project.

Photo 22: Demonstration of direct seeded rice and USAID implementing partner collaboration: CSISA provided technical support to the Winrock led KISAN-II project to conduct the demonstrations in Joshipur rural municipality, Kailali district of Nepal, June 2020 (Photo credit: Pradip Chaudhary, CIMMYT)

In coordination with USAID/Nepal funded Nepal Seed and Fertilizer (NSAF) Project, the Seed Company GATE Nepal and Rice Super Zone, a Hardinath-1 hybrid rice seed production trial was also implemented during the reporting period. Results will be discussed in next semi-Annual Report. In January of 2020, at an agricultural fair organized by the Bardiya Chamber of commerce, 200 DSR fact sheets and 50 spring DSR production advice manuals were distributed farmers in Rajapur. Similarly, 375 fact sheets on DSR were distributed to other 11 farmers groups and two cooperatives in Banke and Bardiya districts including 147 male and 228 female farmers. This was accomplished through CSISA's collaboration with the Prime Minister Agricultural Modernization Project (PMAMP), which CSISA has supported since its inception, in their Rice Super Zone, Agriculture Knowledge Centers operated by the government of Nepal, local agriculture offices and agrovets. As a result of these activities, from October 2019 to March 2020, 13 farmers purchased rice seeding machinery with assistance from PMAMP and local agricultural offices in technical coordination with CSISA.

A.2.2 Aiding the Fight Against Fall Armyworm (FAW) in Nepal

Fall Armyworm Integrated Pest Management (IPM) Trainings


Photo 23: CSISA staff lead Fall Armyworm training participants in Makawanpur, Nepal. (Photo credit: Bandana Pradhan, CIMMYT)

Fall Armyworm has become a serious threat for smallholder farmers growing maize after its invasion in Nepal, officially declared in 2019. CSISA is addressing this threat in collaboration with the USAID/Nepal NSAF project, and jointly with Province Level Fall Armyworm (FAW) Task Force, Agriculture Development Directorate (ADD) of Bagmati (earlier Province 3) and Lumbini Province (earlier Province 5). This consortium organized two days of training on FAW Identification and Management on 16-17th February 2020 in Dang. The training was delivered by the experts from the Plant Quarantine and Pesticide Management Center (PQPMC), CIMMYT (CSISA and NSAF) and International Development Enterprises (iDE) Nepal. During the training, participants learned to identify the different stages of FAW during its lifecycle. Participants also learned about integrated pest management approaches in line with scouting-based approaches. Importantly, this training leveraged those conducted in late 2019 in Bangladesh, during which the CSISA and Fighting FAW project teams in Bangladesh trained trainers from Nepal.


Photo 24: FAW awareness campaign in Banke Maize Zone in February 2020 before COVID-19 lockdowns (Photo credit: NAME CIMMYT)

Similar trainings were also organized in Bagmati Province (earlier: Province 3) on 19-20th February 2020 jointly with respective institutions of Bagmati Province. 131 Participants from Agriculture Knowledge Centers, the NARC, KISAN II, and PMAMP's maize zones and super zones, agro-vets, farmer associations, non-governmental organizations and local municipality agriculture sections participated. Prior to the provincial trainings, CSISA also organized FAW awareness campaign in Banke Maize Zone in coordination with other USAID partners and the PMAMP in February 2020.

Broadscale awareness on Fall Armyworm invasion and its management amid COVID restrictions

Despite the enforcement of COVID-19 lockdowns across Nepal in March of 2020, CSISA played a crucial role in co-designing and implementing FAW awareness activities with related stakeholders during the COVID induced restrictions. CSISA and NSAF, in collaboration with the Ministry of Agriculture and Livestock Development (MoALD), aired awareness raising radio jingles on Fall Armyworm management during April-May 2020 through the Ujyaalo Radio Network (of 183 radio stations) throughout all districts of Nepal. The messages delivered through the network helped to generate general awareness about the pest in Nepal, with emphasis on reaching farmers who grow maize in spring and rainy season in Nepal. Similarly, a revised radio jingle on FAW management was also broadcasted through four radio stations in Dang and Pyuthan, in coordination with the Dang Agriculture Knowledge Center and PMAMP in the during the month of July to create awareness for summer maize growers in the districts. A similar radio message was also delivered in Banke Maize Zone in January-February 2020.

B. SYSTEMIC CHANGE TOWARDS IMPACT

B1. Partnerships for inclusive growth around commercial pockets and neglected niches

Collaboration with the Prime Minister Agricultural Modernization Project (PMAMP)

CSISA works in close partnership with the PMAMP to raise awareness among farmers and governmental staff on crop management practices aligned with the principles of sustainable intensification. PMAMP is run by the Ministry of Agriculture and Livestock Development (MoALD) and started in 2017. PMAMP works on the following topics, many of which closely align with CSISA's interests:

- The development of small business agricultural production centers (which PMAP terms 'pockets', or areas with < 10 ha of the crop of interest, for example, maize or rice)
- The development of commercial agricultural production centers (which PMAP terms 'blocks', 10 - 100 ha ha)
- The development of commercial agricultural production and processing center (which PMAP terms 'zones' 100 – 500 ha)
- The development of large commercial agricultural production and industrial centers (which PMAP terms 'super zones', 500 ha – 1,000 ha).

Since collaboration began, PMAMP has leveraged CSISA as a core technical partner for advice and technical support – especially at the field level. CSISA has shared its experiences and provided technical backstopping for PMAMP to support the scaling up of new technologies like DSR. CSISA's collaboration has also included strengthening the knowledge and skills of PMAMP personnel on appropriate and resource-conserving machines and encouraging PMAMP to work on complete cropping systems rather than just single crops (as per its remit). CSISA also works to help PMAMP target their activities.

Partnership with PMAMP to support income-generating maize farmers in Dang District

On-farm maize demonstrations and evaluations in new sites

In collaboration with PMAMP and local agricultural machinery dealers, CSISA facilitated in ten demonstrations of mechanized maize crop establishment in new sites identified by Dang Maize Super Zone during the reporting period with participation of total of 414 farmers. During the reporting period, CSISA also provided technical support to PMAMP in Dang and Banke to evaluate the newly released maize hybrid Rampur Hybrid-10's performance under metered seeding, integrating with machinery and agronomic evaluations. NSAF is raising awareness of Rampur Hybrid-10 in the FtF zone through seed companies, whereas PMAMP's Maize Super Zone and CSISA support and play a crucial role to raise awareness of mechanized seeding for options to reduce production costs following purchase of more costly hybrid seeds. Following the demonstrations and evaluations organized at Maize Super Zone, six custom new machinery hiring centers were established by PMAMP. Each of them were outfitted with seed drills making the total of drills available to farmers more than 30 within the Maize Super Zone in Dang. Through actions such as these, CSISA has supported an expansion of maize cultivation in Dang of approximately 1,500 ha over the last three years.

Photo 25: Farmers observing maize seeding demonstration in Maize Super Zone Dang (Photo credit: Sagar Kafle, CIMMYT)

During the reporting period, the project was involved in demonstrating and field training of farmers on the appropriate operation of mini-tiller weeders for maize, in collaboration with agricultural machinery dealers and PMAMP, in four new sites. The technology was also demonstrated by Banke Agriculture Knowledge Center (AKC) and the in maize belt of Punarbas Municipality in Kanchanpur during the reporting period. More than 100 farmers observed the demonstrations and learned to operate the machine in the maize fields. As these events increased demand, seven inexpensive mini-tiller weeders sold to enthusiastic farmers from Kishan Trades and Suppliers, a machinery dealer that collaborates with CSISA, in Lamahi.

Machinery Specifications and service provider trainings

In this reporting period, CSISA also worked closely with maize super zone PMAMP staff to train 42 participants (operators of established custom machinery hiring centers and potential machinery service providers) in Dang on 26-27th January 2020 in collaboration with two local machinery dealers (Kishan

Trades and Suppliers, Swargadwari Traders). Along with several machineries including seed drills, weeders, threshers and harvester, a new machine laser land leveler was also tested in presence of the trainees first time in Dang. The latter machine is being evaluated in custom hiring centers through technical support from CSISA technicians to train the operators of the custom hiring centers. Likewise, a training to Banke Maize Zone committee affiliated 32 farmers was held in the month of February 2020 to give insights on agronomic management and useful machineries CSISA also provided description of seven CSISA promoted technology to Agriculture Knowledge Centre, Banke on 25 May 2020, which are anticipated to be included in book of new technologies being published by Lumbini Province.

Introducing a cropping systems approach to PMAMP activities

In the current reporting year, PMAMP has revised its strategy by amalgamating district-based separate project units into a single office. This makes coordination with CSISA more effective and efficient, as there are reduced number of points of contact with PMAMP. In Dang district, maize, honey, and mustard production zones have been taken under one umbrella, which eventually imparting possibilities of expanding the network to broader area for the project like CSISA. On the 9th of December 2019, a joint planning meeting held among key staff of CSISA and PMAMP (with 21 participants) was held in Dang to discuss forthcoming opportunities at hand through collaboration with all three PMAMP project units. The meeting outrightly concluded that the success cases obtained in the Maize Super Zone can be replicated in other locations considering the cropping systems in nearly sites. The custom hiring centers exclusively established for maize cultivation by PMAMP are now also able to provide machinery services for wheat seeding with training to machinery operators on a diversified set of crops provided through CSISA in November of 2019. During the reporting period, two custom hiring centers were able assist farmers in showing 5 hectares of wheat. While this is modest, this is also a good start and encouraging. During the meeting, it was decided that CSISA will provide technical backstopping while establishing custom hiring centers in the zones by PMAMP and both the projects would start campaigning in summer maize in May-June to create awareness of mechanized seeding and weeding in existing maize super zone and honey and also mustard production zones. This however was put on partial hold due to COVID-19 locked downs, movement, and social distancing restrictions. The project anticipates full resumption of this work, however, in 2021 if there are no further disruptions.

Photo 26: Mr. Shaniram Chaudhary observing his machine planted wheat field in Satbariya, Dang. The field was established through CSISA's collaboration with PMAMP's custom machinery hiring centers. (Photo by Sagar Kafle)

CSISA has also encouraged the expansion of mechanized mung bean sowing in Dang during the reporting period. Mung bean is a new crop in the cropping systems of this part of Nepal. It can be grown after wheat or maize and before rice in the same field. CSISA managed to encourage PMAMP staff in the Maize Super Zone to take advantage of the short fallow period after the harvest of winter crops by replacement with mung bean. In March of 2020, prior to COVID-19 lockdown, the Project collaborated with PMAMP to facilitate two demonstrations of mung bean sowing with mechanical seed drills supplied from the Shakti Custom Hiring Center in Gadhawa. A total of 31 participants observed the demonstrations held in Shakti Cooperative and Yuwa Agriculture Farmers' Cooperative members' fields. CSISA's planned to organize other three demonstrations on mung beans during second fortnight of March. This was however disrupted by the COVID-19 lockdown in Nepal. The overall goal of these initiatives was to induce PMAMP to embrace cropping systems perspective without disrupting their mission of prioritizing single crops. It is anticipated that these actions will PMAMP supported custom hiring centers run more sustainably with full utilization of available resources and technologies for all available cropping seasons of the year.

New four-wheel tractor weeder design and testing

Two-wheel mini-tillers are widely used in the Dang PMAMP Maize Super Zone for weeding the maize crop. However, managing service provision by the custom hiring centers for a small machine is challenging as the hiring centers are not always open. Rather, CSISA also prioritizes rural entrepreneurship and machinery service provision by business-minded individuals who purchase machinery and offered services on a fee-for-use basis to farmer clients. As farmers in Dang are increasingly tending towards more commercial maize farming on bigger plots at a time (often by aggregating multiple fields), farmers and service providers have been seeking 4-wheeled tractor operated weeder machinery services. The objective here is to mechanically cultivate between the lines of maize, which when done manually can be very difficult. Also, it can reduce the time of weeding in comparison to minitiller weeding by more than a 50%. As such, CSISA initiated design to develop four-wheel tractor weeders. The project has tested its first design in Khusi Multipurpose Farm in October 2019 and in Satbariya Custom Hiring Center in January 2019 in close partnership with Maize Super Zone and a machinery dealer 'Surya Traders'. Preliminary feedback taken from the farmers, trader representatives, CSISA and super zone staffs depicted that the machine can be operated and considered for extension following fine-tuning. Though follow-up testing could not be completed COVID-19 restrictions in second half of the reporting period, farmers from Satbariya Municipality indicated that they were making use of the weeder

Photo 27: CSISA with PMAMP Surya Traders Company staff testing four-wheel operated weeders in Khusi Multipurpose farm, Dang in October 2019 (Photo by Sagar Kafle).

in maize. They also used the machine for to make raised beds and bunds for vegetable cultivation in July of 2020, and reported that the machinery works well.

Cropping systems and value chain intensification with mung bean

In parts of the Terai, about 70% of cropland remains fallow after harvesting winter season crops such as wheat, lentil, rapeseed and vegetables and before transplanting rice for about two to three months. This period is characterized as dry season, high out-migration of male to India for season jobs, and relatively free time for household laborers, especially women. This fallow land can be capitalized to improve cropping system productivity and household nutrition by introducing the nutritious (24% protein), short duration (70-80days), and relatively drought tolerant leguminous crops such as mung bean.

	Winter	Spring	Summer-Fall
Before CSISA and MoLMAC interventions	Wheat	Fallow	Rice
After CSISA and MoLMAC interventions	Wheat	Mung bean	Rice

Figure 33: Cropping patterns in Kailali and Kanchanpur Districts before and after project interventions.

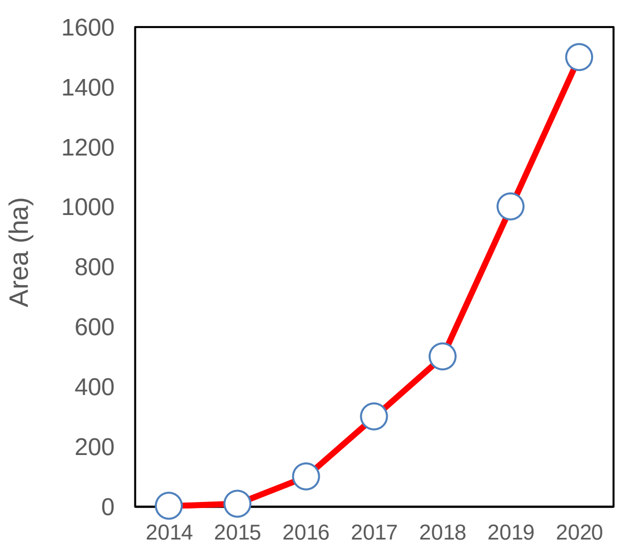


Figure 34. Mung bean cropped area expansion in Banke, Bardiya, Kailali and Kanchanpur within the Feed the Future Zone.

Starting from 2014, CSISA established a framework for mung bean crop expansion to replace fallows across Banke, Bardiya, Kailali and Kanchanpur districts in partnership with National Grain Legume Research Program (NGLRP), seed companies (GATE Nepal and Panchashakti Seed Company), Poshan Food Ltd, local traders processor and Ministry of Land Management Agriculture and Cooperative (MoLMAC) of Sudurpashchim province. This has resulted to increase mung bean area, per capita mung bean consumption and women's empowerment (Figure 34).

During the reporting period, a mung bean action plan 2020 was developed convening 55 public and private sector mung bean value chain actors on February, 6 in Nepalgunj, Banke and on February 7th, 2020 in Dhangadhi, Kailali. As per the plan, radio jingles were broadcasted from five stations for two months starting from February, 2020 forward. These highlighted the benefits and seed availability of mung bean and knowledge products (1,000 production 'fact sheets' also known as 'tips' by farmers, 100 posters) were distributed through government and private sector networks. These stakeholders were AKC Kailali, AKC Kanchanpur, Oilseed Super Zone, Kailali, cooperatives and palikas. In addition, 15 machinery service providers (seed drill operated) were linked in the mung bean production area. In 2020, the Project estimated that a total of 15 tons of mung bean seed were supplied in the aforementioned districts through commercial supply chains (9 tons from seed companies and agrovets, and from government subsidy schemes, 6 tons through PMAMP). In total, this aided in establishing around 600 ha of mung bean in the FtF Zone. Due to the COVID 19 pandemic, it was however not possible to organize field-level trainings for new mung bean farmers to learn about plant protection measures towards the crop flowering period. Some cooperatives from Fattepur, Banke reported that they could not even find plant protection chemicals in local agrovet dues to travel restrictions imposed by government and communities. Surveys conducted by CSISA however indicated that farmers were still able to produce around 300 tons of mung bean. 60% was consumed by the families who grew the crop, while 40% was sold in the market. In case of Banke and Bardiya, local trader Mr. Pappu for example purchased 40 tons of mung bean at a price of Rs. 80/kg, supplying it to Poshan Food Ltd, Butwal and Modern Dall Mill, Bhairahawa. Modern Dall Mill is a new mill collaborating with CSISA to absorb mung bean produced by farmers involved in this new cropping pattern.

In case of Kailali Kanchanpur, local food preparing companies and hotels purchased mung bean at Rs. 100/kg. Bishwas Agriculture Cooperatives Ltd. facilitated the collection and marketing of mung bean grain to these and other buyers. In addition, two seed companies that widely partner with CSISA (Gate Nepal and Panchashakti) produced 3 tons of mung bean seed during the reporting period. They plan to sell the seed on the open market for 2021 planting season, with guidance from CSISA as to best-bet locations for sales where farmers can grow mung bean to optimize cropping patterns.

Photo 28: Kamala Ojha sowing different mung bean products prepared by community members of Bishwas cooperative. The cooperative is also actively involved in marketing to mung bean food processing companies (Photo credit: Merit Maharajan, Amuse Communications)

During the reporting period, CSISA also provided additional and focused support on Poshan Food Ltd. in market promotion of its products. Poshan Food Ltd. was one of the first companies to pioneer mung bean processing in Nepal. They began collaboration during the 2015-19 CSISA Agronomy and Seed Systems Scaling project and have continued to work with CSISA. Support was by giving technical support to this company on how to conduct marketing using radio jingles and branding strategies, and also to access finance.

The company broadcasted radio jingle focusing on its product "Balbhojan" for two months from five radio stations covering five districts (Palpa, Arghakhanchi, Gulmi, Rupandehi and Kapilvastu). As per the owner of Poshan Mr. Narayan Gnawali, significant demand for Poshan food products has come from new customers. The sales volume also increased by 20% per month since February forward, partly attributable to project technical support. The company purchased10 tons mung bean from the farmers facilitated by CSISA via local traders based in in Banke.

Moreover, CSISA supported Poshan Foods to develop a five year business strategy. This was subsequently submitted to the Bank of Kathmandu so Poshan Foods can access appropriate agricultural loans with annual interest rate of just 5%. The bank has started processing the Poshan's document, with loaning expected before the end of 2020. After receiving business development support from CSISA, Poshan Foods also invested in the purchase of a mixture machine with the value of Rs. 3,75000 and developed market plan to supply its products based on the market segmentation strategies as summarized below:

- Bal Bhojan food product targeting to age group 2-5 years old children along with elderly people
- Other products such as Mung Bean (Whole Grain and Split Dal) Maize Grid (Chyankhla), Rice Powder, Hilly Bean, Buckwheat Powder, Millet Powder, Barley and Wheat Powder and Chyankhla will be targeted to age groups from 30 to 60

In addition to these efforts, CSISA has been engaging with the MoLMAC of Sudurpashchim Province, in Dhangadhi, to support in planning, monitoring, training and to create strategic opportunities for scaling agricultural machineries, to expand mung bean as an option to intensify cropping, and in technical advice for improved agronomic practices. In 2019, with technical support from CSISA and following the experience of the Biswas Agriculture Cooperative, Ltd (described below), MoLMAC invested USD $200,000 of governmental funds to encourage farmers to grow mung bean after wheat, an action that permitted farmers to enter into triple cropping by replacing fallows after wheat in a rice-wheat rotation. This action was transformative in that few farmers had experience with mung bean before CSISA's intervention.

To achieve this aim, a joint action plan was developed by CSISA and MoLMAC where CSISA support was focused on technical capacity building, facilitating market linkages between mung bean traders and farmers, and traders and food processors, and the provision of advice on how to best grow mung bean. In turn, MoLMAC's supported the provision of inputs including seed, irrigation, and access to seeding machinery on cost sharing basis with farmers. Through this program, mung bean was planted on 264 ha across Kailali and Kanchanpur districts that had previously fallowed had been cropped to mung bean. Subsequent studies indicate that 270 tons of mung bean were produced by famers, of which 40% was sold into markets, 10% was saved at home for seed, and 50% was consumed as food. Farmers prepared 10 different types of mung bean products that they used for household consumption.

Drawing on the lessons about potential for mung bean on cropping systems productivity, rural employment and nutrition, the Ministry of Agriculture and MoLMAC have suggested that local government, the PMAMP and Government of Nepal's Agricultural Information Centers should work to support the commercialization of mung bean as a viable third crop in previous rice-wheat cropping sequences. Accordingly, the Agriculture and Livestock Commercialization project, PMAMP wheat, oilseed and rice super zones and three palikas (local governments) have also pledged support for mung bean as a viable crop.

Market Systems Facilitation at its best: CSISA launches support for dairy farmer initiatives in the Tarai

Susheli Dairy Cooperative Ltd. was established in 2012, and is situated in Rajapur Municipality, Ward No. 04, Shantinagar, Baridya District. There are 185 farmers (128 men and 57 women) associated with the cooperative. There also Tharu, Madhes and Dalit ethnic groups also involved in the cooperative. The key objectives of the cooperative are to contribute in the livelihood of dairy farmers through the improvement technical and managerial capacity of dairy businesses, and provide quality milk to people at a competitive price. The cooperative collects milk from its members and supplies it to the local market. This includes the Dairy Development Corporation (DDC) based in Kolhapur on processing.

The cooperative started its business after five years of its establishment (2017) with the capital investment of Rs. 100,000. An agreement has been signed between Susheli dairy cooperative and DDC for the supply of 1,000 liters raw milk within a week after establishment. In addition to milk sales, cooperative members also deposit some money at Rs. 100/member/month in the cooperative. By September of 2020, the capital investment in the cooperative has reached to Rs. 3000,000. These funds have money has been used to purchase equipment and cover operational cost of the cooperative. To upgrade the competitiveness of the dairy business, CSISA contact with the cooperative and focus groups indicated that they should start selling the processed milk after installing a processing facility including pasteurizing, heating, drying, and storage. However, the cooperative farmers were unaware of how to best access agricultural loans from financial service providers.

Photo 29: Milk collection operation by the Susheli Dairy Cooperative Ltd. in Nepal (Photo by: Suman Khanal, CIMMYT)

CSISA Intervention

During the reporting period, CSISA provided business mentoring support to the Susheli Dairy Cooperative Ltd. executives, and financial literacy training to the cooperative members focusing on scope of agriculture lending scheme, and facilitated tri-patriate arrangement among the Agriculture Development Bank, Rajapur Branch, the cooperative and Shikhar Insurance Company Ltd., Guleria Branch. In this line, CSISA organized an interaction program on February 5 with cooperative members and these partners. It was clear from the discussion that both the banks and insurance company were interested to support dairy farmers in agriculture lending but there was communication gap between banks, insurance company and dairy farmers to operationalize this intention.

In response, CSISA organized an awareness raising and capacity buildup training event with the Livestock Insurance Policy program for cooperative members on 12th February, 2020 at Rajapur, Bardiya. This was also done in collaboration with the Nepal Agriculture Development Bank, Nepal Bank Limited Rajapur Branch and Shikhar Insurance Guberniya Branch. A total of 48 cooperative members along with operational heads of banks and insurance company attended. During the training program, the Nepal Agriculture Development Bank (ADB), Rajapur Branch office introduced an innovative model they entitled 'Dairy Cooperative Financing and improved Cattle financing" to the Susheli Dairy Cooperative, and requested CSISA to assist in facilitating this approach. One of the pre-requisites of the model is that members should be enrolled in the livestock insurance policy.

Key Outcomes/Results of CSISA's activities:

- As per the model requirement, all the members were enrolled in the Livestock Insurance Policy for reducing financial risk from disasters.
- Susheli's farmers received a subsidized loan amount of NPR 1000,000 at 6.24% annual interest rate from the Nepal ADB, Rajapur Branch and following enrolment of insurance for an amount of NPR 1,800,000 from Shikhar Insurance.
- Susheli subsequently distributed an additional NPR 400,000 loan amount to five member farmers (NPR 80,000 per farmer) for purchase of improved breeds of buffalos and cows.

Photo **30:** Interaction between dairy farmers and livestock experts (Photo by: Suman Khanal, CIMMYT)

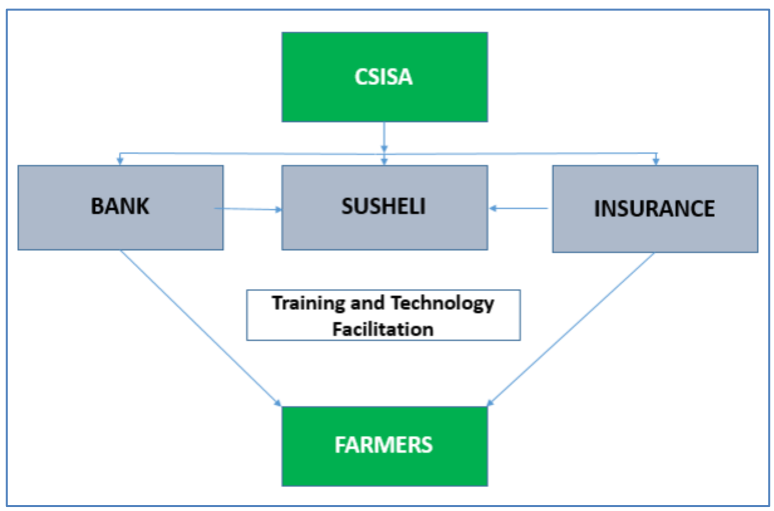


Figure 35: Cooperative financing and improved cattle financing model assisting the Susheli Dairy Cooperative in Nepal.

In the next reporting period, CSISA plans to continue to support the cooperative in Developing business development and operation plans. The project will also work towards facilitating the instillation of the dairy processing facility (installing pasteurizing, heating, drying, and storage equipment) with the loaned funds. CSISA will also assist in cooperative planning of value addition strategies including the production of ghee, cheese, and churpe, among others. Lastly, in collaboration with local livestock advisory offices, trainings will be provided on management if improved livestock breeds.

B1.1 Deployment of better-bet agronomic messaging through input dealer networks and development partners

Media campaigns to raise awareness on registered maize hybrids

During the reporting period, CSISA coordinated with multiple partners to disseminate knowledge products related to maize cultivation. The project aligned with the PMAMP Dang office to distribute the 700 maize production advisory booklets published with the technical support from CSISA, agriculture knowledge centers, zones and super zones of PMAMP and local agriculture offices. The project also technically facilitated Dang Maize super zone and Banke Maize zone to publish 2,000 copies of improved maize production fact sheets. Moreover, CSISA distributed 1,500 copies of maize production tips in different events like trainings, surveys, agricultural fairs and campaigns across three CSISA hubs in Nepal. The project also distributed total of 420 maize production factsheets to the Agriculture Knowledge Centers in Punarbas Municipality and Belauri Municipality and RCT Agro-machinery and Engineering of Kanchanpur, and Bikash Cooperatives, Supravat Cooperatives, RH Agrovet and machinery service providers of Kailali.

Participations in regional agricultural fairs raises awareness of CSISA supported activities

The project participated jointly with PMAMP and machinery traders to organize displays at different agricultural fair supported by the respective District Chamber of Commerce of Kailali, Bardiya and Dang districts on different dates. In Kaiali it was organized on 11-22nd December 2019 and 17-19th February 2020 in Lamahi Dang. Similarly 13-25th January 2020 in Rajapur, Bardiya. Different technologies like registered hybrid seeds (Rampur Hybrid 10, Rajkumar and Bioseed 9220), fertilizer formulations (normal urea, polymer-coated urea and briquette urea), farm machineries (seed drills, reaper-binder, basin planter, spreader, mini-tiller weeders, maize cob harvesters, and other scale-appropriate machines) were exhibited and information about improved production practices of cereal crops and fall armyworm were displayed along with informative posters. During the fairs, 3,000 visitors received coaching from CSISA staff. An estimated 9,000 visitors observed the stalls including all the fairs. In total, 6000 communication materials like factsheets, leaflets and booklets were disbursed to the visitors of different categories. Likewise, video display was arranged in the stall to demonstrate the action videos of different technologies.

Photo 31: CSISA and the Prime Minister's Agricultural Modernization project and local trader jointly organized technology displays at an agricultural fair supported by the Bardiya Chamber of Commerce on 13-25th January 2020 in Bardiya. (Photo credit: Salin Acharya, CIMMYT)

Similarly, the project partnered with Makhalaxmi Traders, a machinery dealer from Dang, and also with RCT Agro-machinery, NB traders from Dhanagdhi, and RK trader' in Bardiya to participate in the fair. The contribution of machinery traders who partook in the CSISA displaces helped to exchange their contact numbers with interested farmers to increase their sales volumes and strengthen the supply chain of the machinery in the future.

Media Campaigns to increase use of mechanized maize seeding

Mechanization in maize seeding has gained popularity in Dang, where more than 1,000 ha are now seeded (mainly in winter and spring seasons) by machinery. The increase in mechanization was after CSISA resumed activities in Dang 2017. Several media campaigns, along with field demonstration of scale-appropriate seeders were arranged in collaboration with the Maize Super Zone Office under PMAMP. These actions were key to the increased interest in mechanical seeding. A similar extension model has been followed by the project in Banke and Bardiya district in the reporting period. As a result, 67.7 ha of maize mechanically sown by 80 farmers from nine different municipalities of the two districts, each of whom purchased seeding services from the custom hiring centers.

Maize area in Banke and Bardiya district is currently around 9,000 ha – indicative of considerable opportunity for expanded use of appropriate machinery, With the aim of scaling mechanized seeding, CSISA in coordination with Agricultural Knowledge Centre(AKC) of Banke conducted media campaign and seeding demonstrations in nine smart agriculture villages scattered in nine different municipalities of Banke and Bardiya district in February 2020, with approximately 50 farmers participating in each campaign. In Banke, PMAMP participated in the awareness raising demonstrations, but also co-designed and then led the radio broadcasting (Nepali version and Maithili Version) of information on maize seeders and their benefits between January and February 2020.

Photo 32: Participants of Maize demonstration conducted in Badhaiyatal Municipality of Bardiya district by Agriculture knowledge center (AKC). (Photo by Yamraj Adhikari).

The campaign's success was accelerated by two different training programs on maize cultivation conducted by governmental agricultural knowledge centers and PMAMP's and Maize Zone in the first week of January.

Photo 33: Maize Seeding in the 'Smart Agriculture Village' of Bakotiya in Bardiya. This Facebook post shows the seed drill and describes an area expansion from 2.67ha to 20ha along with farmers' satisfaction with the crop establishment with machinery. (Photo snapshot from official Facebook page of AKC, Banke posted on 31st May 2020.)

During these events, which were convened by partners, CSISA was invited to provide detailed training on technologies suitable for maize seeding. As a result of these efforts, three different 'Smart Agriculture Villages' (one in Rapti Sonari Rural Municipality, Fattepur of Banke and second in Guleriya Municipality,Tulsipur and third in Badhaiyatal Rural Municipality, Bakotiya of Bardiya district), which municipal governments are using as models to encourage improved farming practices, worked with CSISA to develop investment plans and business models to facilitate purchase of appropriate maize seed drills. The first two Smart Agriculture Villages listed above each bought a four-wheel tractor maize seeder, while Bakotiya Smart Agriculture village purchased a mini-tiller weeder in June 2020. These activities were successful despite COVID-19 lockdowns.

B1.2 Income generating maize production in neglected hill and plateau ecologies

Harnessing the transformative power of hybrid maize in Nepal's mid-hills

Nepal's very low level of maize productivity demonstrates the large untapped potential for increasing productivity. In Nepal, almost one million hectares of maize are cultivated, and almost 80% of this area is located in Nepal's mid-hills. While rice-wheat cropping systems are common in lowland Terai region, maize based cropping systems are common in the mid-hills. Despite maize being a common and stable crop in the mid-hills, maize productivity in Nepal is lowest among the South Asian countries at an average of 2.5 tons/ha. This is caused mainly from maize grown in the hills under rainfed conditions.

CSISA, from its inception has been that farmers who are able to absorb investment risks could consider hybrid maize in Nepal, including in the mid-hills. While Nepal's National Maize Research Program (NMRP) worked to develop and disseminate hybrid maize varieties demanded the farmers, deficits remain. To address this issue, the government of Nepal liberalized hybrid maize seed markets and international seed companies are now able to promote their hybrid maize varieties from 2010 forward. Since then, more than 65 hybrid maize varieties have been registered in the seed quality control center of government of Nepal. Until 2015, these registered varieties were and primarily grown in the FtF ZOI. CSISA helped to expand cultivation of suitable hybrid maize to the mid-hills, as few other initiatives were involved in such work in Nepal. Activities conducted in the previous USAID/Washington supported CSISA Agronomy and Seed Systems Scaling project (2015-2019) assisted farmers from the hills and Terai regions to access hybrid seeds and cultivate hybrid maize sold by an expanding network of seed companies.

To understand the impacts associated with the hybrid maize adoption in Nepal, and to communicate information to partners on effective pathways for varietal adoption, during this reporting period CSISA staff analyzed survey data from the Mid-hills of Nepal. The analysis includes standard treatment models including endogenous switching regression to account the sources of heterogeneities among hybrid maize adopters and non-adopters. The results from the impact assessment show that hybrid maize enhanced maize productivity, profitability, and household food consumption through increased income generation. It should be noted that maize in the mid-hills of Nepal is primarily used for human consumption, unlike in the Terai region where maize is used as the poultry feed. The adoption of hybrid maize increased maize productivity, gross margin, and per capita food expenditure by 109% (2,115 kg/ha), 201% (USD378) and 20% (USD19), respectively, for farmers able to sell their produce to generate income. Additionally, hybrid maize non-adopters could have increased maize productivity, gross margin, and PCFE by 66% (1,327 kg/ha), 168% (USD135) and 64% (USD54), respectively, had they adopted hybrid maize.

However, the study also found the heterogenous effects of hybrid maize adoption across different socio-economic strata. Very small and marginal farms benefited the most from the hybrid maize adoption in terms of gains in productivity and profitability. Despite this, in terms of per capita food consumption expenditure, small farms were least benefited compared to large farms. The low impacts of hybrid maize adoption among the very small and marginal farmers were due to small land areas allocation for hybrid maize. These small farms have allocated <0.1 ha of land sown to hybrids. Although hybrid maize has highest productivity among small farms, because of low area allocation, they benefitted less compared to the larger farms. The productivity benefits of hybrid maize across different farm size quartile for the adopters and non-adopters is presented below. It should be noted that this methodological approach allows the Project to generate the yield scenarios for hybrid maize adopters, had they not adopted the hybrid i.e., counterfactual yield. Similarly, the counterfactual maize productivity was also estimated for the hybrid maize non-adopters, that gives what could have been the maize productivity, had the hybrid maize non-adopters adopted the maize hybrids.

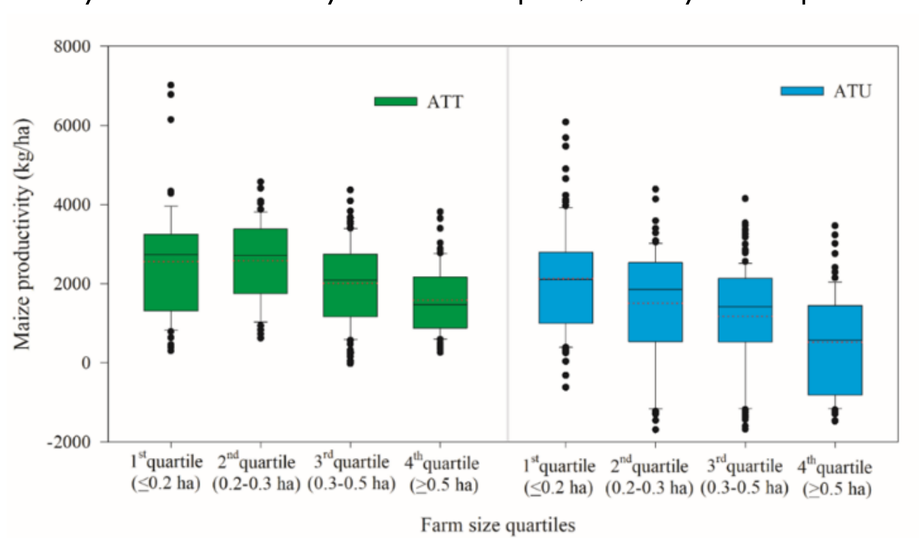


Figure 36: Heterogenous impacts of hybrid maize adoption across different farm size quartiles in the mid-hills of Nepal. ATT stands for average treatment effects of adopters from switching to hybrid maize production from the local varieties. ATU stands for the average treatment effects for the non-adopters which is obtained from the difference between current non-adopters yield and yield obtained from hybrid maize adoption had they adopted the maize hybrids

Results from this research are being used to inform both the CSISA project and also other agricultural development policy initiatives that focus on the hills. It is likely that benefits for smaller farmers will only be significantly accrued through increased land area devoted to hybrid maize. This is likely to be possible in many, but not all cases, though also not to a significant extent. As a result, efforts are now needed to quantify the amount of land that should be devoted to hybrid maize *vis-à-vis* other crops for the entity of smallholders' farming systems, in order to assure more equitable distribution of these benefits.

Utilizing remote sensing tool to estimate maize area in Dang

Cropped area and yield estimation approach in Nepal till date is based on limited field reconnaissance and extrapolation of limited data to large areas. Such methods are prone to error, and as such, PMAMP requested CSISA in the latter half of the reporting period to provide a proof of concept for how crop identification and cropped area could be estimated using satellite-based remote sensing methodologies. Project scientists initiated this work and were CSISA was able to utilize an existing dataset provided by PMAMP of 150 geo-tagged maize fields to estimate the extent of land area under winter and spring maize during the 2019-20 period in Dang district. The team was also able to estimate the area of maize crop grown Dang. Results of this work were work presented to PMAMP officials in Dang on July 29, 2020. Graphical outputs like the ones shown below were described to PMAMP, for many of whom this was the their first exposure to remote sensing. The project team is working with PMAMP to fine-tune analyses, with an anticipated national level presentation to PMAMP and MoALD before 2020 ends.

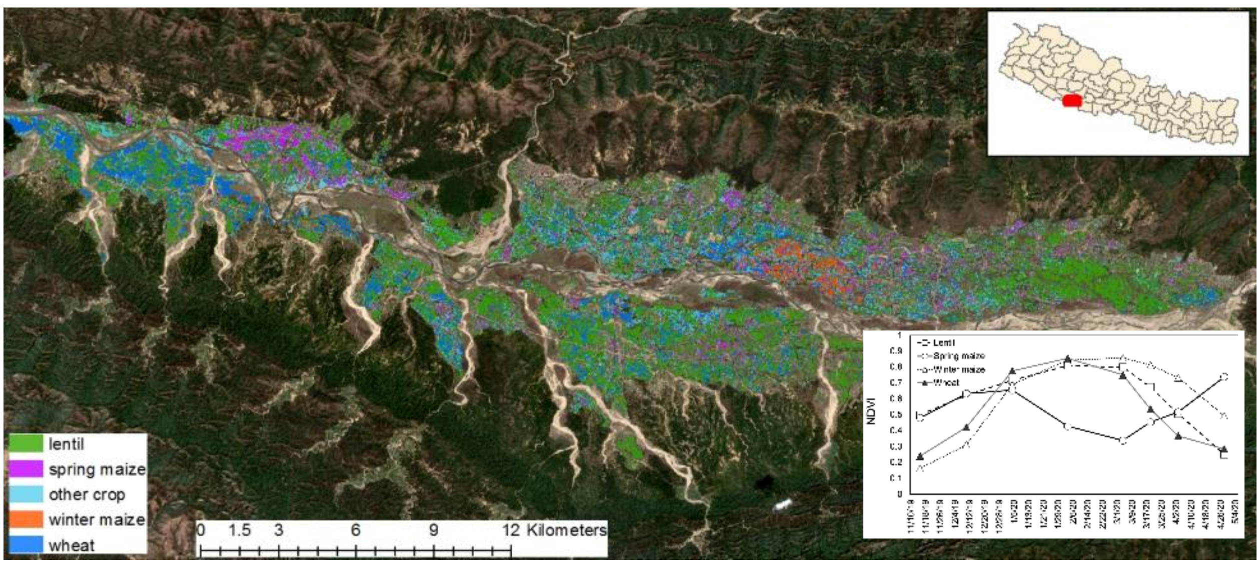


Figure 37: Satellite-aided mapping of crop types, with a focus on maize, developed by CSISA at the request of the Prime Minister's Agriculture Modernization Project in the Deukhuri Valley of Dang in Nepal. The inset shows the temporal patterns of NDVI observed for winter crops (Prepared by Mustafa Kamal, CSISA)

B1.3 Rice-fallows development and intensified cropping patterns

B2. Bringing participatory science and technology evaluations to the landscape and back again

B2.1 Increasing the capacity of the National Agriculture Research and Extension System to conduct participatory science and technology evaluations

In line with the activities and additional support to CSISA provided by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) in a project entitled 'Big Data Analytics for Climate Smart Agriculture' that is aligned with CSISA and described in the Bangladesh B.2.1, CSISA in Nepal is also working to use survey data and data science approaches to analyze survey data and develop improved crop management recommendations for farmers. This work is conducted in close coordination with PMAMP and the Nepal Agricultural Research Council, and represents a major change in the ways in which CSISA's partners conduct research, develop extension recommendations, and advise farmers. The approach is based on the use of digital survey tools and 'artificial intelligence' approaches to the analysis of unstructured and large datasets collected from surveys administered by PMAMP using internet-enabled tables and Open Data Kit, an open-source, free-to-use digital data collection tool. The project uses ODK to conduct farmer surveys, gather information on cereal crop management practices, and track machinery adoption, agronomic management trainings and farmers' adoption of technologies.

Fostering institutional change towards data-driven agriculture: CSISA' support to PMAMP to launch farmer field surveillance and data collection programs

Piloting data driven cereal systems intensification program in Nepal

The PMAMP has been the largest agricultural development project implemented by the MoALD. Since 2016., PMAMP and CSISA have been working together strongly, as PMAMP offers significant economies of scale in efforts to raise awareness on and upscale access to technologies in Nepal. As CSISA is working in tandem with PMAMP in rice, wheat, maize and mechanization themes, the Project was asked to assist PMAMP in the identification of key priorities for effective implementation of their interventions. In the 2019, PMAMP expressed considerable interest in data-driven agriculture, and wished to engage their staff in regular crop monitoring programs and analysis of data from farmers' production practice surveys to identify key intervention areas and extension priorities. PMAMP therefore agreed to adopt the digital data collection systems that have been developed by CSISA over the last several years, in order to enable near real time data collection and rapid analysis from the field. These data on farmers crop management, crop cuts yield, and technology adoption are being used to prioritize the regionally specific management interventions, and are also supported by a complementary investment by the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) in CSISA.

In close consultation with CSISA, the PMAMP piloted their first attempt at large-scale digital survey and crop cut data collection in the summer '*kharif*' rice season. Following on this activity, PMAMP also independently funded and undertook surveys and crop cut assessments of productivity in the 2020 wheat crop cut. PMAMP staff from their respective working locations have been able to collect data from almost 4,000 household following a mid- January digital data collection training.

The areas in which PMAMP is collecting data in collaboration with CSISA are in the mid-hill and Terai regions of Nepal. For the time being, these collected data are deposited in a CSISA server maintained by CSISA, although project scientists are working to coach PMAMP to install their own systems of cloud-based data storage. During this reporting time CSISA in collaboration with NARC's Socio-economics and Policy Research Division and the co-investment by CCAFS assisted in the provision of an additional digital data collection training on rice and wheat crop cut methodologies and ODK based surveys. The rice related training was conducted in Jan 25-26 in Butwal, province 5, the wheat related training was conversely conducted virtually in mid-April of 2020 due to mobility restrictions imposed by the COVID-19.

Photo 34: PMAMP staff learning about how to enter data into tablets and upload data to a cloud-based server for surveys of rice, wheat, and maize farmers in Nepal in January 02 1020 (left); PMAMP Director Dr. Revati Raman Poudel giving a speech about importance of digital data collection and collaboration with CSISA (right). (Photo source: Gokul Paudel, CIMMYT)

Collection of data is however just part of the objective of this work stream. Data must be analyzed in order to draw useful insights that can be used for practical extension messaging. As such, plans had been made for 2020 for CSISA to further capacitate PMAMP and NARC scientist to analyze data through semi-automated machine learning tools. Such tools are relatively easy to operate, and can be utilized to provide details on the major drivers for cereals productivity that will help PMAMP to priorities their interventions. However, following the initiation of lock-downs in Nepal that occurred as a result of the COVID-19 threat, these activities have been put on temporary hold, with likely resumption in the last quarter of 2020 or early 2021.

Photo 35: PMAMP staff participating in the digital data collection for data driven agriculture training event in January 2020, in province 5, FTF operational ZOI. (Photo credit: Gokul Paudel, CIMMYT)

Progress in surveys:

During the reporting period, PMAMP collected the data from different across Nepal's Terai and mid-hills. Almost 2,900 rice and 1,000 wheat crop cuts and production practice survey data were generated during this time. Due to mobility restrictions imposed by lockdowns from COVID-19, the wheat survey was however conducted via telephone. A sub-set of samples from the rice survey were selected for the wheat survey, especially considering for farmers who had mobile numbers. The map below shows the location of the survey areas for the rice and wheat crop cuts and production practice surveys. The rice crop cuts and survey data were analyzed and presented to the PMAMP team, MoALD, NARC and partners in a Zoom meeting in May of 2020, before the onset of rice season this year. The data analysis and results from previous years rice seasons are used for the planning of 2020 rice season. Although a national workshop has been planned to share these results and include those analytical findings in the rice planning for 2020, the Project was unable to hold in-person workshops due to social distancing mandates. A more comprehensive workshop is planned for 2021 once the situation stabilizes and in-person assemblies are possible to share the rice and wheat survey findings, and to increases partners' capacity to analyze data. In the next section some of the results from the rice and wheat survey are discussed.

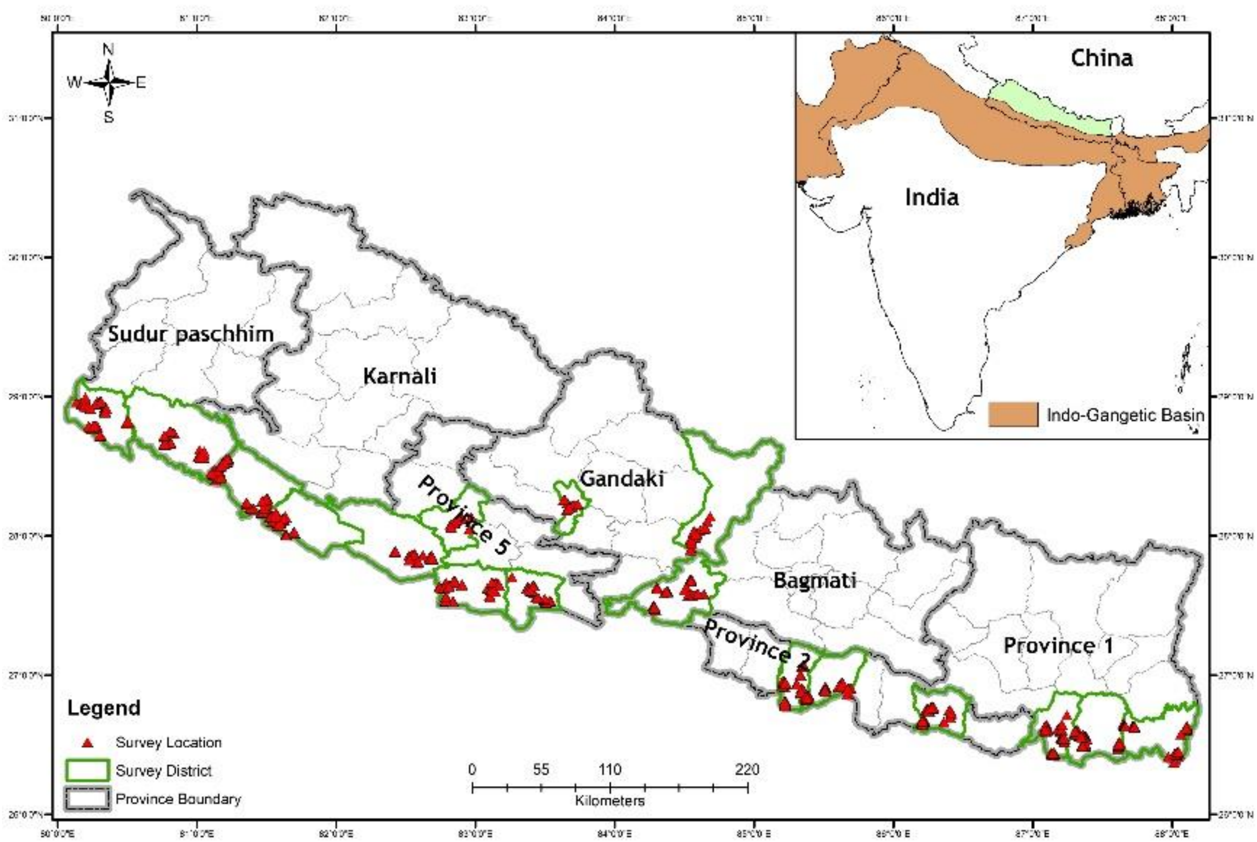


Figure 38: Map of Nepal that shows the locations of the rice and wheat production practice survey conducted areas. A sub-sample from the rice survey were selected for wheat crop-cuts and production practice survey in 2020.

Some of the preliminary analyses of the 2019-20 surveys are presented below. The average rice and wheat yield in the sampled districts were around 4.1 ton/ha and 3.2 ton/ha, respectively. The province wise rice and wheat yield distributions are presented below. Rice yields differed across provinces. In Province 5, where CSISA is operational, and in Bagmati Province in the central Terai where CSISA Phase-I was operational, had the highest mean yields of 4.5 and 4.8 tons/ha. Province 2 has the lowest rice productivity of 3.8 tons/ha. Similar variability in wheat yield was also observed. Differences in yield are associated with different crop management factors, in addition to numerous abiotic and biotic factors.

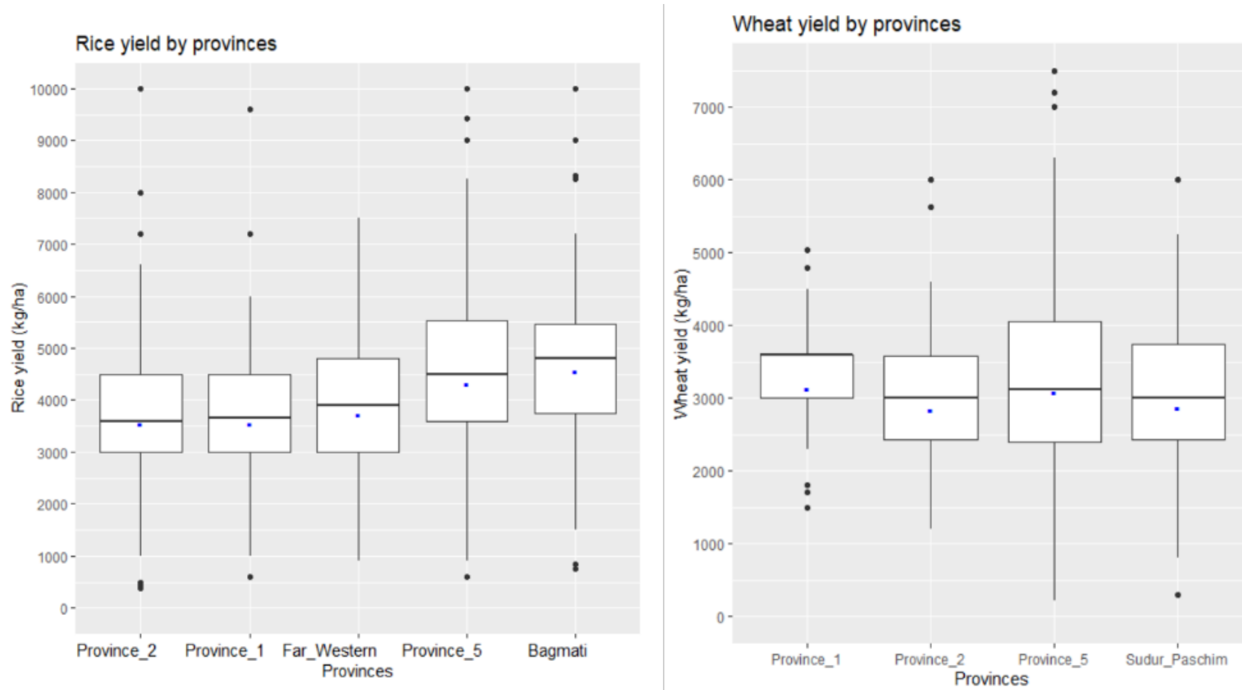


Figure 39: Rice (left) and wheat (right) productivity among different provinces, results from the 201-2020 crop cuts and survey conducted by the PMAMP and CSISA.

To understand the rice and wheat yield variability and the driving factors, the Project team used machine learning (ML) methodologies. This approach generates insight on the most important variables that affect rice and wheat productivity. Preliminary results considering only management factors are shown below; analyses is ongoing with secondary datasets of relevance, particularly for soils and climate.

While the results from the rice productivity drivers have been discussed in the previous semi-annual report, we here provide a preliminary assessment of the productivity drivers for wheat in the study areas. Irrigation, potassium, seed rate, nitrogen, and phosphorus are emerging as the most important productivity drivers in wheat. Wheat in Nepal is grown during the dry winter season and irrigation plays a vital role to enhance productivity. This one of the reasons reason for irrigation appearing as one of the most important drivers of yield in the survey dataset. Moreover, management of nutrients emerging as the second through third most important productivity drivers that influence productivity in Nepal. It should be noted that Nepal is a net importer of fertilizer, therefore, accessibility and availability of fertilizer is major constraint for many farmers. The current fertilizer application rate in wheat is around 82 kg/ha, 52 kg/ha, and 18 kg/ha respectively for N, P, and K. Our data indicate that current fertilizer application rates for wheat tend to be quite well below the recommended rates, indicative that national extension partners such as PMAMP will need to refocus efforts on overcoming these limitations.

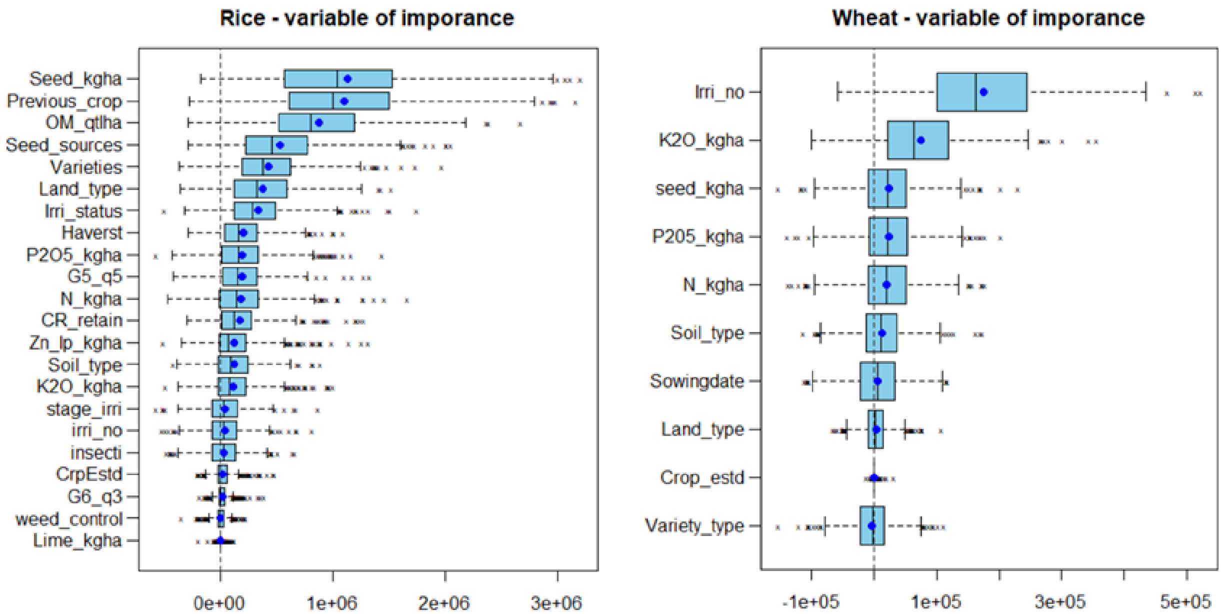


Figure 40: Rice (left) and wheat (right) productivity drivers based on machine learning (ML) algorithms applied to survey datasets collected in the 2019-20 reporting period. The top variable shown on the y-axis shows the modeled most important productivity drivers in the region.

The analytical framework used by CSISA's scientists for these analyses also provides inference on crop yield response to input variables such as irrigation, nitrogen, phosphorus, and potassium. These response curves are known as partial dependence plots or marginal effects plots , as shown below for wheat. For example, the partial dependence plots of irrigation show that most of the farmers are applying 1-2 times of irrigation on wheat, however, the observed yield response is positive until the three irrigations and not after.

This indicates that additional supplemental irrigation in wheat could increase the productivity in the region, and that irrigation should not exceed four, while increases in yield beyond three irrigations are also limited compared to two. Similarly, the application of N, P, and K suggest a positive response in wheat productivity up to a level of 150 kg/ha, 75 kg/ha, and 50 kg/ha, respectively. However, currently farmers are applying around 82 kg/ha, 52 kg/ha, and 18 kg/ha of these nutrients, respectively. The project team is now re-analyzing these data to examine if profitability responses to fertilizer investments show similar trends; where they do not, new opportunities for extension messaging and policy to increase use of appropriate fertilizer rates are warranted. These findings will be shared with national partners by organizing a workshop before the wheat sowing season in 2021, following the full removal of COVID-19 restrictions.

Virtual Zoom meeting with CSISA's partners to respond the current COVID crisis during this rice season and recommendation-based on rice crop cuts and survey data

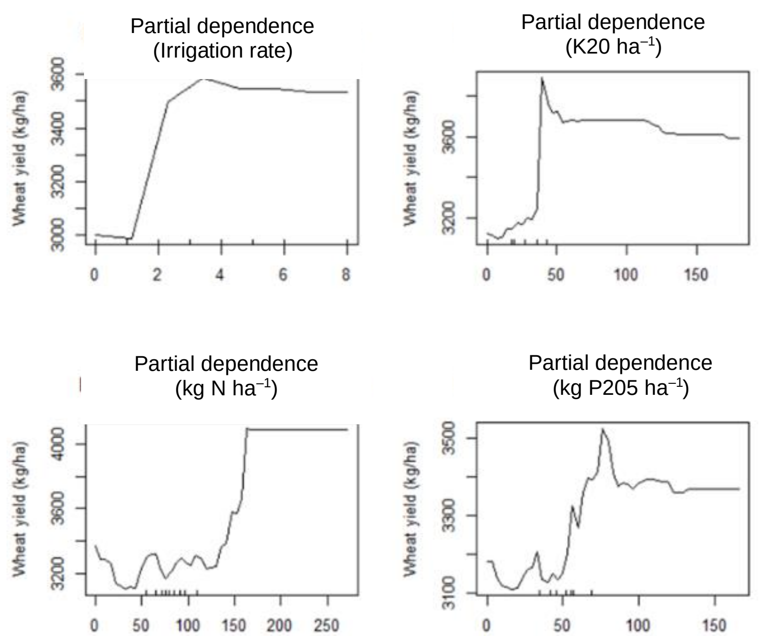


Figure 41: The response curves (also known as partial dependence plots) of irrigation, potassium, nitrogen, and phosphorus with the wheat yield obtained from the machine learning algorithms.

A virtual meeting was held between PMAMP, MoALD and CSISA on June 24th, 2020 by Zoom (due to COVID-19 lockdowns) to present the findings of the Kharif rice crop cut Survey conducted in 2019, and also to discuss ways to respond to COVID-19 in the rice season. Twenty-eight participants from PMAMP's rice super zones and zones, MoALD, NARC, and CSISA participated in the virtual workshop moderated by Mr. Mahindra Poudel from PMAMP.

Following remarks from Mr. Navin Hada from USAID/Nepal in which he highlighted upon the importance collaboration among CSISA, USAID, PMAMP and MoALD, Dr. Rewati Raman Poudel, then Director of PMAMP presented the preliminary findings of crop cut surveys. He also requested CSISA to organize thematic meetings for mechanization in rice, wheat and maize, and expected a continuous support from CSISA to strengthen the data driven approaches to provide the better agronomic advisories. Furthermore, Mr. Rajendra Mishra, the Under Secretary for MoALD, emphasized the potential benefits of the survey data collected taken by PMAMP and CSISA, and highlighted the potential benefits of such data in developing improved extension services. The Under Secretary also highlighted the continued partnership between Ministry and CSISA in the future.

C. ACHIEVING IMPACT AT SCALE

C1. Growing the input and service economy for sustainable intensification technologies

C1.1 Integrated weed management (IWM) to facilitate sustainable intensification transitions in rice

Safe herbicide use and equipment training

Photo 36: A directly seeded rice field with proper weed in Belauri municipality, Kanchanpur district of Nepal, September2020 (Photo credit: Dhirendra Chand)

Integrated weed management is crucial for reducing profitability and labor bottlenecks in intensive rice systems. It is equally important enabling factor for adoption of sustainable intensification technologies such as direct-seeded rice. Most of CSISA's work on integrated weed management takes place in Bangladesh, although some limited key activities are also undertaken in Nepal. In March 2020, CSISA has provided technical support on safe use of herbicide for weed management by conducting a training with agrovets (thee term commonly applied to agricultural input retailers in Nepal) in a location where in 3.8 ha of spring rice was established using DSR in Rajapur, Bardiya district. 13 men and four women farmers participated. CSIA worked to increase awareness of flat fan nozzles, which result in more efficient spraying swath, since farmers generally use cone nozzles which are wide available on the market but that are more appropriate for pesticides. The project had planned several additional activities on weed management, but was unable to implement them in the summer rice season due to COVID-19 restrictions

C.1.2 Accelerating the emergence of mechanized solutions for sustainable intensification

Scaling mechanized wheat seeding through service providers and PMAMP

During the reporting period, CSISA continued support to PMAMP in their Wheat Super zone, Oilseed Zone and Rice Super Zones in Sudurpaschim and Lumbini provinces. The objective of this work was to raise the capacity of agricultural technicians, existing machinery seed drill service providers, and new service providers who can assist farmers with precision crop establishment in wheat. Four major trainings were provided to eight agricultural technicians, in addition to 43 seed drill service providers. The project worked with these service providers to conduct seven demonstrations.

On 6th November of 2019, CSISA led the technical components of additional trainings on zero-tilled wheat, which included seed drill calibration, repair and maintenance. The training was organized by PMAMP's oilseed zone in Sukkhad Kailali, with 28 agricultural machinery service providers trained. Similarly, 25 participants consisting of 10 male service providers and 15 female farmers, learned about minimum and zero tillage wheat production in a workshop help by PMAMP with technical leadership from

CSISA in Masuriya, Kailali on 11th Nov 2019. One to one training was also provided to five new seed drill service providers to assure they could overcome challenges in new use of machinery in Banke and Bardiya in November,2 019. In the reporting period, CSISA also assisted partners to establish five demonstrations of zero tillage seeding in three different farmers groups under a provincial agriculture program called 'Smart Agriculture Villages' in Banke and Bardiya in November 2019. Similarly, Praganna Irrigation Project in Dang also conducted two demonstration of zero tillage wheat water users associations with CSISA on 16th November and 3rd December, 2019. A total of 20 participants including four agricultural engineers from the took part. Resulting data collected by the project indicated that approximately 1,500 farmers adopted mechanized wheat seeding in around 1,000 ha as a result of these and similarly aligned efforts.

Photo 37: Demonstration of zero till wheat seeding in a 'Smart Agriculture Village' Bogatiya, Bardiya district on 21st November, 2020 (Photo by Subash Adhikari)

As a part of creating awareness among new farmers on the benefits of mechanized seeding and linking service provider to farmer-clients, CSISA also worked with PMAMP to conduct several media campaigns during the reporting period in two provinces. Of these, two involved physical displays of seed drills on mobile trucks during November in Rajapur. Three radio jingles on zero till wheat seeding were also aired in Banke and Bardiya. Three 'whole family trainings', in which both husbands and wives were jointly invited to participate and learn about on mechanized wheat seeding were conducted with 35 households. In addition, live video shows on wheat seeding were conducted with 184 farmer viewers. Weekly awareness programs in markets were held in November, with 236 people visiting technology display booths and learning about new mechanization technologies. Lastly, 585 fact sheets on wheat management and establishment methods were also distributed. As a result of these and additional efforts in Kailali and Kanchanpur, nearly more1,000 ha are now under mechanized wheat sowing, including 150 ha of wheat sown through mechanized seed drills.

C1.3 Commercial expansion of scale-appropriate machinery and associated service provision models for reapers and seeders in Nepal

Two-wheeled tractor power tillers are often used by Nepalese smallholder farmers to cultivate their fields. Since 2016, the project has provided technical assistance to machinery value chain actors to increase demand for two-wheeled tractor mounted seed drills in Dang and the surrounding districts they serve. The project is studying their adoption and spread and raising awareness about other labor-saving machines for carrying out the range of farm operations. The following passages review progress on scale-appropriate machinery during the reporting period.

Supporting the spread scale appropriate seeders and harvesters to reduce farm drudgery

To monitor the spread of various planters and seeder across Nepal, CSISA III has developed a series of Google maps available to the public. These maps display the locations and contact information for over 170 seed drills and their service provider owners. A live link of below map (see Figure 41) can be seen through Google Maps as 'Agricultural Machinery in Nepal'.

Figure 42: Map of the seed drills (green) and harvesters (blue and red) now available across Nepal. The live and interactive map can be accessed here.

In addition, the project participated in the planning workshop of the PMAMP wheat super zone on 9th Nov 2019. As a result of advice provided by CSISA, the super zone began to offer a 50% cost reduction as a promotion to encourage farmers' hiring of mechanized seed drills. Nearly 100 hectares of machine sown wheat resulted from these efforts, which took place in Dhangadhi. Considering harvesting equipment, the limited mechanic services available in the market at the peak period of harvesting and short harvesting period of crops, and delays due to breakdowns and inability to repair equipment in the field can cause significant economic losses for machinery service providers and farmers. In order to continue the successful business of service provider as well as to access this technology to large number of rural farmers it is essential to build up their capacity in identifying, repairing and maintenance of reaper parts. As such, CSISA worked during the reporting period to extend training on repairs and the maintenance of harvesting machinery in collaboration with PMAMP in Suklaphata municipality-10, Kanchanpur. In a public-private partnership, the training was held in the RCT agro-machinery company's engineering workshop. Sixteen mechanics participated in an intensive 5-day training starting 16-20 March 2020. In addition, the project distributed reaper operation manuals as a reference for mechanics in the future.

Wheat harvesting in 2020 – which takes place in March and April generally – was affected by COVID-19 as lockdowns with restrictions in movement were particularly strong. In response, CSISA conducted a phone survey with 199 service providers to study the impact of the lockdown during these months. 19 service providers were completely unable to deploy machinery as the machinery operators and spare parts could not be sourced due to movement restrictions. Most service providers were however able to conduct harvesting work, though with limitations and challenges in restricted movement, lack of spare parts, and inability to find skilled machinery drivers or fuel for machinery. But because agricultural machinery service provision continued during lockdowns, in March of 2020, CSISA broadcasted radio jingles in Banke, Bardiya, Kailali and Kanchanpur districts on the principles of COVID-19 safety and safe harvesting and machinery operation. A follow up survey after the completion of the harvesting season was done with the same service providers. It was found that the average harvesting area supported by self-propelled and two-wheel attachable reapers declined by 50% due to restrictions.

Photo 38: Participants are learning to assemble the cutter bar in the practical session of repair and maintenance of reaper in Suklaphata-10, Jhalari, Kanchanpur, Nepal (Photo by Lokendra Khadka)

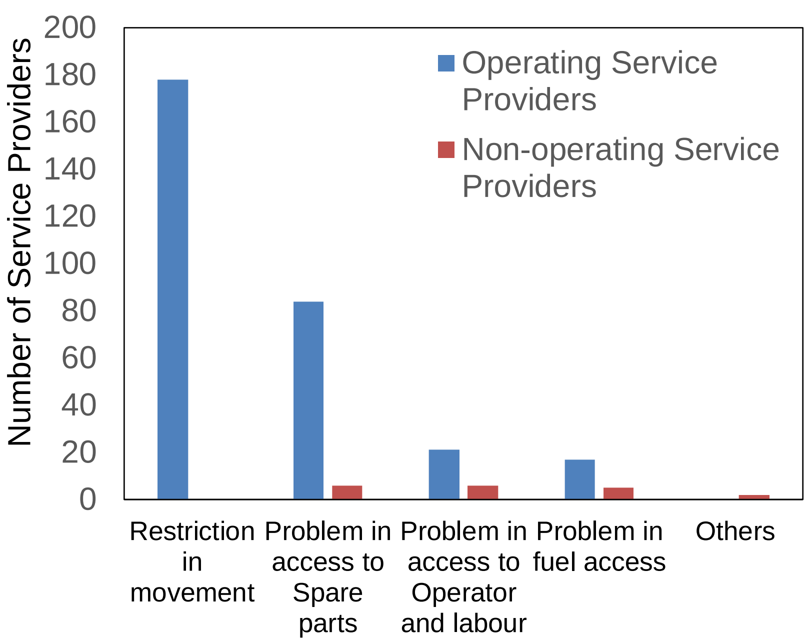


Figure 43: Number of Service Providers (harvesting machine) reporting different problems due to COVID-19,in phone survey done in March 2020. n=199. (note for editor :editable sheet is provided with the figure).

Market support and development for spread of scale appropriate seeders

In addition to exploiting scaling pathways offered by synergies with PMAMP, CSISA also pursues private-sector led scaling of appropriate agricultural machinery in Nepal. CSISA and the company BTL Pvt Ltd (based in Kathmandu) have held multiple demonstrations and farmers field days on '2BMZJ' model precision no-till maize planters. In the first month of the repairing period, CSISA also extended partnerships and began working closely with SKT Pvt Ltd (based in Bhaktipur) who imported four maize planters for field and market testing. SKT Pvt ltd. visited the field with CSISA on 25th of January to observe the performance of the planter in establishing maize. Then in February of 2020, Kuber and Sons Pvt. Ltd (based in Itahari) contacted CSISA and indicated that they were importing an additional 10 drills. During the ensuing lock-down period due to COVID-19, CSISA staff assisted Kuber and Sons Pvt. Ltd in May of 2020 to complete import and set up the drills for field testing,. A third trader from Kailali, D-KAM Microsystem Pvt. Ltd, also showed interest to enter the planter market in Nepal. After contacting CSISA staff for advice, the Project provided them a brief on the importance and specification of planters on 3rd March, 2020 through a Zoom meeting . The resulting competition for the maize planter has driven the per-unit drill price down by nearly 1/3rd. Initial sales of seeders commenced in Chitwan, Bara, Parsa, and other maize planting districts further east, though COVID-19 has slowed growth.

Photo 39: Precision maize planting in Nepal is possible with the 2BCYF planter. The 2BCYF comes with and automatic seeding depth mechanism that allows precise seed placement in uneven fields (left). It also features Kinze type finger meters (right). CSISA is expanding its partnerships with the private sector which has resulted in an initial increase in imports and sales of the 2BCYF in late 2019 and early 2020. (Photos by Kuber and Sons)

Through these partnerships, CSISA also helped introduce second new precision maize no-till planter product which arguably is on par with international levels of technology sophistication and precision but with low prices. The 2BCYF model planter below comes with independent leveling (with parallelogram linkage) row units for more consistent depth control and Kinze finger seed meters (right side) which provide better seed singulation and less missed hills. Farmers in Banke, Bardiya and Kanchapur showed much interest in the initial field and market tests in Mid-March, although subsequent sales have been stymied due to COVID-19 lockdowns, movement restrictions, and financial hurdles.

CSISA has also worked during the reporting period in assessing the rotary till seed drill mode 2BFG-12 (200), imported to Nepal with investments made by SKT Traders Pvt Ltd. This drill was tested in March of 2020 in conjunction with the PMAMP in Rajapur, Bardiya District, which has expressed an interest in this product for its custom hiring centers. Initial field tests have had positive results. CSISA is has planned to assess the potential to modify the seed drill to allow precise strip tillage seeding without full inversion of the soil, which can result in substantial fuel savings. COVID-19 lockdowns have however delayed this work. Farmers who observed the tests showed initial excitement after seeing the germination of spring rice and are eager to use it in next wheat seeding.

Photo 40: Testing of Rotary Till Seed Drill model 2BFG-12 for spring DSR in early March 2020 in with coordination with the SKT's local trader and Custom Hiring Centre of Rajapur, Bardiya district of Nepal in March 2020 (Photo by Subash Adhikari).

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

CSISA's efforts on scaling the sustainable intensification technologies has been reflected, as a success story, from the adoption of reaper in Nepal. The spillover can also be visualized, as a significant number of farmers are adopting reapers both within and beyond the FtF ZoI, indicating the wide applicability of this game-changing technology. Until September of 2020, 4,119 reapers had been sold by the Nepal Agriculture Machinery Entrepreneur's Association (NAMEA). A total of 10 traders were involved in reaper import as compared to just four traders in 2016. Around 90% of these farmers self-financed their without governmental subsidy. An estimated area of almost 17,000 hectares have were harvested by reapers in the 2019-20 reporting period. The adoption of reapers has also impacted the development of a new group of rural entrepreneurs, and been a for income generation for rural youth. A single reaper owner can provide services to the other farmers on an affordable fee-for-service basis. One of the major drivers for reaper adoption is the out-migration of young men as laborers, particularly to other countries.

Breathing new life into partnerships with the USAID/Nepal KISAN II

From February 2020 forward, CSISA has renewed its partnership with the USAID/Nepal funded KISAN II FtF project led by Winrock CSISA is working to support the Joint Rice Implementation Program (JRIP) which was developed by USAID, the MoALD, and KISAN II. CSISA has been a key source of technical support to these bodies to identify and prioritize mechanization options in the project areas, with a strong focus on resource-conserving technologies. Seeing the importance of co-designing the activities with CSISA, the approved guidelines of JRIP during the second half of the reporting period has highlighted the role of CSISA project introducing the CSISA representatives in central and district level program implementation committees.

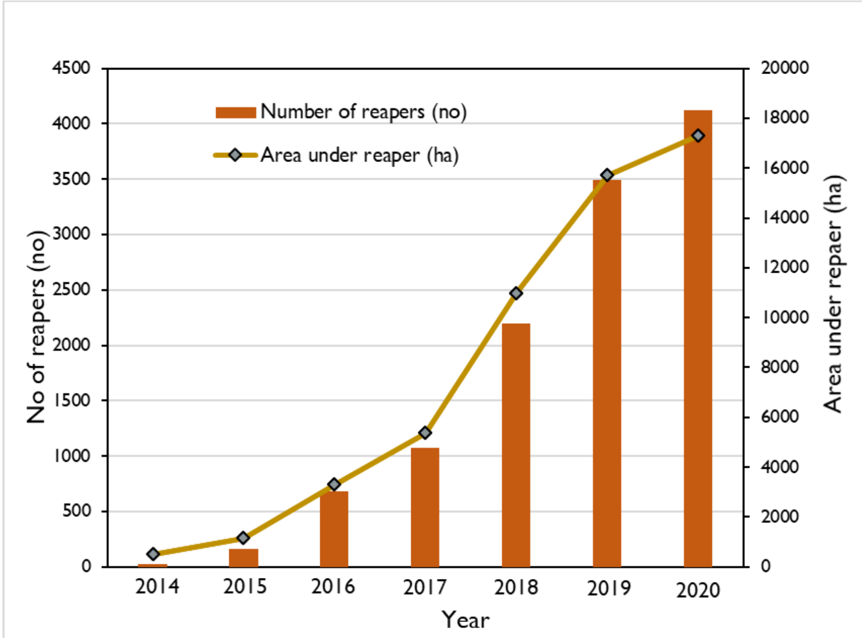


Figure 44: The increasing number of reapers adopted by the farmers and area under reaper in the rice-wheat cropping systems of Nepal.

Impact of mini-tiller adoption on maize productivity, profitability, and household food security in Nepal

Efficient and affordable mini-tillers save farmers' costs and improve rural employment in Nepal. CSISA introduced this technology in 2011 and also validated this technology by conducting series of on-farm experimental trails to refine the mini-tillers and closely worked with public and private sectors for the dissemination of this technology. Because of mobility restrictions due to the COVID-19 crisis, CSISA focused on analysis of data on mini-tiller adoption in the mid-Hills that had been previously collected. This study was conducted in the last quarter of 2017 and number of documents have been published using this data. However, the impact of mini-tiller adoption on maize productivity and household food security have not been analyzed. A total of 1004 sample households were surveyed in 2017. However, only 740 households grew maize, and 274 (37%) were mini-tiller adopters, while 466 (63%) were non-adopters. Adopters and non-adopter's data were used to assess the impact of mini-tiller on land preparation costs, labor costs, total variable costs, maize productivity, gross margin, and household food security. Due to the cross-sectional nature of data, the research team used the quasi-experimental analytical of propensity score matching to create a reasonable counterfactual.

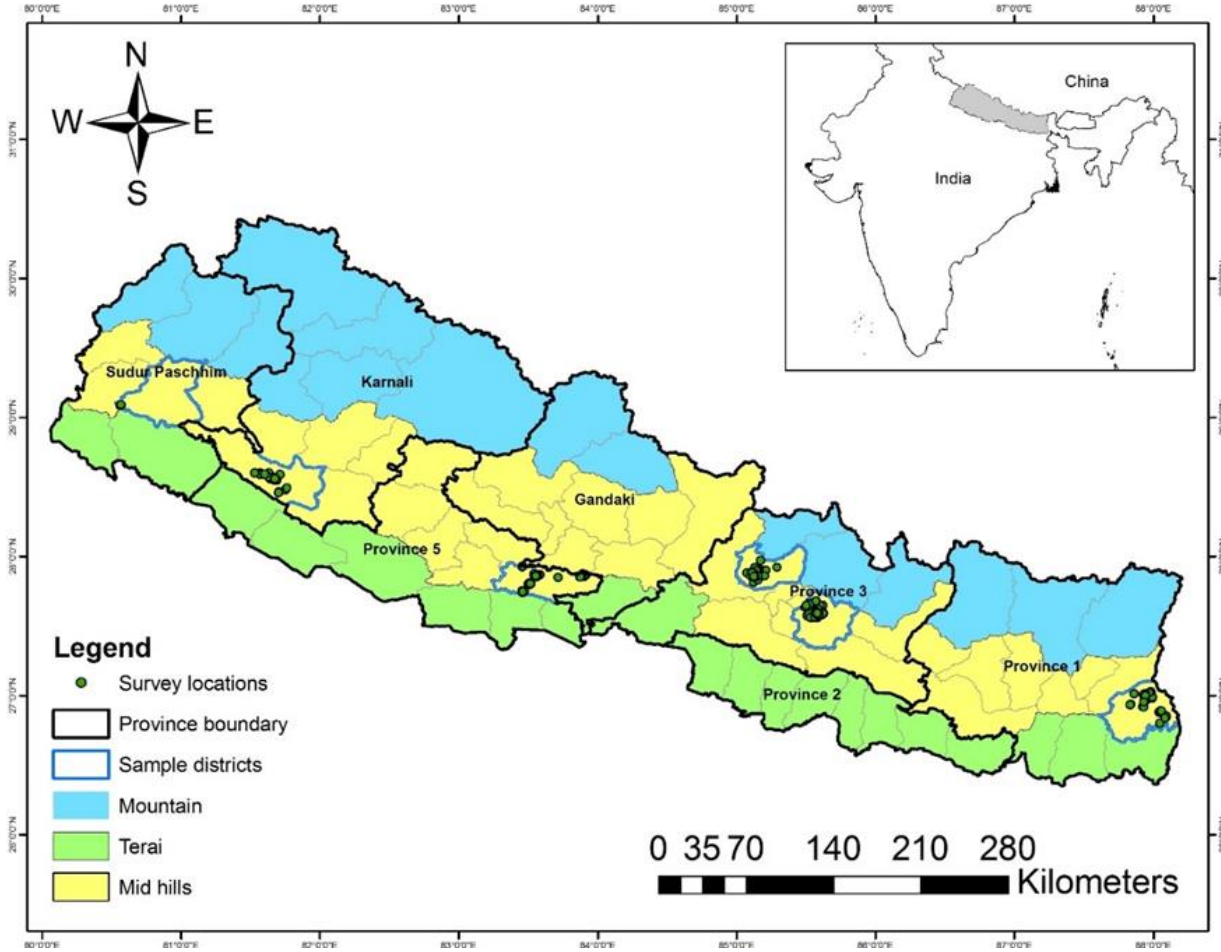


Figure 45: Mini-tiller study areas to assess the impacts of mini-tillers in the mid-hills of Nepal.

The impact assessment results are presented below. Two different matching algorithms were applied to match mini-tiller adopters and non-adopters. All the variables that could affect the productivity and other outcome indicators (such as fertilizer use rate, varieties, farm yard manure, household's income and other socio-economic variables) were controlled to assess the true treatment effects of mini-tillers. Kernel Based Matching and Nearest Neighbor Matching were employed to assess the treatment effects.

Preliminary results show that the adoption of mini-tillers reduced maize land preparation cost, labors cost, and total variable cost by NPR 5,377 – 6,424 (US$ 50 – 60) per ha, NPR 6,424 – 8,185 (US$ 60 – 76) per ha, and NPR 9,037 – 10,501 (US$ 84 – 98), respectively. However, the adoption of mini-tiller enhanced maize productivity and gross margin (profitability) by 20-25% (573 – 673 kg/ha), NPR 19,852 – 23,477 (US$ 186 – 219) per ha, respectively. The decrease in land preparation costs, labor costs, and total cost of production and increased in maize productivity and profitability enhanced household's probability of being food self-sufficient by 24 – 26%. These results show that small-scale mechanization can have positive impacts on farm productivity and household food security in the developing countries. It is important to note that there are now almost 30,000 mini-tillers adopted by the farmers in the mid-hills of Nepal.

Table 21: Impacts of mini-tiller adoption on maize productivity, costs of production, gross margin and household food security in the mid-hills of Nepal.

Matching algorithm	Outcome variables	Mini-tiller adopters (N=466)	Non-adopters (N=233)	Average treatment effects on the treated (ATT)	Standard error
Kernel based matching (KBM)	Maize yield (kg/ha)	3393.06	2717.82	675.23**	315.09
	Land preparation cost (NPR/ha)	13114.00	18490.82	-5376.82***	1538.71
	Total labor cost (NPR/ha)	21090.03	29275.07	-8185.04**	3626.48
	Total variable cost (NPR/ha)	57224.35	66741.83	-9517.48*	5669.87
	Gross margin (NPR/ha)	23964.06	487.07	23476.99***	7354.22
	Food self-sufficiency† (%)	0.48	0.24	0.24***	0.08
Nearest neighbor matching (NNM)	Maize yield (kg/ha)	3393.06	2776.76	616.30*	354.82
	Land preparation cost (NPR/ha)	13114.00	19430.47	-6316.47***	1362.31
	Total labor cost (NPR/ha)	21090.03	28143.87	-7053.84*	3798.07
	Total variable cost (NPR/ha)	57224.35	67725.32	-10500.97*	5606.45
	Gross margin (NPR/ha)	23964.06	1825.02	22139.04***	8630.90
	Food self-sufficiency† (%)	0.48	0.22	0.26***	0.08

Notes: ***Significant at 1% level, **Significant at 5% level, and *Significant at 10% level. ATT: Average treatment effect on the treated. SE: Standard error. Exchange rate 1 US$ = NPR 107 during the survey year. †Households with more than 12 months of food self-sufficiency from their own household production were considered as food self-sufficient and below 12 months were considered as food self-insufficient households.

Expanding farmer demand for mini-tillers in the Midhills

There has been widespread adoption of mini-tillers across Nepal's Midhills since the 2015 earthquakes, mainly for tillage in rice-maize and rice-wheat systems. Inspired by this, and learning of the use of mini-tillers in India's plains for inter-cultivation and earthing up row crops, the previous phase of the project (Phase II) and the early months of CSISA Phase III raised awareness on mini-tillers for both tillage and weeding between maize rows in Nepal's Terai. Evidence of project impact can be found in the strategic partnerships that CSISA fosters, as described below.

CSISA has been coordinating with private sector to develop options for efficient and economic mini-tiller weeders in Nepal. As a result, a new model costing USD 500 less than existing machine is available in Dang. The project assisted Maize Super Zone to conduct four different mini-tiller demonstration and awareness raising programs in new project areas in Dang between December to March of this reporting period. A total of 101 farmers participated the program. As a result, eight new mini-tiller weeders were being purchased by those farmers with price discounts provided by PMAMP and as advised by the project. This increases the number of weeders to more than 40 in Dang being used on around a total of 120 ha per season on average.

The use of mini-tiller weeders can save farmers up to $80 per hectare relative to manual weeding in maize. Seeing the success story of increasing use in Dang, the Project planned to conduct a program of demonstration of mini-tiller weeder lead by private sector partners – particularly traders and machinery dealers –in collaboration with the Agricultural Knowledge Centre in Banke and Bardiya. The aim of the program boost awareness among 80 farmers of nine local bodies who recently practiced mechanized maize seeding on 67.5 ha of land, as these farmers are likely to be early adopters. However, the activity was greatly affected by COVID-19 lockdown and only the 'Smart Agriculture Village' in Bakotiya was able to purchase and use the weeder despite the lockdown.

Photo 41: Farmers from Maize Zone Banke operating weeder machine for inter-culture operation in Duduwa Rural Municipality, Banke District. (Photo taken by Subash Adhikari)

Although weeders are available in the market, their commercial use by farmer is less in Kailali and Kanchanpur districts. To accelerate the adoption of mini-tiller weeders and to create a viable supply chain, the Project facilitated demonstrations of mini-tiller weeder in Punarbas municipality-5, Punarbas, Kanchanpur on 14th March 2020. Demonstrations were led jointly by RCT Agro-Machinery and Engineering, Kanchanpur, and Manjari Traders, Dhangadhi. CSISA invited the local government of Punarbas and Belauri municipalities, representatives from agricultural cooperatives, seed drill service providers and local traders. The project played the key role to bring all supply chain actors in a common platform where they have learnt and shared the experience on this scale appropriate machinery.

Initiating new steps through Virtual Meetings on Mechanization Promotion in Nepal with Public and Private Sectors during lockdown

COVID-19 lockdowns in Nepal from April 2020 resulted in the cancellation of a National Agricultural Mechanization workshop which was planned to be conducted in July 2020 in coordination with Nepalese Society of Agricultural Engineers (NSAE). The objective of the workshop had been to share the mechanization findings and success of CSISA with all stakeholders and help recently formed provincial structures in designing their activities in agricultural machinery promotion. Because a centralized workshop was not possible, NSAE decided to meet with each province virtually using Zoom. They were assisted by CSISA in setting up and conducting these meetings.

Photo 42: Interaction program with private sector partners on the stats of agricultural mechanization during COVID-19 lockdown on 27th May (Snapshot from NSAE Facebook page).

Seven meetings were organized with each provinces from 3rd May to 20th May (on 3rd May in Province 1 ,8th May in province 2, 14th May with Bagmati Province, 16th May in Karnali Province, 17th May in Lumbini Province, 18th May in Gandaki Province and 20th May in Sudurpaschim Province). Each meeting was joined by an Agricultural Minister from MoLMAC, a representative from the Directorate of Agricultural Development (DoAD), and Mayors from and other stakeholders within the province. Most provinces showed interest in custom hiring centers for agricultural machinery, a result that is unsurprising given the governmental focus on hiring centers and subsidy programs. They reported lacking agricultural mechanization specialists in most of the provinces and requested the NSAE to assist in their efforts.

As this provincial governmental program was unable to participation from the private sector, CSISA arranged additional virtual meetings with representatives of the Nepalese Agricultural Machinery Entrepreneur Association (NAMEA) on 27th May, 2020 by Zoom. During the meeting, CSISA presented its study on the impact of COVID-19 on harvesting machinery service business Representative from NAMEA including president Swyambhu Krishna Shrestha stated participated, and provided suggestions that CSISA carried back to provincial governments for consideration.

C2. Managing risk by coping with climate extremes

Climate change is increasingly challenging South Asian agriculture due to the more extreme temperatures and the increasingly erratic and difficult to predict monsoon rainfall. This heightens the importance of farmers having access to irrigation to buffer against drought stress and provide flexibility for early planting that otherwise depend on monsoon rains and residual moisture. CSISA's reach conducted in 2017 and

2018 found that the high cost of irrigation, in combination with smallholder farmers being reluctant to pay for irrigation when rain is likely in the near future, inhibits the productivity of rice Nepal's Terai. This situation presents opportunities for low cost ways of increasing supplementary irrigation to strengthen agricultural resilience. Since 2018, CSISA has focused on overcoming some of the constraints to irrigation identified the early years of the third phase of the project.

Partnerships to reduce irrigation prices through technology development

Since 2017, the project has been (i) exploring options to develop inexpensive solar powered irrigation systems (the '*Sasto Solar Sichai*' technology) made from components that are available in local markets, and (ii) supporting the former DoA's development of low-cost mechanical well-drilling. In February of 2020, CSISA staff supported its private sector partner RCT Agro-machinery and Engineering in Kanchanpur in preparing the *Sasto Solar Sichai* pump for demonstration to visitors from USAID. The project leveraged this time in the field to develop and improve business plans and scaling strategies for the *Sasto Solar Sichai* technology through RCT.

In addition, former CSISA staff Manoj Joshi, who now works at the DoA funded Agriculture Implement Research Centre (AIRC) in Birgunj, continued to pursue the development of improved low-cost mechanical well-drilling technology that was kickstarted by CSISA. Local well-drillers use manual power to lift the drilling shaft requiring significant labor and involving drudgery. The new rig that AIRC allows well drillers to utilize existing small tractors to perform this task, without having to invest into fully mechanized technologies that can cost more than $100,000. While these do not necessarily improve drilling quality as much as fully mechanized systems would, but reduces labor requirements and drudgery at a marginal cost. Survey data about well-drilling technologies were collected from local well-drilling businesses in the Terai during the reporting period to further improve current designs. In addition, CSISA and AIRC have conducted a demonstration of the drilling rig in Rajapur in March – which successfully deployed a hammering method – the most common method for drilling in Rajapur. Additionally the prepared rig was handed over to a local mechanic who will conduct will demonstration of the rig in Rajapur.

This workstream requires considerable in-person work, and action research in the field with partners to test, evaluate, and re-engineer equipment. Activities therefore stalled after the beginning of the COVID-19 pandemic in late March of 2020. Until avenues for safe field work are found, CSISA will therefore focus on its strength in research, analytics and the deployment of timely irrigation advisories through various channels, including mass media. For example, CSISA is currently conducting a training and information demand analysis with existing water user associations. Both canal and deep tubewell irrigation schemes in Nepal are managed by water user associations who schedule water allocations and are responsible for fee collection to support operation and maintenance. As water availability is more secure for many of these water users, they constitute a unique partner needed to develop an enabling environment for irrigation.

However, their training is often limited to water allocation and management, with less attention paid to complementary agronomic practices. CSISA is therefore taking stock of current capacity to identify gaps, as well as assessing demands for agronomic management, market linkages, and issues for handling climate extremes. Based on these analyses, CSISA is planning to prepare tailor-made trainings for trainers to suitable candidates of water user associations. These activities are however likely to have to be held on-line, and will be reported on in the next semi-annual report.

Drivers of groundwater utilization in water-limited rice production systems in Nepal

Photo 43: Farmers in Banke district installing a diesel pump for irrigating their fields (Photo credit: Anton Urfels, CIMMYT)

Inconsistent rainfall has repeatedly damaged paddy crops in Nepal over the last several years, contributing to missed national policy targets of food self-sufficiency and slow growth in cereal productivity, despite many fields being equipped with access to groundwater wells. In a recently published article, project staff explain the drivers of smallholders' underutilization of the groundwater wells to combat in-season drought during the summer rice season in three Terai districts: Rupandehi, Banke, Kailali. The study found that a key constraint is farmers' propensity to schedule their irrigations very late to merely save the crops when in-season drought occurs.

In response, CSISA worked during the reporting together with the international Centre for Integrated Mountain Development to envision ways that seasonal and sub-seasonal precipitation forecasts could be used to advise farmers on irrigation prior to, and during breaks within the monsoon. It is important to note that these forecasts were developed with support from the USAID/Washington funded Climate Services for Resilient Development (CSRD) in South Asia project, led with CIMMYT's implementation. Based on these consultations the CSISA team worked together with local partners including AKCs and PMAMP to develop radio jingles were aired to raise farmers'' awareness of the benefits of using irrigation as well as taking an anticipatory approach to irrigation.

The projections for this year's monsoon season were 'normal-slightly wet'. These prediction materialized with an early onset of the monsoon and no serious dry spells. Given working from home modalities due to COVID19, the CSISA team also made use of data on average precipitation rates encountered over the last seven days reported by the JAXA Climate Rainfall Watch. This allowed the team to screen for the need for any targeted action to combat dry spells and adjust radio and media campaigns accordingly. Fortunately, no major dry spells occurred and jingling was continued on a regular basis, advising farmers to be ready and apply irrigation at the appearance of hairline cracks in the soil of their rice fields and to ensure water availability during critical crop growth stages. CSISA also included COVID-19 related health and hygiene messaging during the radio jingles.

Although lock-downs in Nepal have been for the moment lifted, social distancing measures and altered work modalities remain largely in effect. In response, the team is developing a media outreach campaign including piloting of the use of social media campaigns to reach farmers with additional messaging on weather forecasts and irrigation advisories. The vision is that a system similar to Agvisely will be built, though likely using social media as a primary platform for dissemination. In addition to developing timely schedules for communication and outreach activities based on existing extension materials, CSISA will is also working facilitate linkages between local governmental and farmer cooperative partners with weather information products developed by ICIMOD (e.g. seasonal precipitation forecasts) to guide the development of localized, targeted, and relevant agricultural climate advisories.

What can pump use diagnostics tell agricultural development planners about irrigation priorities?

Groundwater irrigation plays a critical role in supporting food security, rural livelihoods and economic development in South Asia, though large disparities in groundwater access and use remain across the region. In many areas, groundwater development has however also contributed to over-extraction and aquifer depletion, especially in the western Indo-Gangetic Plains. In contrast, groundwater resources in the western Indo-Gangetic Plains of Nepal and eastern India appear to be comparatively under-utilized; current aggregated rates and areas of irrigation also appear to be only a fraction of estimated development potential. A barrier to expansion of groundwater irrigation in the EIGP is the dependence of farmers on expensive diesel or petrol power for irrigation pumping.

Photo 44: Irrigation pump evaluation with CSISA, governmental partners, and collaborators from the University of Manchester and The University of Nebraska–Lincoln in 2020 (Photo credit: Anton Urfels, CIMMYT)

Diesel pumps account for over 80 % of installed irrigation pump horsepower in this region. While desirable in many ways, solar irrigation systems nonetheless face a number of technical and financial challenges that limit their widespread use. Of the nearly 30 million irrigation pumps in use throughout India, about 70 % run on grid electricity, 30 % are powered by diesel, and only 0.4 % are solar. Similar constraints exist in Nepal. Addressing sub-optimal performance of existing diesel-pump irrigation systems could conversely offer an alternative for delivering quick improvements in the affordability of groundwater irrigation.

Results from a survey 434 randomly selected households from Rupandehi and Kapilvastu along with 116 in-situ pumping tests – conducted in partnership with the University of Manchester – show that there are huge disparities in how much individual farmers must pay to access groundwater for irrigation in the Nepal Terai. Access costs range from as little as USD 4 per hectare to USD 53 per hectare for each irrigation event. Highest costs are borne by those farmers that depend on renting pump sets for irrigation, who typically represent the poorest and most marginalized households that have limited capital resources or little access to credit. Specifically, our preliminary results suggest that ownership of a pumps is associated with an increase of 37% (1.19 tons/hectare) in monsoon rice yields and 20% (0.5 tons/hectare) in wheat yields relative to productivity of pumps renters who irrigate crops less frequently due to significantly higher costs of groundwater access.

Pump selection was also found to be a key determinant of irrigation costs, with many farmers using large Indian-made pumps despite the fact that these pumps are more costly to operate and purchase relative to smaller horsepower models. Large horsepower diesel irrigation pump sets traditionally preferred by farmers are found to be approximately 28% more expensive to purchase and operate than smaller horsepower diesel pump sets manufactured in China and widely used in Nepal. These diesel pump sets also outperform newer Indian pump sets with equivalent engine sizes, in large part due to their greater fuel efficiency and lower capital costs.

This work package also clearly indicated that farmers are not fully aware of the potential fuel efficiency or economic benefits provided by diesel pumps. Farmers commonly underestimate fuel consumption of

Indian manufactured diesel pumps, while overestimating the fuel consumption of smaller diesel pumps This suggests that the common perception of smaller pumps being less cost effective due to their shorter operational lifespan and more frequent maintenance requirements is incorrect. Improved fuel efficiency and lower repair costs of small horsepower diesel pumps more than counteract these costs, and the comparative advantage of smaller pumps could be enhanced further through future efforts to improve quality standards of pumps and spare parts.

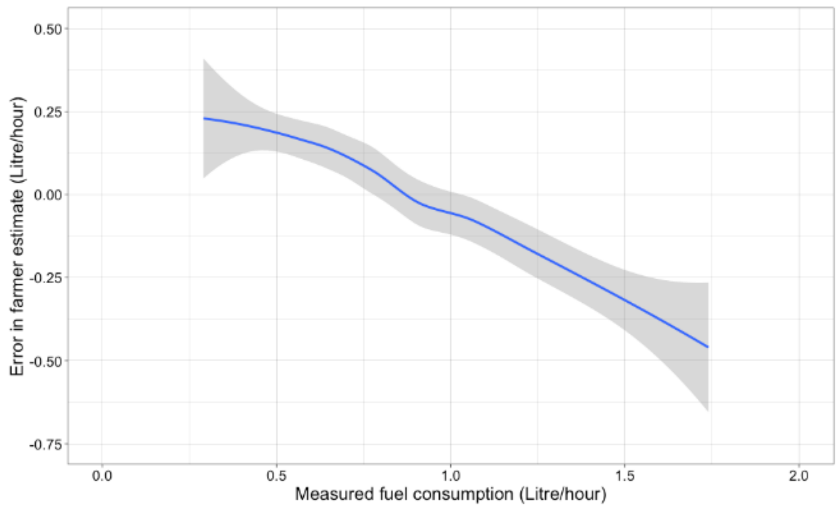


Figure 46: Farmers' error in estimating their pump's fuel consumption plotted against actually measured fuel consumption based on field test of pumps in farmers' fields. Farmers with fuel efficient pumps tend to overestimate their fuel consumption, while farmers with pumps that consume more fuel tend to underestimate fuel consumption.

Variation in irrigation access costs have important implications for how farmers use irrigation and how resilient they are to weather shocks. When irrigation costs not significant, research conducted by CSISA has indicated that farmers irrigate their crops more often and are less exposed to risks posed by drought and year-to year uncertainty in the timing of the monsoon onset. More intensive use of irrigation improves agricultural productivity, with higher crop yields helping to reduce food insecurity, boost incomes and help farmers to escape chronic poverty cycles. Together with previous research on irrigation conducted by CSISA, these findings indicate that while diesel-pump irrigation is still a 'second-best' solution to lower cost and cleaner electrical pumps, there are ways of adapting these existing systems to make them both productive and profitable for farmers.

The outcomes of this workstream indicate that key policy priorities include enhanced financial support, for example through subsidies or credit systems, to enable pump set purchasing by poor and water insecure households. Furthermore, on-the-ground engagement is needed to encourage and support alternative fuel-efficient pumps designs. Low-cost portable pumps appear to fulfill several key needs of farmers. However, adoption remains slow due to limited availability of maintenance services, spare parts, a lack of appropriate standard and quality control within supply chains, and a lack of understanding amongst farmers about the potential fuel and cost savings offered by these pump sets. Near-term improvements in performance of diesel-pump irrigation systems can also have the added benefit of reducing reliance on these systems in the medium- to long-term future. Farmers who have higher incomes and are less exposed to production risks in the present are likely to be more able and willing to invest in new irrigation technologies (e.g. solar) and other productivity-enhancing farming practices. Such changes could contribute to reducing poverty and food insecurity in Nepal and other presently impoverished and water-insecure parts of South Asia.

Based on the above research findings, the CSISA team has started to develop pump set purchase and installation guidelines for farmers and irrigation pump dealers in Nepal's Terai. These guidelines aim to reduce the operation cost of diesel pumps through simple engine settings based on the evidence generated from pump testing and pump engineering best practices. In the next year, CSISA will distribute these guidelines with government and private sector actors and will aim to conduct national consultation with the goal of establishing national pump set recommendations through government partners in consultation with the private sector. A key goal will be to provide documented advice on choosing cost-effective pump technologies for overcoming dry spells.

Irrigation benefits for poverty alleviation: An integrated study in Nepal and India

Understanding the potential impact of technology use on a households' livelihood sheds more light on the dynamics that govern adoption of new technologies such as groundwater irrigation in rice-wheat systems. To better understand these issues and identify avenues for agricultural extension and policy response, CSISA has begun partnering with Dave Harris from the International Center for Research in the Semi-Arid Tropics (ICRISAT) and Kai Mausch from World Agroforestry and leveraged the project's regional data resources to estimate the impact of increasing the number of irrigation in rice-wheat systems on household income.

Given that land fragmentation and large household sizes are often cited as a major inhibitor to agricultural productivity, this workstream examines personal daily income values – rather than profits or yield. With the international poverty line commonly defined as an income of USD 2.10$/person/day, the results of this workstream have provided a new angle on the adoption of supplemental groundwater irrigation and its relation to poverty alleviation. The preliminary results indicate that irrigation increases household incomes, but that for large households and households with small landholdings, irrigated rice-wheat systems alone cannot lift the households above the poverty lines. Rather, additional farming systems interventions and alternative income generation strategies are also needed, which reflects in CSISA's multi-faceted approach to rural development.

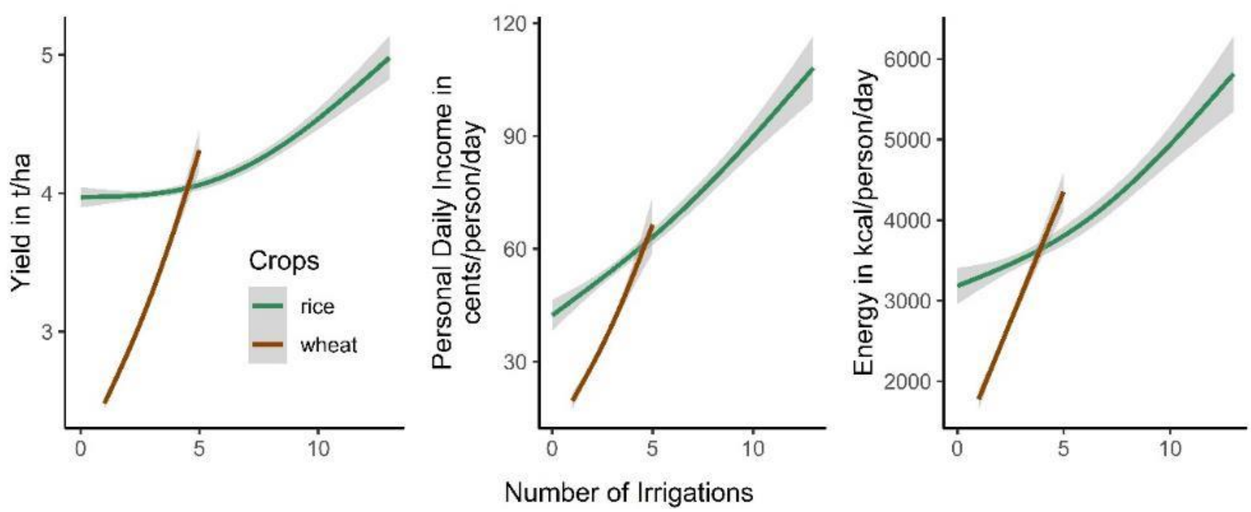


Figure 47: Preliminary results on the impact irrigation on yields, poverty alleviation, and calorie provisioning for different levels of irrigation use. Note that personal daily incomes are in $PPP and assume free irrigation.

We further analyzed typical farm profitability values and found that for best practices the majority of households would also not be lifted above the poverty line. In relative terms, however, agronomic best practices and diversified agricultural production can increase farmer incomes by ca. 30-100%. If these incomes are low to start with, however, gains for poverty reduction in absolute terms require inclusive and decent off-farm work opportunities that can be created through complementary investments in agricultural value chains and mechanization.

Research results also show that sustainable transformations of Nepal's cereal system are feasible, even with existing irrigation technology, but that multi-faceted efforts are required with differentiated targeting of households that take into account their family and landholding sizes, non-agricultural income sources, and additional crops. These further highlight the need for a livelihoods perspective that informs our understanding of adoption outcomes, sustainable intensification strategies and investment planning. Specifically, these findings are being considered for the development of the sustainable irrigation development framework that is being developed with support of the CSISA COVID-19 Resilience buy-in for CSISA from USAID/Nepal (see section 5 of this report).

3. Policy Reform – Achievements

D1. SEED SYSTEMS

Bangladesh

As described in the 2018-19 Annual report, activities in Bangladesh around seed system policy reform were phased down due to transitions in the project's leadership within the International Food Policy Research Institute (IFPRI) and project funding uncertainties as described in the Executive Summary and 'Challenges Faced During the Reporting Period' sections of previous CSISA reports. CSISA, however, maintains a rich network of contacts and partners in seed systems work in Bangladesh, and the project is positioned to leverage these relationships to pursue additional seed systems policy research activities if there is sufficient interest and funding to support such activities in the future. One potential avenue for strengthening this work was to align it with ongoing work in the CGIAR Research Program on Policy, Institutions and Markets. However, due to the departure of yet another key personnel with expertise in seed systems from the project, the proposed study with PIM has been put on indefinite hold.

Nepal

During the reporting period, work on crop varietal turnover in Nepal was reinvigorated with a review of government policies, plans, and regulations about Nepal's seed systems to understand the constraints to attract private investments in the propagation and marketing of improved varieties of rice, wheat, and lentil seeds. We are complementing the policy review with the analysis of the data on varietal adoption of rice, maize, and lentils collected in a primary survey of 1,989 farmers from the FtF districts of Nepal in 2016-17.

As a part of this research, CSISA is preparing an inventory of new open-pollinated varieties (OPVs) and hybrid seeds of rice, maize, wheat, and lentils registered in the last 15 years. The project is also collecting information on time, costs, and procedures involved in the registration of new varieties of seeds. Analysis of primary survey data will the mapping of the penetration of the relatively new varieties of seeds in different parts of Nepal and assess the average age, measured in years since the registration of the variety, of the varieties of seeds of cereals and lentils grown in the FtF districts of Nepal.

Private companies dominate the market for hybrid seeds in Nepal. Nepali seed companies face tough competition from companies and varieties registered in India. There is a vibrant market for Indian seed varieties that come to Nepal without any regulatory clearances. Inadequate production of breeder and the foundation seeds is a major constraint to the rapid adoption of improved varieties of seeds. The Indian Agricultural Research Institute (IARI) has set up a business incubation center to foster partnerships with small and medium-sized seed companies and startups to propagate and market newly released varieties of rice and wheat seeds. Larger private companies tend not to show interest in the business of OPVs because of low margins. Engaging with smaller firms has helped IARI to increase the production of foundation and certified seeds and multiply the outreach to farmers. Before such partnerships started, IARI had to depend entirely on the public extension system for popularizing new seed varieties. The public-private partnership allows IARI to leverage the profit motive and the larger outreach of private companies to accelerate the adoption of new varieties they develop. Each private company also pays a one-time license fee and a small royalty (1-2%) for the right to multiply and sell seeds.

To this end, CSISA is now engaging with the IARI incubation center to understand if a similar public-private model can be replicated in Nepal. We are also exploring if these companies can be paid incentives, instead of being charged a royalty, to sell new varieties in the less developed districts. Further work on this had stalled because of the COVID-19 lockdown and travel restrictions in India and Nepal. This activity will be resumed in the next reporting period after travel restrictions are lifted and the COVID-19 crisis in both countries are under control.

D2. SCALE-APPROPRIATE MECHANIZATION

Bangladesh and Nepal

Due to funding uncertainties, the project halted its direct policy work on scale-appropriate mechanization in Nepal and Bangladesh in 2017. Staff transitions within the CSISA due to funding uncertainties also hindered the project's ability to contribute to this workstream. Efforts were therefore redirected towards soil fertility management and fertilizer market work, which emerged as more relevant workstreams in light of the project's new priorities.

However, we did undertake a pilot study around small scale machine equipment- in particular, fertilizer spreaders- and ways to generate demand for it using innovative extension methods in Nepal. This work was done in Kharif 2019 and data was collected at baseline, before sowing and at the end line, post-harvest. This work straddles both soil fertility management and mechanization workstreams. More details are presented in the next section.

Moreover, due to renewed interest and improved fund availability, policy research activities around scale-appropriate mechanization in Bangladesh will be pursued over the next reporting period. CSISA will be undertaking a process evaluation around subsidy and credit policies and programs for agricultural equipment in Bangladesh, in collaboration with CSISA-MEA (Mechanization Extension Activity) project supported by the and local partners. Both primary qualitative and quantitative data, as well as previously collected administrative data on machine subsidies will be used for this exercise.

D3. SOIL FERTILITY MANAGEMENT AND FERTILIZER MARKETS

In this reporting period, CSISA's policy scientists focused on strengthening soil fertility management and fertilizer policies in Bangladesh and Nepal to leverage existing research and activities on the Bill and Melinda Gates Foundation (BMGF) component of the project, which now focuses on India but also coordinates with Nepal and Bangladesh.

Bangladesh

Impact of non-urea fertilizer price changes on fertilizer use in Bangladesh

Fertilizer subsidies form the highest component of agriculture sector budget allocation in Bangladesh. In financial year 2017-2018, subsidy for fertilizer and other inputs was approximately USD 0.7 billion, almost half of the total agriculture allocation (Bangladesh Economic Review , 2018)[10]. The country has consistently assessed its fertilizer pricing and subsidy policy to ensure a wider reach of fertilizers. Balanced fertilizer application has been a driving force behind these policies. There was drastic reduction of non-

[10] Bangladesh Economic Review. (2018). Government of the People's Republic of Bangladesh. Ministry of Finance, Dhaka.

urea fertilizer prices from 2008 (49) onwards which continued till 2012, following the fall in international fertilizer prices. The sharp price reduction made P & K cheaper in Bangladesh than India. This move was aimed at increasing the access and use of non-urea fertilizers among the farmers and encouraging balanced fertilizer application. Open market sales were reintroduced in 2010 under which farmers could purchase urea at a fixed price and non-urea fertilizers at market prices[11].

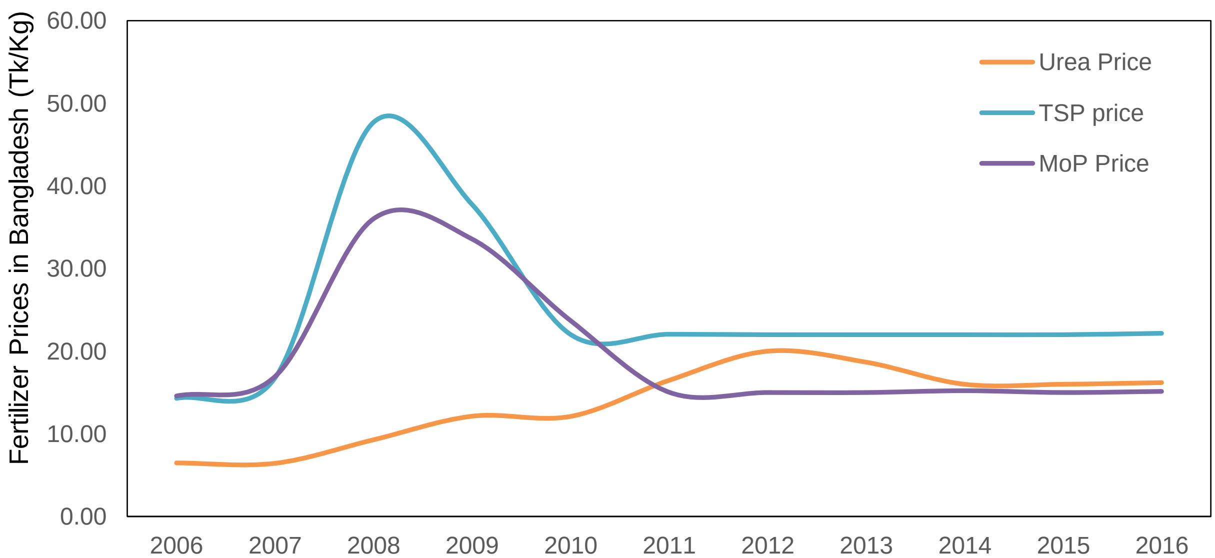


Figure 48: Fertilizer Prices in Bangladesh (Tk/Kg) (Source: Department of Agriculture Marketing, Bangladesh)

However, there has been no substantive evidence on the policy implication of relative price changes on fertilizer use trend of N, P and K among farmers in Bangladesh. While secondary data reflects an expected increase in the consumption of non-urea prices, it is crucial to understand whether the price changes translated into changes in farmer-level use of fertilizers and if farmers were able to reap the benefits of this massive subsidy enhancement.

In this reporting period, CSISA has analyzed three different data sources covering the period of price change to assess its impact on fertilizer use. This includes studying the price and quantity responses via two secondary datasets- Village Dynamics in South Asia (VDSA) collected by ICAR-ICRISAT across India and Bangladesh, and Bangladesh Integrated Household Dataset (BIHS) which collected data across two rounds in 2010-11 and 2013-14 of over 3,000 paddy growing households. The analysis also refers to the secondary fertilizer consumption data from the 2018 Bangladesh Fertilizer Recommendation Guide.

VDSA is a high frequency data, containing plot-level information of over 300 paddy-growing farmers from 2010 to 2014. However, the dataset lacks representation as it was only collected from 12 villages of 11 districts in the country. BIHS, on the other hand, is a larger representative dataset, but was only collected for two time periods and is essentially recall data. While the VDSA dataset provides extensive plot-wise information on farming practices and fertilizer use, it clubs fertilizer application into one variable. Price

[11] Jaim, W., & Akter, S. (2012). Seed, Fertilizer and Innovation in Bangladesh: Industry and Policy Issues for the future. International Food Policy Research Institute.

and quantity matching techniques for the time period are being used to segregate fertilizer use. Due to a similar price range for TSP and MoP, distinction between the two is not possible, and hence, the analysis has been done for combined application of MoP and TSP. The analysis has been conducted based on both datasets, cognizant of their shortcomings.

Differing results across three datasets

The impact of the price fluctuations is evident in the secondary fertilizer consumption data but its impact in farm level data is not equally unambiguous, especially for P and K. Examining secondary data, urea use in the Bangladesh follows the price pattern, as it plummets with the price increase until 2012, though it then increases with the fall in price post 2012 till 2014. The decline in price from 2008 was accompanied by an increase in quantity consumed of non-urea fertilizers, after which MoP consumption fluctuates while TSP consumption maintains an increasing trend.

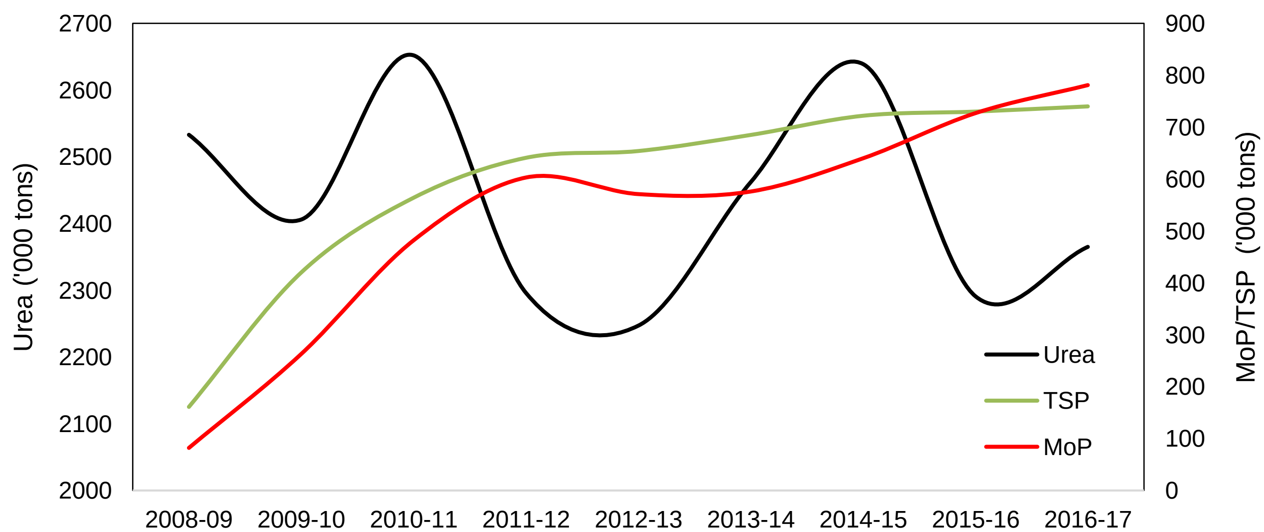


Figure 49: Fertilizer use in Bangladesh ('000 tons) (Source: Bangladesh Economic Review 2018, Bangladesh Fertilizer Recommendation Guide 2018)

According to VDSA, a decline of 11% was observed in urea application post-2012 when the prices were at the highest at Taka 20/kg (less than USD 0.003/kg). 2012 also marked the lowest use of fertilizer in the country. This shows a quick translation of high prices into reduced demand, reflecting price elasticity among farmers. In another primary data based study of fertilizer demand and subsidy in Bangladesh, the authors found that for smaller farmers, the constraints to fertilizer access are financial whereas larger farmers face issues of unavailability[12]. Fertilizer use however picks up in 2014 as per the VDSA data following the same pattern as that of the country-level data. In BIHS data too, a 3% increase in urea application was observed, and 26% and 38% increase in P and K application, respectively, was observed in paddy over the two rounds.

[12] Barkat, A., Faridi, R., Wadood, S., Sengupta, S. K., & Hoque, S. E. (2010). A Quantitative Analysis of Fertilizer Demand and Subsidy Policy inBangladesh. Manob Sakti Unnayan Kendro. Retrieved from http://fpmu.gov.bd/agridrupal/sites/default/files/Barkat.pdf

The decline in MoP prices continued until 2011 before it stabilized. VDSA data shows opposite results as that of BIHS data and secondary data. VDSA data suggests a reduction in application of MoP and TSP as the prices were falling. The VDSA dataset combines the two fertilizers, and hence the change in quantity can be confounded, however, the price trend was same for both the fertilizers.

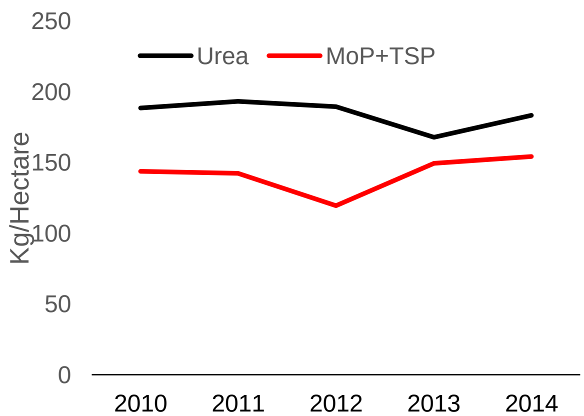


Figure 40: Average Fertilizer use (Kg/Hectare)- VDSA data (Source: VDSA Dataset (ICAR-ICRISAT), 2010-2014)

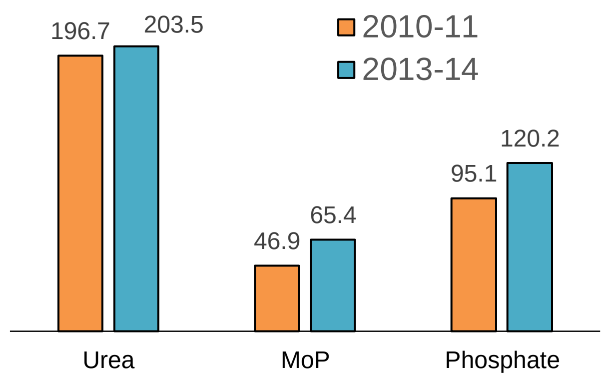


Figure 51: Average Fertilizer use (Kg/Hectare)- BIHS data (Source: Bangladesh Intra-Household Survey (IFPRI), 2015)

Two sources of data corroborate the economic intuition of increase in demand and use as prices fall. However, it is hard to ignore the results of VDSA dataset. The impact on fertilizer use in West Bengal, a neighboring Indian state that shares borders with Bangladesh, was also analyzed using Commission for Agricultural Costs and Prices (CACP) data as fertilizer prices also changed (increased) in India around the same time, and a similar price inelasticity was observed as the use of P increased with increase in prices.

A policy move aimed at correcting fertilizer use and promoting balanced nutrient application requires an examination into whether the objectives have been achieved when policy changes are instituted. More research will enable better understanding of whether such a massive fertilizer subsidy program is the right way to motivate farmers or if it is simply distortionary. Factors such as porous borders also require serious policy considerations as price differentials across Bangladesh-India provide ample opportunity for arbitrage and leakage. Based on the most updated research-based fertilizer recommendations, CSISA plans to assess whether this policy move nudged the farmers in the right direction, and encouraged balanced fertilizer application over the next reporting period. The findings from this analysis will be used to prepare policy briefs and an interactive stakeholder workshop drawing attention to the need for evidence generation and extension to encourage balanced fertilizer application by farmers in Bangladesh.

Nepal

Manual hand crank fertilizer spreaders as an alternative to broadcasting

The work under this sub-workstream built on existing studies being done by CSISA around developing markets for manual hand crank fertilizer spreader machinery. The central hypothesis was based around the finding that fertilizer use in Nepal is both lower than recommended for all macro-nutrients and unbalanced, favoring nitrogen-heavy fertilizers. In such a context, manual broadcasting of fertilizers by hand (as opposed to a manually cranked spreading machine) further contributes to inefficient nutrient recovery by the crop in the short term, and in the long term, exposes farmers to potentially hazardous side-effects from handling of urea and other fertilizers. To remedy this, fertilizer spreaders can be encouraged as an affordable and viable alternative to broadcasting. However, since the technology is novel and not widely used by farmers, it is important to generate demand for it by introducing farmers to it using a mix of extension and financial incentives. A social-experiment study done by CSISA addressed both these components.

The pilot study was conducted with 300 farmers in Province 7 of Nepal in the summer of 2019. This is a major rice growing area in the Terai of Nepal. The respondents were divided into four groups of 75 each. The control group received no extension or financial incentive. The second group was offered one spreader service for up to one kattha (0.034 ha) of land for free without any information on its potential benefits. The second group received information on spreaders in a traditional face-to-face based extension set up by trained enumerators, in addition to the free first service. The final group received all the above and was also shown videos produced by CSISA on ways to use spreaders and its benefits. In the experiment, fertilizer was to be provided by farmers, but the service of spreading the fertilizer using the hand-held spreader was provided for free. After the first use, a second service was offered to the farmers at a heavily subsidized price which was determined from farmers' willingness to pay in the baseline exercise.

The spreader service was availed by 18.2 percent of respondents of the 225 farmers who were offered the service. The data indicated the average uptake of spreader service is significantly higher among male decision-makers than among women. This is not necessarily surprising, given that most fertilizer spreading in Nepal is done by men, although it does underscore that in order to reach women with this intervention, additional strategies and tactics may be needed to raise awareness of, and demand for, the spreaders. As part of the survey, the project team was also able to collect detailed information on fertilizer use by farmers, allowing the study of factors affecting fertilizer access and use among respondents. It was found that fertilizer usage is lower among women agricultural decision-makers than their male counterparts by around 24 kilograms per hectare, on average. Agricultural cooperative membership was the major determinant of fertilizer access, and appears to increase use of fertilizers by 36 kg/ha. One hundred and eighty four farmers were also about the reasons for not choosing spreader services. Among the major reasons reported was an inability to locate spreader service providers (27% of respondents), followed by a preference for the traditional

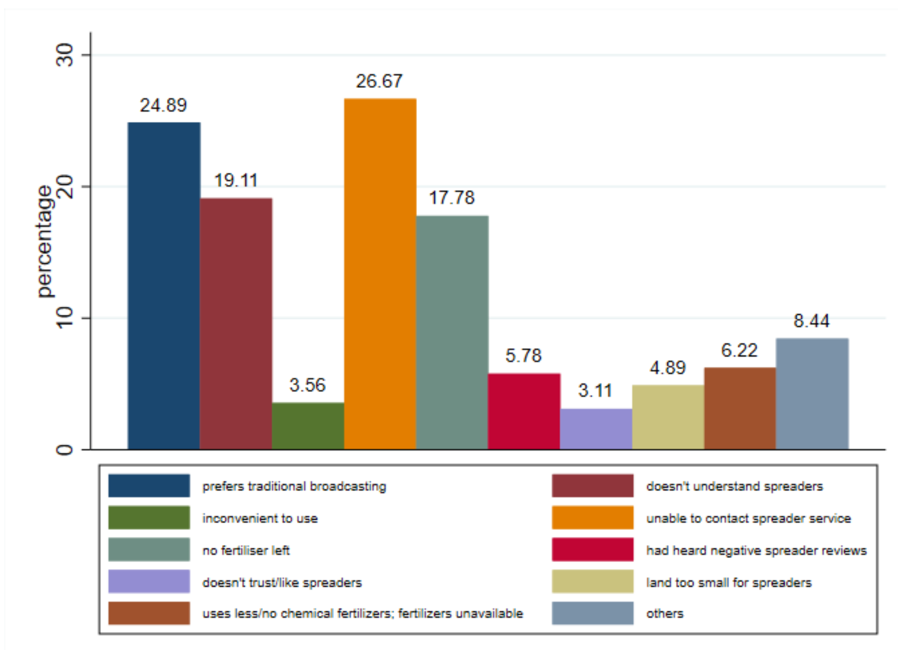


Figure 52: Survey results indicating common reasons for not availing free spreader services in Nepal.

method of fertilizer broadcasting (25%), and also unavailability of fertilizers in markets when and where needed (19%), as well as challenges in use of the spreader (18%).

There were no takers for the paid second spreader service where farmers cited affordability and connectivity issues. A willingness to pay (WTP) exercise was also carried out among farmers for spreader service in both the rounds of data collection. In the baseline data collection, over sixty percent of farmers who were in the treatment groups reported a WTP of NPR 10 per kattha or more (USD 2.5/ha). Out of all those who received a spreader service, over forty-eight percent had reduced their WTP post the spreader service while twenty-nine percent had stated a higher WTP in the end line exercise, and twenty-one percent had not revised their WTP at all. Since they reported realizing benefits from the service, their revisions cannot be attributed to unfavorable experiences with spreaders. Repeatedly reported affordability issues may well mean that they place a lower value on the machine.

D4. AGRICULTURAL RISK MANAGEMENT

Examining risks and extension options for Fall Armyworm mitigation in Bangladesh and Nepal

Given the threat posed by Fall Armyworm (FAW) in Nepal, CSISA conducted an another social experiment to explore the effectiveness of different extension approaches in building farmers' knowledge on the diagnosis and management of FAW, This included efforts to quantify the ways in which extension messaging influences the adoption of Integrated Pest Management (IPM) approaches appropriate for FAW. This is a new workstream in the CSISA project, added due to the emergent threat posed by FAW.

Photo 45: Survey team members participating a field scouting exercise in Dang district, Nepal, as part of the training workshop on "Awareness creation, identification, and management of Fall Armyworm (FAW)" organized by the Province Five FAW Task Force with support from CIMMYT between 16-17 February, 2020 (Photo credit: Prapti Barooah, IFPRI)

Adapting to the COVID-19 pandemic, the experiment centered around the assessment of Information and Communications Technology (ICT) tools for promoting IPM solutions in Dang district of Province 5 in Nepal. While the pandemic curtailed all movements and impacted physical modes of agriculture extension, the looming threat of FAW on maize made it exigent to reach out to farmers with timely and accessible information. Instead of the earlier proposed in-person extension approaches, the experiment was modified to include phone-based extension to farmers.

The objective was to measure the effectiveness of the differing information mediums on improving farmers' knowledge of FAW and related IPM messages. The experiment was carried out in two treatments with one control group. The latter consisted of 970 respondents who were not provided with any information on FAW. The first treatment branch with 991 respondents received an auto-recorded voice call with information on FAW management along with four weekly SMS reminders providing the same information. The second treatment branch of 728 respondents received a phone call from a trained enumerator providing the same information on FAW as that of the voice call, along with the same four weekly SMS reminders. All the experimental arms were administered a knowledge test at both baseline and end line to assess the marginal effects in knowledge gains due to the phone-based interventions. The respondents for this study were identified on the basis of a listing exercise undertaken between February-March 2020 wherein over 5,000 maize farmers were surveyed during the summer cropping season.

Photo 46: A woman farmer in Dang district, Nepal inspecting her maize field for Fall Armyworm (Photo by Prapti Barooah)

For the voice call system and SMS delivery, CSISA partnered with Viamo Inc.. The phone call intervention was carried out with the help of trained enumerators of Institute for Integrated Development Studies (IIDS). Data collection activities were also undertaken by IIDS for both the rounds. The information that was extended to the farmers via these interventions had been developed through close consultation with CIMMYT, and had also been approved by Nepal's National FAW Taskforce.

Baseline data collection was carried out from May-June via phone surveys, using the Survey CTO-CATI platform. The experimental intervention treatments were rolled out in tandem with the baseline data collection, from June-July. The end line data collection was from August last week to September second week, two months after the last intervention batches were rolled out. Information was also collected on the impact of COVID-19 on farmers' livelihoods, agriculture extension, farm input accessibility, and economic impact including remittance inflow dynamics from migrant workers.

Since the data collection exercise had to be limited to phone surveys, only those farmers who had phone accessibility could be contacted for the experiment. The baseline survey covered 2,689 maize-growing farmers from 134 villages across four municipalities (Lamahi, Shantinagar, Rapti and Dangisharan) in the district. With an attrition rate of 15%, the end line survey covered 2,304 farmers. 70% of these respondents were female agriculture decision-makers.

Preliminary survey results considering FAW and the implications of COVID-19 lockdowns on extension information

During the baseline survey, over 80% farmer respondents reported some awareness about Fall Army Worm. Only 14% reported experiencing FAW attack during summer maize cropping in 2019. In the 2020 summer season, the majority of the respondents (>80%) reported experiencing FAW attack on their summer maize. FAW attack on maize impacted the yield of the crop, inputs costs, time allocation, and damaged adjoining crops. Of the farmers who reported FAW attack, 68% report lower yield of maize as an outcome of the attack. Increased input costs and time requirement were also reported by over 47% respondents.

After Nepal's lockdown began, restrictions on movement and distancing norms rendered conventional methods of extension inaccessible. Respondents were asked about their information sources for pest management before and after lockdown. Agrovets (agricultural input retailers) emerged as the most relied upon source of information for over 53% of respondents before the lockdown, followed by the use of social networks or other farmers, and their own knowledge/past experience.

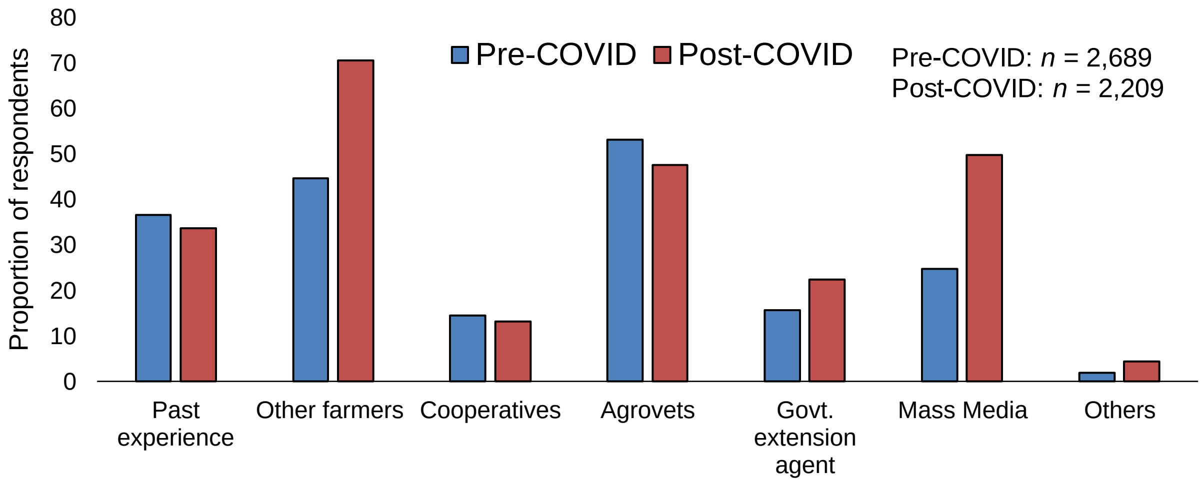


Figure 53: Sources of information to manage pest attack: Pre and post COVID-19 lockdown

After the lockdown, farmers increasingly relied on their own social networks and mass media for agricultural information, along with a decrease in farmers' reliance over agrovets. Female respondents reported higher reliance on other farmers while more male farmers reported agrovets and governmental agencies as sources of information after the lockdown. Over 25% respondents were not able to contact agrovets for any advice/requirement since the lockdown up to June. The change in the information sources and availability of timely and quality extension services impacted farming activities. Around 29% of the respondents reported that the overall quality of agriculture information had worsened, while 35.17% respondents shared that their farm suffered due to their inability to access timely information.

Access to agriculture markets and farming inputs following COVID-19 lockdowns

The baseline survey captured the market conditions faced right after the lockdown (coinciding with wheat harvest), and the end line survey covered the market conditions for crops (primarily, maize) which were harvested in and around the month of August. Many of the respondent farmers are primarily substance providers. Of those who harvested crops before the baseline survey, only 55% reported selling their produce in the market. During the end line survey, only 29% respondents reported selling their crop in the market. Of the farmers who sold their produce during the lockdown, over 29% were not able to sell the produce easily. They faced issues such as mobility restrictions, lack of transport means, poor demand and lower prices. For the subsequent summer crop, which was sold four months after the lockdown, only 7.89% farmers reported facing any issue while selling the produce.

Farmers' curtailed access to markets did not only affect the sales of farm produce but it also bore consequences for further sowing plans and livestock sector. For the crops sown after lockdown commenced (April-June), 54% of the respondents faced issues in procuring inputs. More than half of these respondents faced issues in seed procurement, such as lack of variety, untimely seed availability, higher prices, mobility restrictions. Over 75% of these respondents reported issues in fertilizer access. The proportion of respondents reporting difficulties in procuring inputs increased to 63% for summer maize cropping. Most of the issues around access stemmed from significant limitations in fertilizer access (93% of respondent). Around 30% farmers continued facing issues with seed procurement, citing lack of variety and higher prices as major difficulties.

Economic impact and coping strategies adopted by farmer households following COVID-19 lockdowns

Surveyed respondent farmer have diversified income portfolios. Over 78% respondents reported working on farm/tenancy as a source of income in the first round of data collection, and around 52% farmers reported earning income via salary/wages. Respondents also reported a clear fall in income from remittances, wages/salary and business following the commencement of COVID-10 lockdown in Nepal. Over 80% respondents indicated that remittance income had declined due to the lockdown, while 17% reported no change in the income from remittances. Immediately after the lockdown began, there was a halt on the movement of migrants stuck abroad who could not make their way back to Nepal. Over 90% respondents who depended on business for income generation, indicated there had been a decrease in income.

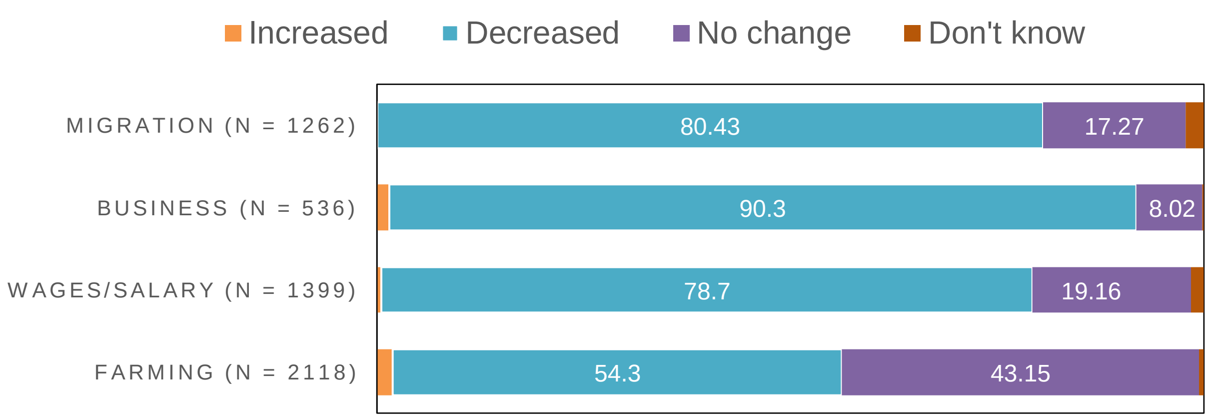


Figure 54: Impact of COVID-19 lockdown on income sources including farmer sample sizes (N)

Respondents were also asked about their monthly household incomes during the two survey rounds. While 26.4% respondents reported no income from mid-April to mid-May; 30% respondents reported no income from mid-July to mid-August. The impact of the COVID-19 lockdown is still being felt as 9% respondent farmers had no monetary income for both periods.

After lockdowns were lifted, over 70% of respondent households had to use at least one coping measure to deal with the economic impact. The most common coping strategies were to use their savings, seeking help from friends, relatives and neighbor, and using less expensive food items. 47% respondents reported using their savings. Farmers also sought help from NGOs and the government, and friends and relatives. During August, over 77% respondents took a security action. Over 42.87% respondent households were still relying on their savings to meet their needs.

The project team is currently working on additional data analysis to determine the effectiveness of the phone-based extension interventions. Post the analysis, the results from this experiment will be disseminated among all relevant stakeholders in the form of discussion papers, research notes, and a journal article. The Project will also be engaging in conversations with regional stakeholders to facilitate cross-country dialogue on effective extension approaches for promoting knowledge and adoption of IPM solutions. In addition to IPM and extension methods, the results from the study can also contribute to the ongoing discourse on building resilience in the agricultural sector post-COVID-19. As distancing becomes the new normal, the relatively high penetration of mobile phone usage within the country can be utilized for remote delivery of extension and advisory services to farmers. The study findings will add to the existing evidence on the effective approaches for conveying IPM messages to farmers, especially during the unprecedented crisis of COVID-19.

4. CSISA Nepal Impact Study

Overview

In order to understand and measure changes in farmer livelihoods due to technological and institutional interventions by the CSISA in Nepal, the project initiated an empirical impact evaluation in early 2020. The objectives of this activity are two-fold: (1) to estimate the farm-level reach and adoption of sustainable intensification practices popularized by CSISA in Nepal Terai, and (2) to document the impact of these technologies on farm profitability, farmer income, and livelihoods of both men and women, and of marginalized groups. In this Annual Report, research results addressing how inclusive these technologies are and whether there is a need for additional social targeting in extension and scaling efforts are addressed. The impact assessment methodology that CSISA is using has been developed and iteratively revised and improved in a process including a detailed review of literature on technology adoption and impacts, field visits, detailed discussions with project personnel, and examination of available datasets and reports. The evaluation process is conducted in three steps:

[1] Estimating the reach of some of CSISA's key interventions in Nepal and clarifying impact pathways for particular agronomic technologies through a census survey and an examination of project documents

[2] Developing a refined gender Theory of Change (ToC) for the CSISA project, and using it to evaluate project performance in Nepal (through a review of the literature and interviewing key CSISA personnel).

[3] Estimating the gendered impacts of selected CSISA interventions on farming systems productivity and farmers' livelihoods (though farm-household surveys)

Methodological background

By October 2020, the team of CSISA evaluating scientists – who were not involved in implementation of CSISA's other research or development activities – have completed Step 1 and partly completed Step 2. However, due to COVID-19 and related travel restrictions and risks, the household survey (Step 3) has been postponed until 2021. Key aspects of Steps 1 and 2 are therefore described here. A list of CSISA interventions was first generated through discussion with project personnel. To estimate the reach of these technologies, a rural household census was next carried out. For this and the following household survey, the team aimed to collect data from eight districts of the Nepal Terai region – Banke, Bardiya, Dang, Kailali, Kanchanpur, Kapilbastu, Parasi, and Rupendehi. These are the primary districts where CSISA has been active in the last decade. These districts are also the major cereal producing parts of the country. From the complete list of wards (smallest administrative unit) of 8 districts, 50 wards were selected randomly. The number of households living in the ward was used to determine the number of sample wards to be included per district. The resulting random list included 17 wards (34% of the sample wards) where CSISA is active.

Village census

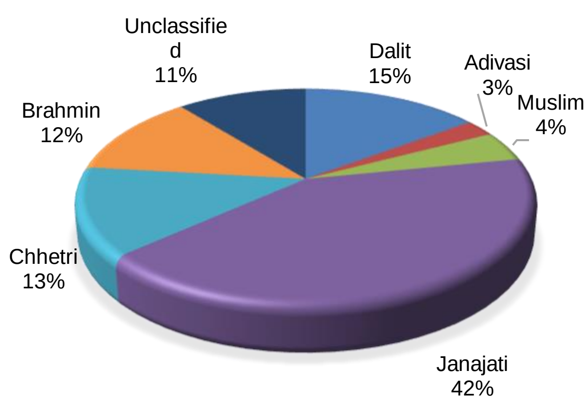
In each of the 50 wards, the household census was conducted within a period of two months (February-March 2020), during which the basic farmer information alongside technology adoption details were collected. The questionnaire coding was carried out by the survey agency, using CAPI software (Surveybe). The questionnaire was revised and finalized based on the suggestions from CSISA researchers. The enumerator training was held in the first week of February at Kathmandu, Nepal. The census questionnaire was discussed in detail, and the investigators were requested to clarify the terms used and functions of various farm machinery. CSISA's scientists made a comprehensive presentation on the questionnaire and explained the technical details of various technologies included, with the help of visuals. Discussions were carried out regarding the procedure to edit, save, and re-edit the data, collect GPS coordinates, and to do the final data submission. Later, the team was asked to pair up and practice a mock (census) survey, in which one member acted as the farmer respondent and the other the investigator. The mock exercise was carried out to acquaint the members in operating tabs, handling software, asking questions, taking GPS coordinates, saving and editing files, and final submission of data. The survey firm manager, supervisors, and the CIMMYT representatives facilitated the mock exercise by sharing the inputs as and when required. Before each interview, informed consent was sought from the respondents, as outlined in the short census questionnaire that also provided assurances that personal identifier information would be protected. Information provided before seeking the consent included reasons for the study, consequences of participation, risks, or discomforts associated with participating, details about confidentiality, and the voluntary aspect of participating. Questions arising at that point were answered, and participants were informed of whom they can reach if there had more questions about the study. The consent was recorded on the tablet through a YES/NO answer.

Focus on social inclusion

Our impact analysis framework gives a special focus on social heterogeneity and its effect on the impact magnitude. We aim to examine the interplay of caste as a hierarchical social institution, and also gender. The relevance of these factors is presented in the figures and tables below.

Village census

Farm-households from the census were categorized into seven caste groups, Janajati is the caste group that contained the largest share (42%), although Dalits, Chhetri, and Bramins also showed of considerable numbers in the survey sample.



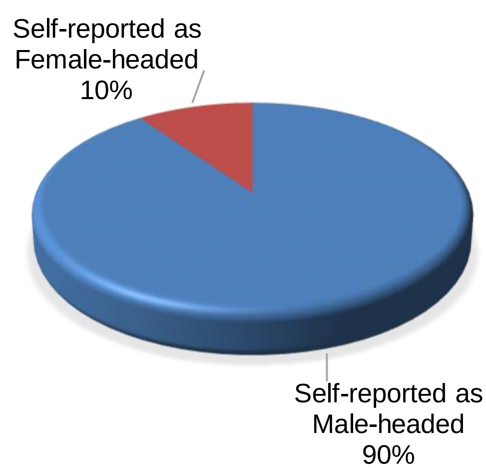


Figure 55: Composition of households with respect to caste and gender in the large-scale census survey. Data are derived from a census survey of 44,004 households.

Only 10% of households were female-headed, although the meaning of 'headed by a female' is to be further explored during the household survey – women respondents were found not naming themselves as the household head even if the men are migrated outside the village, due to socio-cultural reasons. Significant caste and gender differences were also observed with respect to landholding size. The Janajati group, on average, had 41% more owned land than Dalits and Adivasis, and male-headed households had 41% more owned land than female-headed households.

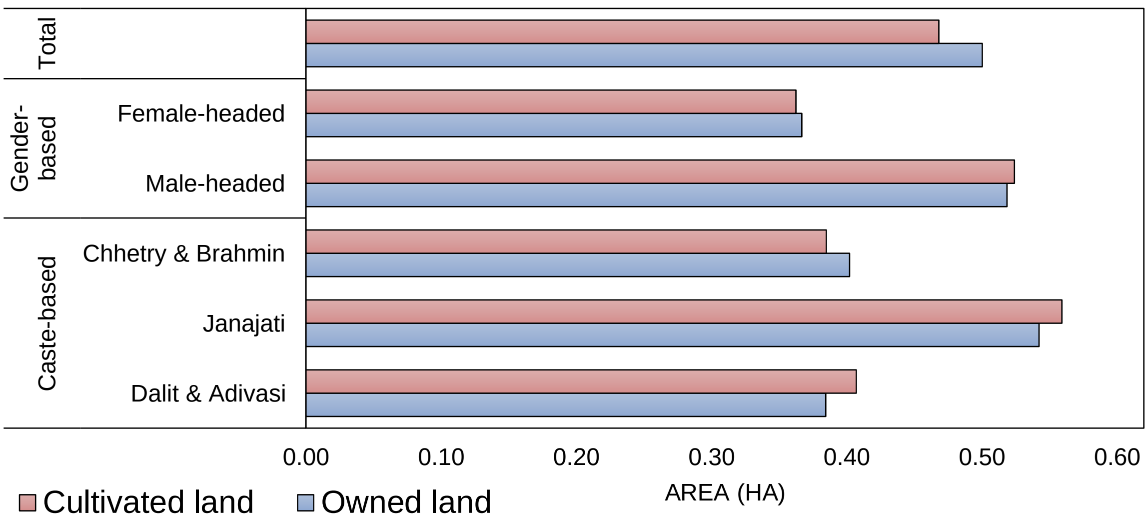


Figure 56: Landholding size among different caste and gender groups identified in the census survey. Data are derived from a census survey of 44,004 households.

In the tables below, we present the differential adoption of crops and technologies by farm-households of the study area from the census. Since we are not analyzing sample data, the statistical significance is not estimated, and only the differences in adoption rate above 5% are highlighted in the text. The inter-caste differences are pronounced in the case of wheat cultivation (mostly by Dalits and Adivasis), maize cultivation (mainly by Chhetri and Brahmins), lentil cultivation (mainly by Janjati), use of chemical herbicides (mostly by Dalits and Adivasis), combine harvesters (mostly by Dalits and Adivasis), and hybrid maize (mostly by Janjati). Women-headed households adopt mini-tillers more frequently, whereas male-headed households adopt chemical herbicides and hybrid maize more frequently. The reasons for the differential adoption figures will be further estimated with the household survey data will be – contingent on COVID-19 restrictions being lifted to permit field work – reported in next year's Annual Report.

Table 22. Caste and gender-based patterns cereals and legume (% farm households ever cultivated) cultivation in the census survey. *n* = 44,004.

	Wheat	Rice	Maize	Mung bean	Lentil
Caste-based					
Dalit & Adivasi	89%	97%	38%	4%	55%
Janajati	83%	97%	51%	6%	61%
Chhetry & Brahmin	80%	96%	55%	6%	55%
Gender-based					
Male-headed	85%	97%	46%	5%	58%
Female-headed	81%	95%	50%	7%	56%
Total	*85%*	*97%*	*46%*	*6%*	*58%*

Gender impact evaluation

During the second half of 2020, an improved revision and draft of a gender ToC was developed to aid in increasing the rigor of the impact evaluation. While most agrarian development programs acknowledge the critical role of gender in designing and implementing interventions, women farmers are still given lower prominence in regard to project monitoring and evaluation (M&E), as well as impact assessment. Gender equity and women's empowerment can be assessed either as an end itself (intrinsic value) or in relation to enhancing the reach and impact of the particular intervention (instrumental value), or both. There are relatively few studies that have estimated the changes in women's agency and empowerment caused by the farming system intensification approach. One of the possible reasons for this knowledge gap is the lack of an explicit gender ToC, with specific impact pathways and underlying assumptions that can be used to assess and guide M&E.

Table 23. Caste and gender-based patterns in technology adoption (% farm households that have at least once used technologies) in the census survey. ***n*** = 44,004.

	Fertilizer spreaders	Mini tiller	Reaper	Herbicides	Combine Harvester
Caste-based					
Dalit & Adivasi	5%	13%	1%	42%	12%
Janajati	7%	16%	6%	37%	9%
Chhetry and Brahmin	4%	16%	1%	27%	6%
Gender-based					
Male-headed	5%	14%	3%	40%	12%
Female-headed	6%	26%	3%	29%	8%
Total	5%	15%	3%	39%	11%

Several of the existing ToCs used in agricultural development projects focus on increasing the diffusion of technologies in order to increase farm productivity in the face of unfavorable climatic change. Against this background, CSISA scientists collaborated with the impact evaluation team to develop a ToC for sustainable intensification in South Asian agricultural development. Activities within the CSISA project were used to guide the ToC, which was then adapted to the agrarian situation in Nepal. The contributions made by CSISA on enhancing rural women's agency and empowerment through gender-responsive knowledge creation and provision, adaptive technologies, targeting of interventions aimed at sustainable intensification, and increasing household income. These topics were chosen for the evaluation.

Because COVID-19 has forced a delay in completion of Step 3 of the impact evaluation, during the second half of the reporting period, the impact evaluation team focused on developing this work into the manuscript of a formal paper that will provide a practical first step and example that can be used to generate a more holistic picture of sustainable intensification projects through establishing links between various technological interventions that can be of use in adaptive management and improved gender impact evaluation. Further updates on progress will be presented in subsequent reports.

Table 24. Caste and gender-based patterns technology adoption disaggregated by crop and technology type (% farm households ever adopted, estimates are conditional on the cultivation of respective crops) in the census survey. ***n*** **=** 44,004.

	Hybrid maize	Zero-tillage wheat	Timely sowing of wheat	Directed seeded rice	Mechanized transplantation in rice
Caste-based					
Dalit & Adivasi	30%	6%	40%	0%	1%
Janajati	40%	10%	40%	1%	4%
Chhetry & Brahmin	33%	6%	39%	1%	2%
Gender-based					
Male-headed	36%	8%	43%	1%	3%
Female-headed	31%	4%	41%	1%	3%
Total	*36%*	*8%*	*43%*	*1%*	*3%*

Note: A total of 44,004 sample households from the Terai region of Nepal across eight districts were covered during the census. In this analysis, we are focusing on the adoption of sustainable intensification technologies on farmers' field. Hence, we had set a minimum landholding size (0.001 ha of cultivated land) and included those with higher landholding (31,110 households) in the analysis.

5. The CSISA COVID-19 Resilience Activity (Nepal)

BACKGROUND:

Although Coronavirus (COVID-19) is a public health crisis, its global economic effects are severe and will be long-lasting. While much of the immediate response to the crisis has focused on implementing measures to contain spread and mitigate the disease's health impacts, substantial secondary shocks the economies of developing nations hare occurring and can be expected. As many South Asian nations are agriculturally dependent, the implications for agriculture and food systems are dire.

The poor – particularly smallholder farmers with limited risk bearing and investment capacity in areas with high COVID-19 caseloads – are expected to suffer disproportionally. In Nepal, many rural farm households – which are frequently headed by women affected by previous rural out-migration – are already suffering from the collapse of remittances normally used to purchase inputs and hire farm labor for time-sensitive agricultural tasks. Conversely, more than 3.5 million Nepalis are estimated to typically work abroad, many in India[13]. Although absolute numbers of migrants who have been forced to return to Nepal due to COVID-19 restrictions, large populations of young men are currently returning or have already returned, Many are now looking for gainful employment within Nepal's borders. Job opportunities will however be challenged by on-and-off periodic lockdowns, social distancing policies, and associated mobility restrictions. Against this backdrop, farm households in the FtF zone within the Terai are affected by climatic stresses in the form of variable precipitation, drought and heat stress that limit the productivity of their farming systems. The COVID-19 crisis has also undermined farmers' ability to effectively adapt to these stresses, thereby undermining their resilience.

With a new investment in the Cereal Systems Initiative in South Asia (CSISA) program, the USAID Mission in Nepal is supporting the project to rapidly and effectively respond to the threats posed by the COVID-19 crisis that undermine the recovery and sustained resilience of farmers in the FtF Zone of Nepal. Activities involve two inter-linked Objectives that address CSISA's strengths in core areas needed to assist in COVID-19 response and recovery over an18 month period (From July 2020- December 2021). The ultimate goal the CSISA COVID-19 Resilience Activity is to develop mechanisms to support longer-term resilience among smallholder farmers and the private sector – with emphasis empowering youth and overcoming challenges faced by women headed farm households. At the same time, the Activity is assisting in efforts to increase smallholder farmers' understanding of, and capacity to protect themselves, from COVID-19. This is achieved through the dissemination of awareness raising messages on public health and by increasing economic opportunities for return migrants, smallholder farmers, and by encouraging resilience-enhancing irrigation.

OBJECTIVE 1: ENABLE RAPID, TARGETED, AND EFFECTIVE AGRICULTURAL COVID-19 CRISIS RESPONSE THROUGH SCALE-APPROPRIATE FARM MECHANIZATION AND RURAL SERVICES PROVISION

Although the long-term implications of the COVID-19 crisis on agricultural and rural economies is only now beginning to come into focus, there are important short- and medium-term effects that are already evident and require urgent attention. Agriculture in developing nations is largely supported with human labor – often in the form of back-breaking work completed by household members. Many farmers in developing economies also hire labor to support their land preparation, planting, weeding, fertilization,

[13] MoLE, 2018. Labour migration for employment. A status report for Nepal, Ministry of Labor and Employment, Government of Nepal, Kathmandu, Nepal.

harvesting and post-harvest activities, in addition to management of livestock. Where social distancing measures and disruptions to markets – particularly for agricultural labor – prevent farmers from managing their fields with the same level of care as prior to the COVID-19 crisis, challenges in maintaining productivity and economic growth in the agricultural sector will result.

Objective I responds to these emerging crises by harnessing opportunities to encourage scale-appropriate mechanization, agricultural machinery services provision and entrepreneurism, to assist farmers in COVID-19 impacted districts to reduce the risks of delayed of foregone agricultural operations. Key operations include land preparation, planting, irrigation, harvesting and post-harvest, as COVID-19 induced labor scarcity and labor costs a significant impact on these time-bound farm operations. For example, if sequenced rice and wheat in the same field are delayed in the establishment of the summer rice crop, yield decline can occur in both rice and wheat, the latter due to subsequent postponement of sowing. This can lead to high temperature stress in March and April. Similarly, rapid post-harvest processing and appropriate handling of harvested crops is essential to reduce losses while also protecting against the development of mycotoxins that can threaten human health.

Work Package 1: Creating 'cool' jobs for young return migrants as machinery and irrigation service providers and entrepreneurs to support farmers affected by the COVID-19 crisis

From June through October of 2020, CSISA initiated a partnership with International Development Enterprises (iDE) in Nepal to assist in business demand creation and access to finance, with a focus on the agricultural machinery services sector and the creation of opportunities for returned migrants to purchase machinery and become entrepreneurial agricultural machinery service providers to smallholder farmers. In addition, CSISA has reinvigorated its partnership with the USAID/Nepal supported KISAN II activity. This has been accomplished by providing technical advising on appropriate machinery types, business models, and time to break even on machinery investments through coordinated meetings with KISAN's Joint Rice Implementation Program (JRIP) activities with MoALD, that also support agricultural mechanization. All activities have had to be implemented remotely, using Zoom, Skype, or the telephone due to on-and-off periodic lockdowns that have continued in Nepal, in addition to CIMMYT's and iDE's own staff safety and social distancing policies.

Despite these challenges, strong starting activities are already under way. Highlights include the development, pre-testing, refinement, and deployment of regular surveys of agrovets, rural laborers, and farmers to generate crucial information on price trends and the impact of the COVID-19 crisis on agricultural systems in the Terai. CSISA has also generated a database of more than 3,000 returned migrants to Nepal, replete with demographic, contact, and locational information. The development of this database is part of the Activity's strategy to sequentially survey and filter from a large group of returned migrants to a smaller group of 500 who exhibit both the capacity and interest to purchase machinery and become agricultural machinery service providers. A second round of telephone surveys are now under way to identify these 500 returned migrants, with an expected completion date of mid-November. These 500 people will be advanced to the next stage during which they will be given a simple-to-respond to business capacity and psychometric test to identify business literacy training needs, entrepreneurial drive, and if they may be suitable candidates for agricultural machinery loan products that CSISA is currently working to develop in partnership with Muktinath bank.

In addition to these surveys, CSISA has also completed a mapping of all agricultural machinery dealers and existing custom hiring centers in Dang, Kailai, and Banke. These are the districts that were identified as having high COVID-19 induced economic risks, large numbers of returned migrants, and also a large number of farmer cooperatives. The latter is particularly important, as part of CSISA's strategy following the linking of returned migrants with financial services for machinery purchase from dealers is to cluster their marketing of services to farmer cooperatives. This is intended to offer substantial economies of scale, as new returned migrant service providers can more effectively market their services to groups rather than individual farmers, the latter of which has high transactions costs.

Although there have been slight delays in the pace of implementation due both to holidays in Nepal and a slight delay in fund transfer from USAID, Work Package II activates remain well on-track. Business cases and financing models for key machinery types are underdevelopment based on interaction with financial institutions and agricultural machinery dealers. These are important ingredients in the local products that CSISA anticipates to be deployed my Miktinath bank before the end of the year. CSISA has also provisionally identified television and radio stations that will be used to deploy a mass media campaign advertising these loan products, in addition to the direct linkage marketing of loan products to the returned migrants identified as high-potential service providers in the database described above.

In addition, 200 sets of toolkits for irrigation service providers and future returned migrant machinery services providers have been purchased. In the former case, 100 sets are in the process of being distributed to irrigation pump owners with requisite numbers of women farmer irrigation clients in larger irrigation schemes where toolkits can be most valuable in reducing the risks of drought resulting from pump breakdowns. In the latter case, the remaining 100 toolkits will be provided to machinery dealers cooperating with the bank finance scheme discussed above. In both cases, however, toolkits will be supplemented by easy to understand and quick repair 'how to' guides developed by CSISA over the last three months[14]. These toolkits will be used as an advertising strategy to enhance the value of purchased machinery, as they will be given away as a free benefit to returned migrants purchasing machines.

Last but not least, CSISA is cooperating with KISAN II and plans to do small-group, socially distanced trainings harvesting equipment trainings for existing machinery service providers and also returned migrants who may become machinery service providers. Trainings will begin in November and extend through the coming months. Beginning in November, CSISA will also commence small-group COVID-19 safe agricultural operations safety trainings in Dang, Kailai, and Banke. These are in addition to the planned training of mechanics who will comprise a core group of 50 well-trained 'mobile mechanics' who can offer point-of-breakdown repair services for machinery owners using COVID-19 safety protocols. Personal protective equipment for trainees and also for returned migrants that will become service providers have also been procured and will be supplied prior to trainings and equipment purchases.

Work Package II: Minimizing the economic impacts of COVID-19 for very poor and women farmers through linkages to established service providers and custom hiring centers

Work Package II also initially targets Dang, Kailai, and Banke. In these districts, Work Package II leverages established service providers and works to target their services to benefit COVID-19 economically impacted farm communities. The activity is also advising CSISA's partners under MoALD on the most appropriate machinery related public-policy and actions that can be taken by PMAMP and the AKCs to support farmers suffering the most from the economic consequences of the COVID-19 crisis. From June

[14] In order to develop 'how to' repair guides, CSISA conducted surveys of existing machinery service providers and agricultural machinery dealers. Twenty types of machines were considered, ranging from land preparation to post harvest equipment. Survey respondents were asked to identify the two most common spare parts that break, and the typical time interval before the first breakdown occurs, and also the time intervals between sequential breakdowns. The repair guides developed by CSISA consequently focus on these problems and necessary spare parts. In addition, the project is working to identify which spare parts can be most easily manufactured within Nepal. This information is anticipated to be valuable in further discussions with MoALD on supporting the growth of agricultural machinery manufacturing in Nepal.

through October of 2020, in-person trainings however had to be suspended due to lock-downs in the Terai. In-person, small group trainings will commence from November, and will be reported on in the Semi-Annual Report.

During the reporting period and as part of Work Package II, CSISA played supportive role to devise machinery specifications required by different governmental and non-governmental organization including PMAMP in Dang, MoALD in Sudurpaschim Province, and KISAN II, to deliver governmental subsidized machines to the aspiring farmer groups, cooperatives, and private farms. Machinery specifications are required by the governmental offices for quality assurance from suppliers enrolled in subsidy programs, as well as for orders of appropriate machinery. For these reasons, CSISA met intensively with these organizations, with particular emphasis on assisting KISAN II that is now working to support mechanization in Nepal, during the second and third quarters of 2020. For example, CSISA assisted KISAN II by providing technical orientation on appropriate agricultural machinery for rice to more than 15 high government officials in a KISAN II led events in Sudurpaschim and Lumbini Provinces on 28th September, 2020. The program was held virtually due to COVID-19 restrictions, with the aim to help the partners in purchasing right machinery for the governmentally led Joint Rice Intervention Project, which aims to intensify rice production throughout the Terai.

These actions have supported governmental authorities and programs in which KISAN II collaborates with government to deliver machinery subsidies to buyers to select machineries including appropriate seed drills, weeders and grain dryers. Because of CSISA's constant engagement with these partners, systemic changes have begun to be observed as governmental project support for appropriate farm mechanization expands, which is an important aspect in the longer-term scaling innovations. In addition, in response to urging by CSISA, PMAMP has been planning to hire agricultural engineers in each province to support their mechanization activities.

In addition, CSISA also pre-tested and has refined a system to track agricultural machinery availability through telephone surveys. This system has also been used to create awareness of machinery services availability for hiring, initially through Facebook. Four initial Facebook groups (कृषि औजार सेवा – बाँके, कृषि औजार सेवा – कैलाली, कृषि औजार सेवा – बर्दिया, and कृषि औजार सेवा – दाङ) have been created for this purpose, with more than 100 machinery dealers and service providers already advertising their businesses in each.

OBJECTIVE 11: BREAK THE SMALLHOLDER IRRIGATION BOTTLENECK AND BUILD RURAL RESILIENCE TO THE COVID-19 CRISIS

Along with high-yielding crop varieties and broad use of fertilizers, expansion of irrigation has provided a core foundation for agricultural intensification and also resilience from climate extremes in South Asia since the 1960s. For more than 50 years, development programs to support irrigation in South Asia have been driven primarily by the idea of area expansion. Access to irrigation has become crucial in building farmers' resilience to climate variability and long-term climate change, and specifically to variable monsoon precipitation patterns, drought, and heat stress, all of which can undermine sustained agricultural productivity. Irrigation can also play an important mediating role to assist farmers in stabilizing or even increasing productivity in the face of the COVID-19 crisis. Nepal's irrigation potential is however largely untapped with very low amounts of available water used for irrigation. Only 30 percent of Nepal's irrigated land has year-

Photo 47: Access to water for irrigation is crucial to resilient farm livelihoods in Nepal. Bida Sen prepares rice seedlings for transplanting in Pipari, Dang (Photo by P. Lowe)

round irrigation facilities using surface water resources. Groundwater aquifer structure and how and where groundwater can be used to sustainable expand irrigation remains an under-researched area.

Given this complicated context, integrated assessment is needed to assure rational natural and sustainable resources management. Such analysis must also consider the current COVID-19 crisis and its medium- to long-term effects on Nepal's agricultural systems and economic growth, with implications for irrigation development as a pathway to increase productivity and hedge against climatic risks with resilience enhancing irrigation. In response, Objective II of the CSISA COVID-19 Resilience Activity consists of four work packages that culminate in an integrated irrigation sustainability framework to assist in inclusive water resources planning and management in Nepal's FtF ZoI. The first package collects necessary data to inform a sustainable irrigation planning assessment. The second and third work packages focus on groundwater monitoring and analysis and the social and biophysical targeting of appropriate irrigation interventions. The final work package is the sustainability framework itself, which will be used inform COVID-19 crisis and post-crisis water resources development investments aimed at efficient, equitable, and rational use of irrigation.

Importantly, the development of this framework will result from multi-stakeholder dialogue and co-design throughout the lifetime of the project. Options for appropriate response and recovery from COVID-19 crisis will be elicited from all participating stakeholders and will be accounted for in the sustainability framework. By integrating these activities and building local capacity in hydrological modeling, sustainability assessment, interpretation of model scenarios for policy formulation and crisis response, the work packages in Objective II prioritize self-reliance by developing capacity of Nepali stakeholders over time.

Work Package I: Towards a systemic framework for sustainable scaling of irrigation in Nepal

Activities within Work Package I are well underway and on track. Led by IWMI-Nepal, first research stream under Work Package I will be completed in December and will provide key information on the biophysical and hydrological constraints to sustainable conjunctive surface and groundwater irrigation development in the FtF zone of Nepal. This work also generates information that will be used for model scenario analyses as described in Objective II Work Package III, while also synthesizing information that will feed into policy and support for irrigation-related investments by the public and private sectors. Specifically, this research addresses the (a) evaluation of water availability (both surface and groundwater) by reviewing water resources assessments from earlier projects and initiatives and (b) identification of evidence for current and future water demand for agriculture and other sectors. It also (c) summarizes key scientific literature and modeling assessments, and (d) synthesizes relevant spatial and non-spatial information to develop a conceptual framework for sustainable groundwater use considering gaps, opportunities as well as challenges.

The second research stream focusses on identifying and understanding systemic barriers, socio-economic and institutional challenges, and opportunities in scaling water access and irrigation technologies in the FtF zone. Key focus areas include (i) policy frameworks that facilitate and hamper public-private interventions in multi-use water resources development to identify institutional arrangements, governance, and challenges and opportunities for public and private sector investments in irrigation and agricultural development. (ii) Where crucial data on irrigation and agriculture development are lacking at the federal to local levels, with emphasis on understanding the implications of existing agricultural plans that respond to COVID-19 and situate irrigation and agricultural development in the context of COVID-19 response. (iii) Public and private interventions in multi-use water resources development in Nepal to identify strengths, weaknesses, opportunities, constraints, and gaps pertaining to irrigation within interventions, (iii) Gaps in irrigation equipment supply chains and services within a broader systemic framework (e.g. through consideration of energy, credit, irrigation technology and suitability and preferences of stakeholders). Importantly, this work aims at identifying which public and private sector actors are best placed to assist in sustainable irrigation development in Nepal. (iv) Gender and social inclusion issues of irrigation development in Nepal to identify systemic barriers hindering women, youth and marginalized groups from meaningful participation in irrigation development. Additional emphasis in this area will focus on multi-use systems and WASH, the latter having important gender and COVID-19 implications.

To accomplish these aims, CSISA is implemented coordinated literature reviews of peer-reviewed literature and also project reports, in addition to convening interviews and focus groups with relevant stakeholders. A national-level virtual workshop to provide information and collect stakeholder feedback on Work Package I activities is planned for November. Feedback garnered during the workshop will be used to refine both research streams.

Work Package II: Preliminary development of a digital groundwater monitoring system to inform sustainable irrigation development and management strategies

Although much is known about surface water resources and hydrological and meteorological linkages between the Terai, Mid-Hills, and Himalayas, Nepal currently lacks a comprehensive system for groundwater resources monitoring. Seasonal monitoring of groundwater levels is crucial for current and future sustainable irrigation development and increasing farmers' resilience to climatic risks. What little data is available is not centralized and often not available in digital form. Reliable and systematic monitoring of groundwater levels therefore forms a critical aspect of sustainable irrigation development and water resources management.

Since the start of the CSISA COVID-19 Resilience Activity, the project team has engaged in strategic dialogues with Nepal's Groundwater Resources Development Board (GWRDB). This resulted in the endorsement of a preliminary work plan that was circulated amongst project partners in August – September of 2020. The work plan outlines the general rational of the activity, equipment intended to be used, and timelines for each step of planned activities. Based on discussion with the GWRDB, Banke district was selected as the target district based on its drought vulnerability, presence of a GWRDB offices and staff to participate in project activities, and ongoing groundwater investment programs. The GWRDB further shared the location of all existing 21 shallow groundwater monitoring wells and four deep groundwater monitoring wells that are currently being analyzed by the project team to devise the pilot setup to ensure that the incoming data can be utilized most effectively. Activities in this work package will expand the number of wells monitored while evaluating the pros and cons of different monitoring technologies.

After the initial engagement with the GWRDB, the project team together with the GWRDB organized a multi-stakeholder dialogue that was held via Zoom online on the 14 October 2020 with the goal to (a) gain endorsement and feedback of the preliminary work plan, and (b) to identify the objectives and information needs that different stakeholders have for a digital groundwater monitoring system. Participants from a wide array of sectors, including the central, provincial and local staff from Department of Water Resources and Irrigation and the Department of Agriculture, local governments, universities, farmer representatives, and civil society joined. The workshop started with an opening address of Mr. Madhukar Prasad Rajbhandari, Director General of Nepal's Department of Water Resources and Irrigation. He discussed several of the sustainability challenges that Nepal's irrigation sector faces and urged the participants to actively engage in the discussion. Subsequently, after a general introduction to the project plan for all stakeholders, the participants were divided into separate online break-out groups for in-depth discussion of monitoring objectives and information needs.

Photo 48: Some of the participants in the October 14th stakeholder online consultation to develop plans for the evaluation of different digital technologies for groundwater monitoring in Nepal.

The discussions resulted in a range of ideas for different methods and approaches to groundwater resources monitoring. Members of the CSISA team worked to facilitate the discussion and identify commonalities. By the end of the workshop, roughly defined and agreed upon information needs and objectives were identified as key enablers for a successful groundwater information system. Overall, the participants agreed that water level monitoring and identification of depletion areas with daily to monthly aggregation of water levels and trends in open-source and public format to be helpful. Furthermore, the Department of Irrigation and Water Resources showed most interest in better understanding and delineating groundwater development potential considering agriculture, but taking stock of urban and industrial development. Interest in water quality monitoring was also highlighted, though this is beyond the scope of the CSISA-19 Resilience Activity. The discussions set the course for the start of monitoring, and clarified critical information needs for water level data. The workshop also and fostered valuable interactions between stakeholders which is crucial for initiating the social change required to create an enabling environment for sustainable irrigation development.

Work Package III: Provide local, district and provincial level assessment of sustainable water use/irrigation development options including risks of unintended consequences at a

watershed (and basin) scale and communicate assessments effectively through trainings and workshops

At the farmer level, irrigation is not a binary 'yes' or 'no' technological choice, but rather reflects a continuum of water management practices that are influenced by factors including infrastructure type (e.g. surface, groundwater), costs and reliability, and the diverse incentives and enabling conditions at the household level that determine the intensity and benefits of use. For more than 50 years, development programs to support irrigation in South Asia have been driven primarily by the idea of area expansion. Massive gains in irrigated area have been achieved, increasingly through private investment in shallow tubewells powered by diesel pump sets. Yet despite area expansion in Nepal, it is generally recognized that many regions – including in the FtF Zone – are chronically water-stressed and that significant gains in climate resilience, crop productivity, and profitability can be achieved through more judicious use of existing irrigation infrastructure. Diagnostic work by CSISA in the region bears this out: for crops like rice and wheat, irrigation intensity is the primary factor governing both yield outcomes and fertilizer use efficiencies, dwarfing the influence of factors such as crop genetics or planting method.

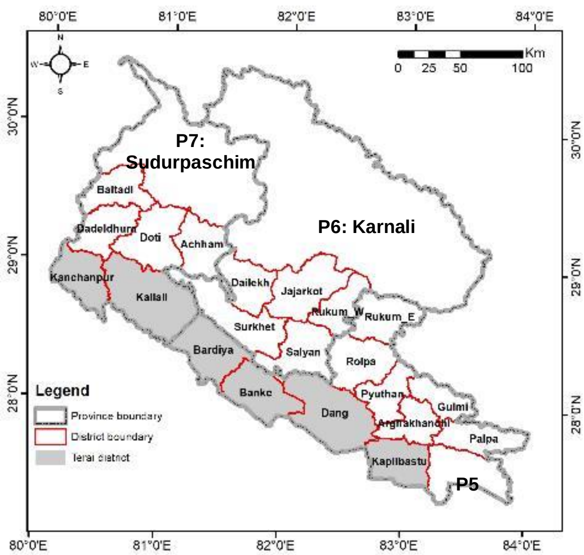


Figure 59: Map of the Feed the Future Zone Provinces 5 (Sudurpaschim) and 7, including districts and the Terai.

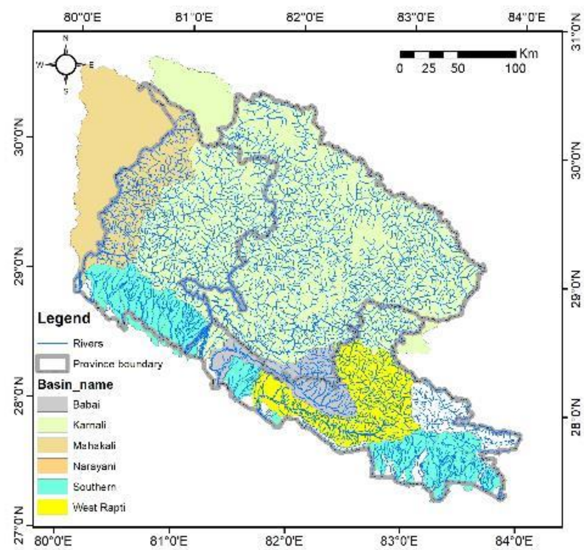


Figure 60: Surface water network complexity in Sudurpaschim Province and Pr0vince 5, with linkages to Province 6 through the extensive Karnali river basin network.

Nevertheless, the benefits of irrigation intensification are not uniform; policy makers, development practitioners, and farmers need better guidance on water management practices so that only those regions and farmers that will achieve significant gains are encouraged and supported to increase irrigation. From a research perspective, this is not a simple question. Optimal irrigation use is influenced by a host of factors including soil type, drainage characteristics, rainfall distribution, planting dates, crop variety characteristics, and higher order interactions among these factors. Nevertheless, by coupling landscape diagnostic surveys of farmers with available spatial databases on soil and climate, new analytical methods using machine learning could offers a novel approach to understand responses to increased irrigation intensity through modern predictive analytics.

Work Package III is working to answer the following questions. (i) What the scope is for ground and surface water irrigation development in Province 5 and Sudurpashchim? (ii) What best-bet crop and cropping systems combinations are suited to irrigation development from both an agronomic and economic standpoint, the latter with emphasis on pump owners and male and female farmers' profit potential, and also on returns to investment in irrigation development at the local, district and provincial levels? (iii) What the potential 'safe operating space' for irrigated (ground water, surface water, and conjunctive use) development in Province 5 and Sudurpashchim, with consideration of assuring reasonable water access to both up- and down-stream water users through appropriate development and options to recharge water upstream and maintain environmental and economic flows downstream? (iv) What locations might be 'best-bet' for future irrigation development in consideration of COVID-19 induced return migrant resettlement patterns, both now and in consideration of the medium-term effects of climate change?

During the reporting period, as series of meetings with CSISA COVID-19 Resilience Activity partners, namely CIMMYT, IWMI, Cornell University, and the Innovation Lab for Small-Scale irrigation at Texas A&M University have taken place. Following discussions, this research will focus primarily on the Terai districts, as well as the broad-valley mid-elevation district of Dang. The team is currently discussing options for simulation of irrigation development scenarios in one hill district, though limitations on available hydrological and cropping systems data may complicate model runs, and could undermine confidence in modeling efforts in the hills. A provisional database of hydrometeorological and cropping systems variables needed to drive scenario modeling efforts in Work Package III for the Terai districts and Dang has been completed. Texas A&M has also hired a full-time post-doctoral scholar who will be focused entirely on driving scenario analyses with the SWAT and APEX models. Following a stakeholder consultation workshop to present progress on Work Package I of Objective II, and after garnering input on futuristic irrigation development and cropping systems intensification scenario options from participants, scenario analysis will commence in January, with a planned completion in July of 2021.

Work Package IV: Sustainability framework for irrigation development in Nepal's Feed the Future Zone

The development of a thorough and stakeholder-vetted sustainability framework for irrigation development in Nepal's FtF ZoI is the ultimate product of Objective II. The framework will serve to guide immediate and medium-term investments and actions that can be taken by the Government of Nepal, USAID, and also by private sector investors. As an integrated product of Work Packages I, II, and III, formal work on the framework other than envisioning its components is not scheduled to commence until early 2021. Work Package IV does, however, have a capacity development component that will commence in November of 2020, with the publication of a competitive applications and proposals by candidates, at least two early-career scientists in the Department of Water Resources and Irrigation Department of Hydrology and Meteorology to develop integrated modeling skills through 1:1 coaching and direct participation in the research outlined in Work Package III.

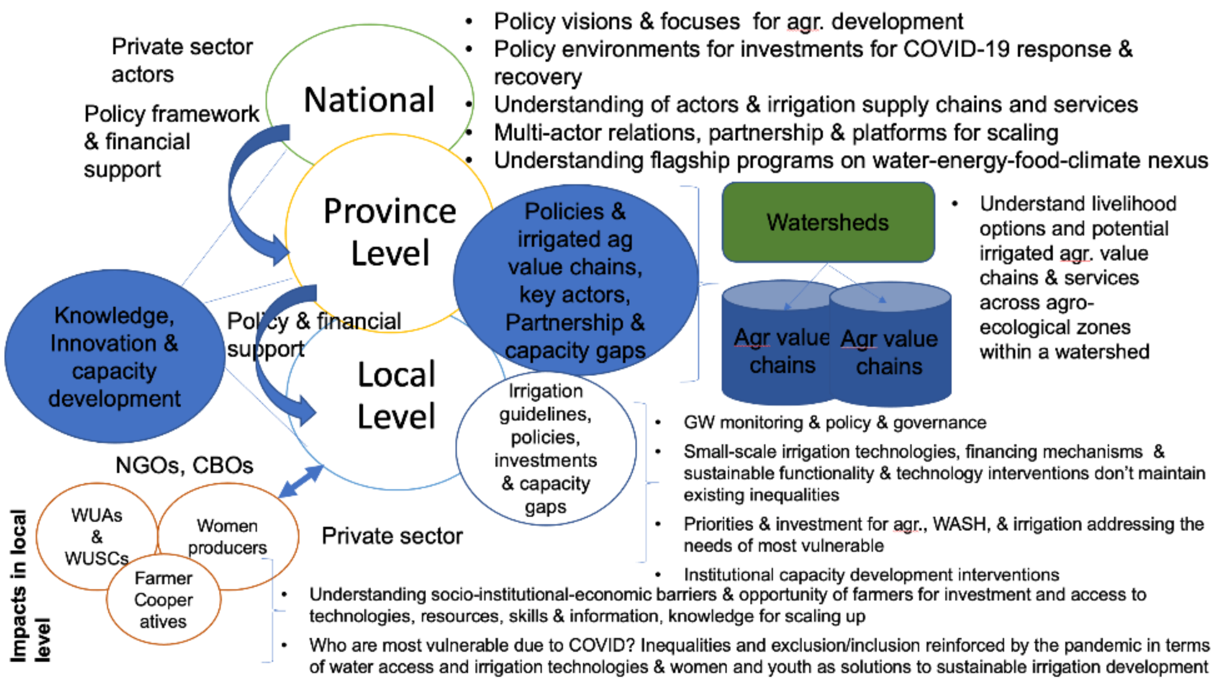


Figure 57: Preliminary framework components for the Sustainability framework for irrigation development in Nepal's Feed the Future Zone being used by project partners to guide and integrate research streams.

6. Challenges Faced During the Reporting Period

CHALLENGES ACROSS COUNTRIES

The COVID-19 crisis rendered this reporting period the most challenging faced by CSISA during its 11 year history. Although the Project had encountered problems in the past – for example during large-scale political instability and nation-wide general strikes and violence in both Nepal and Bangladesh, lockdowns and social distancing measures caused considerable problems from March forward. Although both countries are not at this time on lockdown, the situation remains very unpredictable. The lack of quality reliable data on case numbers means that project programming responsibilities have to be made despite considerable uncertainties. At this time, most CIMMYT, IRRI, and IFPRI staff have been unable to engage in field work and remain largely on work-at-home or rotational office duty only, with little to no field work permitted by these respective institutions. An additional complication has been that members of the CSISA team have been unable to travel between countries (even with airports partially open, quarantine periods and rules present form addable challenges), so most activities have moved to virtual formats, as described in this report. A timeline of key events in Nepal and Bangladesh is provided below, followed by descriptions of additional challenges in each country.

Table 25. Major COVID-19 related dates that have challenged

	Bangladesh	Nepal
COVID -19 confirmed in country	8th March	23rd January
First lockdown declared by government	23rd March	24th March
Most CSISA field work halted	23rd March (largely still ongoing)	24th March (largely still ongoing)
First lockdown withdraw by government	30th May	21st July
Rolling district-level lockdowns	--	August 25th (ongoing)
International airport closed	14th March	22nd March
International airport resume	16th June	15th April

CHALLENGES IN BANGLADESH

COVID-19 has caused significant modifications in workplans and activities in Bangladesh. Due to lockdowns and institutional work-from-home or rotational office work procedures, staff mobility completely ceased and alternate work modalities have been imposed from March 24, 2020. All in-person training programs, demonstrations, video shows and other field related programs were postponed indefinitely due to restriction. As the situation improved and government has withdrawn the lockdown, though semi-strict precautionary measures remain in place. As such, CSISA has remained appropriately cautious in engagement with partners in any other way than through virtual meetings. Activities are only now slowly resuming with some small meetings permitted, though it remains unclear when life will return to normal. A number of members of the project team have also experienced the project developed, with support from headquarters, a set of principles and guidelines for the return to the workplace.

In addition, Cyclone Babul brought excessive in late 2019, which stymied and delayed sowing of dry season crops in coastal areas. This resulted in fields being far wetter than anticipated, which slowed rice harvest and significantly delayed wheat planting in 2019. For this reason, CSISA was unable to meets its early wheat sowing targets in this reporting period, although implementation prior to the COVID-19 pandemic was otherwise unhindered. Cyclone Amphan also made landfall in May of 2020, causing crop losses in coastal areas.

CHALLENGES IN NEPAL

Like Bangladesh, heavy rainfall in the winter *rabi* season posed in Nepal. Unusually heavy rainfall events in January and February of 2020 caused waterlogging in many fields in the west of Nepal, which had negative implications for lentil and wheat productivity.

Starting from March of 2020, lockdown and mobility restrictions have been on-and-off in Nepal, depending on location and the number of COVID-19 positive cases reported. In the start of the pandemic, Nepal reported most of it cases in the border provinces; recently, the concentration of cases has shifted to the Kathmandu valley. Nepal loosened its lockdown in mid-June and planned for a phase-wise reopening, however, due to sudden increases of cases in newly affected districts, the government reconsidered and partial lockdowns have continued through October. The re-opening of the international airport was also postponed until September with limited airlines, flights and airport capacity. As of October, international airlines are operating fully, although entry for foreigners has been largely restricted with strict quarantine procedures in place.

CIMMYT's offices throughout Nepal were closed since late March and have gradually re-opened with rotational work modalities since July; although, as provinces are now responsible of imposing COVID-19 related restrictions, some re-opening plans have had to be continuously postponed. Most CIMMYT staff continue teleworking from their home base, however, by early late November it is expected for staff to return to duty posts, though office attendance will be rotational. To ensure the wellbeing of our staff, the CIMMYT-Nepal office has developed, with support from CIMMYT headquarters, a set of principles and guidelines for the return to the workplace.

7. Additional Information

ENGAGEMENT WITH MISSIONS, FEED THE FUTURE PARTNERS AND PROJECT SUB-CONTRACTORS[15]

USAID/Nepal and Mission

The project continued to engage with the USAID Bangladesh and Nepal Missions during this reporting period, with new investments in the CSISA program provided by the USAID/Nepal Mission in the CSISA COVID-19 Resilience Activity, in addition to the support for the Fighting Fall Armyworm Activity and CSISA-MEA (the second phase of the CSISA-MI project) awarded in 2019 by USAID/Bangladesh, which works in synergy with CSISA.

Feed the Future partners

The project also directly collaborated with the following Feed the Future projects:

- **Rice and Diversified Crops Project** – The Rice and Diversified Crops (RDC) Activity is led by the Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance (ACDI-VOCA). It aims to increase incomes and improve food security and nutrition in the Feed the Future zone through systemic market changes that promote a diversified farm management approach oriented to intensified rice production and higher-value, nutrient-rich crops. CSISA Phase III provides regular technical advice to RDC.
- **Fighting Fall Armyworm in Bangladesh** – Supported by the University of Michigan and USAID, this project cooperates with national research and extension partners, CABI and the FAO to strengthen efforts to mitigate impact of the pest on farmers' income, food security and health. The project is supported in kind by CSISA Phase III. The project works to (1) Develop educational materials to help reach audiences with information to improve understanding and management of fall armyworm; (2) Assist the Department of Agricultural Extension (DAE) in deploying awareness raising and training campaigns; (3) encourage institutional change to improve crop protection and integrated pest management; (4) Prepare the private sector for appropriate fall armyworm response, (4) Support the development of a Bangladesh standing multi-threat pest emergency taskforce, and (5) Generate data and evidence to guide integrated fall armyworm management. The project spans 2019-2021.
- **Cereal Systems Initiative for South Asia Mechanization Extension Activity** – Building on the successes of the CSISA-MI project the FtF Bangladesh Cereal Systems Initiative in South Asia Mechanization Extension Activity (CSISA MEA) began on 1st October 2019. It has three main objectives: (i) increase the competitiveness and efficiency of domestic and private sector-led agricultural machinery manufacturing, assembly, use, and servicing (ii) enhance institutional capacity for agricultural mechanization through the development of skilled and youth workforce, and (iii) widespread uptake of sustainable intensification practices in Rohingya refugee impacted communities in South-eastern Bangladesh. Through activities designed to meet these objectives, the activity will aim to address a number of challenges faced by the light engineering sector involved in the manufacture of agricultural machines and spare parts. These include poor manufacturing processes,

[15] A full list of partners and details can be found in Appendix II.

use of old and inefficient manufacturing equipment, limited supply of good quality materials, limited access to appropriate financial services and low levels of workforce skills.

- **The Nepal Seed and Fertilizer (NSAF) project** (2016–21) is a $15 million USAID-Nepal initiative and a direct outshoot of progress made by CSISA on seed systems and integrated soil fertility management. CSISA staff collaborate frequently and deeply with NSAF on scientific and operational matters.
- **The KISAN project** – The Knowledge-based Integrated Sustainable Agriculture and Nutrition project is part of USAID's global Feed the Future initiative. It is a five-year project (2017–22) which is facilitating systemic changes in the agricultural sector including: (i) greater climate-smart intensification of staple crops and diversification into higher value commodities; (ii) strengthening local market systems to support more competitive and resilient value chains and agricultural related businesses, and (iii) improving the enabling environment for agricultural and market systems development. This project reaches of hundreds of thousands of farmers, many of whom have been exposed to CSISA information, materials, and technologies through the partnership between CSISA and KISAN.
- **The Innovation Lab for Nutrition** – The Nutrition Innovation Laboratory pursues applied research that supports the goals of USAID's Feed the Future initiative, builds institutional capacity for analysis and policy formulation in developing countries, and offers scholarships that support individual capacity development through formal degree education in the United States and elsewhere. Tufts University's Friedman School of Nutrition Science and Policy has served as the Management Entity for USAID's Nutrition Innovation Laboratory since October 2010. Tufts manages the activities and conducts research in close partnership with several US university partners. CSISA collaborates with the Nutrition Innovation Laboratory on the analysis of survey data and modeling of the intra-household nutritional status implications of agricultural development interventions in Bangladesh.
- **The Sustainable Intensification Innovation Lab** – Since 2015, Kansas State University (KSU) and International Rice Research Institute (IRRI), in collaboration with Sustainable Intensification Innovation Lab (SIIL) and other national research and development agencies have been working in the coastal zones of Bangladesh. The FtF SIIL is a USAID-funded program that supports research, knowledge sharing, and capacity-building in relation to smallholder farming systems, and increasing ecological intensification for the production of food, fiber, and other products in Asia and Africa. From the fourth reporting quarter of the 2019-20 period, CSISA has initiate a collaboration with the SIIL Pathways of scaling agricultural innovations for sustainable intensification in the polders of coastal Bangladesh project (SIIL-Polder Project: phase II) in screening fodder species for tolerance and growth in salt affected soils in coastal Bangladesh. Field trials are planned for the 2020-21 year.
- **The Feed the Future Innovation Lab for Small-Scale Irrigation (ILSSI)** – Based a at Texas A&M University, ILSSI is a research-for-development project that aims to expand farmer-led, small scale irrigation principally in Ethiopia, Ghana, Mali, and Tanzania. Sustainable, profitable, and gender-sensitive irrigation contributes to agricultural growth, resilient food systems, and better nutrition and health, particularly for vulnerable populations. Now in its second phase (2019-2023), ILSSI is working to identify the best ways to expand the use of small scale irrigation within environmentally sustainable limits. ILSSI is a part of the U.S. Government's Feed the Future Initiative. With the new CSISA/Nepal buy-in to the CSISA program with the CSISA COVID-19 Resilience Activity, the ILSSI team has begun to work on hydrological modeling with a focus on working towards the development of a sustainable irrigation development strategy for the FtF Zone in Nepal.

Project sub-contractors

CSISA Phase III maintains three sub-contractual partners in Bangladesh, who are essential for scaling-out project-supported technologies and for reaching farmers. This is particularly important as the project is coordinated through a partnership of three research institutions. These partnerships enable the dissemination of CGIAR research findings to farmers through knowledge products. Details of what each of these partners achieved can be found throughout this report in the sections for Bangladesh and Nepal in particular.

CSISA vets and selects partners based on their alignment with the CSISA approach and their ability to generate impact at scale. In this reporting period the project maintained partnerships with the following three organizations:

- **Agricultural Advisory Society** – The Agricultural Advisory Society (AAS) is a Bangladeshi NGO that works to improve the economic condition of small and poor farmers by improving their agricultural skills and capacities and by demonstrating ways in which they can better manage available resources. The purpose of the project's sub-agreement with AAS is to increase knowledge, skills, and practice of farmers on quality rice seedling production, early wheat sowing and to combat fall armyworm through video shows in the project areas in Bangladesh.
- **Agricultural Input Retailers' Network** – Bangladesh's Agricultural Input Retailers' Network (AIRN) was formed as a result of efforts led by Cultivating New Frontiers in Agriculture (CNFA), a previous USAID funded agricultural inputs project. Partnering with CSISA, AIRN trains input dealers on the principles and practices of integrated weed management and on combatting fall armyworm.
- **The Bangladesh Rice Research Institute** (BRRI) was founded in 1970 and is the country's apex rice research body. BRRI assists the project with the following activities:
    1. Implementing on-farm trials of new premium quality rice varieties in 6 upazilas (sub-districts) in three CSISA hubs to identify best-bet premium quality varieties in terms of yield and farmers', millers' and traders' preferences.
    2. On-farm performance evaluations of integrated weed management options to increase yield and profits in farmers' fields.
    3. On-station trials to develop and fine tune the mat nursery method of raising rice seedlings for manual transplanting.
    4. Organizing additional on-farm trials.
- **The Bangladesh Wheat and Maize Research Institute** – The project's agreement with the Bangladesh Wheat and Maize Research Institute (BWMRI), founded in 2019, has established a cooperative and mutually beneficial relationship for carrying out activities with CIMMYT on the following topics:
    1. germplasm exchange, development, delivery, intensification and diversification;
    2. promoting sustainable intensification-based conservation agriculture crop management and improved seed system farm equipment and machinery;
    3. addressing socio-economic and policy constraints that affect the adoption of new technologies;
    4. mainstreaming gender concerns in research for development;
    5. building the capacity of national scientists and partners through training;

6. engaging the private sector on value chain and market development to benefit maize and wheat farmers.
7. CSISA leverages this agreement and cooperates with BWMRI on all wheat related work in Bangladesh that the project focuses on.

- **The Bangladesh Department of Agricultural Extension (DAE)** – The vision of the Department of Agricultural Extension, under the Ministry of Agriculture is to provide eco-friendly, safe, climate resilient, sustainable productive good agricultural practices and sustaining natural resources to ensure food security as well as commercial agriculture with a view to accelerating socio-economic development of the country. The mission of the DAE is to provide efficient, effective, decentralized, location specific, demand responsive and integrated extension services to all categories farmer in accessing and utilizing better know how to increase sustainable and profitable crop production; thereby ensure socio-economic development of in Bangladesh. CSISA collaborates widely with DAE on a range of initiatives and activities in Bangladesh that are detailed in this report.
- **Manchester University –** Since 2019, CSISA has collaborated with Dr Tim Foster (lecturer in Water-Food Security of Manchester University in research to optimize the technical and social acceptability of irrigation in the Terai of Nepal.
- **The International Water Management Institute (IWMI)** – is a non-profit research organization with headquarters in Colombo, Sri Lanka, and offices across Africa and Asia. Research at the Institute focuses on improving how water and land resources are managed, with the aim of underpinning food security and reducing poverty while safeguarding vital environmental processes. With the new CSISA/Nepal buy-in to the CSISA program with the CSISA COVID-19 Resilience Activity, the IWMI team in Nepal has been engaged in working towards the development of a sustainable irrigation development strategy for the FtF Zone in Nepal.

The details of what the partners achieved in the reporting period are given throughout the report and principally in Sections 2 and 3. See Annex 2 for more details on project subcontractors and key partners.

Appendix 1: CSISA III Key Leadership Staff

Name	Role	Institution	Address	Phone	Email
Timothy Krupnik	Senior Scientist (Systems Agronomy) and Regional Strategic Team Lead for Sustainable Intensification in South and Southeast Asia. CSISA Project Leader (Nepal and Bangladesh)	CIMMYT	Dhaka, Bangladesh	+88 0175 556 8938	t.krupnik@cgiar.org
Joe Dale	Regional Program Manager	CIMMYT	Kathmandu, Nepal	--	J.DALE@cgiar.org
Cynthia Carmona	Project Manager	CIMMYT	Kathmandu, Nepal	+977 9851197994	c.carmona@cgiar.org
T.S Amjath Babu	Agricultural Economist	CIMMYT	Dhaka, Bangladesh	--	T.AMJATH@cgiar.org
Santiago Lopez-Ridaura	Agricultural Systems/Climate Change Adaptation	CIMMYT	Mexico, HQ	--	S.L.Ridaura@cgiar.org
Vijesh Krishna	Lead Economist (Impact Assessment)	CIMMYT	Hyderabad, India	--	V.KRISHNA@cgiar.org
Sudhanshu Singh	Rainfed Lowland Agronomist and IRRI Coordinator for CSISA	IRRI	New Delhi, India	+91 9654543301	Sud.singh@irri.org
Virender Kumar	Senior Scientist- Weed Science/Systems Agronomy and Coordinator of Direct-Seeded Rice Consortium	IRRI	Philippines	--	virender.kumar@irri.org
Prakashan Chellattan	Research Fellow	IRRI	New Delhi, India	--	pc.veettil@irri.org
Arindam Samadar	Monitoring, Learning and Evaluation	IRRI	New Delhi, India	--	a.samaddar@irri.org

Name	Role	Institution	Address	Phone	Email
Muzna Alvi	Associate Research Fellow	IFPRI	New Delhi, India	--	M.Alvi@cgiar.org
Avinash Kishore	Research Fellow	IFPRI	New Delhi, India		A.Kishore@cgiar.org
Vartika Singh	Program Manager	IFPRI	New Delhi, India	--	Vartika.Singh@cgiar.org
Manohara Khadka	Country Representative, Nepal	IWMI	Kathmandu, Nepal	--	M.Khadka@cgiar.org
Vishnu Pandey	Regional Researcher - Water and Climate	IWMI	Kathmandu, Nepal	--	V.Pandey@cgiar.org
Petra Schmitter	Research Group Leader - Agriculture Water Management	IWMI	Myanmar	--	P.Schmitter@cgiar.org
Raghavan Srinivasan	Regents Fellow Professor	Texas A&M University	USA	--	r-srinivasan@tamu.edu
Nicole Lefore	Director, FtF Innovation Lab for Small Scale Irrigation	Texas A&M University	USA	--	Nicole.Lefore@ag.tamu.edu
Corey O'Hara	Country Director	iDE, Nepal	Kathmandu, Nepal	--	cohara@ideglobal.org
BANGLADESH					
Dinabandhu Pandit	Senior Technical Coordinator	CIMMYT	Dhaka, Bangladesh	+88 01712130599	d.pandit@cgiar.org
Khaled Hossain	Research Associate III and Lead Research Coordinator	CIMMYT	Dhaka, Bangladesh	+880 17 1776 5505	k.hossain@cgiar.org
Md. Syed-Ur-Rahman	Monitoring Evaluation and Learning (MEL) Manager	CIMMYT	Dhaka, Bangladesh	+88 1711584808	syed-ur.rahman@cgiar.org
Syed Nurul Alam	Senior Consultant	CIMMYT	Dhaka,	+8801711907886	alamsn09@gmail.com

Name	Role	Institution	Address	Phone	Email
			Bangladesh		
HUSSAIN, Ghulam	Senior Consultant	CIMMYT	Dhaka, Bangladesh	+880 1715885608	G.HUSSAIN@cgiar.org
Murshedul Alam	Senior Associate Scientist II	IRRI	Dhaka, Bangladesh	+880 1715077894	m.alam@iiri.org
Shafiqul Islam	Jashore Hub Coordinator	CIMMYT	Jashore, Bangladesh	+880 171145 1064	Shafiqul.Islam@cgiar.org
Hera Lal Nath	Barisal Hub Coordinator	CIMMYT	Barisal, Bangladesh	+880 171686 6635	h.l.nath@cgiar.org
Alanuzzaman Kurishi	Research Associate (responsible for Dinajpur field office)	CIMMYT	Dinajpur, Bangladesh	--	a.kurishi@cgiar.org
Sharif Ahmed	Specialist – Agricultural Research and Development	IRRI	Jashore, Bangladesh	+ 880 1723916674	s.ahmed@irri.org
Nazmul Alam	Communication Coordinator	CIMMYT	Dhaka, Bangladesh	+880 1973401073	NA.ALAM@cgiar.org
Titus Doffo	Project Assistant	CIMMYT	Dhaka, Bangladesh	--	T.DOFFO@cgiar.org
Achal Rahman	Project Assistant	CIMMYT	Dhaka, Bangladesh	--	A.RAHMAN@cgiar.org
NEPAL					
Scott Justice	Mechanization Specialist	CIMMYT	Kathmandu, Nepal	+977 9851027678	sejustice@gmail.com
Gokul Paudel	Socioeconomist	CIMMYT	Kathmandu, Nepal	+977 9845089438	g.paudel@cgiar.org
Anil Neupane	Technical Field Coordinator	CIMMYT	Banke, Nepal	--	A.NEUPANE@cgiar.org
Subash Adhikari	Agricultural Mechanization Engineer	CIMMYT	Banke, Nepal	+977	s.adhikari@cgiar.org

Name	Role	Institution	Address	Phone	Email
				9841893657	
Lokendra Khadka	Area Coordinator	CIMMYT	Kailali, Nepal	+977 9845198379	l.khadka@cgiar.org
Salin Acharya	Area Coordinator	CIMMYT	Banke, Nepal	+977 9851223521	s.acharya@cgiar.org
Sagar Kafle	Assistant Research Associate	CIMMYT	Dang, Nepal	+977 9845156044	a.kafle@cgiar.org
Saral Karki	GIS Analyst	CIMMYT	Kathmandu, Nepal	+977 9851239936	s.karki@cgiar.org
Bikesh Bade	Assistant Research Associate	CIMMYT	Kathmandu, Nepal	+977 9851104723	B.BADE@cgiar.org
Anton Urfels	Consultant	CIMMYT	Kathmandu, Nepal	--	anton.urfels@outlook.com

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 policies, and being integrated in the Ministry of Agriculture, BARI provides leveraging opportunities to mainstream sustainable intensification innovations into the Government of Bangladesh's National Agriculture Research and Extension System.	In 2016, the previous sub-grant was amended and the deliverables shifted towards the newly established Bangladesh Wheat and Maize Research Institute (BWMRI) (see below).
Bangladesh Wheat and Maize Research Institute (BWMRI)	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 inputs into the development of extension materials, approaches and policies, and being integrated in the Ministry of Agriculture, BWMRI provides leveraging opportunities to mainstream sustainable intensification innovations into the Government of Bangladesh's National Agriculture Research and Extension System.	The Wheat Research Centre (WRC), a former component of BARI, was transformed into BWMRI in mid-2018. In 2019 CIMMYT signed a sub-grant agreement with BWMRI to continue research on wheat blast and other subjects. The second Sub-grant letter for "Purchase of Truthfully Lebel Seeds (TLS) of blast resistant wheat variety BARI Gom 33 for strengthening farmers to farmers seed promotion" in 2020-21 will be issued on April 2020.
Bangladesh Rice	Development,	Innovation	With a network of regional research stations and	The International Rice

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Research Institute (BRRI)	validation, and refinement of technologies and new research methods, boosting scaling capacity	towards impact	strong inputs into the development of extension materials, approaches and policies, and being integrated in the Ministry of Agriculture, BRRI also provides leveraging opportunities to mainstream sustainable intensification innovations in the Government of Bangladesh's National Agriculture Research System.	Research Institute (IRRI) maintains a formal partnership with BRRI. BRRI collaborated with CSISA in Phases I and II, continuing in Phase III. Funding for BRRI's research partnership was on hold due to fund unavailability, but restarted in 2019 with resumption of USAID funds.
Department of Agricultural Extension (DAE)	Extension and scaling	Achieving impact at scale	The DAE has over 13,000 field extension agents located across Bangladesh. The department collaborated with CSISA Phase II and the USAID/Bangladesh Mission funded CSISA Expansion project in Bangladesh in the Feed the Future zone and Dinajpur hub. The sensitization of DAE agents on sustainable intensification technologies and approaches provides large opportunities for reaching and raising the awareness of farmers, with sustainability through messaging after Phase III ends.	The project continues to collaborate with DAE informally and synergistically, despite funding cuts. The volume of activities reduced in reporting period due to the project's inability to support large field campaigns and collaborative meetings with DAE. CIMMYT also worked with DAE through its Climate Services for Resilient Development (CSRD) and the USAID/Bangladesh mini-grant on wheat blast that closed in September of 2019. And as a part of project activities, the DAE works with CIMMYT to disseminate better bet agronomic practices. In this

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
				period, DAE spread messages developed by CIMMYT, BARI and BWMRI on early wheat sowing and fighting wheat blast, fighting back fall army worm and mung bean cultivation.
Agricultural Information Services (AIS)	Production of extension materials for DAE use	Achieving impact at scale	AIS is a government agency that produces extension materials and media used by DAE. Strategic partnerships with AIS facilitate the integration of sustainable intensification principles into extension materials and messaging.	Collaboration continued informally. In Dinajpur, AIS supported project activities by conducting village level video showings and trainings on healthy rice seedlings and early wheat sowing in 2018-2019. The activity is exploring further opportunities to work with AIS in disseminating better bet practices among farmers.
Bangladesh Meteorological Department(BMD)	Conduct collaborative research and development activities related to weather, agro-climatology and climate services and undertake programs for strengthening the capabilities and dissemination of useful research findings,	Achieving impact at scale	BMD provides clientele services related to weather and climate to more than 100 national and international organizations. BMD has a network of meteorological stations across the country. BMD generated weather forecasts are being used in the field of agriculture by GOs and NGOs for providing agro-meteorological advisory services to farmers.	BMD completed a sub-grant during 2017-2019. After the completion of the project the collaboration still continues under the Memorandum of Understanding signed on September 15, 2019.

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	advisories, and technologies within Bangladesh.			
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	The commercial joint venture agreement with this firm was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID. However, since then, CSISA has maintained active discussions with this partner and could re-establish relations if clear funding timing and commitments can be provided by USAID.
Metal Pvt. Ltd	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	The commercial joint venture agreement with this firm was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID. However, since then, CSISA has maintained active discussions with this partner and could re-establish relations if clear funding timing and commitments can be provided by USAID.
Rangpur Foundry	Development and sales	Achieving	Import of sustainable intensification scale-	The commercial joint venture

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Limited (RFL)	of scale-appropriate machinery	impact at scale	appropriate machinery and sales through the private sector	agreement with this firm was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID. However, since then, CSISA has maintained active discussions with this partner and could re-establish relations if clear funding timing and commitments can be provided by USAID.
Advanced Chemical Industries (ACI)	Sale of scale-appropriate machinery, fungicides, weed control products and seed. IRRI works with ACI to produce a range of hybrid and open-pollinated rice seeds	Achieving impact at scale	Import of sustainable intensification scale-appropriate machinery and sales through the private sector, along with a range of chemical and cereal seed products.	The commercial joint venture agreement with this firm was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID. However, since then, CSISA has maintained active discussions with this partner and could re-establish relations if clear funding timing and commitments can be provided by USAID.
Ispahani Agro Limited	Scale up the commercialization of the recently registered biological product Fawligen, SfNPV, a highly specific natural pathogen as well as	Achieving impact at scale	There are 10+ activities, viz. ToT for sales team, video development and showing, promotional material development and disbursement, crop consultant program, IPM championship program, educational and marketing campaign, dealers, retailers and farmers training, advertisement like road show etc. included in the agreement that aim	The 1:1 matched fund agreement with this company has been started on August 2020 and will continue till June 2021.

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	other biological products against the invasive pest Fall Armyworm		for a rapid commercialization of the product.	
Syngenta Bangladesh Limited	Awareness raising to assist in the rapid commercialization of Fortenza 60FS a low-toxic seed treating agent against FAW.	Achieving impact at scale	There are several activities specially to provide technical support to Syngenta by training their channel line dealers and village-level sales and commission agents on different aspects of FAW. Also video development and showing, promotional material development and disbursement, dealers, retailers and farmers training etc. included in the agreement that aim for a rapid commercialization of that product.	The 1:1 matched fund agreement with this company began on October 2020 and will continue until June 2021.
Auto Crop Care Limited (ACCL)	Commercialization of safe and less toxic herbicide molecules found through on-farm research as well as creating awareness among farmers through on-farm demonstrations, make the safe herbicide molecules available with the local input dealers.	Achieving impact at scale	Sales of less toxic and safe herbicide molecules including safety equipment increase.	CSISA project and ACCL have been partnering each other since the start of boro season 2019-20 (November 2019). ACCL provided all the required post emergence herbicides free of cost for the 200 om-farm IWM demonstrations, jointly with project established IWM demonstrations and organized field days.
NGOs				
Agricultural Advisory Society (AAS) (project	Facilitates village screenings of training films and conducts	Achieving impact at scale	The project worked with AAS in Phase II and CSISA-Bangladesh to reach 110,000 farmers with village training video screenings accompanied by	AAS works under project sub-grants to conduct village-level video shows and on training

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
subcontractor)	follow-up studies		question and answer sessions to raise awareness among farmers on scale-appropriate machinery and associated crop management practices. During CSISA III, AAS is working to promote better bet agronomy practices including healthy rice seedlings, early wheat sowing and fighting the fall armyworm.	farmers on core CSISA topics. In the reporting year, AAS organized a total 1,080 video shows in 921 villages where 1,32,358 farmer audiences watched those shows. Under this sub-grant, AAS has shown video on healthy rice seedling, early wheat sowing and awareness on fall army worm.
Agro-Input Retailers Network (AIRN) (project subcontractor)	Trains input dealers and retailers	Achieving impact at scale	AIRN was awarded sub-grants in project year 2018/19 for i) training AIRN dealers on the principles and practices of integrated weed management and ii) equipping them to fight the threat of fall armyworm.	Partnering with the project, AIRN trained input dealers on the principles and practices of integrated weed management and fall armyworm management. In the reporting year, AIRN provided training to 42 batches of agro input dealers on Fall Army Worm in 9 district; total 1,047 input dealers participated in those training. The contents of the training included introduction of fall army worm, its life cycle, IPM usage and methods, monitoring system and use of pesticides among other topics.
Universities				
Department of	Strategic research on	Innovation	The project leader is an active academic committee	Ongoing successful

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Crop Sciences at the University of Illinois at Urbana-Champaign (UIUC)	precision nutrient and rice crop management	towards impact	member for Shah-Al Emran, a Bangladeshi PhD student at this university. Emran is working towards the production of two manuscripts using CSISA data.	partnership.
Wageningen University	Strategic research on farmer decision making processes and the intensification of fallow fields	Innovation towards impact	Strategic high-end research capacity to assist in the analysis of farmer decision-making processes on intensification decisions	A formally established working relationship with CIMMYT for 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 the rapid prototyping of machinery innovations and technical support on testing in collaboration with BARI	Established informal relationship in support of CSISA III, with ongoing collaboration on manuscripts related to machinery engineering and development. A manuscript on the prototype laboratory is under development.
Bangladesh Agricultural University	Bangladesh's largest and first agricultural university	Innovation towards impact	Bangladesh's largest agricultural university has large influence over the next generation of agricultural scientists, many of who will go on to work in BARI, BRRI and the DAE.	The relationship with this university continued informally. Increased collaboration on fall armyworm control is under way at the time of reporting.
Projects				
Sustainable and Resilient Farming	Extending CSISA technologies to areas	Achieving impact at	CSISA's experiences in scaling up resource conserving technologies in Bangladesh are an asset	Active partnership since 2014

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Systems Intensification in the Eastern Gangetic Plains (SRFSI)	of Northern Bangladesh	scale	to jump start new technologies in northern Bangladesh. This Australian Centre for International Agriculture Research (ACIAR) funded project is scaling up these activities. CSISA supports NARC and other SRFSI partners to spread its technologies.	
Cereal Systems Initiative for South Asia – Manufacturing Systems Activity (CSISA-MEA)	CSISA-MEA will support Bangladeshi manufacturing firms to develop well-structured business cases that describe the business problem and opportunities to be addressed; articulate alternative solutions; identify potential costs and benefits; and identify the motivations and incentives for businesses to adopt the most suitable one for them, if any.	Achieving impact at scale	The CSISA-MEA project through its Manufacturing Systems Activity will work with micro-, small- and medium-sized businesses in the agricultural machinery manufacturing sector in Bangladesh to research and develop business cases for four distinct scenarios: (i) larger companies with dealership networks that will adopt a business model to assemble machines from parts made by smaller companies (OEM-supplier network); (ii) larger manufacturing firms venturing into the domestic manufacture, assembly and/or spare parts production of more complex agricultural machines, such as combine harvesters; (iii) all sized firms that will domestically manufacture a wider range of spare parts as a means to reduce dependency on expensive imported parts; and (iv) the feasibility of manufacturing for export machines, such as threshers, by all sized firms that must meet export standards. CSISA Phase III leverages this project's work by aligning its themes with geographies where local service providers have emerged, particularly with respect to fallows development through irrigation, reapers to facilitate rapid rice harvesting and early wheat sowing, and directly	Active since 2019

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
			sown rice aligning with CSISA MEA objective iv.	
Rice and Diversified Crops (RDC) Activity	RDC is led by ACDI-VOCA and is working to i) improve food security through systemic changes that increase rural incomes, ii) increase farm productivity and iii) increase farmers' participation in profitable market systems	Achieving impact at scale	The USAID Feed the Future Bangladesh Rice and Diversified Crops (RDC) Activity is increasing incomes and improving food security and nutrition in the Feed the Future zone through systemic market changes that promote a diversified farm management approach oriented to intensified rice production and higher-value, nutrient-rich crops. RDC is working towards its goals through targeted technical assistance to create scalable market system impacts, ultimately benefiting rural households and expanding opportunities for women and youth.	Active since 2016. CSISA Phase III is in discussions with RDC regarding collaboration on integrated weed management and linkages with the private sector. CSISA also advises RDC on a regular yet informal basis.

NEPAL

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Government of Nepal				
Ministry of Agriculture and Livestock Development	Technical guidance for Government of Nepal investments in agricultural development	All themes	The government's Agriculture Development Strategy (2015–2035) was approved in late 2015. CSISA acts as a technical partner to shape the loan and investment programs associated with the strategy, which may exceed $100 million.	Active and sanctioned by CIMMYT's host country agreement
Nepal Agricultural Research	Strategic and applied research on sustainable intensification	Innovation	NARC is responsible for providing the scientific basis for	Active and long-

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Council (NARC)	technologies, crop diversification, and crop management practices	towards impact	all state recommendations, their endorsement and the ownership of emerging sustainable intensification technologies.	standing
Provincial governments	To strengthen provincial level policies and provincial government support for agricultural development activities	Achieving impact at scale	Provincial governments are the middle tier of government under the new federal constitution and have a large degree of independence. They have important policy making and oversight roles on agricultural development. In this reporting period the project engaged with and supported the Province 5 and Far Western Province governments.	Active and new since federal government restructuring
Local governments	To strengthen local government support for agricultural development activities	Achieving impact at scale	Local governments are the local tier of government under the new constitution. They have significant roles for implementing agricultural development in their areas and are thus important stakeholders that the project seeks to engage.	Active and new since federal government restructuring
Nepali private sector				
DKAM (farm machinery importer/dealer)	Introduction and market development of reaper-harvesters in Dang (Province 5)	Achieving impact at scale	The rapid expansion of investments in scale-appropriate machinery and support for emerging service provision markets.	Initiated in first half of project year 2018/19

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Naya Tulsi Traders (farm machinery importer and dealer)	Introduction and market development of reaper-harvesters in Dang (Province 5)	Achieving impact at scale	The rapid expansion of investments in scale-appropriate machinery and support for emerging service provision markets.	Initiated in first half of project year 2018/19
BTL (farm machinery importer and dealer)	Introduction and market development of scale-appropriate machinery	Achieving impact at scale	The rapid expansion of investments in scale-appropriate machinery and support for emerging service provision markets.	Active and long-standing
SK Traders (farm machinery importer and dealer)	Introduction and market development of scale-appropriate machinery	Achieving impact at scale	The rapid expansion of investments in scale-appropriate machinery and support for emerging service provision markets.	Active and long-standing
Dahal (farm machinery importer and dealer)	Introduction and market development of scale-appropriate machinery	Achieving impact at scale	The rapid expansion of investments in scale-appropriate machinery and support for emerging service provision markets.	Active and long-standing
NIMBUS (Nepali feed mill company)	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
Trade associations				
Nepal Agricultural Mechanization Association (NAMeA)	Trade association formed CIMMYT's help to create an enabling environment and policy dialogue for scale-appropriate mechanization	Systemic change towards impact	Important voice for the private sector with GoN as Agriculture Development Strategy support programs take shape.	Active since 2014

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Seed Entrepreneurs Association of Nepal (SEAN)	Trade association strengthened with help of CSISA to create an enabling environment and policy dialogue for strengthening seed system and small and medium seed enterprises in Nepal	Systemic change towards impact	Important voice for the private sector with GoN as Agriculture Development Strategy support programs take shape. Provided input to studies on maize hybrids in Nepal	Active and long-standing
Universities				
Agriculture and Forestry University (Rampur, Chitwan)	Expanded use of digital data collection tools for field diagnostic surveys	Innovation towards impact	Engagement with students and professors to conduct field work and do thesis with CSISA	Previously established and re-invigorated in the reporting period
Wageningen University	Role of livestock and value chains in farmers' 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 formulating new research questions.	Active since 2012
Manchester University	Testing pumpset efficiency and groundwater irrigation livelihoods in the Terai	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 formulating new research questions.	Active since 2019
Texas A&M University (TAMU)	Support on predictive models and scenarios analysis to provide local, district and provincial level assessment of water resources	USAID/Nepal mission buy-in	Collaboration with advanced research institution increases the quality of science conducted in Nepal. National partners learn new research methods and	Active since mid-2020

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
			contribute to formulating new research questions.	
Projects				
Knowledge-based Integrated Sustainable Agriculture and Nutrition (KISAN)	Strategic partnership to co-support 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 $20 million five-year program to advance food security by increasing agricultural productivity. KISAN uses CSISA's technical and extension materials and advice to improve the uptake of better-bet sustainable agriculture production and post-harvest practices and technologies for cereals. KISAN reaches hundreds of thousands of farmers and exposes them to CSISA information, materials, and technologies.	Active since KISAN's first phase
Nepal Seed and Fertilizer Project (NSAF)	Strategic partnership to co-support the large-scale deployment of extension information and technologies	Achieving impact at scale	The USAID Nepal-funded NSAF project ($15m for 2016–2021) focuses on the applied science-to-development continuum, including market facilitation to expand private sector-led fertilizer and seed sales. CSISA is disseminating the better-bet technologies at scale through NSAF's networks.	Active since 2016/17

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Sustainable and Resilient Farming Systems Intensification in the Eastern Gangetic Plains (SRFSI)	Extending CSISA technologies to areas of eastern Nepal	Achieving impact at scale	CSISA's experiences in scaling up resource conserving technologies in western Nepal are an asset to jump start technologies in eastern Nepal. The ACIAR funded SRFSI is scaling up these activities. CSISA is supporting NARC and other SRFSI partners to spread its technologies.	Active since before 2016/17
Organizations				
International Water Management Institute (IWMI)	Support on predictive models and scenarios analysis to provide local, district and provincial level assessment of water resources	USAID/Nepal mission buy-in	Collaboration with advanced research institution increases the quality of science conducted in Nepal. National partners learn new research methods and contribute to formulating new research questions.	Active since mid-2020
iDE, Nepal	Provide expertise on business models.	USAID/Nepal mission buy-in	Collaboration with advanced research institution increases the quality of science conducted in Nepal. National partners learn new research methods and contribute to formulating new research questions.	Active since mid-2020

Building Resilience in South Asia's Cereal Systems

The Cereal Systems Initiative for South Asia (CSISA) Works to reduce hunger and increase food and income security for resource poor farm families in South Asia through the development and inclusive adoption of new cereal varieties, sustainable agriculture technologies and policies.

Established in 2009 with a goal of benefiting more than 8 million farmers by the end of 2020, CSISA is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI). Operating in rural 'innovation hubs' in Bangladesh, India and Nepal, CSISA works to increase the adoption of various resource-conserving and climate-resilient technologies, and improve farmers' access to market information and enterprise development. CSISA supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills. CSISA works in synergy with regional and national efforts, collaborating with myriad public, civil society and private-sector partners.

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