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CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA

CSISA

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List of Acronyms and Abbreviations

2WT	two-wheel tractor
4WT	four-wheel tractor
AAS	Agricultural Advisory Society
ABSPTC	Agribusiness Promotion Support and Training Center
ACCL	Auto Crop Care Limited
ACIAR	Australian Center for International Agricultural Research
AEZ	agro-ecological zones
AICC	Agriculture Information and Communication Centre
AIRN	Agriculture Inputs Retailers' Network
AIS	Agricultural Information Services
AKC	Agriculture Knowledge Center
AMTRC	Agricultural Machinery Testing and Research Centre
AMMI	Additive Main Effect and Multiplicative Interaction
ATT	Average treatment effect on treated
ATU	Average treatment on untreated
BADC	Bangladesh Agriculture Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural 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
CABI	Centre for Agriculture and Bioscience International
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
CHC	custom hiring center
CIMMYT	International Maize and Wheat Improvement Center
CoDEC	Consortium of Development Education Centers
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 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
ICIMOD	International Centre for Integrated Mountain Development
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
INFS	Institute of Nutrition and Food Science
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
LSP	local service provider
ML	machine learning
MNBBL	Muktinath Bikas Bank Limited
MoALD	Ministry of Agriculture and Livestock Development
MoLMAC	Ministry of Land Management, Agriculture and Cooperative
MoP	muriate of potash
MOT	mitigation options tool
MSP	machinery solution provider
NAMEA	Nepal Agricultural Machinery Entrepreneurs' Association
NARC	Nepal Agricultural Research Council
NARES	national agricultural research and extension systems
NMRP	National Maize Research Program
ODK	Open Data Kit

OPTs	nutrient omission plot trials
OPVs	open-pollinated varieties
NARC	Nepal Agricultural Research Council
NPR	Nepali rupees
NSAF	Nepal Seed and Fertilizer project
PFPN	partial factor productivity of nitrogen
PMAMP	Prime Minister Agriculture Modernization Project
PQR	premium quality rice
PRS	Pulses Research Center
PTOS	power-tiller operated seeder
PTR	puddled transplanted rice
RARS	regional agricultural research station
RDC	Rice and Diversified Crops Activity
RY	relative yield
SAAO	Sub-Assistant Agricultural Officer
SAWBO	Scientific Animations Without Borders
SI	sustainable intensification
SIIL	Sustainable Intensification Innovation Lab
SP	service provider
SPIA	Standing Panel on Impact Assessment
SRFSI	Sustainable and Resilient Farming Systems Intensification in the Eastern Gangetic Plains
ToC	Theory of Change
TOT	Training of Trainers
USAID	United States Agency for International Development
USG	urea super granules
WMRI	Wheat and Maize Research Institute
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), the International Water Management Institute (IWMI), 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 Activity 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 of some aspects of programming, although the Activity is in discussion with USAID about an anticipated extension into 2022.

Bangladesh Highlights

Some of the key highlights from CSISA's work in Bangladesh during the October 2020 – March 2021 reporting period include:

- CSISA's work to beat back the risks posted to wheat farmers in Bangladesh by wheat blast disease are growing. For the last several years, CSISA worked with BWMRI, the Department

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

of Agricultural Extension, the Bangladesh Meteorological Department (BMD), and Embrapa in Brazil to develop a weather-forecast based wheat blast early warning system – which can be found at www.beattheblastews.net. More than 6,000 agricultural extension agents are now enrolled in the early warning system, and are positioned to get alerts in the event of outbreak risks in their working locations. These efforts gained attention of the Bangladesh Rice Research Institute (BRRI). BRRI approached CSISA in late 2020 and has since requested a research collaboration to adapt the wheat blast early warning system to predict rice blast outbreaks. Collaboration with BRRI's Department of Plant Pathology is now underway in response to this request. Scientists from both teams have assembled a comprehensive dataset of more than 3,500 GPS located reports of rice blast over the last few years.

- In this reporting period, in collaboration with the Bangladesh Wheat and Maize Research Institute (BWMRI) and the Department of Agricultural Extension DAE, the Activity conducted farmer's participatory block-wise intensive seed multiplication of the blast resistant wheat variety BARI Gom 33, targeting early wheat seeding farmers in the Feed the Future (FtF) Zone of Influence (ZoI) in Bangladesh. Distribution of 25.1 tons of BARI Gom 33 wheat seed took place in Jashore, Khulna, Faridpur and Dinajpur agricultural regions, with the Activity bearing the cost of the seed and handover to DAE for block-wise producer groups seed multiplication. DAE distributed BARI Gom 33 seed to around 1,223 farmers (138 women, 1085 men) in 74 *upazilas* in 21 districts.
- 'Agvisely' is an agro-meteorological services tool developed by CSISA, DAE and the Bangladesh Meteorological Department (BMD). The web-application integrates real-time numerical weather forecast model outputs with crop advisories and automatically provides location-specific advice to farmers, covering eight crops at different phonological stages in each of Bangladesh's 492 sub-districts. For each crop, each phenological stage has specific temperature and rainfall thresholds, above or below which crop stresses occur. Agvisely contains advisories for these stages, to be triggered for different values of temperature and rainfall that may arise within the following five-day periods. During the reporting period, a total of 1,160 SAAOs from the 58 *upazilas* in 19 districts were trained in using Agvisely on their internet enabled smart phones or tablets. After completing the training program, more than 500 extension agents were registered in the app. In addition, to popularize the app and ensure its wider use, CSISA, with DAE's support, formed a campaign team and from 4 October 2020 onwards started a phone registration campaign targeting DAE staff. The Activity also organized a series of Zoom meetings with high-level DAE officials (including ADs, DDs, UAOs and AEOs) to disseminate information about the Agvisely app and demonstrate its most recent updates.
- In November 2020, CIMMYT and CSISA organized a national seminar at the Bangladesh Agricultural Research Council (BARC) in Dhaka, Bangladesh on the Activity's work to develop an early warning system for controlling lentil *Stemphylium* blight disease. 18 of Bangladesh's key research and extension management personnel participated. The Activity anticipates that the early warning system will be handed over to the Bangladesh Agricultural Research Institute (BARI), BMD and DAE by late 2021 for national use; though CSISA will continue to provide assistance as needed after the handover.
- CSISA co-supported USAID/Bangladesh backed efforts by the Fighting Fall Armyworm (FAW) project during the reporting period. In an effort to boost women's standing in

agricultural extension, as well as to provide a conduit for women extension agents to reach women headed households and farmers with advice on FAW IPM, the Activity implemented a series of women's only trainings on FAW in collaboration with BWMRI from 22 November to 01 December 2020 in Chuadanga and Dinajpur, respectively, representing key regions for maize growth in southern and northern Bangladesh. To this end, 107 women DAE officials participated in hands-on in-person trainings on FAW while maintaining social distance and with COVID-19 restrictions in place. These trainings mark what is hoped to be a watershed moment in empowering women extension agents in Bangladesh. Subsequent monitoring and evaluation efforts indicated that these women leaders in agricultural extension shared what they learned with 2,530 other staff within the DAE through both formal trainings in their working offices and also informal engagements. The survey also suggested that this modality resulted in approximately 17,000 farmers receiving additional IPM advice for FAW, with 23 percent of these farmers themselves being women or women headed households.

- Mung bean is a highly profitable legume crop, widely cultivated in the southern central coastal region of Bangladesh (especially Patuakhali, Barguna and Barishal districts). However, every year during the harvesting period (mid-April to the end of May), heavy rain and storm events cause large yield losses (and thus income loss) to mung bean farmers. In response, CSISA partnered with a now closed EKN and Mott MacDonald funded pilot project that ran from 2018-2020 that built an interactive voice response (IVR) system for mung bean farmers in some coastal areas of Bangladesh (Patuakhali and Barguna districts). This IVR system provides real-time weather alerts warning farmers to harvest their mung bean ahead of forecasted heavy rainfall events that could damage their crop. During the reporting period, CSISA expanded the reach of the IVR service described above to 10,000 mung bean farmers in Patuakhali and Barguna districts in preparation for the 2021 harvesting period (March-June).
- Smallholder farmers are the engine of food system transformation in developing countries, and their integration into high value chains is critical to achieve rapid transformation and improve local livelihoods. A carefully designed, quality oriented value chain also creates opportunities for small-scale actors such as traders, retailers and processors, across the value chain. CSISA has therefore been working to integrate and incentivize smallholder farmers and other small-scale value chain actors into emerging value chains for premium quality rice (PQR) in Bangladesh. During the reporting period, CSISA proactively initiated partnerships with various stakeholders in the region, with a view to making premium rice more profitable and attractive to farmers in the FtF zone. These partnerships include involving prominent seed companies, millers and traders in the region and linking them with PQR producer groups. In addition, the Activity developed an integrated service model, where seed companies also offer mechanized harvesting and sometimes even purchasing of produce from farmers. CSISA identified six local seed companies in Jashore district: (1) Uzirpur Organic Multipurpose Cooperative Society Ltd (Narail), (2) Modern Agro Private Ltd. (Chuadanga), (3) Square Seed (Meherpur), (4) Konica Seed Company Ltd (Damurhuda, Chuadanga), (5) Friend Seed (Maheshpur, Jhenaidah), and (6) Adarsha seed company (Shailkupa, Jhenaidah), and initiated a private sector grant designed to effect the rapid expansion of PQR in the areas by giving these companies 10% seed support (the seed companies contribute 90% of seed expansion to meet the target of 20,000 tons of PQR

production). During the reporting period, CSISA facilitated the process through four virtual and four face-to-face meetings at hub offices, and developed an agreement with these seed companies for PQR seed and grain production, branding and market expansion. In Faridpur district, the Activity engaged with two seed companies (INSAF and Nur), a partnership which led to the creation of 41 PQR producer groups, involving a total of 1,189 smallholders (36% women).

- During the reporting period in October of 2020, a dialogue was initiated with Bayer Crop Science to gauge their interest in working to raise awareness of weed control products and varieties suitable for DSR technology in Bangladesh. As a result of the Activity's engagement with Bayer, collaborative activities have been planned for the spring *aus* season in 2021. This will include an on-farm performance evaluation of DSR to confirm results obtained in the previous two *aus* seasons of CISA and BRRI's collaborative research.
- In September and November 2019 of the previous work cycle of CSISA, the Activity had facilitated the screening of a video about the benefits of early wheat sowing, reaching 87,084 farmers (19% women) and with AAS registering 40,356 farmers. In this reporting period (2020–21), the Activity conducted a telephone survey to assess technology adoption rate. Data collection and analysis indicated that approximately one-third of video viewers had taken up and are utilizing early wheat sowing techniques on an average of 0.17 ha of land each.

Nepal Highlights

Some of the key highlights from CSISA's work in Nepal during the October 2020 – March 2021 reporting period include:

- The Government of Nepal has prioritized the expansion of rice area and production to meet the growing demand in Nepal. However, there is limited opportunity to achieve this goal in the main monsoon *kharif* season. CSISA has regional experience in understanding spring season rice, and so the Activity is working to enhance the technical capacity of rural municipality extension staff as part of the collaborative activities with KISAN-II (another USAID Implementing partner Activity led by Winrock) and governmental partners in the Joint Rice Implementation program (JRIP). During the reporting period, CSISA worked closely with KISAN-II to advise on best management practices and appropriate agricultural machinery that the government could procure and provide support for under its JRIP subsidy plan.
- In partnership with the Plant Quarantine and Pesticide Management Center (PQPMC), Directorate of Agriculture Development (DoAD) of Lumbini Province, USAID Nepal's Nepal Seed and Fertilizer (NSAF) Project, and iDE Nepal, the Activity organized two days (3–4 March 2021) of 'Training on Fall Armyworm Management and Safe Handling of Pesticides' to agrovet association representatives in Lumbini Province.
- During the reporting period, CSISA worked with the Sustainable and Resilient Farming Systems in the Eastern Indo-Gangetic Plains (SRFSI) project, supported by the Australian Center for International Agricultural Research (ACIAR) to develop a stepwise framework

to understand the reasons behind the slow adoption of DSR and other SI technologies in Nepal's Terai. A household survey was conducted among 1,569 farmers in the Terai, including FtF ZOI operation districts. The stepwise framework consists of four phases designed to understand the reasons behind the adoption and dis-adoption of the DSR technology. The first phase starts with the farmers' "exposure phase," in which farmers are exposed to the DSR and other SI technologies, followed by the "progression phase" dealing with farmers' adoption, the (third) "continuation phase" and finally the "utilization phase." Results suggest that decades of activity have not yet led to the substantial closure of exposure gaps, nor sufficient ownership of machines that enables accessible fee-for-hire service provision. Exposure gaps were substantial in all machines, meaning current demonstration programs may not be achieving their targeted outcomes. Across nearly all machinery, a primary reason for limited progression to sustained adoption was a lack of service providers, a manifestation of limited machinery ownership, meaning current broad subsidy programs aimed at procurement may not be achieving intended outcomes. However, substantial pools of potential adopters and concentration of supply-side constraints highlight that with targeted intervention, rapid rural mechanization is possible in the near future on the Nepal's Terai.

- In Nepal, as within the wider Indo-Gangetic Plains, significant regional climatic gradients, and management practices and constraints, strongly impact farmers' decision-making. Alongside these issues, poor understanding of the interaction between management decisions on the timing of crop planting activities within a host of operational constraints limit the development of spatially targeted crop management advisory systems. To address this bottleneck, CSISA has developed a regional crop simulation framework, based on the parallel system for integrating impact models and sectors (pSIMS) and the APSIM crop model. The model is currently being deployed as part of a study that aims to assess the impact of different planting strategies on yield patterns, resilience and water use, with an initial focus on rice. Preliminary results suggest that if farmers have complete information about the start of the monsoon season (enabling them to grow their nurseries on time, and prepare inputs and main fields for transplanting with the first significant rains), they can achieve potential rice yields of 8,000 kg ha^{-1} (and more in some cases). At the same time, their potential wheat yields are also increased. In addition, such early planting can increase system stability to shocks: the increased preparedness is of additional value in years with late monsoon onset, as this pushes the system further towards the critical threshold of temperature-related stresses to crop growth
- In parts of the Terai region of Nepal, about 70% of cropland remains fallow for about two to three months after the harvesting of winter season crops (such as wheat, lentil, rapeseed and vegetables) and before transplanting rice. This period is characterized as a dry season, with high out-migration of the men to India for seasonal jobs, and a relatively quiet time for household laborers, especially women. This fallow land can be capitalized to improve cropping system productivity and household nutrition by introducing nutritious (24% protein), short duration (70–80 days), and relatively drought-tolerant leguminous crops such as mung bean. Back in 2014, CSISA had established a framework for mung bean crop expansion to replace fallow land across Banke, Bardiya, Kailali and Kanchanpur districts in partnership with NGLRP, seed companies (GATE Nepal and Panchashakti Seed Company),

Poshan Food Ltd, local traders processor and the Ministry of Land Management Agriculture and Cooperative (MoLMAC) of Sudurpashchim province. As described in previous reports as a result of CSISA's encouragement, local governmental partners in collaboration with PMAMP has also started to include mung bean in its regular programming and as such is encouraging farmers to grow mung bean after wheat harvest and before rice. Activities were somewhat hampered, however, during the reporting period as a consequence of the COVID-19 crisis. Nonetheless, farmers in Ghodahodi municipality extended in 20 ha under mung bean, these in Bhajani municipality extended 10 ha. Farmers in Bedkot municipality and Krishnapur municipality also converted 10 and 7 hectares of fallows into mung bean during the reporting period. Similarly, the PMAMP rice super zone had allocated a budget to support farmers with mung bean seed 20 ha and the oilseed zone for 10 ha. In addition, Bishwash Cooperative in Jhalari planned to start seed-producing in 50 ha to avoid the risk of seed scarcity at the time of seeding to their 200 members.

- During this reporting period, CSISA and the Nepal Agricultural Research Council (NARC) supported the Prime Minister Agriculture Modernization Project (PMAMP) in conducting rice crop cuts and farm management practice surveys in Rice Super Zones and Zones in Nepal's Terai. CSISA provided capacity development training (6–7 January 2021) to PMAMP staff, enabling them to conduct the crop cuts as well as landscape diagnostic surveys, using the ODK digital tool. Independent enumerators were hired to collect data from the areas not covered by PMAMP. Due to mobility restrictions imposed by COVID, the training was conducted virtually, and only districts from the Nepal's Terai were included in the sampling frame. The crop cuts were conducted among 170 plots, while the rice production practices survey was conducted with 2,100 households, located in the Terai, by telephone. The data generated by PMAMP and NARC have been used to provide farmers with better agronomic management recommendations. NARES data is analyzed every year and the findings incorporated into PMAMP's programs.

Policy Research and Reform Highlights

Some of the key highlights from CSISA's work under policy research and reform during the October 2020 – March 2021 reporting period include:

- During the reporting period, the policy research team analyzed previous year's data and information on fertilizer prices and policies in South Asia. There was drastic reduction of non-urea fertilizer prices from 2008 onwards which continued till 2012, following the fall in international fertilizer prices. This 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 more appropriate and balanced fertilizer application. To facilitate better understanding of whether this price change translated into changes in farmer-level use of fertilizers and if farmers were able to reap the benefits of this massive increase in subsidy, CSISA, in the previous reporting period, had analyzed different data sources covering the period of price change to assess its impact on fertilizer use. This included 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 BIHS which collected data across two rounds in 2010–11 and 2013–14 of over 3,000 paddy growing households. While there were differing results across the three datasets, the findings corroborate the economic intuition of increase in demand and use as prices fall. According to secondary data sources, urea use in Bangladesh followed the price pattern, as it plummets with the price increase until 2012, though it then increases with the fall in price post-2012 until 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. 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. The decline in MoP prices continued until 2011 before it stabilized. VDSA data conversely shows opposite results compared to the BIHS 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. In the current reporting period, the findings from this analysis are being used to prepare a policy brief and/or journal article. An interactive stakeholder workshop drawing attention to the need for evidence generation and extension to encourage balanced fertilizer application by farmers in Bangladesh is planned for the later part of the year, depending on the COVID-19 scenario and associated regulations and travel restrictions.

- CSISA completed data analysis of a willingness to pay study for knap-sack fertilizer spreaders in the Terai. The spreader is hand-operated, and using it distributes the fertilizer and seed uniformly across the plot. This reduces the patchy crop standing and minimizes within-field yield variability. CSISA introduced this cost-efficient technology in FtF ZOI in 2014. Initially, however, farmers found the cost (USD 80) prohibitive. CSISA worked with multiple partners, including NAMEA (Nepal Agricultural Mechanization Entrepreneurs Association) and a manufacturer in China, and introduced a more cost-effective spreader, at around USD 25. However, many farmers are unaware of this technology. To identify the potential demand for this affordable and gender-friendly spreader, in early 2020 CSISA conducted a study on Terai farmers' willingness to pay for the spreader and the data was analyzed during this reporting period. A total of 1,569 famers were considered in the sampling frame for the study. On average, the large farms were willing to pay 33% lower than the average market price, while small farmers were willing to pay 50% lower than the market price. These results suggest that farmers may require a support mechanism to initially adopt this technology. A similar result across household's gender cohorts was observed, where male headed households were willing to pay higher than the female headed households, although for both categories average willingness to pay was lower than existing market price.
- In response to the threat posed by Fall Armyworm (FAW) in Nepal, in the previous reporting period (April 2020 to September 2020), CSISA carried out an experiment in Dang district, Province 5 in Nepal to explore the effectiveness of phone-based 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 IPM approaches appropriate for FAW. This is a new workstream in the CSISA project, added due to the emergent threat posed by FAW. The objective of this workstream was to

measure the effectiveness of the differing information mediums in improving farmers' knowledge of FAW and related IPM messages. The experiment was carried out in two treatment arms and one control group. The results from this experiment will be disseminated among all relevant stakeholders in the form of discussion paper, research note, and journal article. CSISA will also engage in conversations with regional stakeholders to facilitate cross-country dialogue on effective extension approaches for promoting knowledge and adoption of IPM solutions. The findings will help in communicating to the policy makers the impact and feasibility of deploying ICT tools to aid agriculture extension systems in the country, particularly in times of crisis. As social 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. 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.

- The CSISA team also used data from the FAW study to complete a landscaping of the effects of Nepal's COVID-19 crisis on agricultural systems. The baseline survey captured the market conditions faced immediately after the lockdown (coinciding with the wheat harvest), and the endline survey covered the market conditions for crops (primarily maize) which were harvested in and around August 2020. Many farmers in our sample practice farming for self-consumption and basic food security. Of the farmers who had harvested crops before the baseline survey, only 55% reported selling their produce in the market. Of these, 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. During the second round of data collection, fewer farmers reported selling crops as they were still in the process of harvesting maize when the endline survey was conducted. Of the farmers who sold summer maize, 67% reported obtaining lower prices than the previous year and 15% reported facing difficulties in selling the crops. Farmers reported persisting issues of lower prices, lack of transport, and movement restrictions as lockdown was being reimplemented across the country around that time. Farmers covered in the study have diversified income portfolios to cope with the economic stresses associated with the COVID-19 crisis. Over 78% of 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. Around 46% respondents indicated remittances as a source of income for their households. Respondents reported a clear fall in income from remittances, wages/salary and business following the COVID-19 lockdown in Nepal. Over 80% of respondents indicated that remittance income had declined (17% reported no change). After lockdowns were lifted, over 70% of respondent households had to use at least one coping measure to deal with the economic impact. These findings highlight the need for policy action to ensure food and income security, especially among marginalized farmers. Lack of access to markets and reduction in both farm income and remittances is likely to reduce investments in agriculture inputs, further trapping farmers in a cycle of low output and productivity. The impacts are exacerbated by the mass reverse migration and loss of remittance income, which is the single most important source of income for the country.

Some of the key highlights from CSISA's work during the October 2020 – March 2021 reporting period for the CSISA COVID-19 Resilience Activity in Nepal, which is a buy-in to the wider CSISA program from USAID/Nepal, include:

- CSISA implemented innovative methods to overcome access to finance constraints to the procurement of agricultural machinery by migrant workers who returned to Nepal following the COVID-19 crisis's first wave in India. Banks are initially reluctant to loan to returnee migrants. This is because they were perceived as (a) higher-risk clients that could flea in the event of loan default, (b) lack of adequate collateral for loans, and (c) because banks rarely lend for agricultural machinery, and when they do, they tend to implement a policy in which loanees must have a verified residence within a 3 km diameter area of the bank branch extending the loan. The latter is another risk and transactions cost reducing measure on the part of banks, so they do not have to expend considerable time, money, and effort locating defaulting clients. Finally, (d) many banks indicated that machinery can breakdown easily, and when not repaired, loanees may not be able to generate business to repay their debts. These criteria, however, are clearly constraints to engaging returnee migrants as service providers. In order to tackle this challenge, CSISA worked during the reporting period closely first with Muktinath Bikas Bank Ltd. (MNBBL), and then later with Nabil Bank, MegaBank, and Century Commercial Bank, to develop risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery. In order to reach agreements, high-profile coordination meetings were held following COVID-19 safety guidelines. While it took time to navigate these challenges and come to agreements with these banks, the process is beginning to yield impact, and is anticipated to be a more sustainable model of assuring meso-level finance to bank clients who are considered to be part of risker lending portfolios from the standpoint of banks in Nepal, particularly return migrants. At the time of writing, 32 returned migrants had purchased machinery and entered into rural entrepreneurial business service farmers as a result of CSISA's interventions.
- CSISA worked with established machinery dealers to develop a 'service provider and sub-dealer pilot learning program', that was very successful. In total, 17 returnee migrants with an interest in agricultural machinery and services provision were selected by 13 agricultural machinery dealers that collaborate with CSISA. The target for this work was to enroll and support 15 returnee migrants, and the Activity exceed this target by two people. The machinery dealers that participated in this program included Krishi Solution in Banke, Swostik Traders in Bardiya, Quality Agro Suppliers in Bhurigaun, Karnali traders in Bardiya, Aayeshaa Power Tiller Mermat Kendra in Joshipur, NB Krishi Auzaar Kendra, in Kailali, RTC AgroMachinery and Engineering Workshop in Kanchanpur, RK traders in Kanchanpur, and Swargadwari Trade Link, Surya Traders, and Kishan Trade and Link, the latter three in Dang.
- CSISA has also partnered with Texas A&M University to develop a framework for sustainable irrigation development in the FtF Zone of Nepal. During the reporting period, the Activity completed two large-scale reviews to provide information for this framework (the first on Conjunctive Use of Surface Water and Groundwater Resources as a Response

to 'Water Access Challenges in the Western Plains of Nepal', the second on 'Understanding systemic barriers, socio-economic and institutional challenges, and opportunities in scaling water access and irrigation technologies').

- In addition, CSISA worked with the Groundwater Resources Development Board (GWRDB) to implement Nepal's first-ever pilot project for digitally backed groundwater monitoring systems in the Terai. The project team is also working to complete scenario modeling assessments using a participatory approach driven by stakeholder input to finalize the framework for irrigation development within the calendar year.

Context, Approach and Theory of Change

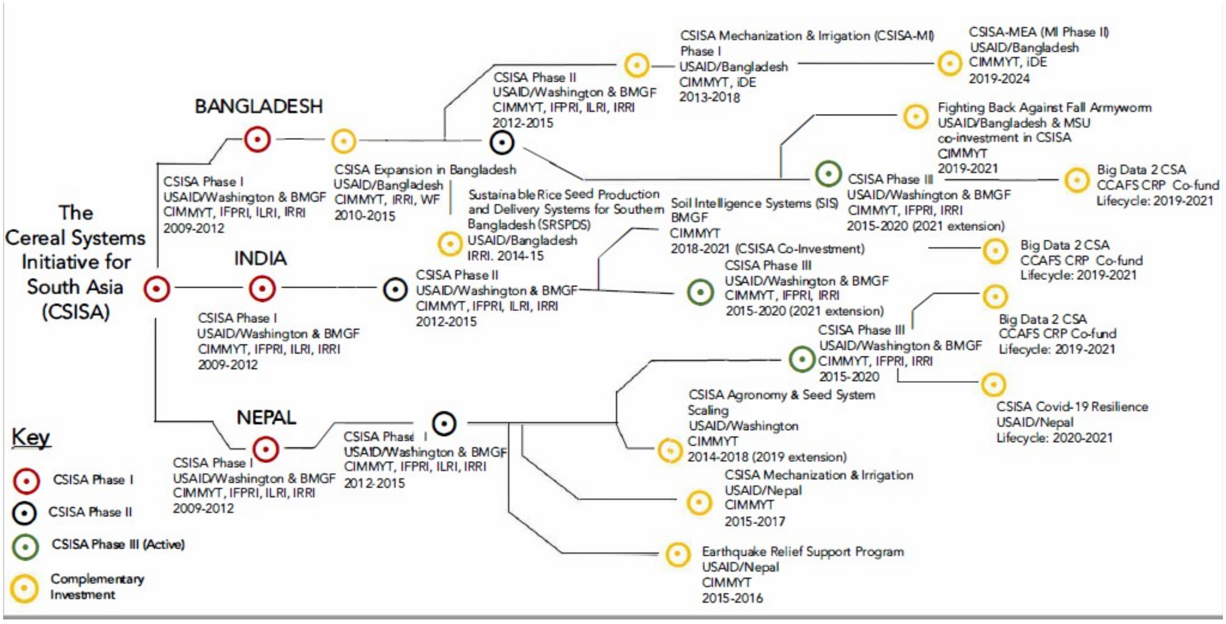
Ever since the food price crisis of 2007–2008, agricultural research and development in the developing world has received considerable public sector, private sector and donor investment. In South Asia, attention has shifted to focus on the impoverished areas of the Eastern Indo-Gangetic Plains – particularly 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 in 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

[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

and sustain transformative change. 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 Activity 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.



***Above**: The 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-MEA activity 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 Activity 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 CSISA 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 Activity generates data and evidence on improving crop production and identifying

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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.

[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).

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.

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 Activity 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

A. INNOVATION TOWARD IMPACT

A1. Reducing risk to facilitate uptake of sustainable intensification practices

A1.1 Direct-seeded rice to address labor and energy constraints to precision rice establishment

In South Asia, researchers have long encouraged a 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 dramatically reduce production costs and improve and reduce the environmental impact of rice production. For farmers that transition from transplanted rice to DSR, however, significant changes in management practices and often the use of agricultural machinery are needed. DSR is established without flooding the field and through use of machine-aided sowing rather than transplanting. In combination, this saves labor and water, cultivation costs, and can lower greenhouse gas emissions. But while DRS has benefits, farmers tend to emphasize that it also has risks that limit its adoption in South Asia, including Bangladesh. Examples of these concerns include poor and uneven crop establishment, weed management challenges, and a lack of suitable cultivars for DSR. In addition, soils need to be of the right texture, and farmers need to be able to much more carefully manage irrigation and floodwater depths. Rice is also sensitive to cold – particularly early in the winter season.

Because of cold injury risks to seedlings during the winter '*boro*' rice season and uncontrollable flooding in the summer '*aman*' season, the research conducted by CSISA on DSR has focused mainly in the pre-monsoon '*aus*' season (usually sown in April–May and harvested in July–August – also known as *kharif*-1). Efforts have also been targeted in select portions of the southwest of the country where soil and hydrological conditions are likely to be better suited to cropping.

***Above**: Establishment of directly sown rice, or DSR, in Bangladesh is often done with specialized machinery.*

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 mechanized seed drill owners) in the spring *aus* season. The primary research activity streams relate to efforts to quantify the impact of DSR on yield profitability as compared to farmers' predominant practices of wet tillage and manual transplanting. Because varieties that are weed competitive and establish rapidly under nontransplanted conditions are needed, CSISA also works closely with BRRI to identify the most suitable rice varieties compatible with DSR in the *aus* season. Public field visit days to on-farm trials are also used to raise awareness regarding DSR. In particular, CSISA has made use of field visits from policy makers within the Ministry of Agriculture to boost their understanding that DSR can be an option in the right season and location, and with the right varieties. Activities pertaining to DSR in the October 2020–March 2021 reporting period are detailed below.

Direct-seeded rice: Performance evaluation study 1

The goal of this on-farm performance evaluation of DSR 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. The *aus* season for DSR activity starts in April 2021 and is thus outside this reporting period. However, seeing the encouraging results from the last two *aus* seasons reported in the 2019 and 2020 annual reports, CSISA and its partner BRRI plan to continue this DSR performance evaluation study (1) in the coming *aus* season 2021 to confirm the results, in the expectation that the COVID-19 situation will be under control. The DSR performance evaluation study (2) and awareness-raising activities were suspended because of COVID-19 and have not yet been rescheduled.

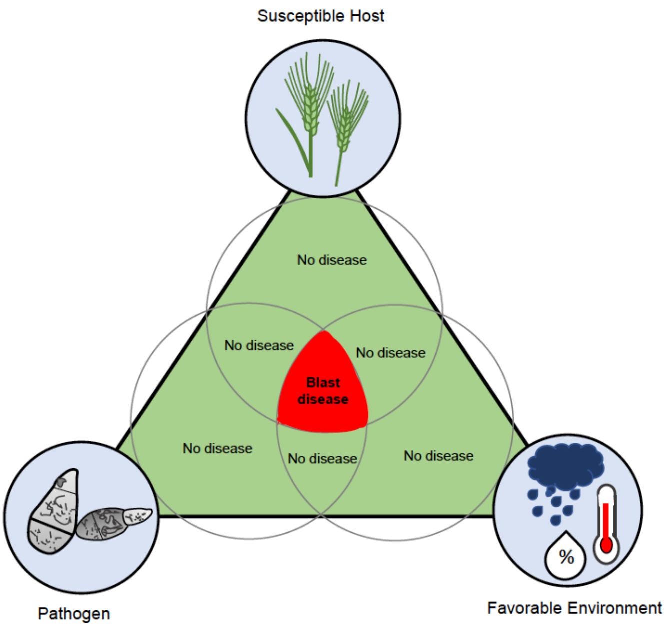
During the reporting period in October of 2020, a dialogue was initiated with Bayer Crop Science to gauge their interest in working to raise awareness of weed control products and varieties suitable for DSR technology in Bangladesh. As a result of the Activity's engagement with Bayer, collaborative activities have been planned for the spring *aus* season in 2021. This will include an on-farm performance evaluation of DSR to confirm results obtained in the previous two *aus* seasons of CISA and BRRI's collaborative research.

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. However, this study has been temporarily suspended due to COVID-19 restrictions in Bangladesh. However, if the situation permits then this will start again in this *aus* (May–August) season.

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

Wheat blast is a fast-acting fungal disease that – under the right weather conditions – can dramatically affect wheat productivity. Endemic in South America, this disease can also now be found in South Asia. In 2016, Bangladesh suffered its first severe outbreak of wheat blast, and in 2017, CSISA and other CIMMYT led projects partnered with the Bangladesh Maize and Wheat Research Institute (BWMRI) released a blast-resistant wheat variety (BARI Gom 33) developed from breeding lines maintained at CIMMYTs headquarters in Mexico and verified through laboratory work undertaken by the United States Department of Agriculture.



Above: *Although a major outbreak has not occurred since 2016, wheat is still widely grown and the pathogen is still present in the environment. With the right weather conditions, wheat blast could reoccur and be a major problem for farmers in Bangladesh.*

However, although it was possible to release this variety quickly, supplies of seed remain limited, despite efforts to multiply seed. This renders wheat crops in Bangladesh and South Asia continually vulnerable to blast. 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 conditions, more humid or hot years are likely to see additional outbreaks.

Above: *CSISA Project Leader Timothy J. Krupnik and Israil Hossain, former Director General of the Bangladesh Wheat and Maize Research Institute, explains advances in breeding and early warning systems against wheat blast to Mohammad Abdur Razzaque, Bangladesh's Minister of Agriculture and Iqbalur Rahim, member of Bangladesh's Parlament in Dinajpur in March of 2021. (Photo: Md. Harun-Or-Rashid/CSISA)*

Large-scale registration to the wheat blast early warning system

As described in the previous Annual Report, CSISA worked with BWMRI, the Department of Agricultural Extension, the Bangladesh Meteorological Department (BMD), and Embrapa in Brazil to develop a weather-forecast based wheat blast early warning system – which can be found at www.beattheblastews.net. The early warning system was formally endorsed by the key Ministry of Agriculture line agencies responsible for its endorsement. Just one year ago in the 2019-20 winter wheat season, only 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. Twelve months later, CSISA's cooperation with DAE has yielded a significant increase in enrollments. More than 6,000 agricultural extension agents are now enrolled in the early warning system, and are positioned to get alerts in the event of outbreak risks in their working locations.

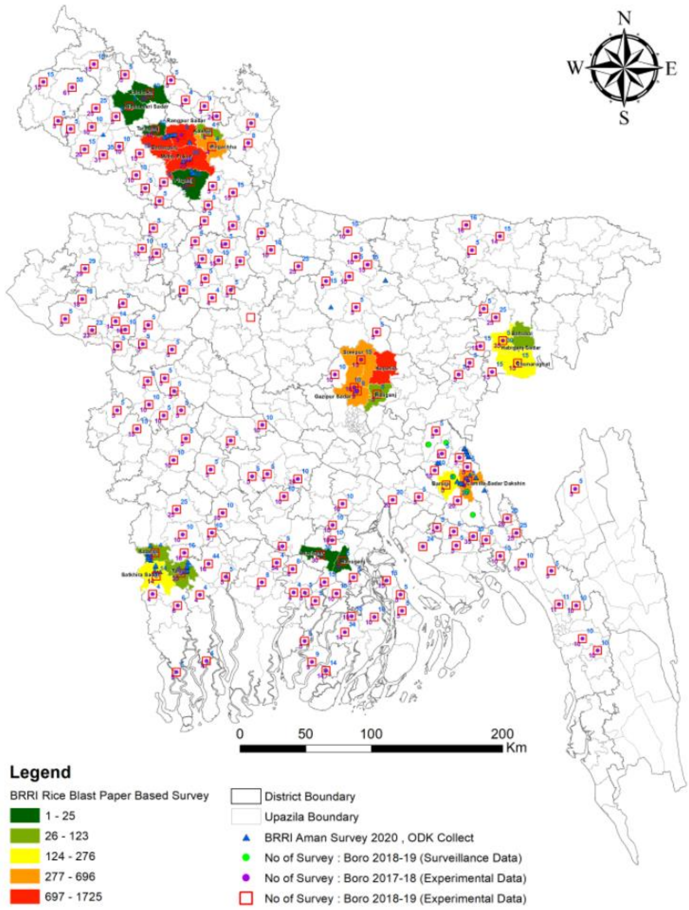
***Above**: Md. Harun-Or-Rashid of the CSISA team monitors wheat blast spores caught by an automatic aerial spore trapper each year to help assess the risk of wheat blast outbreak reoccurrence in Bangladesh..*

Thankfully, however, no major outbreak occurred in the 2020-21 wheat season. This appears to be due to favorable climatic conditions (relatively cooler and less humid winters), in addition to relatively sparce densities of spores found through atmospheric trapping. The early warning system – which functions automatically from January through March, the key times of each wheat season in Bangladesh when blast is most susceptible – however serves as a buffer to provide information that can reduce farmer's exposure to risks.

Towards a rice blast early warning system

Wheat blast is caused by the fungal species *Magnaporthe oryzae* pathotype *Triticum.* Rice blast disease, caused by the same fungal species but by the *Oryzae* pathotype, is a common problem in Bangladesh. After gaining awareness of the wheat blast early warning system, BRRI approached CSISA in 2020 and has since requested a research collaboration to adapt the wheat blast early warning system to predict rice blast outbreaks. Collaboration with BRRI's Department of Plant Pathology is now underway in response to this request. Scientists from both teams have assembled a comprehensive dataset of more than 3,500 GPS located reports of rice blast over the last few years. These are being used to cross reference and validate the ability of the wheat blast model to identify these locations, although tweaking of some of the mathematical parameters of the model will be required for this effort. As this work only recently commenced, more information on research progress towards a rice blast early warning system will be provided in the 2020-21 Annual Report.

Wheat blast surveillance



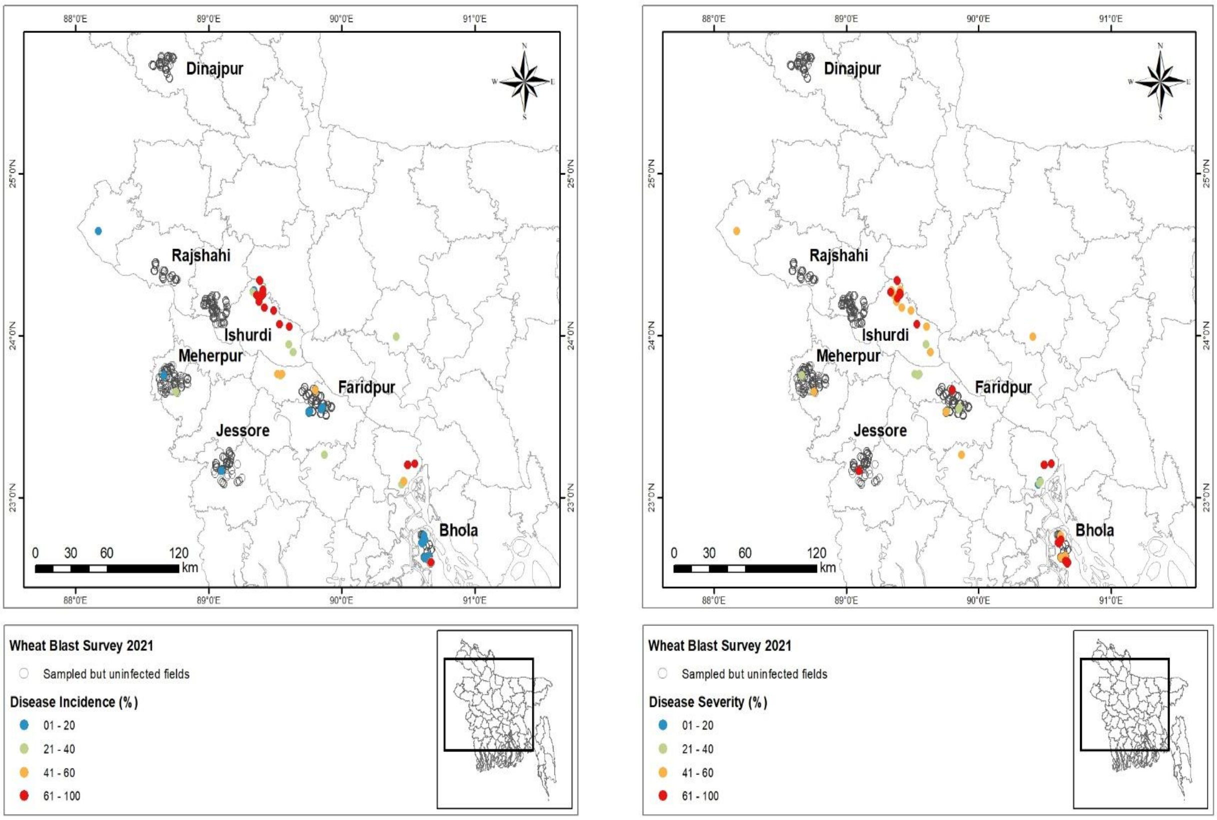
***Above**: Historical observations of fields infected with rice blast disease that will be used to test the applicability of the wheat blast model developed by CSISA to predict wheat blast to rice blast.*

From 2016 forward onwards, CSISA has supported comprehensive wheat blast surveillance activities, which has been conducted during the last four *rabi* seasons across the country in collaboration with BWMRI, DAE and Bangladesh Meteorological Department (BMD). As in previous years, the monitoring for wheat blast disease was conducted in seven major wheat growing districts (Dinajpur, Rajshahi, Pabna, Faridpur, Jashore, Meherpur and Bhola). The surveillance data was used to validate the wheat blast early warning system which CSISA has developed in partnership with Universidad de Passo Fundo and EMBRAPA in Brazil and through its synergies with the Climate Services for Resilient Development (CSRD) in South Asia project, also supported by USAID.

Taking into consideration results from the previous years and the period in which wheat blast usually occurs, only one visit was maintained during the heading stage from 20 February to 1 March 2021. Prior to this, the activity organized a training program in two batches (9–10 February and 11–12 February 2021). CSISA and BWMRI scientists led the training program and trained enumerators to identify and collect data on the disease, using a digital data collection tool, Open Data Kit (ODK).

Above: *wheat blast disease surveillance in the Faridpur region (Photo: Md. Amirul Islam/CSISA)*

A total of 789 fields were observed across seven districts, out of which wheat blast disease was found in only 87 (see figures below). Incidence and severity of disease were low, except in Pabna and Bhola districts, where incidence was found in 18 fields out of 58 (Pabna) and 31 fields out 88 fields (Bhola). In both cases, disease severity varied from 25% to 80%. In the Faridpur region, only 34 fields (out of 205) were found to be infected.



Above: *wheat blast disease incidence (%) and severity (%) observed in sampling locations in the 2020-21 wheat season. Map courtesy of Mustafa Kamal (GIS & Remote Sensing Analyst, CSISA)*

No disease was observed in the Dinajpur, Jashore and Ishwardi regions. It was evident from the survey that only older varieties (BARI Gom 24, BARI Gom 26) appear to be much more affected by blast. Although incidence of blast disease was low this year, as the experience of 2016 showed, the risk of outbreak remains given that the Activity has continuously observes reservoirs of infection and found inoculum during aerial spore trapping in the wheat-growing zones. All that is needed to trigger an outbreak are more hot and humid winters, which could certainly occur in the future.

Effect of cultivar mixtures on wheat blast

Genetic uniformity makes a crop more vulnerable to diseases, and to address this, one potential, low-cost method of increasing genetic diversity is the use of seed mixtures of different cultivars. Studies suggest that different varieties of cultivar mixtures can reduce disease intensity (incidence and severity), and stabilize (and in many cases increase) yield through the dilution of spores, barrier effect caused by resistant cultivars, induced resistance, disruptive selection and compensation effects. Starting in 2018, CIMMYT conducted an experiment in collaboration with BWMRI at the Regional Agricultural Research Station (RARS) (23.188069 N; 89.190033 E), BARI, Jashore to identify (1) efficient mixture combinations to mitigate wheat blast disease, and (2) to what extent fungicide can control wheat blast under high disease pressure and a favorable environment.

Above: *mixture trial experiment with misting irrigation system to stimulate infections under high disease pressure (Photo: Md. Harun-Or-Rashid/CSISA)*

This is the third year the experiment has been run in the same location and with the same treatments and layout. The major outputs of the first and second year seasons' experiments (2018–19 and 2019–20) were (1) cultivar mixtures used with blast resistant and tolerant wheat varieties (BARI Gom 33 and BARI Gom 30) can better control diseases (Blast and BpLB), and (2) fungicide spray is remarkably effective at controlling both diseases, even under high inoculum pressure.

In all three years, three wheat varieties – BARI Gom 26 (blast susceptible), BARI Gom 30 (blast tolerant) and BARI Gom 33 (blast resistant and 2NS segmented) – were selected to test in mixtures with different seed densities. Ten sub-plot treatments were prepared and sown on 23

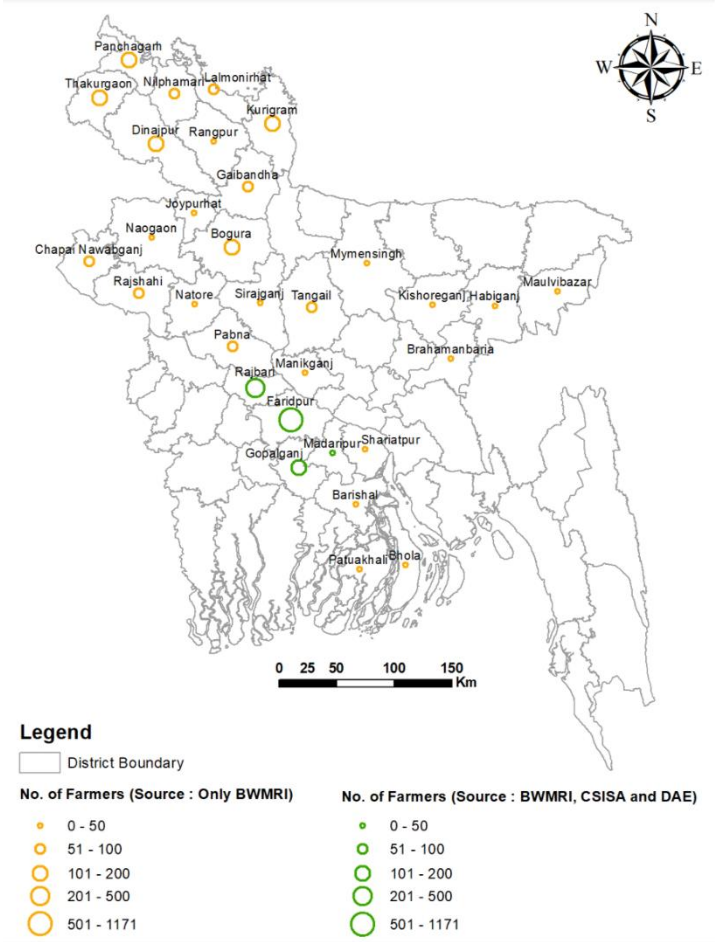
December 2020 with 3 sole-variety, 6 two-variety and 1 three-variety mixtures with (1) 33% + 66%, (2) 66% + 33%, and (3) 33% + 33% + 33% cultivar seed densities. The design of the experiment is a split-plot with five replications, with the main plots divided into fungicide and without-fungicide treatments to further assess if cultivar mixtures can reduce relative yield losses when fungicide-protected plots are compared to unprotected plots under high disease pressure.

Above: *CSISA and BWMRI staff planning the harvest of the cultivar mixture experiment in March of 2021*

The 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. Nativo 75WG (Trifloxystrobin 25% + Tebuconazole 50%) fungicide was sprayed five days after each inoculation in the fungicide main plot. During fungicide spraying the no-fungicide main plots were protected from contamination by thick plastic sheeting. The whole experiment was put under mist irrigation (see photo, above), with misting stopped from 24 hours before to 24 hours after fungicide spraying. As well as blast, the experiment was also infected with *Bipolaris* leaf blight (BpLB), the most common wheat disease in Bangladesh. The effect of fungicide on mixture combinations and sole plots were then measured.

The experiment is being harvested at the time of writing. The disease data of the experiment has been recorded, but data recording of yield and other yield components is not yet complete. When all data has been collected, three years' data will be analyzed and reported in the Annual Report. Adoption of the technology might prove challenging in Bangladesh, although motivational activities may overcome this, and mixed varieties cultivated if it output.

Multiplication of wheat blast In 2017, three high yielding, early maturing, heat- and disease-tolerant wheat varieties (BARI Gom 31, BARI Gom 32 and BARI Gom 33) were released in collaboration with CSISA and HarvestPlus. BARI Gom 33 is a selection from a cross (KACHU/SOLALA) resistant to wheat blast with a 2NS chromosome segment and a high Zn content (50–55 ppm, compared to other wheat varieties with an average of 40 ppm), will be very useful in reducing childhood stunting and micronutrient deficiency, in addition to preventing wheat blast spreading. This variety is also tolerant to lodging, and its yield is 4,000–5,000 kg/ha. In 2017–18 and 2018–19, small-scale demonstrations and seed production programs were conducted using these varieties.



***Above**: Locations across Bangladesh in which CSISA, BWMRI, and DAE have collaborated with farmers to multiply BARI Gom 33 seed, which is blast resistant and zinc fortified, during the 2020-21 cropping season. Multiplied seed will be widely distributed to farmers before the subsequent 2021-22 wheat growing season.*

However, in Bangladesh, it generally takes at least four to five years for a new wheat variety to reach large masses of farmers. This is because first, institutes like BWMRI need to produce breeder seed for two years. Then the third year, BWMRI handover the breeder seeds to Bangladesh Agriculture Development Corporation (BADC). Then BADC further multiplies them for another two to three years or more to produce certified seeds, which will be subsequently disseminated to farmers DAE.

In this reporting period, in collaboration with BWMRI and DAE, the Activity conducted farmers participatory block-wise intensive seed multiplication of blast resistant wheat variety BARI Gom 33, targeting early wheat seeding. Distribution of 25.1 tons of BARI Gom 33 wheat seed took place in Jashore, Khulna, Faridpur and Dinajpur agricultural regions, with the Activity bearing the cost of the seed and handover to DAE for block-wise producer groups seed multiplication. DAE distributed BARI Gom 33 seed to around 1,223 farmers (138 women, 1085 men) in 74 *upazilas* in 21 districts.

The Activity also forged a communication link between LSPs, DAE seed growers and SAAOs. There was wide acceptance by farmers of blast resistant wheat variety BARI Gom 33, and DAE expressed its appreciation of the seed expansion work effected by CSISA. Production was approximately 592 tons (3.5 tons/ha) for this season, with 414 tons (70%) produced as seed. CSISA also provided four rounds of ToT to DAE SAAOs on wheat seed production, preservation and expansion.

CSISA has collected a wheat distribution master roll and signup sheet from DAE with GPS coordinates from every farmer's field. Data input in Microsoft Excel is underway, after which the information will be shared in the 2021 CSISA Annual Report.

Table 1. *CSISA–BWMRI–DAE BARI Gom 33 seed multiplication program*

Name of district	No. of *upazilas*	Allocated BARI Gom 33 seed (kg)	No. of farmers			Total land (ha)
			Male	Female	Total	
Faridpur	9	3,100	111	20	131	20.5
Rajbari	5	1,500	53	15	68	10
Gopalganj	4	1,000	39	8	47	6.75
Madaripur	4	900	38	7	45	6
Shariatpur	5	900	37	2	39	6
Barishal	6	1,000	42	2	44	6.75
Bhola	5	1,650	55	11	66	11
Patuakhali	5	1,000	41	4	45	6.75
Jalakhati	2	500	21	5	26	3.5
Barguna	2	450	23	1	24	3
Sub-total (Faridpur)	***47***	***12,000***	***460***	***75***	***535***	***80.25***
Jashore	4	3,200	144	5	149	21.3
Narail	1	1,000	50		50	6.7
Magura	3	1,900	87	3	90	12.7
Jhenaidah	3	2,240	111	37	148	14.9
Chuadanga	3	1,300	65		65	8.7
Mehepur	3	2,000	100		100	13.3
Khulna	3	240	12		12	1.6
Satkhira	2	120	6		6	0.8
Sub-total (Jashore)	***22***	***12,000***	***575***	***45***	***620***	***80***
Dinajpur	3	700	31	17	48	5.6
Thakurgaon	1	350	16	1	17	2.8
Nilphamari	1	60	3	0	3	0.5
Sub-total (Dinajpur)	***5***	***1,110***	***50***	***18***	***68***	***8.9***
Grand total	**74**	**25,110**	**1085**	**138**	**1223**	**169.15**

2. Adding value to extension and agricultural advisory systems

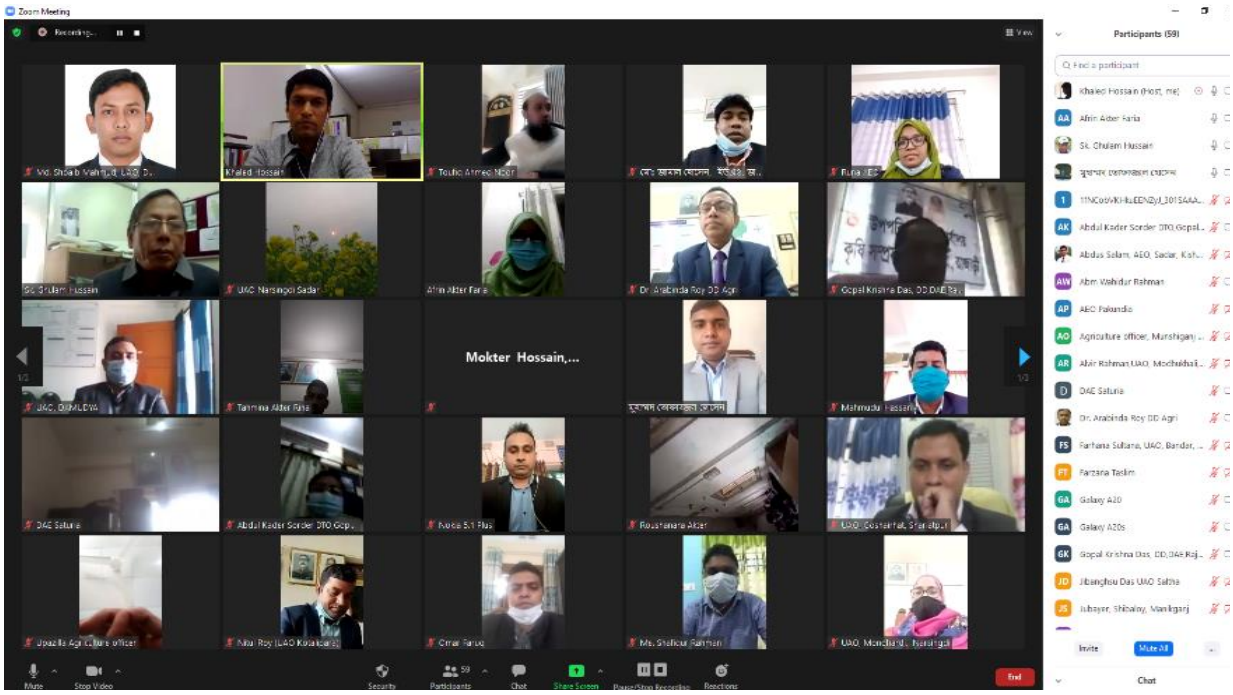
A.2.1 Strengthening the foundations of agro-advisory through knowledge organization and data integration

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

'Agvisely' is an agro-meteorological services tool developed by CSISA, DAE and BMD. The web-application integrates real-time numerical weather forecast model outputs with crop advisories and automatically provides location-specific advice to farmers, covering eight crops at different phonological stages in each of Bangladesh's 492 sub-districts. For each crop, each phenological stage has specific temperature and rainfall thresholds, above or below which crop stresses occur. Agvisely contains advisories for these stages, to be triggered for different values of temperature and rainfall that may arise within the following five-day periods.

In November 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. To implement the application in the field, several ideas were discussed with DAE's top management in late 2020. CSISA then facilitated in the capacity development of DAE with trained UAOs and AEOs as ToTs. These trained DAE personnel then trained 20 SAAOs in 58 selected *upazilas*. A total of 1,160 SAAOs from the 58 *upazilas* in 19 districts were trained in using Agvisely on their internet enabled smart phones or tablets. After completing the training program, more than 500 extension agents were registered in the app. In addition, to popularize the app and ensure its wider use, CSISA, with DAE's support, formed a campaign team and from 4 October 2020 onwards started a phone registration campaign targeting DAE staff. The Activity also organized a series of Zoom meetings with high-level DAE officials (including ADs, DDs, UAOs and AEOs) to disseminate information about the Agvisely app and demonstrate its most recent updates.

Between launching the app and the time of writing, the campaign team has completed the first phase of the campaign, having called 7,099 DAE sub-assistant agricultural officers (SAAOs), who are front-line extension agents, and reached 6,275, of whom more than 1,850 are now fully trained and registered as users of the app. CSISA also continues to work to improve the app. In response to SAAO demand, a Bangla version has been added alongside the English version, as well as five-day forecast of humidity data, and temperature and rainfall forecasting as a weather variable. Every week, CSISA arranges a Zoom call with users; so far, 20 Zoom sessions have been conducted with SAAOs/UAOs, with 55 participants proving user level feedback, their expectations of the app, and how its use can provide them with a better service.



***Above**: a series of Zoom meetings, organized with senior DAE officials about the Agvisely an automated climate advisory service tool for major field crops of Bangladesh.*

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

Lentil (*Lens culinaris*) is an economically and socially significant legume crop and an integral part of many nutrition-sensitive cropping systems in South Asia. *Stemphylium* blight (SB) disease, caused by *Stemphylium botryosum*, presents a considerable threat to the sustainability of lentil production in the region. Only a few varieties of lentil have full resistance to the disease, meaning that the scope to manage SB just through the manipulation of genotypes is limited. Calendar-based fungicidal control is recommended, but this is not always effective or profitable, as the incidence and severity of the disease, driven by weather conditions, varies between years and between locations. Over-use of fungicides can also present human and environmental health risks.

In order to support farmers in making climate-smart decisions on fungicide application to maintain productivity and resilience in the face of disease risks, the 'Stempedia' model was developed, calibrated and validated using large-scale field surveys (collating data from 480 farmers' fields each year) conducted in Bangladesh, India and Nepal during the growing seasons of 2017–18 and 2018–19 through the CSRD project. Having acquired evidence-based satisfaction with the performance of the Stempedia model in South Asian environments, CSISA, with the closure of CSRD, took on the further development of lentil crop disease research activities, with the goal of running validation field tests with national partners and working to move the model into a formal weather forecast-based early warning system.

The last CSISA Annual Report concentrated on four aspects of the lentil disease modeling system: (1) development of the broad implementation framework for the early warning system

(EWS) for lentil *Stemphylium* blight disease (LSB) in Bangladesh and Nepal, (2) raising stakeholder awareness and facilitating consultations on the feasibility and applicability of EWS–LSB in Nepal and Bangladesh, (3) analysis of the value of model-guided fungicide application in controlling lentil SB disease, and (4) protocol design and development of a plan of action for the field testing of the EWS–LSB in the 2020–21 lentil season. Updates on this work are provided below.

Stempedia activities conducted in the 2020–21 reporting period

In the reporting period, CSISA activities focused on (1) national endorsement of the Stempedia model and model-based EWS, (2) formalization of partnership with key national organizations, (3) field operations in implementing validation of a model-based EWS in partnership with national organizations, (4) forecasting system set up and development, and (5) devising and delivering a communication campaign to the stakeholders.

Above: *Moin Salam's presentation as part of the national seminar, "Early warning system for controlling lentil Stemphylium blight disease: Validation and application of Stempedia model", 23 November, 2020 BARC, Dhaka, Bangladesh. At the far end Dr. S. M. Bakhtiar (center), Executive Chairman of BARC, Dr. Timothy J. Krupnik (left), Country Representative for Research and Partnerships of CIMMYT-Bangladesh and Mr. Md Asadullah, Director General of DAE. (Photo: Md. Washiq Faisal/CSISA)*

Serious COVID-19 lockdowns and movement restrictions, as the previous report highlighted, continued to disrupt physical meetings, face to face consultations, and office and field visits. This was the case in both Bangladesh and Nepal, where research to develop the Stempedia model into an early warning system for lentil are underway. CSISA conducted as many of these consultations as possible via Zoom; however, virtual communication systems have not been effective in implementing on-farm research activities or consultations with stakeholders unaccustomed to or without internet connectivity. Nevertheless, the Activity was able to fulfill many of the planned tasks without greatly compromising on quality. Actions that we succeeded in implementing are reported on below.

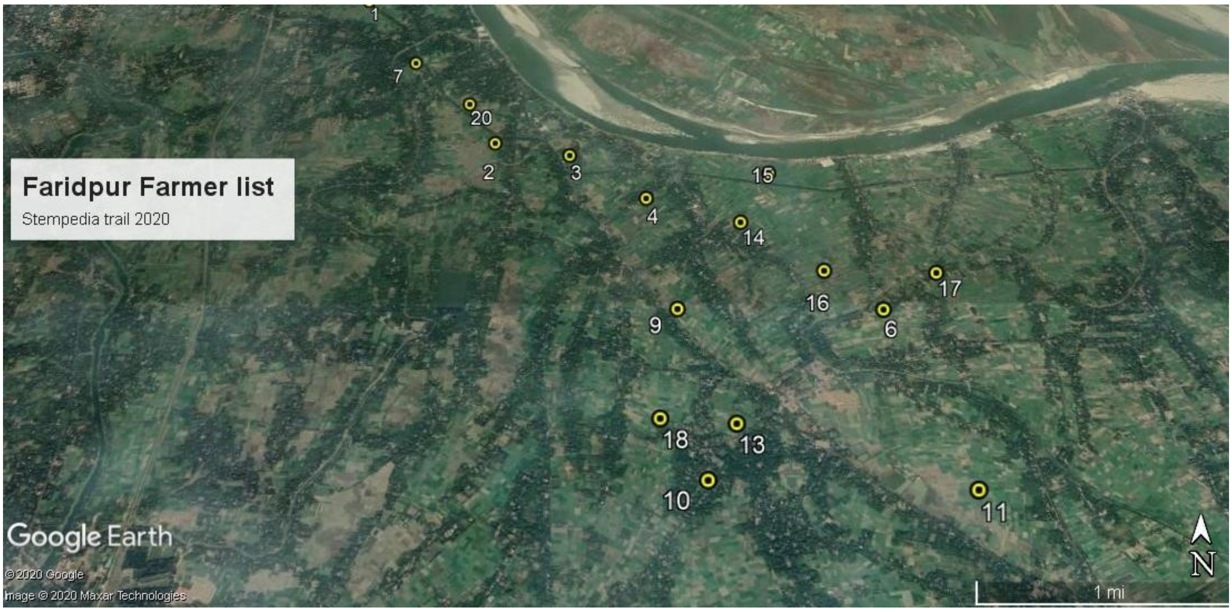
National endorsement of Stempedia model and model-based early warning system: In November 2020, CIMMYT and CSISA organized a national seminar at BARC, Dhaka, Bangladesh. CSISA's lead consultant working on lentil diseases, Moin Salam, presented "Early warning system for controlling lentil *Stemphylium* blight disease: validation and application of Stempedia model" to 18 of Bangladesh's key research and extension management personnel. Presided over by Dr. Timothy J. Krupnik (Country Representative for Research and Partnerships (CIMMYT–

Bangladesh), Regional Strategic Team Leader for Sustainable Intensification in South and Southeast Asia, and Principal Investigator and Project Leader of CSISA PIII Bangladesh and Nepal), the seminar was graced by Chief Guest Dr. S. M. Bakhtiar, Executive Chairman, BARC, Dr. Md. Nazirul Islam, Director General, Bangladesh Agricultural Research Institute (BARI), Mr. Md Asadullah, Director General of the Department of Agriculture Extension (DAE) and Dr. Md. Abdul Mannan, representing the Director of BMD as Special Guest. Attendance was kept limited due to COVID-19 restrictions. Dr. Salam highlighted the progression of Stempedia modeling work, as the weather-based early warning system to control lentil SB disease.

The model was also field tested again in the 2020–21 in Bangladesh and Nepal to generate data that will be used in the next six months to demonstrate to key stakeholders the value of such a system in guiding the frequency and timing of fungicide application for controlling the disease. It was further noted that at the same time as developing the an early warning system for lentil disease, CSISA has also been nurturing deeper partnerships between BARI (in a technical role), BMD (in a weather-forecast generating role) and DAE (a dissemination role). The Activity anticipates that the early warning system will be handed over to BARI–BMD–DAE next year; though CSISA will continue to provide assistance as needed after the handover.

Formalization of partnership with key national organizations: Two partnership agreements were formalized during the reporting period. The first was signed on January 18, 2021 with Nepal Agriculture Research Council (NARC), engaging its National Grain Legumes Research Programme (NGLRP) to field test the early warning system for controlling *Stemphylium* blight disease of lentil in the 2020–21 season in Nepal. For the same purpose, q second agreement was signed on February 07, 2021 with BARI, engaging its On-farm Research Division (OFRD) for lentil work in Bangladesh. On accessing weather data for forecast development, a formal agreement with BMD is already established servicing other CSISA programmes; the process is underway to finalize a similar agreement with the Department of Hydrology and Meteorology (DHM) of the Government of Nepal. In the meantime, for the purpose of 2000–21 activities, DHM provided weather data to the Activity without finalizing the formal agreement.

Field operations in implementing validation of model-based EWS in partnership with national organizations: In this reporting period, CSISA PIII developed a protocol for field to test the Stempedia model guided fungicide application in controlling lentil *Stemphylium* blight disease. As part of this work, the Activity selected 20 farmers' fields in each of Faridpur, Jashore and Meherpur districts of Bangladesh, and Banke, Dang and Kailali districts of Nepal, procured seed and fungicide, and facilitated the laying out and seeding of the fields according to treatments. Fungicides were applied as per the treatments and disease-scoring done according to the protocol. Crop cutting to obtain yield measurements is underway at the time of reporting.



Above: *Geo-locations of 20 farmers' fields in Faridpur district, Bangladesh undergoing field testing of Stempedia model-guided fungicide application to control lentil Stemphylium blight disease*

Forecasting system set up and development:. To formulate the frequency and timing of the Stempedia model-guided fungicide application, the Activity set up a forecasting system in MS-Excel and in R software. We accessed year-to-date measured weather data (daily maximum and minimum temperature, sunshine hours, rainfall and relative humidity) through BMD and Department of Hydrology and Meteorology (DHM) of those Nepal weather stations nearest to the testing fields, and five-day projected weather data from either BMD or DHM, or online weather forecast sites (www.weatheronline.co.uk; https://www.weather-forecast.com/). The Activity ran the validated Stempedia model for each field testing site using measured and forecast weather data, and noting the timing of fungicide application.

Plan of activities for the rest of the year: During the remainder of 2020–21 (that is, up to the end of September 2021), CSISA will undertake the following activities:

- Complete data tabulation, cleaning and analysis, and technical report-writing by core CSISA III staff (June–September 2021).
- Organize and host a post-season conference on Stempedia trial results (August 2021).
- Conduct training of NARES staff on disease modeling (August 2021).
- Devise a full plan of action and secure its endorsement by national stakeholders for roll-out of lentil advisories in next season (September 2021).

The ultimate aim of CSISA is to develop the capacity of Bangladesh's national research institutes (BARI and NARC) towards sustaining disease management systems, by looking into a new dimension of disease management system generation and practical and financially viable technologies. The result of its work to implement the tasks listed above will be able to generate a knowledge- and evidence-based product: an early warning system for lentil Stemphylium blight disease in Bangladesh and Nepal. Following a final endorsement workshop anticipated within the next reporting period, the Activity anticipates that the early warning system will be scaled out among farmers and service providers (input dealers in Bangladesh and Agrovets in Nepal).

Above: *chief Scientific Officer and Head of On-farm Research Division (OFRD), BARI, Dr. Akkas Ali (middle) comparing lentil seed yield performance between treatments at the field testing site, Faridpur, Bangladesh. Also present: Dr. Md. Faruk Hossain (left), Principal Scientific Officer of OFRD and Mr Hera Lal Nath (right), Coordinator of Faridpur Hub of CIMMYT Bangladesh (Photo: Md. Washiq*

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 previous reports no major activities were undertaken in this work package during the reporting period.

A.2.3 Aiding the Fight Against Fall Armyworm in Bangladesh

Fall Armyworm (FAW) is an invasive Lepidopteran crop pest native to the Americas, that has migrated to Africa and then to Asia, and has been in the process of colonizing Bangladesh since late 2018. FAW feeds on more than 80 species of plants, but maize (*Zea mays)* is its preferred host. The arrival of FAW in Bangladesh caused considerable concern – particularly within the Ministry of Agriculture – as maize has grown to be the country's second most widely grown cereal crop of significant economic importance to farmers, exceeded only by rice. For farmers in Bangladesh, maize means money. The vast majority of maize is sold on the market, often earning farmers in excess of $1,000 per hectare. Bangladesh is also near self-sufficiency in maize production, and aims to cease maize imports in before 2030.

Now found throughout Bangladesh and much of Asia, farmers' response has typically been to apply pesticides to control the highly apparent signs of damage caused by FAW's feeding. This is particularly problematic if highly toxic insecticides are indiscriminately used. In response, and supported by the University of Michigan and USAID/Bangladesh, the Fighting FAW Activity was initiated in 2019 as a synergistic project cooperating with CSISA and with national research and extension partners, in addition to the private sector, to mitigate impact of the pest on farmers' income, food security and health. Some of the key achievements that CSISA and the Fighting FAW Activity have accomplished in the last six months that involved cost-shares between the Activities include the examples provided below.

Building women's leadership in agricultural extension and Fall Armyworm advisories: In an effort to boost women's standing in agricultural extension, as well as to provide a conduit for women extension agents to reach women headed households and farmers with advice on FAW IPM, the Activity implemented a series of women's only trainings on FAW in collaboration with BWMRI from 22 November to 01 December 2020 in Chuadanga and Dinajpur, respectively, representing key regions for maize growth in southern and northern Bangladesh. To this end, 107 women DAE officials participated in hands-on in-person trainings on FAW while maintaining social distance and with COVID-19 restrictions in place.

Above: *One of four batches of DAE women IPM Fall Armyworm leaders trained in November 2020 in Chauadanga and Dinajpur.*

These trainings mark what is hoped to be a watershed moment in empowering women extension agents in Bangladesh. Subsequent monitoring and evaluation efforts indicated that these women leaders in agricultural extension shared what they learned with 2,530 other staff within the DAE through both formal trainings in their working offices and also informal engagements. The survey also suggested that this modality resulted in approximately 17,000 farmers receiving additional IPM advice for FAW, with 23 percent of these farmers themselves being women or women headed households.

Above: *Women leaders in Integrated Pest Management (IPM) of Fall Armyworm in the Department of Agricultural Extension scout fields for pests, record data on pest populations, and provide recommendations for IPM during intensive trainings in November through December of 2020.*

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), Agricultural Advisory Society (AAS), and the Agricultural Input Retailer's Network (AIRN).

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

Above: *A large-scale rice demonstration of mechanical rice transplanting facilitated in In Faridpur Sadar in January of 2021. Photo Credit: Abdul Mabud*

Despite a 7%–10% rice grain yield increase as a result of the use of healthy rice seedlings (HRS) and very encouraging results of HRS awareness-raising activities (such as HRS video screenings, leaflet distribution, training and community seedbeds, conducted during the last reporting period and reported in the CSISA Annual Report 2020), in March 2020 all the Activity's awareness-raising activities were suspended because of COVID-19 restrictions, except HRS community seedbed preparation. During the reporting period, only community seedbed preparation for mechanized transplanting (mat or tray nursery) and community-based ideal seedbeds were established in the *aman* 2020 season in Faridpur, in collaboration with the USAID/Bangladesh CSISA-Manufacturing and Extension (CSISA-MEA) Activity and DAE. Mat and tray nurseries were established on 0.45 ha land, with the resulting seedlings being used to plant a 9 ha main field using a mechanized transplanter. A total of 38 farmers (63% women) were involved in the mat nursery preparation. Community-based ideal seedbeds were established in 16 locations, covering 2 ha land and involving 667 farmers (44% women).

In response to the COVID-19 situation, in February 2021 the CSISA monitoring and evaluation team switched to conducting one of its follow-up activities by telephone. It contacted 662 farmers, out of which 480 reported having seen a video promoting HRS and had raised HRS (see the table below for detailed results). The telephone survey followed a series of structured questions on the retention and use of knowledge gained through the mass media campaign, in order to determine the farmers' adoption status of HRS-raising practices. Each respondent had been previously registered as having viewed the HRS videos during the mass media campaign and as having received HRS leaflets.

***Table 2**: Results of survey of farmers who have seen healthy rice seedlings video, February 2021.*

Rice seedling management practices applied	Before video show		After video show	
	Number	%	Number	%
Number of farmers considered for selecting the suitable land for seedbed (multiple response)				
Seedbed located not below tree or shed	206	31%	234	35%
Seedbed located on a soil is that is fertile loam or clay	181	27%	193	29%
Fresh water is available for irrigation	79	12%	198	30%
Drainage facility is available to remove excess water	74	11%	187	28%
Apply manure (80 kg per decimal)/compost	57	9%	162	24%
If manure/compost not available then apply 280 gm urea, 160 gm TSP, 280 gm MoP, 400gm Gypsum per *decimal*	25	4%	113	17%
Number of management practices followed for selecting suitable land for seedbed				
At least one management practice followed out of six	230	35%	248	37%
At least two management practices followed out of six	205	31%	241	36%
At least three management practices followed out of six	114	17%	233	35%
At least four management practices followed out of six	55	8%	209	32%
At least five management practices followed out of six	15	2%	139	21%
All of six management practices followed	3	0.45%	17	3%
Number of farmers considered for ensuring seed quality (multiple response)				
Used certified seed	125	19%	151	23%
Checked germination of seed	16	2%	96	15%
Removed bad seeds through floating method	35	5%	107	16%
Use fungicide	9	1%	55	8%
Didn't ensure seed quality	91	14%	1	0.15%
Number of management practices followed for ensuring seed quality				
At least one management practice followed out of four	157	24%	247	37%
At least two management practices followed out of four	21	3%	109	16%
At least three management practices followed out of four	6	1%	49	7%
All of four management practices followed	1	0.15%	4	0.60%
Didn't ensure seed quality	91	14%	1	0.15%
Use raise seedbed with drainage channels	83	13%	248	37%
Number of farmers followed technology (3–3.5 kg/*decimal*) of seed sown	20	3%	45	7%
Number of farmers considered age of the seedling when transplanted in field				
Transplants seedings to the field at < 30s day-old	20	3%	86	13%
Transplants seedlings to the field at 30–40 days-old	159	24%	151	23%
Transplants seedlings to the field at > 40 days-old	69	10%	11	2%

The survey results showed sustained adoption of HRS agronomic practices among the rice farmer respondents, with adoption rates increasing remarkably after seeing the HRS video in terms of seed bed preparation, use of young seedlings, use of quality seed and conducting seed germination tests.

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

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

Table 3. *Distribution of CSISA produced extension information through public and private sector partners in Bangladesh, during the October 2020 to March 2021 reporting period (cumulative figure presented in the table)*

Extension material name	Quantity distributed	Which partner assisted in distribution of these materials?
Leaflet, healthy rice seedlings (Bangla)	113,000	District and sub-district level DAE offices, SAAOs, AIRN/dealers, AAS, civil society partners and lead farmers
Leaflet, early wheat sowing infographics	132,600	As above
Factsheet, wheat blast	109,330	As above
Leaflet, wheat blast disease control (Bangla)	110,000	As above
Leaflet, wheat rust	500	DAE, 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?	25,000	DAE officers
Pocket booklet, 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, growing vegetables with hybrid maize	4,000	As above
Fall Armyworm (Bangla) infographics	647,300	DAE, NARS, SAAOs, farmer field days, Bayer Crop Science Ltd, Auto Crop Care Ltd (ACCL), Petrochem Bangladesh Ltd, NAAFCO, Supreme Seed Company Ltd, Xplore Business Ltd, Konika, AIRN,
Early wheat sowing (EWS) festoons	450	DAE
EWS stickers	5,500	DAE offices, agricultural input dealers
EWS banners	500	DAE offices, market places
Wheat blast festoons	200	DAE
Wheat blast stickers	2000	DAE officials, agricultural input dealers,
Wheat blast banners	100	agricultural fairs, DAE offices, market places

During the reporting period, CSISA's two field offices (Jashore and Faridpur) and the Dinajur field office also conducted training for DAE cadre female officials (November 2020) and FAW training for DAE and NARS scientists/SAAOs (March 2021). The Activity participated in an agricultural technology fairs and farmer meetings, and meetings with DAE and private companies, farmer field days, and microphone advertising as part of CSISA mass media campaigns. The field offices distributed a range of learning materials among diverse clients, including farmers; these included a Healthy Rice Seedlings leaflet (Bangla)(13,000), an EWS infographic leaflet (32,600), a Wheat Blast factsheet (29,200), FAW infographics (Bangla) (249,300), a one-page FAW factsheet

(Bangla) (800), EWS festoons (400), EWS stickers (2,500), EWS banners (300), wheat blast festoons (200), wheat blast stickers (2,000), wheat blast banners (100). The three offices organized these different events through public and private sector partners in Dinajpur, Thakurgaon, Rajshahi, Rangpur, Nilphamari districts (Dinajpur field office), Jashore, Chuadanga, Jhenaidah, Narail and Meherpur districts (Jashore field office) and Faridpur, Rajbari, Gopalgonj, Madaripur and Sharitpur districts (Faridpur field office).

B1.2 Rice-fallow 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 the goal of increasing cropping intensity. CSISA therefore conducts strategic research on pathways and approaches to encourage fallow land intensification, including de-risking crop production in the central coast of Bangladesh. Major activities conducted in the reporting period are discussed below.

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

***Background**:* Mung bean is a highly profitable legume crop, widely cultivated in the southern central coastal region of Bangladesh (especially Patuakhali, Barguna and Barishal districts). However, every year during the harvesting period (mid-April to the end of May), heavy rain and storm events cause large yield losses (and thus income loss) to mung bean farmers. Providing the farmers with timely, forecasted weather information would contribute to enabling them to avoid adverse weather conditions and to harvest the crop in good time, preventing large harvest losses. In response, CSISA partnered with a now closed EKN and Mott MacDonald funded pilot project that ran from 2018-2020 that built an interactive voice response (IVR) system for mung bean farmers in some coastal areas of Bangladesh (Patuakhali and Barguna districts). CSISA has since continued to steward this IVR system, which provides automated interactive telephone voice alerts at least four days prior to forecasted heavy rainfall and storm events. In addition, CSISA is partnering with the private sector to assess rhizobia inoculant products aiming at enhanced nitrogen fixation and improved productivity in the central coast of Bangladesh.

***Expanding IVR services**:* During the reporting period, CSISA worked to expand the reach of the IVR service described above to 10,000 mung bean farmers in Patuakhali and Barguna districts in preparation for the 2021 harvesting period (March-June). To increase the number of mung bean farmers receiving these IVR services, the CSISA team randomly selected an additional nine unions to receive voice alerts in Patuakhali and Barguna districts. At the time of writing, IVR services are being provided to mung bean farmers from a total of 17 unions (eight from 2020 and nine new unions from 2021) during the 2021 harvest period. This is accomplished using customized rainfall forecasts from BMD supplied to the Activity that are generated for 17 unions at a resolution of 17 km^2. Unlike the last two years five-day rainfall forecasts, BMD is providing four-day forecasts in the selected 17 unions onward as the previous five-day forecasting BMD product is no longer available. The outcomes of these activities will be detailed in the 2020-21 Annual Report.

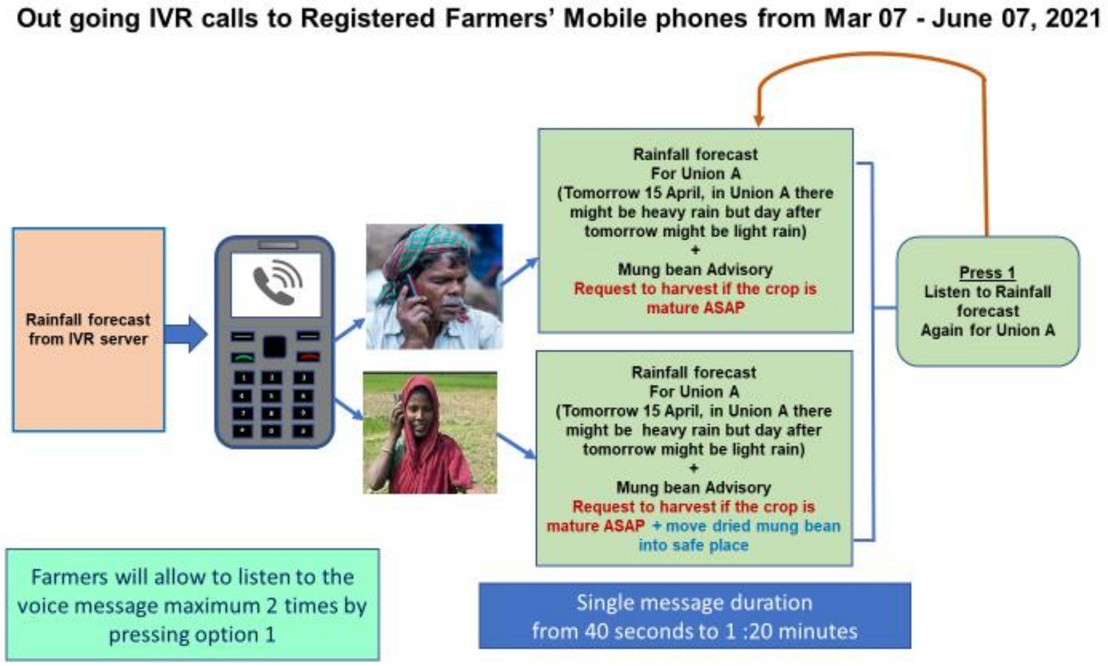
Collecting information of an additional 10,000 mung bean farmers with farmers mung plot's GPS points by ODK: After careful analysis of the cost of expanding the IVR service to at least 10,000 mung bean farmers, and discussing costs with three ICT companies during several Zoom meetings, CSISA has decided to proceed, and in the coming reporting period will disseminate rainfall forecasts by IVR voice message to 10,000 mung bean farmers and to more than 70 DAE government extension agents in 17 locations (unions) during the mung bean harvesting period (7 March 2021 to June 2021).

Above: *CSISA training enumerators to use ODK software to collect mung bean farmers information, CODEC training center, Patuakhali, 7 Feb, 2021. (Photo: Hera Lal Nath/CSISA)*

Above: *CSISA-trained enumerators surveying mung bean farmers using the ODK form, Hazikhali village, Madarbunia union, Patuakhali district, 28 Feb, 2021. (Photo: Golam Morshed Rokon/CSISA)*

First, in February 2021, at the Patuakhali Consortium of Development Education Centers (CODEC) training center, CSISA trained nine enumerators to use ODK software to collect the additional 10,000 farmers' phone numbers, including the GPS location of their main (largest) plot. Between 8 February–22 March 2021, the enumerators obtained this information from 10,690 mung bean farmers (500 women, 10,190 men).

Designing IVR services for the 2021 mungbean season: CSISA identified that during the harvesting period, demand from mung bean farmers is high only for rainfall forecasts and not for additional agronomic information, and as a result planned and designed only rainfall forecasts to be deployed during this period.



Above: *Flowchart of IVR voice calls for 10,000 mung bean farmers during the mung bean harvesting period, 2021*

In 2022, additional agronomic information is likely to be deployed via IVR in the beginning of the season, thus allowing farmers to be able to act on the non-harvest oriented agronomic advice given during the season.

The Activity employed a voice artist to record 316 combinations of voice message. As the contract with CSISA's previous ICT partner Bangladesh Institute of ICT in Development (BIID) had expired in June 2020, ICT company ARENA Phone BD Ltd, was hired, based on their technical knowledge, experience of IVR solutions, and cost-efficient financial proposition. Its brief was to set up the IVR system and disseminate rainfall forecasts via IVR voice messages to mung bean farmers during the 2021 harvest period. The IVR system was ready from March 2021; at the time of writing, no call has been generated as no rain was forecasted between 7 March–31 March, 2021.

Installing rain gauges to collect rainfall data during the mung bean harvesting period: CSISA has installed 52 rain gauges in 17 unions and trained 51 male mung bean farmers to collect rainfall data from March–June 2021. As in the last two years, CSISA scientists will analyze actual versus forecasted rainfall events occurring during the 2021 mung bean harvesting period.

Plans for the next six-month reporting period (March to September 2021): The CSISA team has planned the following activities for the next six months (a) deploy IVR voice calls on rainfall forecasts (up to 7 June), (b) analyze the IVR call reports following deployment, (c) conduct a telephone survey to obtain feedback from mung bean farmers who receive IVR calls after the harvesting season, (d) examine yield benefits of mung bean for three trial treatments in combination with IVR service, (e) analyze the actual vs forecasted rainfall event which occurs during the mung bean harvesting period.

Above: *52 rain gauges like the one pictured have been installed in mung bean fields to collect rainfall data during the harvest (7 March to 7 June, 2021). (Photo: Golam Morshed Rokon/CSISA)*

Rhizobium inoculant trial: To examine the yield benefits of the rhizobium inoculants sold by the private sector in Bangladesh, CSISA is conducting mung bean farm trials in south central Bangladesh. In December 2020, in collaboration with ACI Fertilizers Ltd., the team established 160 mung bean trial plots for 160 farmers in eight unions, under four *upazilas* in Patuakhali and Barguna districts (Kalapara, Amtali, Patuakhali Sadar, Mirzaganj). These trials will continue until June 21. A total research area of 19.42 hectares (4,800 decimals) is under these inoculant growth promoter trials.

Three types of treatments (T) are being studied: T1 (farmer's independent choice of fertility practices), T2 (farmer's practice with rhizobium inoculant application), and T3 (BARC-recommended fertilizer application with Rhizobium inoculant application). Trial participants are cultivating both local and high yield (BARI Mung-06 and BINA Mug-08) varieties of mung bean. Participant farmers will be provided with IVR voice calls with rainfall forecast information during the mung bean harvesting period, and at the end of the season CSISA scientists will study the combined yield gains of farmers who applied inoculant growth promoter and received the IVR calls. This will be reported on in the CSISA Annual Report for the whole of 2010-21.

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

Smallholder farmers are the engine of food system transformation in developing countries, and their integration into high value chains is critical to achieve rapid transformation and improve local livelihoods. A carefully designed, quality oriented value chain also creates opportunities for small-scale actors such as traders, retailers and processors, across the value chain. CSISA has therefore been working to integrate and incentivize smallholder farmers and other small-scale value chain actors into emerging value chains for premium quality rice (PQR) in Bangladesh. CSISA's PQR workstream focuses primarily on expansion activities through 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 Activity works to develop producer groups to cultivate PQR, and to assure the supply of quality seed to these producers through innovative private sector grants, wherein producer groups are linked to seed companies through business expansion mode, ensuring the supply of quality seed through linking these seed companies to BRRI for regular breeder seed supply. CSISA is also working to create direct linkages with midstream value chain actors such as millers and marketing firms, and 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 below.

PQR expansion and market development activities in Khulna Division

During the reporting period, CSISA proactively initiated partnerships with various stakeholders in the region, with a view to making premium rice more profitable and attractive to farmers in the FtF zone. These partnerships include involving prominent seed companies, millers and traders in the region and linking them with PQR producer groups. In addition, the Activity developed an integrated service model, where seed companies also offer mechanized harvesting and sometimes even purchasing of produce from farmers. CSISA identified six local seed companies in Jashore district: (1) Uzirpur Organic Multipurpose Cooperative Society Ltd (Narail), (2) Modern Agro Private Ltd. (Chuadanga), (3) Square Seed (Meherpur), (4) Konica Seed Company Ltd (Damurhuda, Chuadanga), (5) Friend Seed (Maheshpur, Jhenaidah), and (6) Adarsha seed company (Shailkupa, Jhenaidah), and initiated a private sector grant designed to effect the rapid expansion of PQR in the areas by giving these companies 10% seed support (the seed companies contribute 90% of seed expansion to meet the target of 20,000 tons of PQR production). During the reporting period, CSISA facilitated the process through four virtual and four face-to-face meetings at hub offices, and developed an agreement with these seed companies for PQR seed and grain production, branding and market expansion. In Faridpur district, the Activity engaged with two seed companies (INSAF and Nur), a partnership which led to the creation of 41 PQR producer groups, involving a total of 1,189 smallholders (36% women). Through this partnership, the following were achieved:

- In Jashore, through six local seed companies, around 11 tons of seed (7.3 tons of BRRI dhan 50, 3.8 tons of BRRI dhan 63, *dhan* meaning 'rice' in Bangla) were distributed among 2,466 farmers (83 of whom were women) engaged in PQR grain production; 94% of the farmers are new to this reporting period.
- 11 ha of community seedbeds (involving 96 farmer groups) were achieved through the partnership with six local seed companies.
- In Faridpur, a total of 5.9 tons of PQR seeds were supplied to these producer groups (67% from seed company expansion) covering a total of 240 ha with an expected production of 1,200 tons (of which 150 tons are seed).
- CSISA's Jashore field office facilitated four local seed companies to develop linkage with BRRI and purchase breeder and foundation PQR seeds (870 kg breeder seeds of BRRI dhan50 and 780 kg of breeder seeds of BRRI dhan63).
- Four training of trainers (ToTs) were held on PQR seed production for 40 field technicians/officers of local seed companies (in Meherpur, Chuadanga, Jhenaidah and Narail districts).

- 55 consultation meetings were held with contract farmers by local seed companies to develop unique farmer communities for PQR seed/grain production and expansion (in Meherpur, Chuadanga, Jhenaidah and Narail districts).
- Two meetings were arranged with farmers to facilitate the formation of small PQR groups for quality grain production (miller-centered) (in Alamdanga and Chuadanga districts).
- Four ToTs were delivered to SAAOs on quality PQR grain production, post-harvest processing, grading and linkage to the private sector to obtain price incentives (in Jhikargacha, Sailkupa, Magura Sadar and Meherpur Sadar).

Above: *Konica Seed Company distributes seed, Talshar, Kotchandpur, Jhenaidah. (Photo: Kamrul/CSISA)*

Above: *A farmer tends her community seed bed, Jamjami, Monirumpur. (Photo: Hasan/CSISA*

PQR expansion and market development activities in Rangpur division: With an aggressive plan to scale PQR in Dinajpur district, Rangpur division, with a target to massively expand PQR production and marketing in 2021, in this reporting period CSISA has adopted innovative new partnership models with seed companies and auto rice mills. These partnerships, together with CSISA's sustained efforts, have together translated into developing institutional engagement with DAE, and formal associations with PQR producer groups. With reference to quality seed production and supply, CSISA identified two seed companies in the region (Srizon Agro and J.R. Agro) and developed formal linkage with BRAC Seed, Agro Enterprise and ACI Seed to ensure a local supply of PQR seed. In addition to the 28 producer groups (comprising 500 farmers) already established, thirty-six new PQR producer groups (76 women, 800 men) have been created in partnership mode with these seed companies, DAE and CSISA, CSISA has also established a marketing channel for selling PQR, by engaging with three auto rice mills (Dui Bhai, Thakurgaon, Shamsul Haque/Avijath Group, Nilphamari and Bengal auto rice mill, Dinajpur) and ensured fair and premium prices for farmers.

In another four districts of the division, in the 2020–21 *boro* season CSISA in collaboration with DAE distributed 3.64 tons of PQR seed (BRRI dhan 50) among 36 producer groups in 11 *upazilas* in four districts as part of private sector grants to two local seed companies. These companies sold three tons of PQR seeds through their eight outlets in the same region, as per their commitment to PQR expansion activities. Demand for PQR seed is increasing at both the farmer and consumer levels, and, in response to CSISA's encouragement, BRAC and ACI have together sold about 5 tons of BRRI dhan 50 seeds in the region. In the 2019–20 *boro* season, CSISA also encouraged the PQR groups created earlier (comprising 132 farmers) to store 7.02 tons of BRRI dhan50 seeds for their own use and for sale to neighboring farmers. We estimate therefore that in Rangpur division, almost 4,500 tons of new PQR will be produced in the current *boro* season. With CSISA's coordination, the two selected seed companies have purchased breeder seeds (100 kg of BRRI dhan50 and 50 kg of BRRI dhan63) from BRRI with a target to produce 40 tons of foundation seed and same amount of certified and TLS seed. They will then market these seeds in this region in the next *boro* season (December 2021 to February 2022).

This is the first time that CSISA has undertaken PQR expansion activities through PQR farmers' producer groups in Rangpur division based on the value chain approach. The Activity emphasized not just production but also the marketing of premium rice for rapid expansion. However, the major achievements during the reporting period are as follows:

- In the 2020 summer *aman* rice season, CSISA selected the seed company J.R. Agro, which produced 19 tons of PQR seed (13 tons of BRRI dhan 87 and six tons of BRRI dhan 75 after grading) through CSISA PQR producer groups. This PQR seed will be sold by J.R. Agro in CSISA's Dinajpur working area in the next *aman* season (2021).
- Through 28 producer groups, in the 2021 *aman* season CSISA facilitated in the production and marketing of around 500 tons of PQR (BRRI dhan 87 and 75) and despite the COVID-19 pandemic succeeded in linking these groups with several millers, resulting in the producers securing an additional premium of BDT 2–3 per kg of grain than they would have obtained through cultivation of alternative varieties. The producer groups have expressed interest in continuing to cultivate BRRI dhan 87 in the next *aman* season (2021).

Above: *A market linkage workshop at CSISA office, Dinajpur (Photo: Bappi/CSISA)*

- During the COVID-19 pandemic, while ensuring all necessary safety measures were in place and observed, CSISA provided eight Training of Trainers sessions to PQR group leaders (one woman and one man from each group) on PQR production technologies, pest management, post-harvest processes and market linkage strategy, in the presence of the respective DAE SAAOs, local combine harvester service providers, and representatives from the private sector, private seed companies and Auto rice mills. A total of 76 group leaders (25 women and 51 men) participated in the training, which has facilitated the development of linkage with auto rice mills and other value chain actors.
- 46 community seedbeds (each 30 to 45 *decimals*) have been established to facilitate the raising of healthy seedlings through seed companies, with support from DAE and technical support from CSISA.

- 36 consultation meetings with PQR producer groups were organized by CSISA during the reporting period, with the help of seed companies and DAE.
- Four meetings were held with seed companies to share information on quality seed production technology.
- CSISA selected two seed companies who established 9 ha land under PQR foundation seed using 150 kg breeder seed (100 kg BRRI dhan 50 and 50 kg BRRI dhan 63).
- Eight informal and one formal market linkage meetings with PQR group leaders and auto rice millers have been conducted for PQR grains marketing.
- The Activity organized one formal linkage meeting with Bengal Auto rice mill to sell PQR produced by the producer groups; 1 formal meeting was held with Avijat Group to brand BRRI dhan 87 as premium quality rice. Avijat Group has expressed great interest in working with CSISA on PQR, including the branding of new, promising varieties such as BRRI dhan 87.

PQR on-farm research in partnership with BRRI: As a part of the expansion of PQR varieties in Bangladesh, during the reporting period, CSISA in partnership with BRRI initiated three on-farm research interventions. These are:

1. Determination of the effects of rice sowing date, seedling age, and rice growth duration on yield of popular premium quality rice varieties. This experiment was initiated in the *aman* 2020 season in three regions: Dinajpur representing north Bangladesh, Gazipur representing central Bangladesh and Jhenaidah representing south-west Bangladesh. The major objectives are: (a) to determine the effects of sowing dates, seedling age and transplanting dates for popular premium quality rice varieties having different growth duration at three locations (north, south and central) in Bangladesh, and (b) to generate rice crop data for simulation modeling by using the ORYZA v3 simulation model to determine optimum transplanting window, sowing time and seedling age, target yields and develop associated management recommendations for increased rice yields and higher water productivity in different regions of Bangladesh (north to south) which have different climatic conditions.

During the reporting period, BRRI in collaboration with CSISA successfully completed the planned experiment for *aman* 2020 in three locations (Dinajpur, Gazipur and Jhenaidah districts). In each location the experiment was established in a split-split plot design with three replications. The main plot factor was three PQR varieties: BRRI dhan 75 (115-day growth duration, photo-insensitive and slightly aromatic), BRRI dhan 87 (127-day growth duration, photo-insensitive and long slender fine grain), and BRRI dhan 34 (135-day growth duration, photosensitive and aromatic). The sub-plot factor was five seed bed-sowing dates (20 June, 5 July, 20 July, 4 August and 19 August, all in 2020), and the sub-sub plot factor was seedlings of three ages: 20-days old, 30-days old, and 40-days old. Data compilation, management and analysis are in progress and the results will be reported in the next CSISA Annual Report.

The experiment was also established in the 2020–21 *boro* season in all three locations using a split-split-plot design with three replications. The main plot factor was three PQR varieties: BRRI dhan63 (146-day growth duration, photo-insensitive and long slender fine grain), BRRI dhan 50 (155-day growth duration, photo-insensitive and long slender fine grain, aromatic) and BRRI dhan

92 (160-day growth duration, photosensitive and long slender fine grain). The sub-plot factor was five seed bed-sowing dates (16 November, 1 December, 16 December, 31 December in 2020 and 14 January in 2021). The sub-sub plot factor was seedlings of three ages – 35-days old, 45-days old and 55-days old. Data using the same parameters as in the *aman* season will be collected. The crop will be harvested in May 2021 and the results reported in the next CSISA Annual Report.

The experiment was also established in the 2020–21 *aus* season in two locations (Jhenaidah and Gazipur) in a split-split plot design with three replications. The main plot factor was the two-crop establishment method (DSR and transplanted rice). The sub-plot factor included two PQR varieties: BRRI dhan 85 (110-day growth duration, photo-insensitive and long slender fine grain) and BRRI hybrid dhan 7 with 110-day growth duration, photo-insensitive and long slender fine grain). The sub-sub-plot factor was four seed bed or main plot sowing dates (15 March, 30 March, 14 April and 29 April, all in 2021). The seedling age for transplanted rice was 20 days for all seed bed sowing dates. Data using the same parameters as in the *aman* season will be collected. The crop will be harvested in June–July 2021 and results reported in next CSISA Annual Report.

2. On-farm trials in to validate the results for PQR varieties predicted by ORYZA v3 model. This research was initiated in the 2021 *boro* season in three regions of the country: northern (Dinajpur Rangpur, Thakurgaon and Nilphamari districts), central (Gazipur and Kishoreganj districts) and south/south-western (Jhenaidah and Kushtia districts) Bangladesh. The main objectives are to (1) validate model predicted results, with observed results of on-farm trials, and (2) evaluate the performance of PQR varieties in different regions of the country. During the reporting period, in each of the north, central and south-western regions of the country, on-farm trials with the PQR varieties used in the *boro* season were established in 30 farmers' fields (10 field for each variety). A similar intervention is also planned for *aus* 2021 and *aman* 2021.

3. Determine the effects of nutrient management practices on PQR variety(s) for improved yield, grain quality and milling traits. This is an on-farm research intervention, planned to observe the impact of K, Zn and Si on grain yield, quality traits including milling, and aroma. During the reporting period, in each of the northern, central and south-western regions of the country, on-farm trials with the PQR varieties used in the *boro* season were established in 30 farmers' fields (10 fields for each variety). Each farmer's field will represent one replication and have nine nutrient management treatments. Crops will be harvested in May 2021 and the results reported in the next CSISA Annual report. Similar interventions are also planned for *aman* 2021.

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

The rapid transformation of food value chains opens new opportunities to improve the livelihoods of smallholder farming households in low- and middle-income countries but at the same time places substantial pressure on these farmers to adapt their production practices. Although many positive examples exist, the evidence so far shows mixed results in terms of inclusion but also welfare gains. The Activity analyzes the current PQR value chain system; conformity of quality traits, constraints faced by value chain actors, and potential investment needed to upgrade the value chain to meet "quality" demands are central in importance. It also studies production optimization of PQR and works to develop an inclusive supply chain and market linkages with millers and traders, so that smallholders are not left out in this transformed food value chain. During the reporting period, CSISA analyzed and estimated the agronomic contributions to the productivity and efficiency of PQR production, implemented a retailer survey, and tested whether value chain improvements are able to incentivize retailers to invest in quality oriented value chains.

Above: Surveying rice wholesalers to determine their investment preference, part of the activity to develop an improved PQR value

Decision choice experiments and hypothetical intensification pathways: During the reporting period, CSISA continued implementing decision choice experiments, started in the previous reporting period and delayed because of COVID-19. These aimed to test farmers' ability to allocate production enhancing inputs efficiently in PQR cultivation, with an emphasis on the lack of sufficient and robust extension information. To this end, CSISA's scientists conducted a social experiment with 1,420 farmers, presenting them with a hypothetical budget to allocate to six different inputs advised for efficient production of PQR, thus mimicking familiar production decisions made seasonally on their own farms. The initial results show that even without any budget or access constraints, farmers are inefficient in their allocation of inputs in PQR cultivation, overspending on seed, fertilizer and pesticide. Farmers with better access to agricultural information (such as through PQR-specific extension services) attained substantially higher efficiency scores and are likely to spend significantly less on fertilizer. In general, though, without future adjustments, the implied higher production costs lower the profitability of PQR cultivation for smallholder farmers and limit potential income gains.

The decision experiment is being administered involving PQR producers, traders, millers, wholesalers, retailers and urban consumers in Mymensingh, Khulna, Dinajpur and Dhaka in Bangladesh. After a significant delay due to Covid-19, in October 2020 the Activity completed the survey of farmers and millers and the decision choice experiments, and handed over the final cleaned data in December 2020. The trader, retailer and wholesaler surveys and experiments were rolled out in March 2021. Enumerator training was conducted from 14–19 February, 2020 in Rajshahi and the survey instruments were pre-tested in Rajshahi by the enumerators. We expect to complete the survey work by May 2020, and then implement the consumer survey. A total of 200 paddy traders, 125 wholesalers, 275 retailers and 1,200 consumers will be interviewed in Dinajpur, Sherpur, Jhenaidah, Kushtia and Dhaka city.

Nutritional and grain quality assessment of PQR as a function of processing, value chain handling and cooking techniques. CSISA is using grain samples from different nodes of the PQR value chain in Bangladesh to develop a comprehensive assessment of grain quality including nutritional and sensory parameters as a function of production, processing, value chain handling and cooking techniques. The first step in this activity encompassed collecting paddy/grain samples and then properly barcoding and shipping samples to Centre of Excellence in Rice Value Addition (CERVA), IRRI South Asia Regional Centre (ISARC), India, a process which required a phytosanitary certificate and import permits from the Indian Council of Agricultural Research. COVID-19 pandemic caused substantial delays to this work; the first set of 487 samples reached CERVA on 21 August 2020; the second and final batch from farmers and millers, containing 150 samples arrived there on 15 February 2021 and is being analyzed at present. Samples from traders, retailers and wholesalers will be shipped by May of 2021.

At the time of writing, grain quality analyses are underway. Analyses involve estimating four groups of quality parameters: textural, cooking, sensory and nutritional qualities. The mean gel consistency is between 33% to 66%; most PQR has a soft gel consistency. Average iron content is 10.56 ppb and zinc content is 16.97 ppb. Samples collected from millers have a slightly higher iron (11.18 ppb) and Zn (18.68 ppb) content. When research and analysis is complete, CSISA will be uniquely positioned in South Asia to provide strategic investment requirement information *advice vis-à-vis* the market potential for PQR, such that an appropriate level of investment 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 late 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 in 2017 and 2018 that resulted from the uncertainty in project funding. 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: To modernize and refine their crop-cut data collection process used to estimate regional yields for key crops, DAE expressed an interest in digitalizing the survey system to harmonize crop-cut activities. In response, CSISA has been working to support and coach DAE to conduct thousands of crop cuts and production practice surveys for *boro* and *aman* rice, executed by the DAE field level SAAOs. As part of this data-driven initiative and its project programming, DAE has purchased and distributed thousands of internet-enabled Android phones and tablets that used by front-line extension workers across Bangladesh. Harnessing this opportunity for digital agriculture, CSISA and the CCAFS project described above are collaborating to develop a robust platform that can build improved surveys, carry out cloud-based analysis, and provide a dashboard representation of research results (beta version of the dashboard available here: http://cimmyt-bigdata-monitor.herokuapp.com/).

Table 4. *Crop cut and production management surveys implemented by DAE in various seasons in Bangladesh*

Season	Crops	Number of farmer surveys planned by DAE	Number of farmer surveys planned by DAE	Total number of farmer surveys achieved by DAE	Achieved (%)
2019–20	*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%
2020–21	*Aman* rice	2,921	1,673	4,594	102%
Total		*11,552*	*5,931*	*17,483*	97%

Starting in late 20219, CSISA facilitated the training of 125 SAAOs in using the digital survey tool Open Data Kit (ODK), using android devices to implement surveys and crop cuts with farmers. Over the next two years, DAE conducted a total of 17,483 crop cut and crop production management surveys across key hear and rice growing districts of Bangladesh. The data were immediately uploaded to a cloud using the tablets maintained by DAE, with the resulting data being made available to CSISA (see table, below). In the *aman* 2020–21 season, more than 100% of targets for data collection have been achieved; data for four out of six crop seasons have been collected and by the end of the year, DAE plans to have collected data on yield and management practices from 4,500 wheat farmers. All data were entered using internet-enabled devices and ODK, and uploaded to the CSISA server for semi-automated analysis using the Big Data Monitoring tool developed by CSISA.

On 16 March 2021, the Activity held a virtual coordination meeting with DAE representatives (Assistant Directors and Deputy Directors from Jashore, Faridpur, Rajshahi, Dinajpur and Rangpur districts). Discussion centered around the current status of collected data and a review of descriptive analysis of the data, as well as progress and strategies on upcoming crop cut surveys and how to further improve input data quality.

Participants learned how they could check incoming data quality using a web-based dashboard. Our ultimate goal is to identify the best options to enable farmers to maximize productivity and profitability while minimizing greenhouse gas emission, to generate advisories for better-bet practices in agricultural management which DAE can deploy as part of their regular extension support. More detail on the application of these datasets to improve extension officers' advising to farmers will be presented in the 2020-21 Annual Report.

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

Background. Large-scale policy and development initiatives, including those funded by USAID, and the Government of Bangladesh, have tended to invest in agricultural interventions and hold implementing partners for nutritional outcomes based on assumed linkages between increased agricultural productivity and improved nutrition of households. However, households with different farming systems and types of income generation can vary in their capability to provide food-derived energy, vitamins and nutrients. Because of this, linkages between farm production and nutrition are not always direct; in response, it is crucial to generate knowledge to guide nutritionally-sensitive agricultural development investments. To this end, CSISA is working to develop the 'Agricultural Systems to Nutrition (AgSyst2N): Linking Agricultural Systems to Nutrition' decision tool to assist in assessing how agricultural interventions may or may not lead to nutritional outcomes, for men, women, and children within households and as a function of differing farm types.

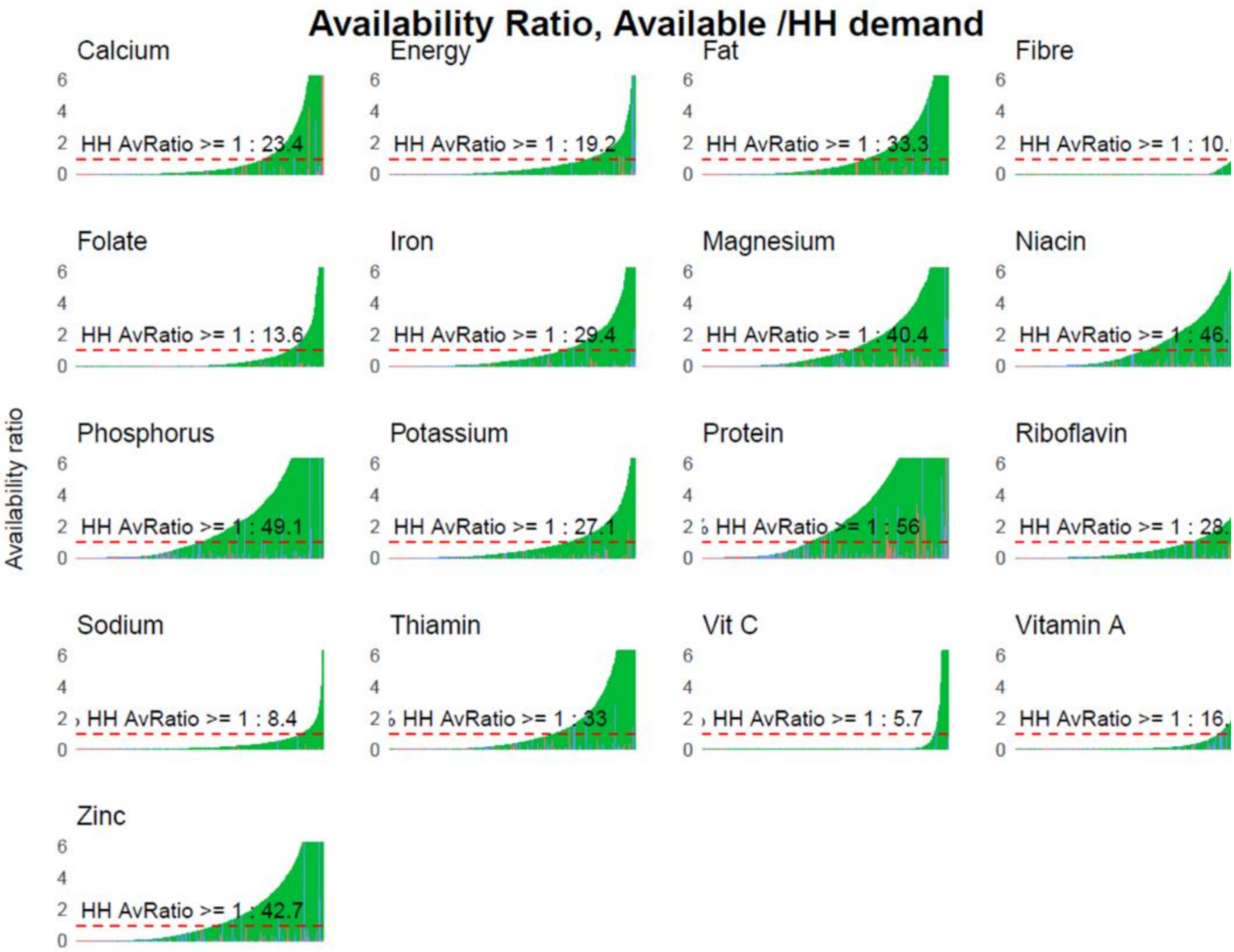
ASgSyst2N is being developed through a partnership with the Feed the Future Innovation Lab (Friedman School of Nutrition Science and Policy) for Nutrition, Tufts University. Working at the interface between nutrition, and agronomic and food security perspectives this collaboration seeks to assess and ultimately improve the links between agricultural systems and nutrition for smallholders Bangladesh's FtF ZoI. Partnership with Tufts University has resulted in the availability of an existing dataset from a household survey conducted by the Innovation Lab for Nutrition (INL) of 3,000 farming households. The dataset has detailed food production and consumption data from male members/household heads, mother/female caregivers (aged 15–49 years) and children aged under 5 years) across Dhaka, Barisal, and Khulna divisions in Bangladesh covering the 102 unions of the FtF zone baseline survey.

Activities. As discussed in the previous Annual Report, CSISA and Innovation Lab for Nutrition have already identified the major farming and livelihood system types in the study area using a multivariate analysis of major structural and functional characteristics. The second step, which was implemented in the reporting period, follows in the assessment of the contribution of current agronomic practices and alternative agricultural development interventions to nutritional outcomes on the ability of households o produce or buy sufficient nutritious food a healthy life. To achieve this, two main analyses were carried out: (1) nutritional availability for rural households from production of crops, livestock and fish enterprises by rural households, given the end destination of farm produce (markets or self-consumption), and (2) consumption of nutrients by rural households and the origin of nutrients consumed (i.e. own production or purchased).

The figure below shows the nutrient availability ratio for the surveyed farm households in southern Bangladesh from production. Farm households are arranged in ascending order in terms of their availability ratio for each nutrient (household nutrient availability ratio). In each case, the values after 'HH AvRatio ≥1' is the percentage of households that have sufficient availability of that specific nutrient to satisfy the needs of the household (i.e. they have availability ratios equal or above 1).

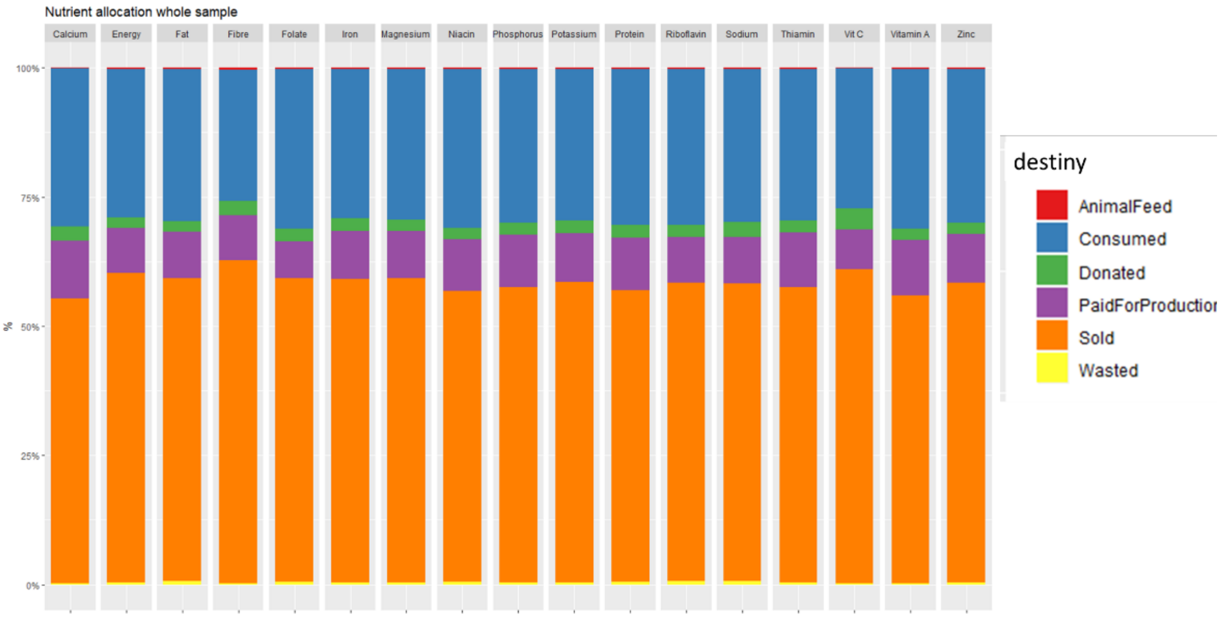
The analysis shows that more than 80% of the sampled farm households in the FtF zone fail to produce enough fiber, folate, sodium, Vitamin C and Vitamin A to meet their needs. It is to be noted that the typical farming household consumes only a fraction of the produced nutrients and sells the rest into the market. This is very important, as it indicates the mixed nature of farm production and market sales to generate incomes and livelihoods in the FtF zone. In addition, at least 50% of the nutrients that are produced as part of crop harvests by these households is sold in the market. The figure also presents the nutrients consumed, sold in markets, used an animal feed, paid as crop shares, donated and wasted.

An examination of household consumption and nutrient intake, based on seven-day recall data, indicated that 80% of the population are unable to meet their daily recommended needs of calcium, folate, riboflavin and Vitamin A. The analysis also revealed purchased sources as the major source of nutrients, providing a clear indication of the role of market participation in increasing availability of the majority of nutrients. The results from both the production and consumption sides show the importance of markets in the nutritional security of rural households in southern Bangladesh. Strengthening such market exchanges (both for agricultural products as well as for goods consumed) and refocusing income generated on purchases of quality food products is an important opportunity to improve their nutritional security.



Above: *Availability ratios for 16 nutrients and energy for the surveyed farm households (HHs) in Southern Bangladesh against the household demand*

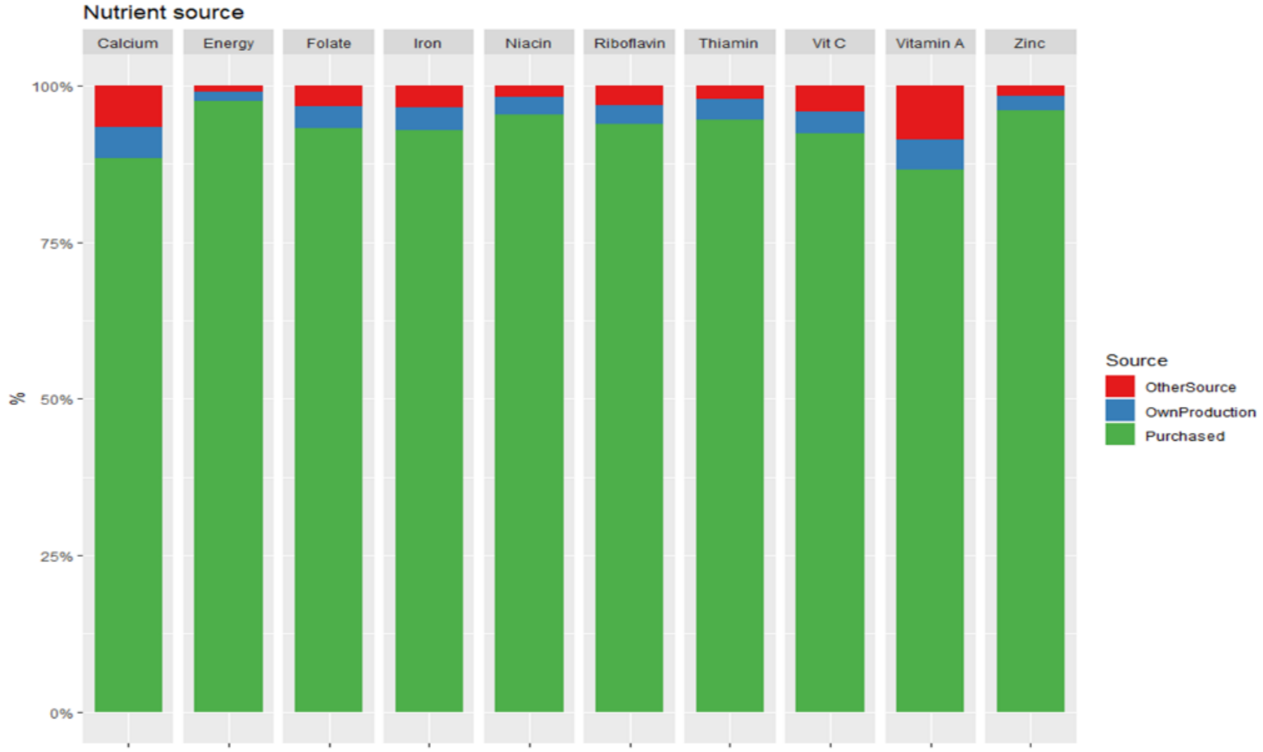
Furthermore, the analysis conducted during the reporting allowed the Activity to confirm that for different farm types identified through typology construction based on multivariate analyses (see the previous Annual Report), significant differences can be found in terms of the nutrient availability. The figures below shows the correlation of different farm types with the distribution of satisfaction for household demands of some nutrients (13 more nutrients are available), in quartiles. It can be seen, for example, that resource-poor farm households with limited production (Farm type 1, including 35% of the population) are consistently associated with low levels of satisfaction in terms of nutrient availability in relation to the needs of the family. Similarly, Farm type 3 (small cereal-based households covering 34% of the population) are significantly associated with higher than average availability of nutrients from their agricultural production.



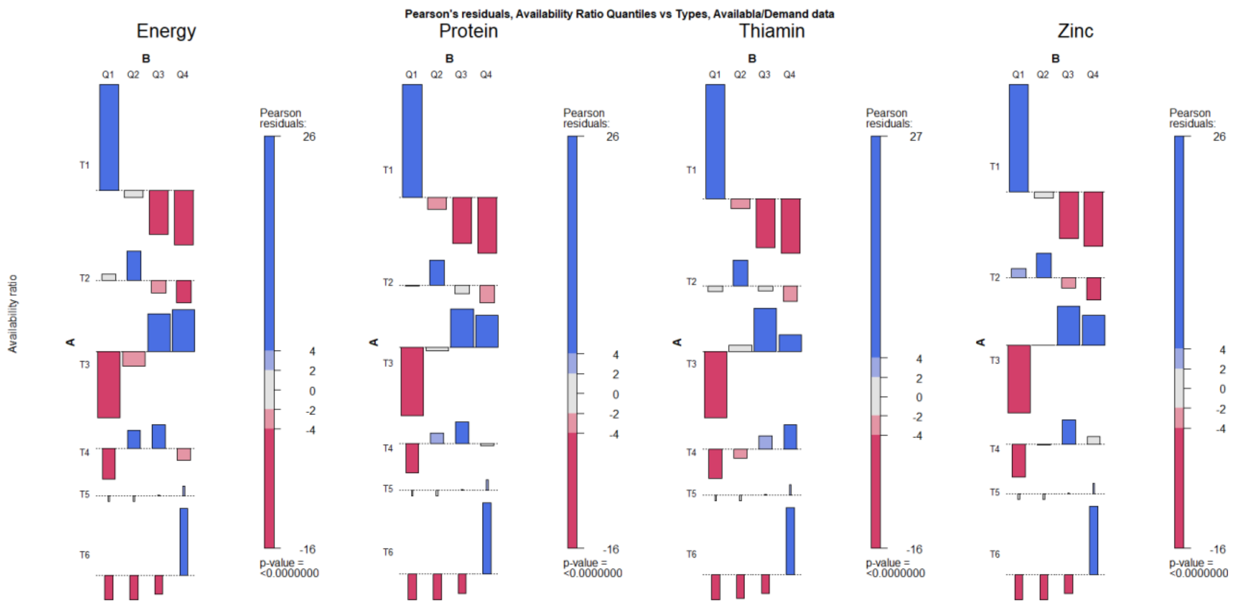
Above: *Proportion (%) of nutrients coming from agricultural production destined for different uses by surveyed farm households in southern Bangladesh.*

Activities of the next six months of 2021 are directed towards (1) identifying the main products among crop, livestock and fish products, either produced or purchased, that contribute to closing the nutritional gaps of rural households in southern Bangladesh and (2) assessing, through an *ex-ante* assessment tool (production-consumption balance model) that can be driven by stakeholder input in model scenario selection and runs – for example by incorporating input from USAID – to identify the contribution of specific interventions to (a) sustainable intensification of crop, fish and livestock through modelling the relations of selling and household consumption, and (b) specific nutrition-targeted interventions (e.g. biofortification of crops, home garden cultivation of specific produce) to improve the nutritional security of specific types of rural households.

These analyses will are aimed at providing decision support to better inform the process of agriculture and nutrition development interventions for the FtF zone in Bangladesh. As such, work is on track to have the decision support tool ready for *ex-ante* assessment in the second half of 2021. The COVID-19 scenario did not affect the progress of this work as it was being conducted based on an existing dataset and following remote work modalities. Further outputs from this research will be provided and detailed in there 2020-21 Annual report, due to be submitted in September of this year.



Above: *Proportion (%) of sources from of nutrients consumed based on the seven-day recall data from surveyed farm households in Southern Bangladesh*



Above: *Pearson's residuals by quartile showing the significant difference between the expected frequencies of nutrient availability ratio for different farm types and quartiles of satisfaction ratios for energy, protein, thiamin, and zinc.*

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, CSISA has worked closely with public and private sector partners and 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

In collaboration with BRRI, CSISA has identified the most effective and profitable options for transplanted rice through on-farm research in 2016/17 and 2017. These results identified the careful and safe application of Mefenacet + Bensulfuron methyl as pre-emergence herbicide followed by either Bispyribac-sodium or Penoxsulam as post-emergence herbicide followed by one hand weeding. This combination, both responds to the labor constraints experienced by farmers while also using less toxic products than those typically applied in rice production in Bangladesh – particularly for higher yielding crops. Building on these research results, the Activity has worked to develop awareness and market demands for these products, in close partnership with the private sector.

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

Since 2019, CSISA has worked to scale-out the use of relatively safe, efficient and profitable IWM options and practices through market systems development approaches to control weeds in transplanted rice. Improved IWM practices were identified through on-farm experiments in partnership with BRRI over three seasons (the 2016 *aman* season, the *boro* season 2016–17 and the 2017 *aman* season). In addition, the Activity maintained and developed new partnerships with the private sector to increase awareness of and access to the new and safer herbicide molecules. Despite the challenges resulting from COVID-19 restrictions in Bangladesh, during the reporting period CSISA has continued dialogue with its private sector partner Auto Crop Care Limited (ACCL) and AIRN to engage them in making safe and cost-effective herbicide molecules and safety equipment available in local markets, the printing and dissemination of IWM leaflets, and conducting IWM demonstrations in the 2021 *aman* season and onward. During the reporting period, CSISA provided technical backing to ACCL which implemented 200 on-farm demonstrations in the Activity's working areas (100 farmers' fields in Jashore region and 50 farmers' fields in each of the Faridpur and Dinajpur regions). ACCL provided the pre- and post-emergence herbicides for all the on-farm IWM demonstrations. These demonstrated the application of mefenacet + bensulfuron methyl as pre-emergence, followed by penoxsulam as post-emergence herbicide, followed by one hand weeding if required (referred to below as IWM option 2), which were then evaluated for their impact on rice yields, and weed management costs compared with current farmers' weed management practices.

Farmers' weed management practices conversely included were either two to three manual weedings or the application of pretilachlor as a pre-emergence herbicide, followed by two manual weedings. In each farmer's field, the IWM option was demonstrated along with the farmers' weed management practice, as well as two checks (weed-free and weedy micro-plots). The weed-free plot was kept free from weed competition by frequent hand weeding. In the weedy microplot, weeds were allowed to grow and compete with the crop throughout the season.

In the 2020 *aman* season, rice grain yields were similar in IWM, farmers' management practice, and weed-free treatments in all three regions (see table below). In the weedy plots, yields were significantly reduced (by 1.35 t ha-1 in the Jashore region, 1.39 t ha^{-1} in the Dinajpur region and 0.73 t ha^{-1} in the Faridpur region).

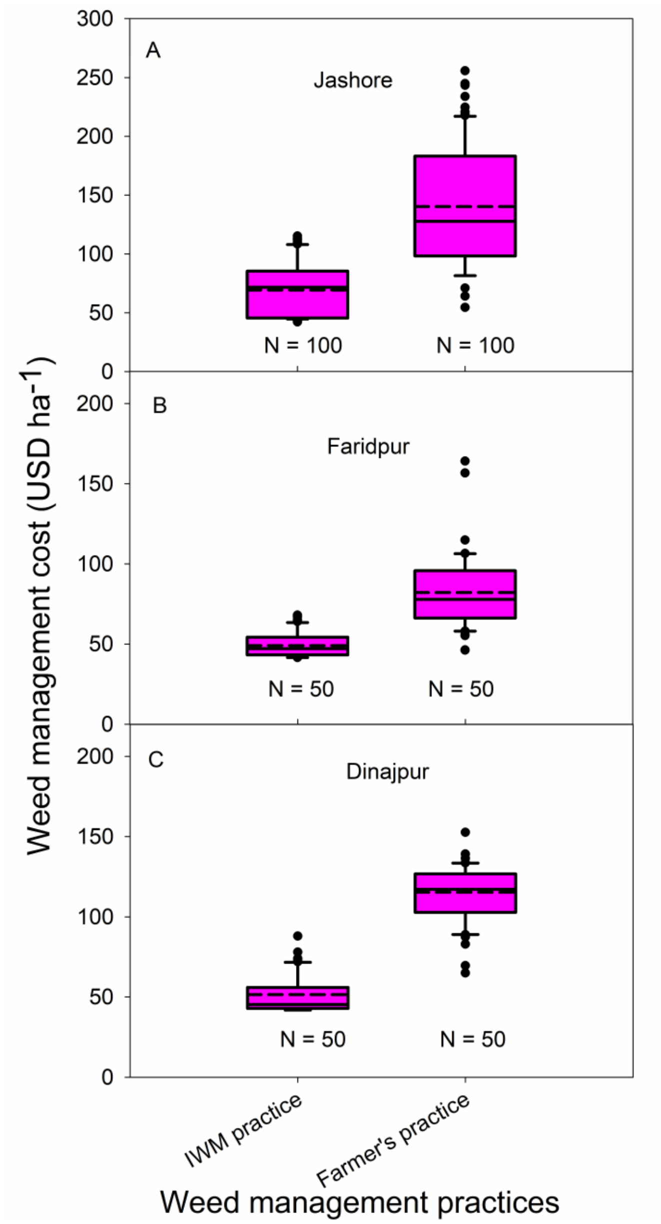
***Table 5**: Grain yield of transplanted rice as influenced by weed management (IWM) options in on-farm demonstrations in Jashore, Faridpur and Dinajpur regions,* aman *season 2020*

Weed management option	Grain yield (t ha^{-1})		
	Jashore	Faridpur	Dinajpur
IWM*	5.57 a	3.77 a	5.01 a
Farmers' weed management practice	5.43 a	3.83 a	4.96 a
Weed-free	5.61 a	3.93 a	5.25 a
Weedy	4.26 b	3.20 b	3.86 b

Note: (a) and (b) denote statistical differences at the 95% level using Tukey's Honestly Significantly Different test. *Mefenacet + Bensulfuron methyl as pre-emergence herbicide, followed by Penoxsulam as a post-emergence herbicide, followed by one hand-weeding if needed.

Despite attaining similar yields, weed management costs differed significantly between the IWM treatment and farmers' management practice across the regions. The mean weed management costs for IWM treatment were USD 70 ha^{-1}, USD 50 ha^{-1} and USD 55 ha^{-1} in the Jashore, Faridpur and Dinajpur regions respectively, which in comparison to farmers' management practice were far lower – by USD 70 ha^{-1} less, USD 35 ha^{-1} less and USD 60 ha^{-1} less – in the respective regions (see figure below).

Raising awareness of integrated weed management option among farmers



Above: *Weed management cost of IWM option in comparison to farmers' practice in aman 2020, in Jashore, Faridpur and Dinajpur regions. The horizontal dashes within the box diagram indicates the mean value; the solid line is the median value; N indicates numbers of IWM demonstration fields and farmers' study fields.*

Between February and March 2021, CSISA in partnership with ACCL staff conducted eight batches of formal knowledge-sharing meetings in Dinajpur regions for LSPs, lead farmers, input dealers, and DAE SAAOs on the IWM option large scale expansion (see photo, right). These meetings were attended by total of 179 participants (38 women, 141 men). Outcomes from these meetings will be presented in the 2020-21 Annual report.

Achieving weed competition reduction win-wins: results from collaboration with BRRI to examine rice cultivar competitiveness with weeds

The identification of weed-competitive, high-yielding rice cultivars is an attractive low-cost strategy as part of an overall IWM program to reduce herbicide use and weed management costs. In Bangladesh, limited information is available on the weed competitive ability of high-yielding rice varieties currently on the market. To address this, since 2018 CSISA, in partnership with BRRI has been jointly conducting both on-station and on-farm research activities, to identify high-yielding and weed-competitive rice varieties under transplanted conditions in the *boro* and *aman* seasons.

During the reporting period, 11 popular high-yielding varieties[5] were successfully tested for their ability to compete with weeds in the 2021 *aman* season (July to December 2021). For each variety, weed density and weed biomass were observed, and rice grain yields in weedy and weed-free conditions collected. Mean yield data for the *aman* season 2020 are presented in the table

[5] The 11 varieties tested were BRRI dhan 23 (VI), BRRI dhan 34 (V2), BRRI dhan39 (V3), BRRI dhan 49 (V4), BRRI dhan 52 (V5), BRRI dhan 66 (V6), BRRI dhan 70 (V7), BRRI dhan 71 (V8), BRRI dhan 72 (V9), BRRI dhan 80 (V10) and BRRI hybrid dhan 5 (V11).

below. BRRI dhan23 was found to be the most weed suppressive, as well as high yielding at both on-station (Gazipur) and on-farm (Kapasia) sites, with yield reductions of 23% and 18% due to full season weed competition at on-station and on-farm sites, respectively.

Above: knowledge-sharing meeting, Dinajpur during aman *2020. (Photo: Bappi/CSISA)*

Rice grain yield reduction for other rice varieties due to full season weed competition ranged from 36%–44% at on-station sites and 10%–42% at on-farm sites. At on-farm sites, BRRI dhan 72, BRRI dhan 34 and BRRI dhan 39 were found to be weed suppressive but not at the on-station sites; these conflicting results need further investigation. Hybrid rice varieties produced the highest yields under weed-free conditions, and similar or higher yields than inbred varieties under weedy conditions, but yield loss due to weed competition was 36% and 42% during on-station and on-farm trials, respectively. Data analysis of other parameters is in progress and will be presented in the CSISA Annual Report. The experiment is continuing for the *boro* season 2020–21 with a separate set of varieties; these will be harvested in May 2021 and that data also presented in the next report.

Table 5: *Mean rice grain yields in weedy and weed-free plots of different rice varieties at on-station (Gazipur) and on-farm (Kapasia) sites in the* aman *season, 2021.*

Variety	On-station (Gazipur) site Grain yield (t ha^{-1})			Yield loss (%)	On-farm (Kapasia) site Grain yield (t ha^{-1})			Yield loss (%)
	Weedy	Weed-free	Difference		Weedy	Weed-free	Difference	
V1	3.94	5.15	1.21	23	3.42	4.16	0.74	18
V2	2.41	4.31	1.9	44	3.11	4.29	1.18	27
V3	3.45	5.62	2.17	39	3.18	4.37	1.19	27
V4	3.6	5.84	2.24	38	3.27	5.09	1.82	36
V5	3.51	5.81	2.3	39	3.2	4.79	1.59	33
V6	3.41	5.92	2.51	42	3.13	5.11	1.98	39
V7	3.48	5.89	2.41	41	3.34	5.03	1.69	34
V8	3.52	5.89	2.37	40	3.29	4.94	1.65	33
V9	3.3	5.69	2.39	42	4.71	5.24	0.53	10
V10	3.48	6.00	2.52	42	3.43	4.86	1.43	29
V11	3.9	6.11	2.21	36	3.2	5.55	2.35	42

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

C1.2 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 particular, the ebb and flow of funding has complicated the Activity's ability to enter into joint business arrangements with partners companies. 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 and are unlikely to be resumed before the completion of the project unless funding levels and consistency can be restored. 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 ran from 2013-2019, and which emerged from the set of USAID/Washington core investments in CSISA, the Feed the Future Bangladesh Cereal Systems Initiative for South Asia Mechanization Extension Activity (CSISA-MEA) began on 1 October 2019.

The Activity underwent some modifications during the reporting period and now has three main intervention areas:

1. Build the capacity of the agricultural machinery manufacturing sector to produce high quality, competitive pricing of agricultural machinery and spare parts through providing training in manufacturing skills and technical advice on manufacturing processes and machinery systems, and by facilitating improved access to finance.
2. Support agricultural machinery marketing companies to expand new agricultural machinery technology marketing into southern Bangladesh and Cox's Bazar district and 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 to provide machinery solution providers (MSPs) with 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, from planting through to marketing. Particular emphasis will be given to developing new or existing agricultural service provision businesses managed especially 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 commissioned by CSISA from the Bangladeshi company, Inspira. They 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. The COVID-19 pandemic has added new challenges to the sector which has also affected the country's agriculture production. Amid this crisis, labor costs have also increased, creating barriers in terms of production, harvesting and post-harvest activities.

Following publication of a request for expressions of interest, eight lead firms were selected for negotiation of agreements with the activity to support Objectives 1 and 3. CSISA-MEA has signed Service Agreements with six of these lead firms (ACI Motors, Abedin Equipment, TML, Alim Industries, Janata Engineering and RK Metal), and two financial services providers (ILDC and BRAC Bank). These agreements were signed before the reporting period, but have allowed activities to continue during the reporting period. The agreements also mean that an alliance has been forged with these companies through which new machinery will be developed, tested and marketed, and sales and service provision for the machines they sell will be improved. These service agreements cover:

- new machinery technology development and testing (currently jute fiber extraction, onion and garlic planting)
- technical training for mechanics and operators of the machines they sell. This will focus on combine harvesters and rice transplanters but will also include smaller machines such as reapers, power tiller operated seeders (PTOS), maize shellers and fodder choppers
- pre-season maintenance of these machines
- video tutorials on how to operate these machines
- MSP development program for these machines
- finance for machine purchase and financial management training
- support to two lead firms to find ABLE enterprises capable of manufacturing spare parts for the machines they sell. These are principally for combine harvesters, attachments to 4-wheel tractors and rice transplanters. CSISA-MEA engineers support the selected ABLE enterprises design systems for the manufacture of these parts.

In this reporting period, these strategic alliances have resulted in the sale of seven combine harvesters, four rice transplanters, 31 reapers, seven livestock fodder choppers and six PTOS machines, with a total value of USD $106,100. The CSISA-MEA Activity has facilitated 18 credit support arrangements totaling USD $284,941 from financial institutes for 11 workshop owners (USD 239,412), 5 machinery service providers (USD22,00) and 2 machinery dealers (USD

23,529). This has helped machinery service providers to purchase machines at the time they were needed. The Activity is working to extend this service among other workshops and service providers. In the Rohingya crisis-affected Cox's Bazar, CSISA-MEA has signed joint venture agreements with three lead machinery companies and four dealers.

CSISA-MEA also completed collection of basic data on products manufactured and size of 443 light engineering enterprises, based on MSMEs in Bogura district, Khulna division and Dhaka division (Faridpur, Rajbari and Gopalganj districts). From these, the Activity selected 97 companies as potential partners, and following publication of an expression of interest request, these were further reduced to select 53 MSMEs with a total workforce of 1,624 as project partners for the planned activates under Objectives 1 and 2. In partnership with two training service providers (TMSS in Bogura and RRF in Jashore), CSISA-MEA developed and began a training program, Incorporating curricula specially developed for metal workers, concentrating on welding, lathing, bending, cutting, drilling and painting skills. Already, 46 metal workers have received training and 56 are due to finish the course by April 2021.

As part of the JVA signed in the reporting period, CSISA-MEA arranged for Janata Engineering to send its technician from Jashore to Cox's Bazar to provide training for 17 mechanics on the maintenance and use of the combine harvester, reaper and rice transplanter. Under the terms of the JVA, Janata Engineering provided its mechanic free of cost.

Above: *Janata Engineering facilitating mechanics training as part of its JVA with CSISA. Ramu, Cox's Bazar. (Photo: Md. Ashraful Alam/CSISA)*

Above: *Janata Engineering facilitating mechanics training. Ramu, Cox's Bazar. (Photo: Md. Rafiqul Islam/CSISA)*

The seven mechanics trained by Janata Engineering then in turn provided training to 13 owners of various agricultural machines (reapers, combine harvesters, rice transplanters and fodder choppers) on their maintenance and use. Training was given by private sector partners (Janata Engineering and The Metal Ltd) to 62 LSPs on the operation and maintenance of combine harvesters, reapers and rice transplanters.

Pre-season service campaign by Abedin Equipment and The Metal Pvt. Ltd.

JVAs signed with these lead firms in the previous reporting period provided pre-season servicing of 62 combine harvesters located across the FtF ZOI from Meherpur, Chuadanga through Faridpur to Bhola and Patuakhali in Barisal division. At the same time, the firms' engineers showed

93 owners and operators (if not the same person) how to maintain and drive their combine harvester, ensuring that combine and its operator were both fully prepared for the upcoming wheat harvest season.

CSISA-MEA, in both the FtF Zone of Influence and also the 'Zone of Resilience' in Cox's Bazar District, has trained 20 LSPs and 210 farmers to use the mat method of raising seedlings to be transplanted out using mechanized rice transplanters; this was done either in collaboration with the Activity's lead firms or directly by lead firms with technical support from CSISA-MEA staff and the DAE. This resulted in the planting of 202 ha of rice using rice transplanters, as well as interest in or firm purchase of 29 rice transplanters.

During the reporting period, a farmer and land coverage survey conducted by activity Monitoring team indicated a total of 40,528 farmers (13% woman) had purchased mechanized land preparation, irrigation and harvesting services from 1,514 machinery solution providers: irrigation (22 MSPs), PTOS (1,286), combine harvesters (81), reapers (117) and rice transplanters (8). These services covered a total of 13,124 ha of cropland, which represents 90% of our annual target.

Above: *Service team providing mechanics from the metal Limited, a company partnering with CSISA-MEA, conducting training on combine harvester maintenance. (Photo: Md. Hafijur)*

Above: *Abedin Equipment team training combine harvester operators, Cox's Bazar. (Photo: Md. Ikram Hossain/CSISA)*

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

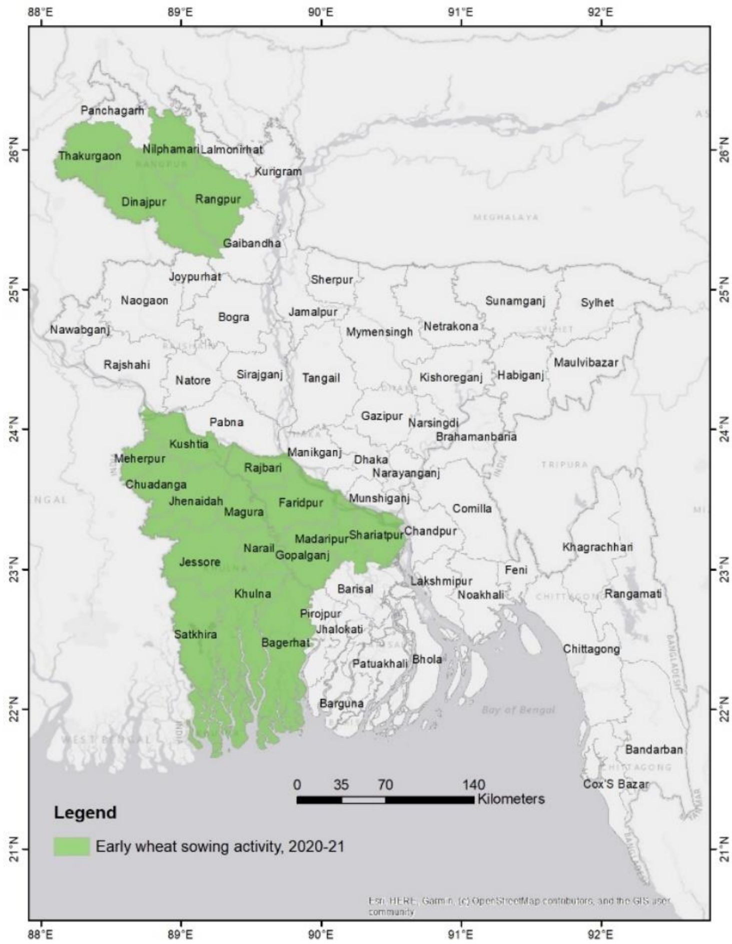
Following rice and maize, wheat is the third most widely grown cereal crop in Bangladesh. Grown mainly by poor farmers, with much of what is produced being consumed, wheat is important for meeting basic food security needs. Consumption of wheat has increased in the last five years which can be linked to factors such as population growth, eating habits and urbanization. Despite the availability several high yielding cultivars, production of wheat is not increasing adequately in line with population growth and demand. One important reason for low yields is the cultivation of wheat under late sowing conditions, that is, after the harvest of transplanted monsoon rice (referred to in Bangladesh as *T. Aman*). Late planted wheat experiences heat stress, especially during the grain-filling period, resulting in lower yields than wheat sown at the right time. Research has shown that temperatures above or below the optimum (12°C–25°C) change the phenology, growth and development of the crop, resulting in reduced yields. Sowing wheat after 30 November each year reduces yield at the rate of 36 kg ha^{-1} day^{-1}. In USAID's Feed the Future Zone, located in the south of the country with higher temperatures, losses can be up to 51 kg ha^{-1} day^{-1}.

Above: *Wheat grown in South Asia is vulnerable to the effect of extreme heat, particularly at the end of the growing season, that can significantly lower yield.*

These issues can only fully be tackled within a cropping systems context that considers the growth of both wheat and of rice. The production of monsoon season rice (*T. Aman*) is fully dependent on the rainy season and due to lack of timely/adequate rainfall, sometime cultivation is delayed. This can result in a late harvest and delays to the timing of the next crop (wheat) production. Heavy precipitation during the monsoon can result in the high moisture content of the soil, which inhibits harvest and prevents tillage being carried out in good time for the crops which follow.

BRRI has released short duration high yielding *T. Aman* varieties, which can replace existing long duration varieties. During the reporting period CSISA worked to raise awareness among the relevant stakeholders about the importance of growing wheat at the optimum time, including campaigns to increase awareness and demand for short duration but high yielding rice cultivars. Despite several important scheduled tasks being compromised by COVID-19 restrictions, remarkable progress was made in early wheat sowing in the Activity's working areas, including in the following:

- For timely harvesting of rice using a mini combine harvester, 15 farmer groups communicated with machinery services providers through virtual media arranged harvesting and subsequent machine sowing of wheat on a total of 38.5 ha of land (engaging 287 farmers).
- CSISA's video on early wheat sowing was delivered to DAE personnel in 32 *upazilas* under the Activity's Dinajpur and Faridpur field office and screened in DAE SAAO and farmers' meetings at the beginning of the season.
- Prior to the wheat season, CSISA facilitated virtual discussion on early wheat sowing activities in e collaboration with 26 *Upazila* agriculture officers.
- CSISA also conducted training for 100 farmers (20% women) on the production technology for newly released wheat varieties.
- The Activity established six trial plots on 4.4 ha of land to observe the performance of seed rate (150, 180 and 210 kg/ha) when two different wheat cultivars (BARI Gom 28 and BARI Gom 33) are used in relay cropping practice. We selected comparatively lower-lying lands, where the soil is saturated 10-15 days prior to the *T. Aman* rice harvest. The Activity also established 2 surface seeding trials (0.40 ha) in flood-affected areas of Bhanga *Upazila*, Faridpur district where *T. Aman* could not be grown, and performance observed/supervised by CSISA and DAE. Seventy-one farmers from different locations, as well as regional and district level DAE officers, visited the plots to observe performance first-hand, and expressed their interest in such techniques. Further results will be provided in the coming 2020-21 Annual report.



Above: *Areas in which CSISA's early wheat showing activities re implemented in the north and southern part of Bangladesh*

- In response to seeing the benefits of relay cropping last year, 6.7 ha of land was covered by relay cropping of wheat in *aman* fields which comprises of 42 farmers (21.5% women) this season. In addition, surface seeding (broadcasting on bare moist land) can be an alternative in monsoon flood-affected areas. To this end, CSISA and DAE implemented demonstrations of relay sowing on 3.12 ha of land. Participating farmers were encouraged because by practicing surface/relay seeding they were enabled sow the wheat seed at the right time, while production costs are kept low because of zero tillage.

- CSISA created seven social media groups (with 264 members on Facebook and WhatsApp) to disseminate information on the importance of early wheat sowing.
- Also contributing to raising awareness of early wheat sowing, in this reporting period CSISA distributed 16,000 leaflets, 7,200 factsheets, 300 banners, 300 festoons and 1,500 stickers to publicize its benefits. An advertisement about early wheat sowing was published in four different local newspapers for 16 days, starting from 5 November, 2020, with a total of 8,000 copies of the newspapers distributed to readers each day. Miking publicized the benefits of sowing seed at the optimum time in 33 wheat-growing *upazilas*, and early wheat sowing information was shared via two radio channels over 10 days. LSPs/lead farmers conducted 112 farmers' discussions at tea stalls which had positive impacts.
- Farmer field days are always an important medium for information dissemination. During the reporting period, the Activity facilitated eight farmer field days, engaging a total of 433 farmers (37.5% women), gathered information on early wheat sowing, BARI Gom 33, its usefulness and production technique.
- In September and November 2019 of the previous work cycle of CSISA, the Activity had facilitated the screening of a video about the benefits of early wheat sowing, reaching 87,084 farmers (19% women) and with AAS registering 40,356 farmers. In this reporting period (2020–21), the Activity conducted a telephone survey to assess technology adoption rate. Data collection and analysis indicated that approximately one-third of video viewers had taken up and are utilizing early wheat sowing techniques on an average of 0.17 ha of land each.

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

Optimum seeding time is considered an important management strategy for improving wheat production. Above-optimum temperatures hinder crop physiological performance; sowing far too early produces weak plants with poor root systems, while planting wheat late shortens the duration of the life cycle and exposing the plant to high temperature stress at the flowering to grain-filling stage. To address this, CSISA has collaborated with BWMRI over the last four years to evaluate the performance of newly released wheat varieties sown at different dates, to identify (1) the optimum sowing time for specific varieties, and (2) which varieties are heat and wheat blast tolerant. In first two seasons, six existing elite wheat varieties (BARI Gom 26, BARI Gom 28, BARI Gom 30, BARI Gom 31, BARI Gom 32 and BARI Gom 33), in third year (2019–20) seven wheat varieties (the preceding six + the newly released WMRI Gom 1) and in the fourth year (2020–21) seven wheat varieties (BARI Gom 26, BARI Gom 30, BARI Gom 32, BARI Gom 33, WMRI 1, WMRI 2 and WMRI 3) were evaluated in five sowing conditions, from 25 November 2020 to 4 January 2021, with a 10-day interval between each sowing.

In Dinajpur, all of the wheat varieties sown under optimum sowing conditions (25 Nov) produced maximum yield and escaped wheat blast disease, in all four years in all locations. Yields of all varieties decreased when sown late in all three location and all four seasons. No incidence of wheat blast was recorded. In Rajshahi and Jashore, wheat blast was found in the last three sowings (15 December and 25 December 2020, and 4 January 2021) in first two seasons, and in all sowing conditions in the third and fourth seasons. In terms of yield performance, BARI Gom

30 performed the best in all sowing conditions as well as late sown heat stress condition in Dinajpur, followed by BARI Gom 32, BARI Gom 33, WMRI 3, WMRI 2 and WMRI 1.

In Rajshahi and Jashore, BARI Gom 33 also performed the best, followed by BARI Gom 30, BARI Gom 31, WMRI 3, WMRI 2 and BARI Gom 28. The maximum severity of wheat blast in Rajshahi and Jashore was observed with BARI Gom 26; the lowest severity was found with WMRI 3 and BARI Gom 33. WMRI 3, BARI Gom 30, BARI Gom 32 and WMRI 2 all experienced comparatively lower severity of disease when exposed to high disease pressure under late sown conditions in all three locations. After four years of observations, CSISA and BWMRI's data appear to confirm that there is remarkable variety location interaction with yield and disease incidence; as such, location- and sowing-date recommendations for specific varieties will be needed for optimal cropping. These results will be shared with DAE in the next reporting period and are anticipated to form the basis of new management recommendations to be provided to farmers throughout Bangladesh. Full analysis of the data including genotype $\times$ management $\times$ environment interactions will be presented in the 2020-21 Annual Report.

2. Nepal – Achievements

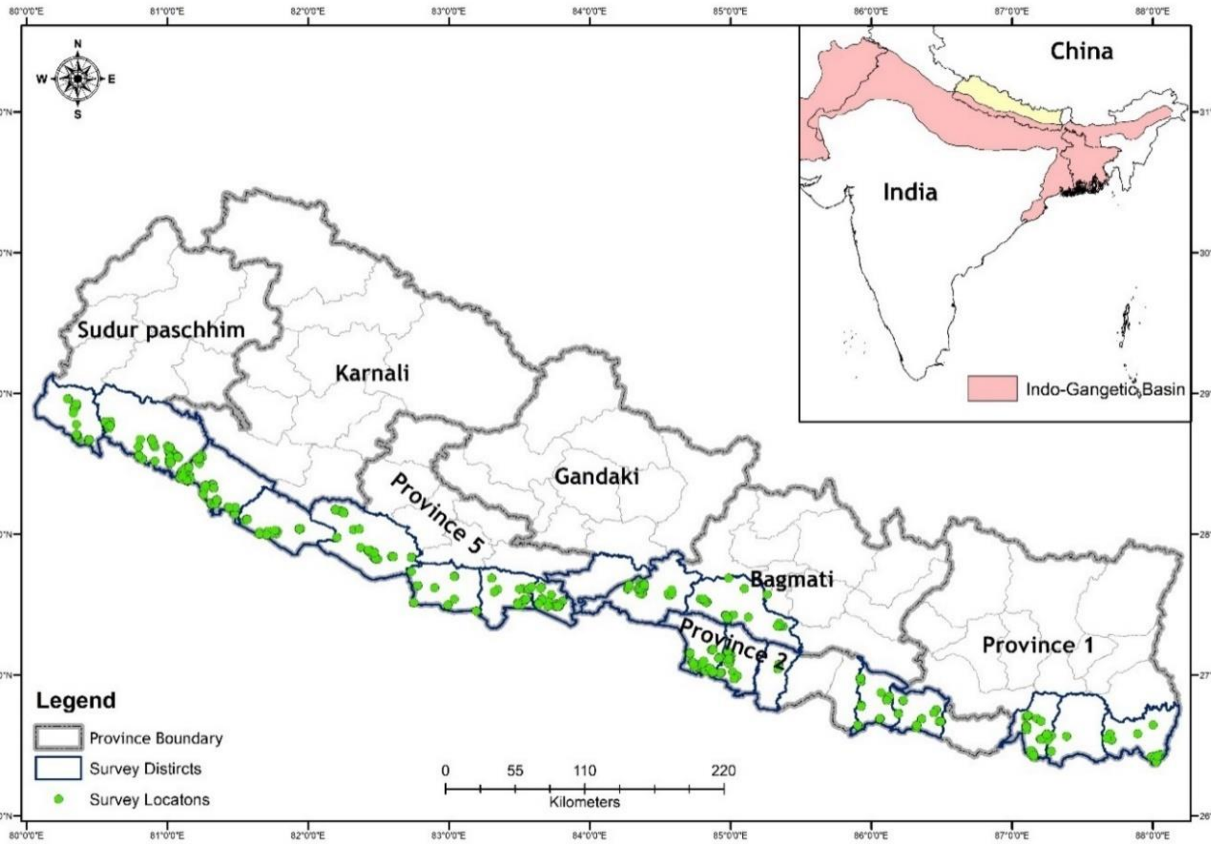
***Above:** Farmers Kanchimaya Pakhrin and her neighbor Phulmaya Lobshan checking on growth progress of rice seedling beds that will be used for mechanical transplanting in Purnabas, Kanchanpur. (Photo: P.Lowe)*

A. INNOVATION TOWARD IMPACT

A1. Reducing risk to facilitate uptake of sustainable intensification practices

A1.1 Direct-seeded rice to address labor and energy constraints to precision rice establishment

CSISA has been working with National Agricultural Research Institutes (NARES) and development partners (including the USAID/Nepal supported KISAN-II and Prime Minister's Agriculture Modernization Project, or PMAMP) to facilitate awareness and empower farmers to use direct-seeded rice (DSR), which has the potential to overcome the acute labor shortages created by labor out-migration and address the energy constraint related to rice establishment. DSR is an alternative to transplanting rice (which uses a great deal of labor) and is a labor-, water-, and energy-efficient technology. As rice is a major staple crop in Nepal, the government prioritizes technological innovations that can enhance rice productivity, reduce the cost of cultivation, and minimize the trade deficit created from Nepal's rice import dependency. The latter has which have an annual value of almost USD $270 million. CSISA has been prioritizing DSR to address these foundational production constraints of rice in Nepal since its inception. However, the rate of DSR adoption by farmers is constrained by several factors. Farmers have adopted only around 350 seed drills needed to plant DSR so far. This is a relatively lower number than expected, with most purchases supported by different programs, mainly in the form of governmental subsidy. Studies indicate the significant advantage of DSR in rice-based cropping systems in Nepal and the reasons for the slow adoption of DSR seed drills are largely unknown. To identify constraints and address the primary bottlenecks of DSR seed drill adoption, during this reporting period CSISA conducted an assessment using a purposive sample selection of DSR adopters, dis-adopters, and non-adopters around the FtF ZOI, as well as in some districts in the eastern Terai where CIMMYT's Australian Center for International Agricultural Research (ACIAR) supported Sustainable and Resilient Farming Systems Intensification in the Eastern Gangetic Plains (SRFSI) project has worked to accelerate awareness and adoption of DSR. The study focused on seed drills as well as the eight other machines that CSISA has been involved in market facilitation for in Nepal's rice system.



Above: Districts and survey locations for the Direct Seeded Rice and agricultural machinery technology assessment.

The nine technologies were studied as a group to understand the reasons behind the slow adoption of these SI technologies, and its findings will help NARES and development partners (e.g., KISAN-II, PMAMP) to refine their programs to help enhance adoption rates.

As reported in the Annual Report 2020–21, this study opted for a stepwise framework to understand the reasons behind the slow adoption of DSR and other SI technologies in Nepal Terai. A household survey was conducted among 1,569 farmers in Nepal Terai, including FtF ZOI operation districts. The stepwise framework consists of four phases designed to understand the reasons behind the adoption and dis-adoption of the DSR technology. The first phase starts with the farmers' "exposure phase," in which farmers are exposed to the DSR and other SI technologies, followed by the "progression phase" dealing with farmers' adoption, the (third) "continuation phase" and finally the "utilization phase." In each phase, farmers were asked to provide information related to DSR (seed drills) and other SI technologies, its utilization, and qualitative reasons if not adopting and/or dis-adopting the SI technologies. While most of the assessment results were reported in the previous reporting period, in this reporting period we discuss in detail the major reasons behind, specifically, the stagnation at the exposure phase.

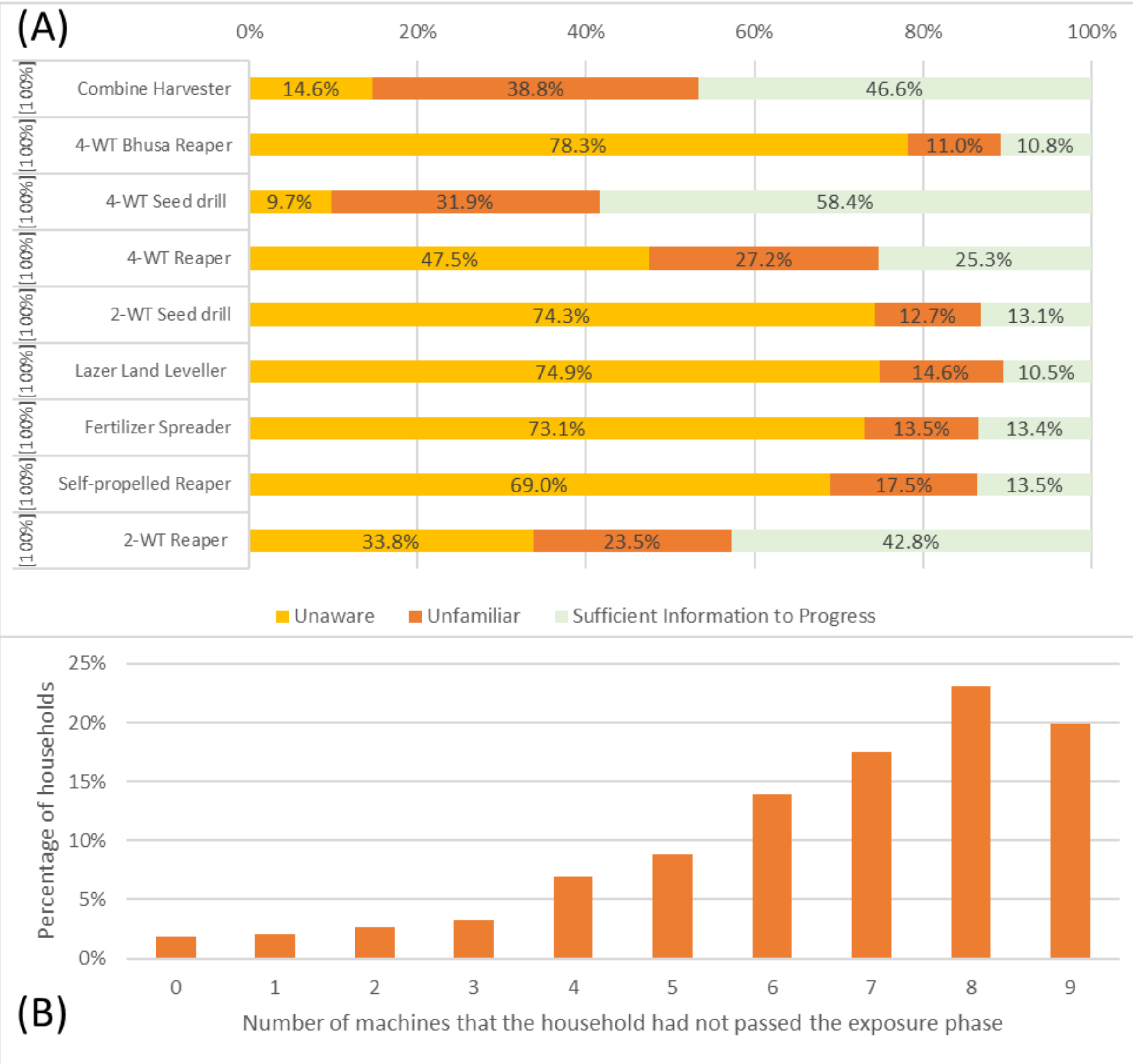
Stagnation at the "exposure" phase for many machineries including seed drills compatible with DSR

The exposure phase compares and quantifies those with insufficient information (i.e. 'Unaware' and 'Unfamiliar') to those who have sufficient information to understand if awareness is a core constraint to the adoption process. Lower exposure suggests that information flows may potentially constrain movement along the adoption pathway. That means communities cannot sufficiently obtain information, learn about potential innovations and evaluate the potential benefits of DSR and other technological options. Overall, there were some information gaps identified at this stage for seed drills and other machinery. In the case of seed drill use with four when tractors (4WT), the majority of respondents have sufficient confidence in their held information to progress to the next phase of the stepwise framework (below, figure A). However, the primary self-identified reason for lack of exposure to seed drills was that 'no farmers in the area use that machine' (53% of all responses by those with limited exposure, and the primary reason 'no information access').

In six cases, unawareness was the dominant component of the non-exposure rate, indicating minimal recognition of investigated machinery. Such a trend is consistent with each household's overall exposure to seed drills. The majority of households were either unaware or unfamiliar with seed drills, while 20% were aware or familiar with them. Only 2% of respondents were familiar all of the machinery technologies described, including seed drills, and only 10% of households were familiar with at least three of the technologies. This highlights substantial information gaps that are broadly constraining agricultural mechanization, including the use of seed drills, in the investigated communities.

To explain why unfamiliar respondents have not progressed to use, they were asked for the primary reason for lack of progression. Interestingly, knowledge was never a priority reason, usually ranking low compared to other causes. Instead, the unavailability of services was the primary reason identified for each technology. The only exception to this was the 4WT seed drill, whose inappropriateness was noted by 22% of respondents due to small landholding sizes. This was marginally more important than the unavailability of services (21%). Cost was surprisingly not identified as a reason for unfamiliarity, meaning perception of cost did not stop farmers from seeking information. There were some poor perceptions of both the 4WT seed drill and fertilizer spreader, but they were not the dominant factor influencing movement to progression. Hence, unfamiliar respondents appear to be easily convinced to move ahead if they could access machinery service providers. This also highlights the importance of empowering service providers as change agents within communities, alongside other extension efforts (e.g.

encouraging not relying totally on government-led promotional activities) to achieve rapid change.



Above: *[A] Exposure phase results for each of the nine investigated machines, with overall non-exposure rate provided on left-hand side. [Brackets] provide % of the population visualized in this figure. [B] Summary of the cumulative number of machines that households had not passed the exposure phase. A higher number suggests lower exposure to various SI technologies, including seed drills.*

While five of the investigated technologies have been available for less than a decade in Nepal, the study results indicate that overall low exposure rates are not solely related to length of availability as a determining variable. This is exemplified by the experience of the 2WT reaper, which with only six years of presence in Nepal has achieved exposure to nearly half of the population.

The CSISA and SRFSI research teams consequently have identified three potential e driving reasons for limited exposure occurring broadly in surveyed communities. Each of these reasons have important relevance for agricultural development and mechanization policies, as well as for development projects that rely on market facilitation methods to achieve their aims. Firstly, to explain the disconnect between exposure gaps driven by a perception of a lack of local ownership and availability in the same communities where substantial use is found (exemplified by the combine harvester, where a 25% adoption rate was found, yet 52% of unaware and unfamiliar farmers said nobody in their community used combine harvesters), it is likely that social hierarchy and caste system limit information exchange outside of existing social circles. As such, efforts are needed to address this lack of information flow across communities. Secondly, the lack of a well-functioning public extension system in Nepal presents a significant gap. As part of the ongoing process of decentralization in Nepal, district-level agricultural officers have been disbanded and new systems to enable agricultural extension are still being developed, although those that have been formed have been found to have limited capacity. The institutional capacity of human resources, infrastructure, financial funds and other resources is currently insufficient to enable a successful extension system. Studies on extension officers' degree of knowledge and resulting extension capacity regarding appropriate machinery are lacking, highlighting a significant development need. Thirdly, the study findings suggest that development-led machinery awareness raising activities (such as with seed drills) may have been less effective than those led by the private sector, which ties in with localized intervention concepts and a lack of extension system though which projects may converge with governmental implementation. As such, efforts are needed to support the private sector's leadership in this area, rather than the predominant focus on public support for mechanization options including DSR.

Mentoring and building the technical capacity of extension staff of rural municipalities for expanding spring rice production frontier in Nepal

The Government of Nepal has prioritized the expansion of rice area and production to meet the growing demand in Nepal. However, there is limited opportunity to achieve this goal in the main monsoon *kharif* season. CSISA has regional experience in understanding spring season rice, and so the Activity is working to enhance the technical capacity of rural municipality extension staff as part of the collaborative activities with KISAN-II and governmental partners in the Joint Rice Implementation program (JRIP). For example, the CSISA team has facilitated trainings on suitable farm machinery for spring rice production to both KISAN staff on12 October, 2020. Several technical and extension staff of rural municipalities participated in this event.

Above: *Learning by doing. Participants practicing nursery raising in Bhajani, 5 Feb, 2021. (Photo: Lokendra Khadka/CSISA)*

Moreover, as CSISA has regional expertise in spring rice production, the Activity brought experts from Bangladesh to help facilitate training in Nepal, and on 25 January 2021 provided the JRIP, Ministry of Agriculture and Livestock Development (MoALD), MoLMAC training PMAMP, and NSAF with a virtual training on spring rice production. There were 40 participants in the event, and as a result of this training and capacity development, PMAMP has been able to expand its spring rice production in Nepal's FtF ZOI. Currently, during this reporting time, the plantation of spring rice around FtF ZOI in Nepal is ongoing; information on the outcomes of this activity will be presented in the 2020-2021 Annual Report.

During the reporting period also, CSISA provided hands-on training to KISAN-II, millers and key farmer technicians in improved methods for spring rice nursery raising, to be used in conjunction with a mechanical rice transplanter. This training was organized jointly by KISAN II, Agriculture Knowledge Center, Kailali, Naya Tulasi Trade Link PVT, Ltd, and Bhajani municipality on 5 February, 2021. There were 20 participants (5 women, 15 men) and the training started with a screening of the nursery preparation video, followed by a practical session in the field. The participants learned the complete steps of spring rice nursery preparation methods for mechanical rice transplanter. In addition, CSISA provided technical support to operate and handle the rice transplanter machine to the service provider on 7 March, 2021 in Bhajani, Kailali. Women farmers showed great interest in observing the machine's performance in the field.

Raising awareness about direct-seeded rice

The Activity facilitated a range of agricultural machinery dealers and government partners to conduct joint demonstrations locations within the FtF Zone where soils and hydrological conditions are suitable for DSR. Most notably, the Activity supported Swostik Traders in Bardiya district to conduct eight rice seeding demonstrations using seed drill and drum seeder machine on 25 February, 2021. Similarly, with the local agriculture office's financial support, Bhajani, and technical support from CSISA, NB Krishi Auzaar Kendra conducted eight spring rice establishment demonstrations using drum seeder seed drill machines in Bhajani, Kailali on 12 February, 2021. The demonstrations were conducted in coordination with KISAN II, a local farmers' cooperative, and PMAMP. A strong linkage was created between local suppliers and importers to develop machinery supply chains through such demonstrations and interactive platforms. These demonstrations of spring DSR covered 6 ha each in Kailali and Bardiya. The demonstrations of spring DSR using a drum seeder and seed drill were established adjacent to plots in which farmers established rice by transplanting, so that farmers could compare the different rice establishment methods. Grain yield and economic data will also be collected for the performance evaluation of these technologies and will be reported in the Annual Report for 2020-21.

Above: *Seedling stage of drum seeder planted spring rice in Bhajani-5, Kailali. (Photo: Lokendra Khadka/CSISA)*

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

Fall Armyworm Integrated Pest Management (IPM) Training

Fall Armyworm's threat to the maize crop and the maize growers has remained constant in Nepal after its official detection in 2019. CSISA is collaborating with related stakeholders improve the capability of farming communities to manage the pest using an integrated pest management (IPM) approach. In partnership with the Plant Quarantine and Pesticide Management Center (PQPMC), Directorate of Agriculture Development (DoAD) of Lumbini Province, USAID Nepal's Nepal Seed and Fertilizer (NSAF) Project, and iDE Nepal, the Activity organized two days (3–4 March 2021) of 'Training on Fall Armyworm Management and Safe Handling of Pesticides' to agrovet association representatives in Lumbini Province. The training targeted 24 district agrovet associations from 12 districts in Dang, and was facilitated by experts from PQPMC, CIMMYT and iDE Nepal.

Above: *FAW training event in Dang, 3–4 March 2021. (Photo: Darbin Joshi/CSISA)*

Above: *Learning to scout for Fall Armyworm. (Photo: Pramin Manandhar)*

During training, participants learned to identify the different stages of the FAW lifecycle and about monitoring and scouting protocols, IPM approaches, and the safe and effective pesticides recommended for Fall Armyworm management. Recent changes in government policies and regulations regarding pesticide registrations and marketing were also discussed. The training is expected to further strengthen effective supply chain management, including biopesticide formulations against Fall Armyworm. Details on the outcomes of the training will be reported in the 2020-21 Annual Report.

Above: FAW awareness field campaign in the Dang Maize Super Zone, November 2020. (Photo: Sagar Kafle/CSISA)

Broad scale awareness on the invasion of FAW and its management during COVID-19 restrictions

Working within COVID-19 restrictions enforced across Nepal during March of 2020, CSISA played a crucial role in co-designing and implementing FAW awareness activities with related stakeholders. In collaboration with MoALD's PMAMP-Maize Super Zone in Dang, the Activity organized five awareness campaigns on FAW identification, scouting and management from November 2020 to March 2021. These field-based campaigns were organized for the five farmer groups involved in commercial maize farming, and focused on timely management of the pest at the early stages of the maize crop. The campaigns were successful in establishing the concept of field scouting by the farmers at regular intervals throughout the crop season to manage the pest damage within the threshold level and ultimately reduce the number of sprays per season. Details on the outcomes of the training will be reported in the 2020-21 Annual Report.

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 PMAMP to raise awareness among farmers and governmental staff on crop management practices aligned with sustainable intensification principles. PMAMP is run by MoALD and started in 2017, working 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 PMAMP terms 'blocks' of 10–100 ha)
- the development of commercial agricultural production and processing centers (which PMAMP terms 'zones', 100–500 ha)
- the development of large commercial agricultural production and industrial centers (which PMAMP terms 'Super Zones', 500–1,000 ha).

Since the collaboration began, PMAMP has leveraged CSISA as a core technical partner for advice and technical support, especially at the field level. The Activity has shared its experiences and provided technical backstopping for PMAMP to support the scaling-up of new technologies, such as 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 its activities more effectively.

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

On-farm maize demonstrations and evaluations in new PMAMP sites

CSISA coordinates with public and private stakeholders to create, introduce and facilitate markets for resource-conserving and efficient/precise technologies in maize-based cropping systems. Two-wheeled tractor (2WT) power tillers are widely popular among smallholder farming households in the FtF ZoI districts of the western Terai. This machine is however normally used for tillage alone. To increase the power tiller's versatility and multiple-uses CSISA has been working on engineering solutions for precision crop planters – with an initial focus on maize seeding – which can be operated by the existing power tiller. In collaboration with PMAMP-Maize Super Zone, Dang, and machinery dealer Swargadwari Trade Link (based in Lamahi), in this reporting period CSISA organized six newly introduced demonstrations of a 2WT-operated maize planter (Model: 2BSF-1) in newly maize growing areas identified by the

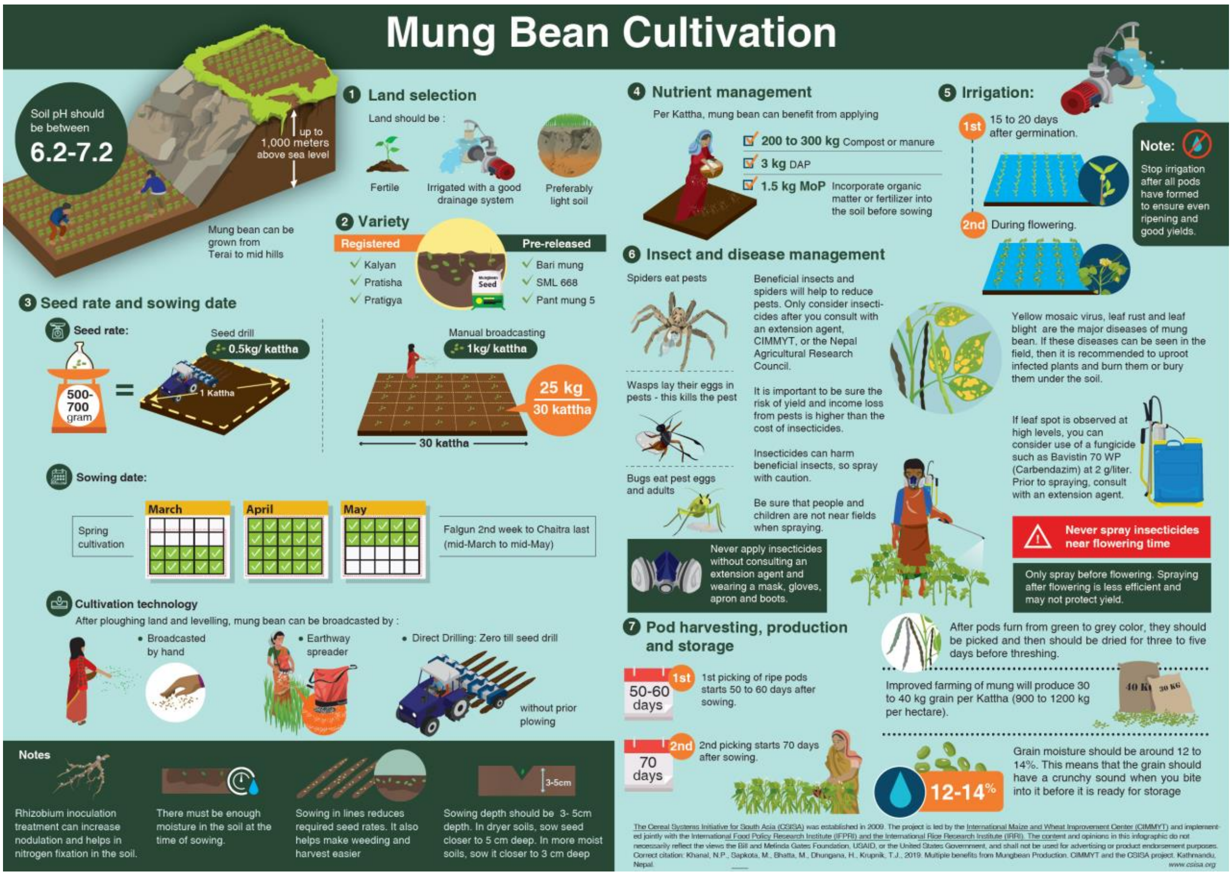
Maize Super Zone. A total of 101 farmers (40% women) benefited participated in demonstrations and farmer field days during the reporting period.

Above: *A two-wheel tractor driven two-row maize planer demonstration in Madhyanagar, Lamahi on February 2021 (Photo: Sagar Kafle/CSISA)*

The 2WT-operated maize planter is a miniature version of the 4WT-tractor-operated precision maize planter, initially introduced by CSISA in 2017 and now widely adopted in maize growing domains. The demonstration programs were integrated with the Rampur hybrid maize variety-based 10 promotion activities, promoted by the Maize Super Zone to ensure the farmers' extension of technology packages. Swargadwari Trade Link took the lead role in the events, to demonstrate the technology in order to improve its linkages with farmers. The dealer was also involved in importing the prototype into Dang and, in response to feedback from CSISA and PMAMP experts, they have made necessary adjustments to provide a seating arrangement for the machine operator. With the satisfactory performance of the maize planter, the Maize Super Zone has decided to add this machine in its subsidy schemes, and in the virtual meeting organized by PMAMP (18 February 2021), the same message was delivered to Lumbini Province's other maize zones. Details on sales of the machine and its use will be reported in the 2020-21 Annual Report.

Cropping systems and value chain intensification with mung bean

In parts of the Terai region of Nepal, about 70% of cropland remains fallow for about two to three months after the harvesting of winter season crops (such as wheat, lentil, rapeseed and vegetables) and before transplanting rice. This period is characterized as a dry season, with high out-migration of the men to India for seasonal jobs, and a relatively quiet time for household laborers, especially women. This fallow land can be capitalized to improve cropping system productivity and household nutrition by introducing nutritious (24% protein), short duration (70–80 days), and relatively drought-tolerant leguminous crops such as mung bean. Back in 2014, CSISA had established a framework for mung bean crop expansion to replace fallow land across Banke, Bardiya, Kailali and Kanchanpur districts in partnership with NGLRP, seed companies (GATE Nepal and Panchashakti Seed Company), Poshan Food Ltd, local traders, processor and the Ministry of Land Management Agriculture and Cooperative (MoLMAC) of Sudurpashchim province.



Above: *CSISA infographic on the multiple benefits from mung bean production in Nepal*

As described in previous reports as a result of CSISA's encouragement, local governmental partners in collaboration with PMAMP has also started to include mung bean in its regular programming and as such is encouraging farmers to grow mungbean after wheat harvest and before rice. Activities were somewhat hampered, however, during the reporting period as a consequence of the COVID-19 crisis. Nonetheless, farmers in Ghodahodi municipality extended in 20 ha under mungbean, these in Bhajani municipality extended 10 ha. Farmers in Bedkot municipality and Krishnapur municipality also converted 10 and 7 hectares of fallows into mung bean during the reporting period. Similarly, the PMAMP rice super zone had allocated a budget to support farmers with mungbean seed 20 ha and the oilseed zone for 10 ha. In addition, Bishwash cooperative in Jhalari planned to start seed-producing in 50 ha to avoid the risk of seed scarcity at the time of seeding to their 200 members. Updates on the outcomes of these efforts will be discussed in more detail in the 2020-21 Annual Report as mungbean has yet to be harvested at the time of writing.

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

Participation in regional agricultural fairs raises awareness of CSISA-supported activities

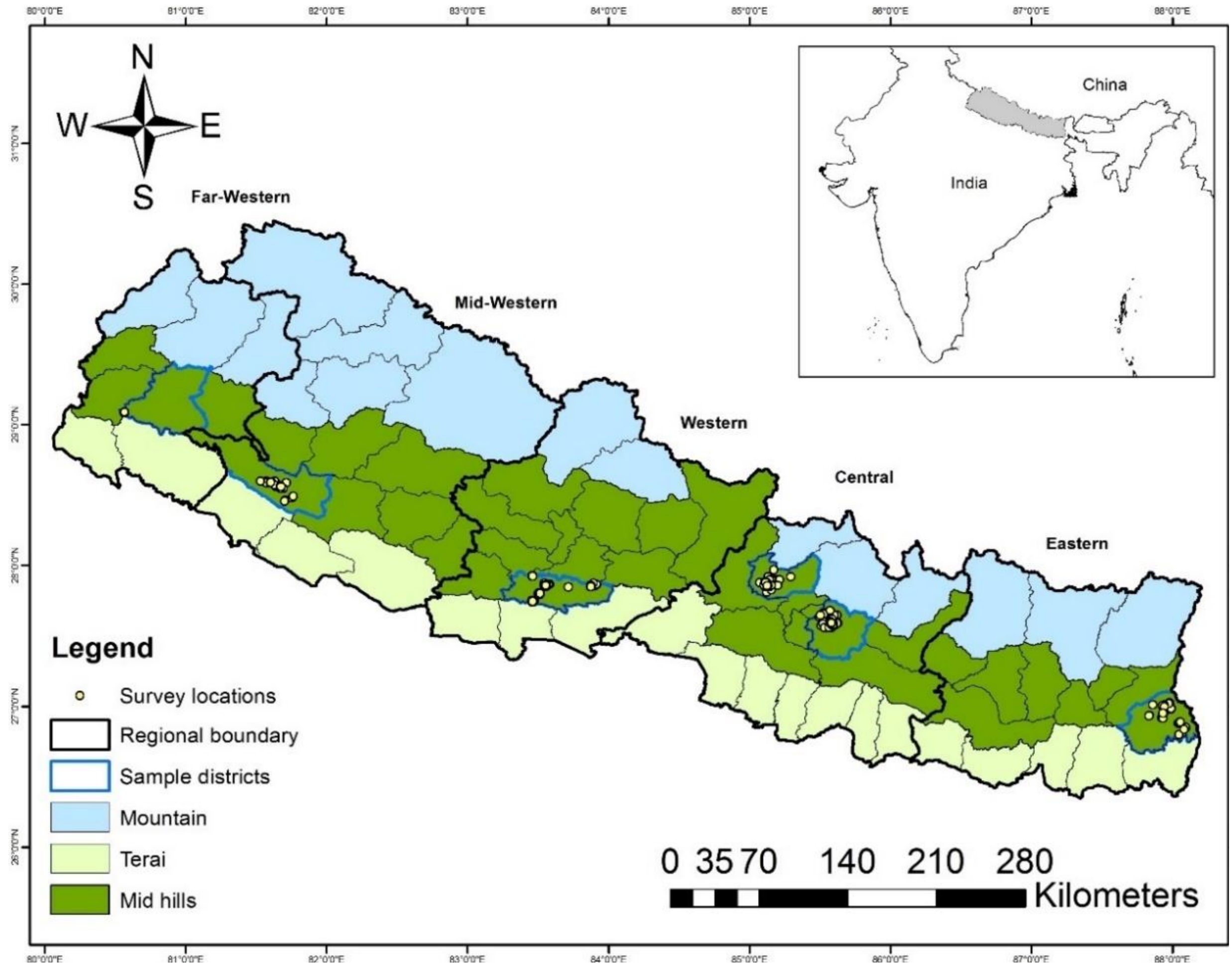
Due to the COVID-19 pandemic, the government restricted fairs and other mass gathering events. As a result, CSISA did not participate in agricultural fairs during this reporting period.

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

Harnessing the transformative power of hybrid maize in Nepal's Midhills region

Nepal's current maize productivity is well below the regional average. Asa a result, Nepal imports nearly 0.6 million tons of maize grains annually, all of which comes from its neighbor, India. The emerging poultry industries located in Nepal's Terai regions are the major consumer of this maize. Although the maize area in the Terai – mainly winter maize – has grown in recent years to around one million ha, most (almost 80%) is located in the country's hilly regions (or Midhills). Here, maize is primarily used for household consumption and partly for livestock feed, with low productivity due to lack of high-yielding cultivars and low input use such as inorganic fertilizers.

To overcome the challenges of access to high-yielding maize cultivars, in the Midhills CSISA has worked to facilitate seed and input markets maize hybrids which have a higher genetic yield potential than open-pollinated and traditional cultivars. In addition, the Activity has worked to link farmers growing hybrids to markets where maize can be sold for a profit, justifying investment in higher seed and input costs, while also providing much needed income to farmers. It is important to note that until 2015, farmers in the FtF ZOI did not have access to these hybrid cultivars, and in 2016 CSISA along with the National Maize Research Program (NMRP) expanded the domains of elite hybrid maize cultivars in the FtF ZOI and many other Mid-hill domains. This domain expansion of maize hybrids has led to the rapid adoption of high-yielding hybrids, and it is estimated that almost 6% of the Midhills area is now under hybrid maize. However, until recently there has been no empirical evidence to demonstrate the impact of hybrid adoption on maize productivity, profitability and welfare outcomes.



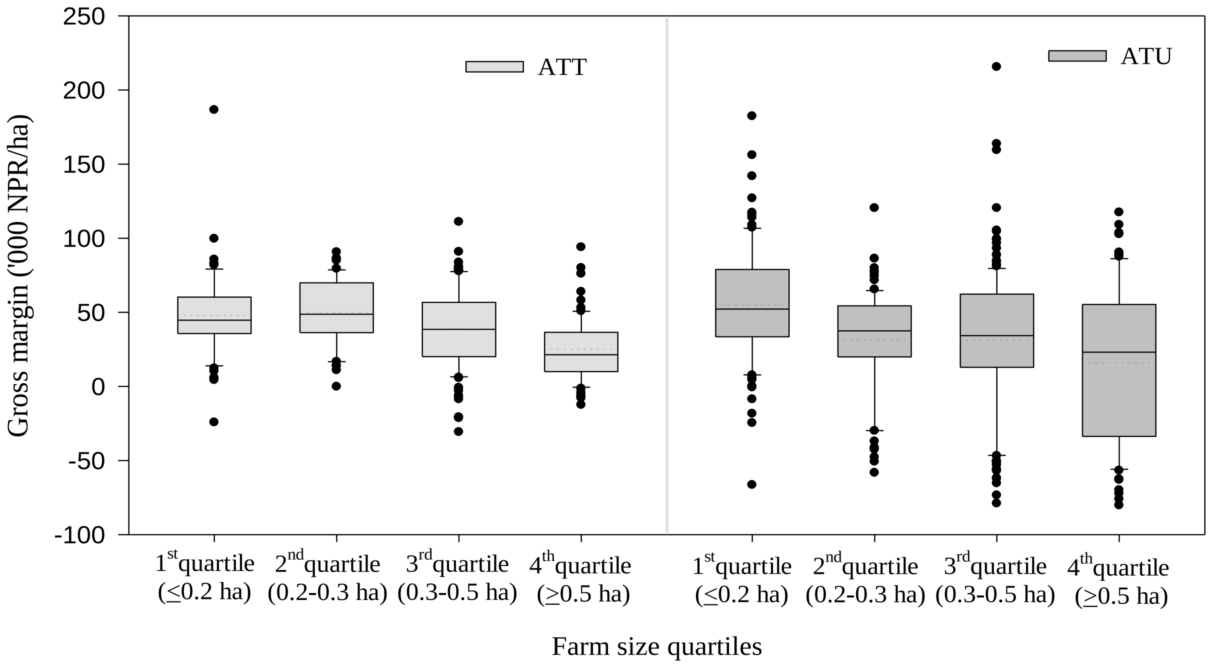
Above: *Study locations for hybrid maize impacts in Nepal's Midhills*

To understand the impacts of hybrid maize adoption in Nepal's Midhills, during this reporting period – in which field activities were necessarily slowed due to the COVID-19 crisis and movement restrictions – CSISA staff focused on an analysis of the data collected in previous years. The locations of districts and samples of the study are presented in the figure below. The analysis included the standard treatment effects models such as endogenous switching regression to account for the sources of heterogeneities between hybrid maize adopters and non-adopters. The impact assessment results show that cultivating hybrid maize enhanced maize productivity, profitability and per capita household food consumption (although as noted above, maize in the Midhills is primarily used for human consumption, and so an increase in per capita food expenditure would be expected). The adoption of hybrid maize was found to enhance maize productivity by 109% (2,115 kg ha–1) for hybrid maize-adopting farms.

The adoption of hybrid maize has also been shown to be highly beneficial for smallholder farming households, providing very high gross margins. Adopting maize hybrids also enhanced a household's per capita expenditure by almost 20% (USD 19). The study found that hybrid maize non-adopters would have achieved similar productivity, profitability and per capita food expenditure if they had adopted the maize hybrids grown in the Midhills of Nepal. During this reporting time, this assessment was drafted in the form of journal article and has been submitted for peer review.

The study also found that small farm holdings of less than 0.3 ha of land were highly productive and that hybrid maize adoption was highly beneficial. However, the welfare impact of hybrid maize adoption was only observed among larger farms (>0.3 ha) and was due to extensive landholdings.

The study also found that constraints to production inputs (such as chemical fertilizers, labor scarcity, rising rural wages and higher costs of hybrid maize cultivation) were associated with low welfare impact among smallholders. It found that even after increasing market access, smallholder hybrid maize adopters were not benefited from gains in welfare outcomes. Finally, the study recommended actions to facilitate multi-layered technological interventions (e.g.

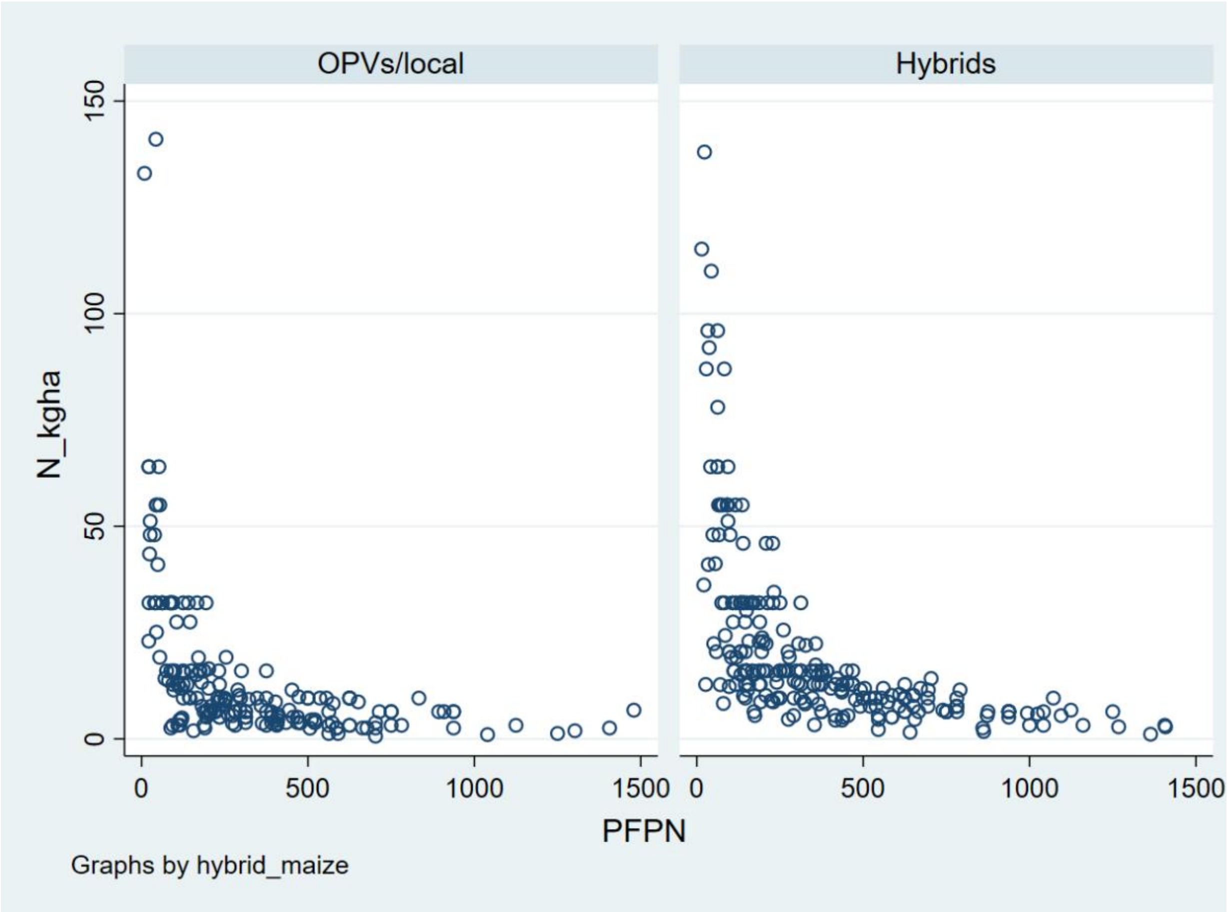


Above: *Hybrid maize adoption results, on average, in a higher gross margin (profits) gains for adopters and non-adopters. ATT is the average treatment effect for treated (adopters); ATU indicates the untreated average treatment effect (non-adopters)*

coupling hybrid maize with proper fertilizer application, mechanization to overcome the labor bottlenecks, and better bet agronomy) among farmers, rather than single, piece-wise promotion of technology (such as only hybrid maize) to enhance the welfare effects of technology adoption among smallholder farmers in the hill ecologies of Nepal.

Coordination with Nepal Seed and Fertilizer project (NSAF) to enhance fertilizer use efficiency in maize in the Midhills of Nepal

During this reporting period, CSISA also analyzed data from maize-based systems to determine the nutrient use efficiency of hybrid and open-pollinated varieties in the Nepal Midhills region. Results revealed the higher nitrogen use efficiency of hybrid maize compared to open-pollinated maize varieties. Data from this region suggest that farmers are quite widely overexploiting the soil by not ensuring sufficient levels of nutrients, the most immediate being nitrogen. This nutrient mining from soil could affect long-term soil productivity and highlights the importance of balanced fertilizer application. Although hybrid maize adopters were found to apply a higher dose of nitrogen than non-adopters and hybrid varieties with higher nutrient use efficiency, the current nitrogen application rate with hybrid maize is lower than the recommended dose.



Above: *The x-axis indicates the nitrogen use efficiency (partial factor productivity of nitrogen, or PFPN) for open-pollinated and hybrid maize varieties, and y-axis is the applied nitrogen by the farmers for OPV, and hybrid maize cultivation in Nepal's Midhills*

This indicates the potentially substantial scope to enhance maize productivity by applying proper rates of inorganic fertilizers when and where they are needed. It should be noted that Nepal is facing several constraints in its importing of inorganic fertilizers and that this is affecting productivity. CSISA is currently working with NSAF to promote better fertilizer recommendations for maize growers in the Midhills and the FtF ZoI districts in Nepal.

B1.3 Rice-fallow development and intensified cropping patterns

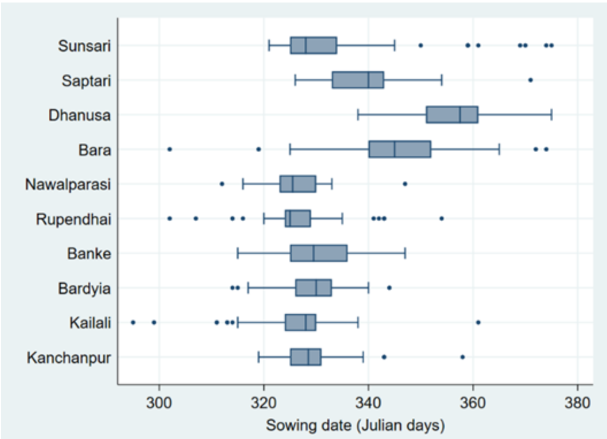
B2. Bringing participatory science and technology evaluations to the landscape and back again

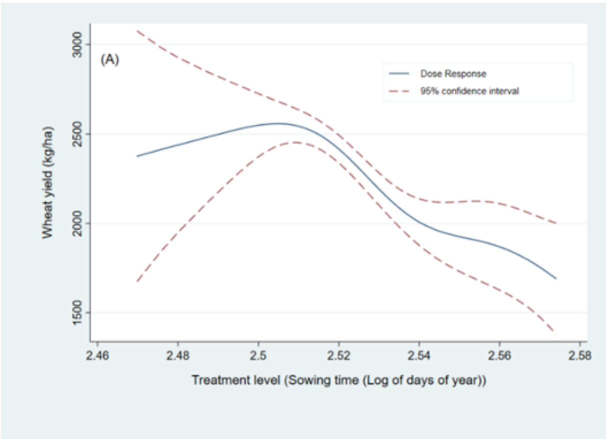
B2.1 Increasing the capacity of the National Agriculture Research and Extension System to conduct participatory science and technology evaluations

In line with the activities and additional support provided to CSISA provided 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 significant change in how 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 analyzing 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, track machinery adoption, agronomic management training, and farmers' adoption of technologies.

Sharing survey findings to NARES and include them in program implementation

CSISA is working with national partners including PMAMP and NARC to generate near real-time data on different crop management practices for rice, wheat, and maize. This data is collected using ODK, and is analyzed immediately after being deposited on the CSISA server. Major findings are delivered to PMAMP to be incorporated in its next programs or before a crop is planted. During this reporting year, wheat data from previous years was analyzed and the major findings shared virtually with PMAMP Wheat Super Zones and Zones in October 2020. The analysis revealed the importance of the sowing date and its impacts on wheat productivity. Farmers in Nepal Terai generally sow their wheat after November due to delays in harvesting the previous rice crop. Delayed sowing of wheat, especially after November, is likely to expose it to terminal stress, which is associated with high heat stress during March when wheat is at the grain-filling and maturity phase stages. The exposure of wheat to high temperatures at the time





Above: *Distribution of wheat sowing dates in Julian days of a year in different districts across Nepal Terai (left) and negative slope of sowing date with wheat yield derived from dose response function model (right).*

of grain filling reduces grain productivity leading to crop senescence. Early sowing of wheat (especially before the last week of November) or the adjustment of the wheat sowing time and adopting a long duration variety is considered the best way to minimize the threat of terminal stress. The distribution of sowing dates across different districts in Nepal Terai, including FtF ZOI districts, is presented in the figure below (left), and the response of sowing date in terms of yield is on the right, as shown in the dose-response function model. The analysis also revealed that each day's delay in wheat sowing after 28 November 28 reduced wheat yields by 20 kg^{-1} day^{-1}.

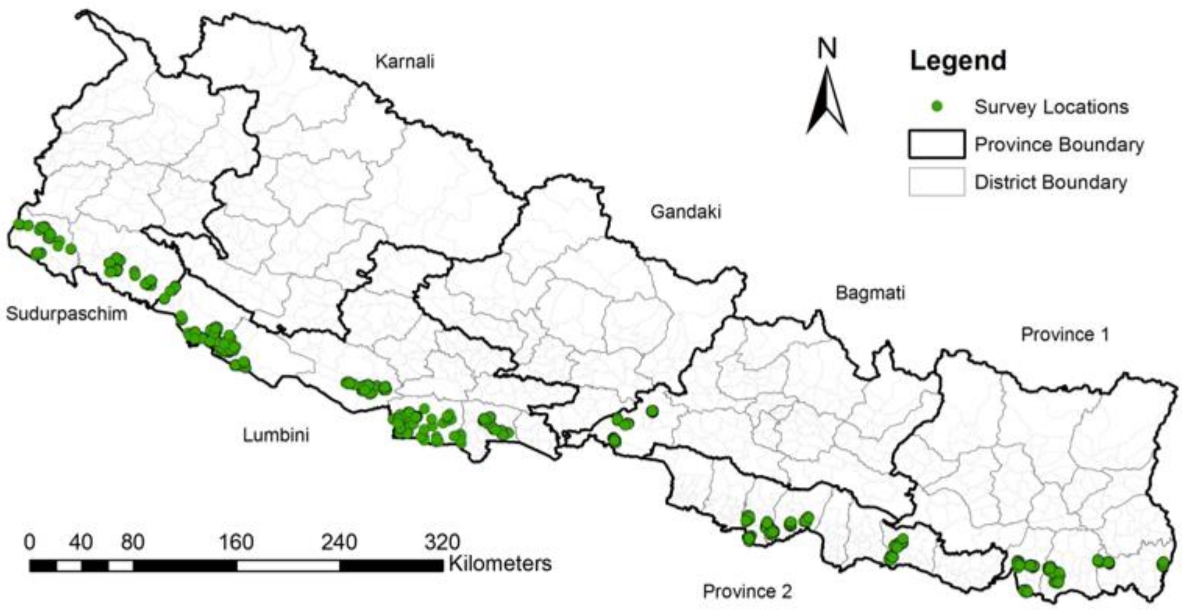
The PMAMP Wheat Super Zones and Zones Chief, who participated in the virtual meeting, understood the importance of early sowing and its potential role in overcoming terminal stress. Following the meeting, PMAMP informed farmers in its coverage areas to sow their wheat before the end of November. To also reach farmers beyond the PMAMP command areas, CSISA facilitated the broadcast of radio jingles promoting the importance of timely sowing, with more than eight being aired before the start of wheat sowing time. Finally, a discussion with policy-makers and breeders at NARC has been planned to develop and encourage increased use short duration but higher yielding rice cultivars. These allow farmers to harvest rice earlier which in turn enables them to sow wheat early and benefit from overall cropping systems.

Capacity building of NARES and PMAMP

During this reporting period, CSISA and NARC supported PMAMP in conducting rice crop cuts and farm management practice surveys in Rice Super Zones and Zones in Nepal's Terai. CSISA provided capacity development training (6–7 January 2021) to PMAMP staff, enabling them to conduct the crop cuts as well as landscape diagnostic surveys, using the ODK digital tool. Independent enumerators were hired to collect data from the areas not covered by PMAMP. Due to mobility restrictions imposed by the COVID, the training was conducted virtually, and only districts from the Nepal Terai were included in the sampling frame. The crop cuts were conducted among 170 plots, while the rice production practices survey was conducted with 2,100 households located in the Terai by telephone. The data generated by PMAMP and NARC have been used to provide farmers with better agronomic management recommendations. NARES data is analyzed every year and the findings incorporated into PMAMP's programs. Advanced level artificial intelligence (such as machine learning algorithms) are used to analyze the data, which is described in the next section.

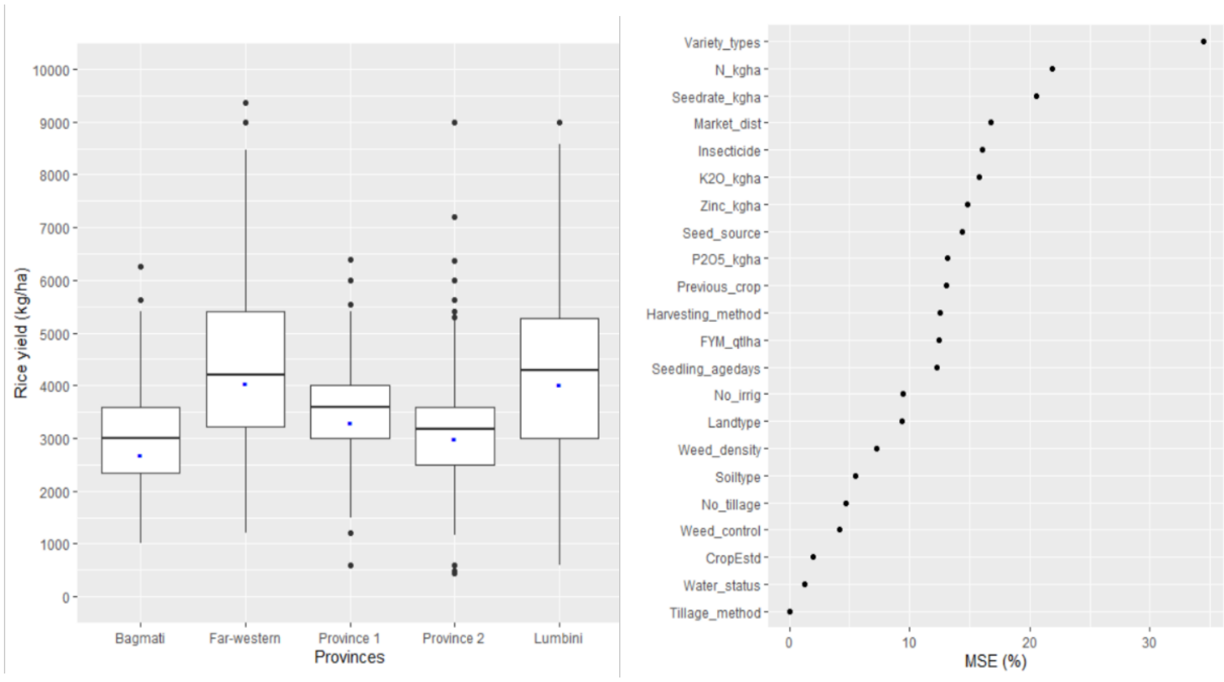
Recent and anticipated crop-cut surveys to identify ways to improve farmers' crop productivity

As mentioned in the previous section, in collaboration with PMAMP and NARC, rice crop cuts and surveys were completed in January 2021. Collected data was analyzed by CSISA staff in consultation with PMAMP and NARC stakeholders in Kathmandu, and findings will be shared with PMAMP before the rice planting season begins in May/June 2021. PMAMP will incorporate this survey in their developmental programs in respective Rice Super Zones and Zones. Here we briefly highlight the initial results of the recent rice crop cuts and production practice survey analyzed using a machine learning approach. The distribution of the samples and selected districts is presented in figure below.



Above: *Districts and sample locations of the recent rice crop cuts and production practice survey completed in 2021 January jointly by PMAMP and CSISA*

The analysis results show that the average rice yield in Terai is around 3.8 tons/ha. This is relatively lower than rice productivity in neighboring Indian states but is similar to that currently estimated by the Nepal government. However, there was a substantial difference in rice productivity across provinces. In the FtF ZoI where CSISA and its partners are working jointly to enhance rice productivity, rice yields appear to be better than other provinces. For example, productivity in the Far-west and Lumbini provinces is around 4.3 tons ha^{-1}, significantly higher than the 3.6 tons ha^{-1} in Province 1, 2.9 tons ha^{-1} in Bagmati province, and 3.2 tons ha^{-1} in Province 2 (see figure, below left). Higher productivity is related to better crop management and farmers' use of improved varieties, which at times include hybrids, and more balanced nutrient management. The machine learning algorithm outputs show that variety and appropriate nitrogen application are the major two productivity factors that drive rice productivity in these systems (see figure below, right). It should be noted that a limited number of farmers in the Terai use hybrid rice varieties; the use of traditional and improved rice varieties remains quite common, indicating opportunities for increased market development for seed companies. Also, the current use rate of fertilizer such as urea, which supplies the nitrogen to the crop, is lower than the recommended dose. These results suggest that PMAMP and other programs should focus on variety and proper fertilizer application to increase rice productivity.



Above: *Province-wise yield distribution (left) and machine learning outputs indicating a major variable of relative importance that drive rice productivity in Nepal's Terai (right).*

The results also show that only 20% of farmers use hybrid rice varieties, the rest using traditional and improved varieties. However, the adoption of the hybrid rice varieties appears to increase productivity by 0.8 tons ha^{-1} compared with other varieties (below figure-left). The current nitrogen application rate in rice is very low: results show that farmers on average used around 80 kg ha^{-1} of nitrogen in rice. However, the machine learning outputs suggest that the nitrogen response is positive until it is applied at 150 kg ha^{-1} (figure below, right). This indicates that farmers can enhance rice productivity by improving current nitrogen application rates. Other crop management factors affecting productivity were seed rate, phosphorus application rates, and irrigation. However, machine learning algorithms predict that these factors have a relatively lower contribution to enhancing rice productivity than the variety and nitrogen levels.

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

In Nepal, IWM activities focus mainly on the rice crop. Much of the rice grown in the FtF ZoI in Nepal is grown in the summertime; for this reason, no major activities too place during the October-April reporting period.

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

Combine harvester training to develop Nepalese operators

During this reporting period, and in a public-private partnership, CSISA co-organized a fifteen-day combine harvester maintenance and operation training with the Ministry of Land Management, Agriculture and Cooperative (MoLMAC), Sudurpashchim province, Agribusiness Promotion Support and Training Center (ABSPTC), RCT Agromachinery and engineering workshop, a private sector trading combine harvester in Kanchanpur.

Above: *Men and women participants training to operate a combine harvester, Kanchanpur, with a resource person from Dashmesh Company India. (Photo: Lokendra Khadka/CSISA)*

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

Nepalese smallholder farmers often use 2WT power tillers to cultivate their fields. Since 2016, the project has provided technical assistance to machinery value chain actors to increase demand for 2WT-mounted seed drills in Dang and the surrounding districts they serve. The Activity is studying their adoption and spreading awareness about other labor-saving machines for carrying out the range of farm operations.

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

During the last five years, Nepal's Ministry of Labor, Employment and Social Security has granted four million labor permits to work abroad, and the increasing trend of labor out-migration has resulted in acute labor shortages. This affected smallholder farming households, resulting in the rural wage rate increasing sharply; crop cultivation costs have also increased. Together, these have affected the farm enterprise's productivity and profitability. In Nepal's Midhills region, maize is a major staple crop whose productivity and profitability have been affected negatively, with many farmers in this region having started to leave their agricultural land fallow because of acute labor shortages and negative returns from maize farming.

Also due to a lack of labor, farmers are unable to manage their crop management practices on time. Delays in crop establishment and other inter-cultural operations have reduced maize productivity in the Midhills, where maize is a staple crop. This has contributed to decreased food supply and increased food insecurity and rural poverty. CSISA has been working to facilitate markets for scale-appropriate farm mechanization to overcome this problem of acute labor shortages in Nepal. Since 2011, the Activity worked to build markets for mini-tillers (small 5-9 horsepower tractors primarily used for agricultural land preparation). The mini-tiller can also be also used for pumping water from canals and rivers and as a power source for threshing and harvesting. Initially, CSISA tested and validated the mini-tiller in the Midhills and worked with the public and private sectors for its promotion. So far, Nepal's farmers have adopted over 30,000 mini-tillers. However, their performance in terms of productivity, profitability, costs of cultivation, food security and rural livelihoods has not been assessed.

During this reporting period, CSISA staff analyzed data collected from Nepal's Midhills on mini-tiller adoption and its impacts on maize-based systems. The analysis investigated the research questions of what drives the adoption of mini-tillers in the mid-hills of Nepal and whether mini-tiller adoption enhanced maize productivity and profitability, food security and reduced the cost of cultivation and rural poverty. This study also linked with the potential contribution of small-scale mechanization to the United Nations Sustainable Development Goals (SDGs) of zero hunger and no-poverty. It used the quasi-experimental approach, including propensity score matching methods, to assess mini-tiller adoption impacts.

The results of this study are presented in the table below and show that mini-tiller adoption reduced land preparation costs, labor cost and total cost of maize production by NPR 6,316 ha^{-1}, NPR 7054 ha^{-1}, and NPR 10,501 ha^{-1} respectively. At the same time, mini-tiller adoption enhanced maize productivity and gross margin (profitability) by 22% (616 kg ha^{-1}) and NPR 22,139 ha^{-1}, respectively. The decrease in land preparation costs and total production cost, together with increased maize productivity and profitability, enhanced households' probability of becoming more food self-sufficient by 24%. Moreover, the increase in productivity, gains in gross margin (profits), and savings from labor costs, land preparation costs and maize cultivation costs, and increased household's food self-sufficiency status, enabled households to reduce the depth and severity of poverty by 9.30% and 5.58%, respectively. These findings support the broader positive impacts of CSISA's investment in small-scale agricultural machinery market development in Nepal. Finally, the study has also suggested expanding rural mechanization to developing countries experiencing similar problems like Nepal.

Table 6: *impacts of mini-tiller adoption on maize productivity, cost of cultivation, profit (gross margin), household food security, and rural poverty.*

Impact indicators	Average treatment effects (ATT)	Standard errors	*t*-stat
Maize yield (kg ha^{-1})	616.30*	354.82	1.74
Land preparation cost (NPR ha^{-1})	-6316.47***	1362.31	-4.64
Total labor cost (NPR ha^{-1})	-7053.84*	3798.07	-1.86
Total variable cost (NPR ha^{-1})	-10500.97*	5606.45	-1.87
Gross margin (NPR ha^{-1})	22139.04***	8630.90	2.57
Food self-sufficiency (%)	24.32***	7.97	3.57
Poverty gap (%)	-9.30**	3.97	-2.34
Square poverty gap (%)	-5.58*	2.95	-1.89

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

CSISA supported the preparation of suitable machinery for promotion in Joint Rice Implementation Program (JRIP) implemented by KISAN and MoALD

Before the start of the *kharif* season rice land preparation time (which generally begins in May/June), the CSISA and KISAN jointly discussed the potential farm machinery for promotion in JRIP-operational areas, eventually identifying 14 machines suitable for promotion in the rice-wheat cropping systems. The CSISA team, which included agricultural engineers and researchers, provided details on costs, payback periods, operational capacity and potential dealers to access these machines in the FtF ZOI. (see List of 14 machineries). This document supported technicians and farmers under the JRIP program in selecting suitable machinery based on area, budget and farmer need, making the farm machinery support programs more effective.

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

CSISA has been organizing regular bi-weekly calls with KISAN II throughout the reporting period and providing regular technical and backstopping support, particularly in agriculture mechanization, irrigation and the other areas realized by KISAN II. This has been in s primarily in support of the Joint Rice Implementation Plan (JRIP). As an example, in one session KISAN II acquired the skills needed to train its staff, as well as PMAMP and AKC staff, in spring rice cultivation. In Nepal, spring rice production and productivity can be higher than summer/rainy season rice; however, there are many constraints, including drought and scarcity of water during nursery raising and heavy rainfall during harvesting.

Above: *Resource person, guests and participants during virtual training/experience-sharing workshop on spring rice production on 25 January 2021 (Photo: Timothy J. Krupnik/CSISA)*

Facilitating international learning and exchange of information, expert M. Murshedul Alam, Ph.D. from CSISA/CSISA facilitated the one-day virtual training/experience-sharing (25 Jan 2021) on spring rice production to KISAN II-JRIP, PMAMP, AKCs, and CIMMYT-CSISA staff. The opening session was attended by the Secretary of MoLMAC-Far-western, Chief of Chief, National Rice Research Program, NARC, Hardinath, Senior Monitoring and Evaluation Officer, PMAMP, PMU, Kathmandu.

They expressed their thanks to CSISA for organizing the fruitful training and contribution to mechanization, weed management, and technical backstopping on rice development in Nepal. Fifty-four participants attended the virtual training/experience workshop, which was focused on methods of healthy seedling raising, seed, fertilizer, weeds, irrigation and water management, harvesting and post-harvesting. Successful experiences from Bangladesh were also shared as part of the session.

Orientation on machinery selection to government officials involved in JRIP

Although most stakeholders involved in JRIP were familiar with farm mechanization, an orientation program organized by KISAN and covering different types of farm machinery and its details was provided to government officials from Sudurpashchim and Lumbini provinces (28 August 28, 2020). The CSISA agricultural engineer provided the orientation, the overall objective of which was to provide the basic idea behind machinery selection for the JRIP support program. COVID-19 meant the program was conducted online. The orientation program discussed various potential farm machinery used in rice production (for land preparation, direct seeding, transplanting, weeding, harvesting and threshing). The presentation details can be accessed by clicking on the following link (Orientation program).

Training in operational models of mechanization service provision in JRIP

On August 28th, 2020, KISAN organized the orientation and training program on "Different Operational Service Provision Models of Farm Mechanization" that could intervene in JRIP operational areas. CSISA's socio-economist staff provided the orientation and training events. This event's overall goal was to familiarize the different models of service provisions of farm mechanization in South Asia and in Nepal in particular. Because of the spread of COVID-19, the program was conducted online. Several government officials from Sudurpashchim province, Lumbini province, Rural municipalities, and other programs participated. In this event, three different types of service provision models were discussed based on the ownership approach. Several questions were raised on the effectiveness of the collective ownership approach, such as custom hiring centers (CHCs) that Nepal's current government has been prioritizing for promoting farm mechanization in Nepal. On the contrary, several participants also asked why some of the individual-owned rice trans-planter successfully provided the services to farmers. CHCs however appear to operate at sub-par efficiency. The presentation details can also be accessed by clicking on the following link (Mechanization service provision models).

Above: *A service provider providing rice transplanting services, Western Nepal. (Photo: Subash Adhikari/CSISA)*

C2. Managing risk by coping with climate extreme

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. Following research that found that high cost of irrigation, combined with smallholder farmers being reluctant to pay for irrigation when rain is likely in the near future, inhibits rice productivity in Nepal's Terai, CSISA has focused on overcoming these constraints.

Partnerships to reduce irrigation prices through technology development

During this reporting period, CSISA continued its efforts to support the development of low-cost irrigation technology, focusing specifically on developing the low-cost drilling rig in coordination with local drillers of Bardiya district. The low-cost mechanical drilling rig is intended to substantially reduce the drudgery and labor required to construct shallow tubewells, which account for a large portion of irrigation borewell construction cost, as manual well-drilling is usually conducted crews of 10 people or more. After initiating this work in 2017 and extensively field testing and improving the equipment, the CSISA team has now conducted several successful borings with different professional well-drillers in Bardiya district. After continued demonstrations, field surveys and development of the technological design, the Activity guided the well drillers in the installation and operation of the equipment and facilitated a co-creative learning experience to generate feedback from the well-drillers and interest of them in further deploying and developing the technology. After several weeks of training and practice under the guidance of CSISA staff, two well-drillers expressed professional interest in acquiring the new technology for deployment in their private business enterprise. CSISA has agreed to organize an official handover of one technology piece to each of them in an effort to kick-start commercial use of this innovation. Further discussion on this will be provided in the 2020-21 Annual Report.

Above: *Improved technologies developed through the Activity's research (Photo: Baburam Tiwari/CSISA)*

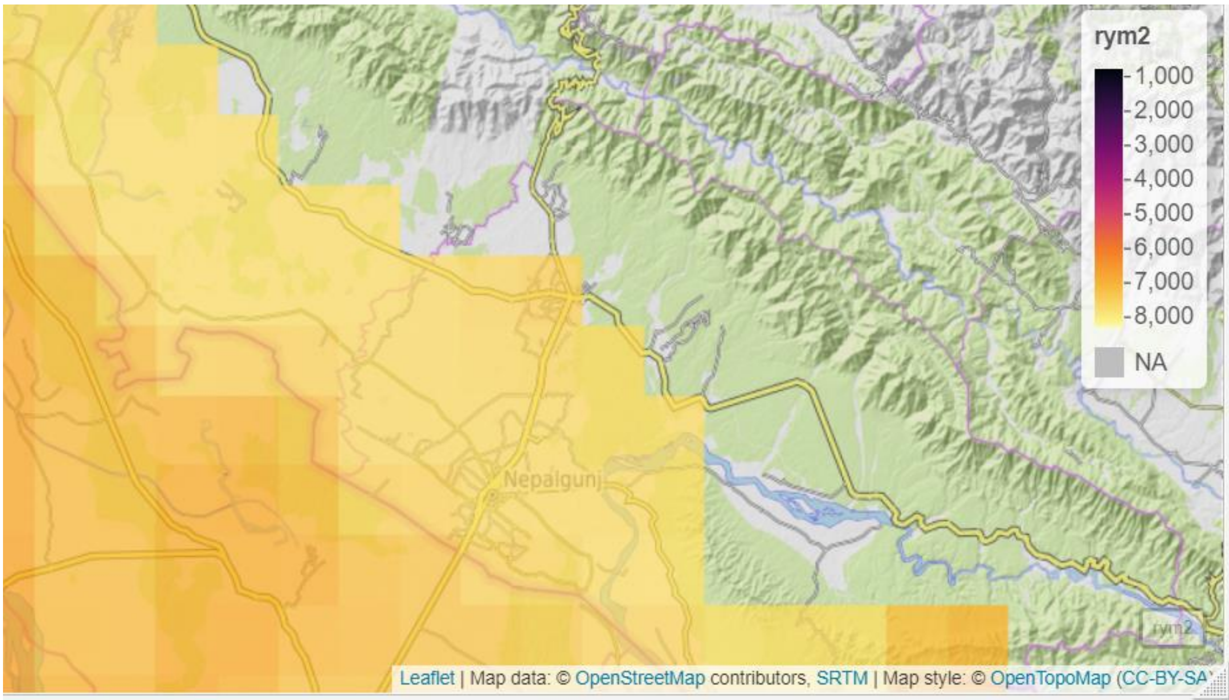
Using pump-testing diagnostics to build public support for a strong private sector

CSISA's previous research efforts have shown that significant improvements in pump technology selection can be made, but that sufficient information about the characteristics of different pumps that exist in the market is often just not available. Where it is, it tends to mislead farmers about potential cost savings and hence more affordable irrigation. To solidify the advances it has made, the Activity is collaborating with small-scale private machinery workshops to establish national testing protocols for machinery technologies, including irrigation pumps. Discussions showed that there is a large interest in rapidly building machinery testing centers' capacity to strengthen their foothold in scale-appropriate technologies, including shallow tubewells and small pumps. Testing centers that CSISA is collaborating have also agreed to further strengthen the partnership through the development of pump-testing and promotion strategies, through which the centers can support local government in selection of adequate irrigation equipment specifically suited to the local environment and uses. In addition, these programs are aimed to build trust with farmers who currently face information asymmetry and often rely on the limited experience of their neighbors, families or even contacts in India for making investment decisions that are often not well-suited to their water system. Through improving information availability to farmers and other investors, CSISA seeks not only to reduce this asymmetry, but also to institutionalize organizational linkages that allow adaptive development planning through bringing back information from the private sector to government agencies, who can then use it to further reduce bottlenecks to achieving sustainable private sector irrigation development and scaling.

Developing a regional crop simulation framework to support spatio-temporally targeted advisories

In Nepal, as within the wider Indo-Gangetic Plains, significant regional climatic gradients, and management practices and constraints, strongly impact farmers' decision-making. Alongside these issues, poor understanding of the interaction between management decisions on the timing of crop planting activities within a host of operational constraints limit the development of spatially targeted crop management advisory systems. To address this bottleneck, CSISA has developed a regional crop simulation framework, based on the parallel system for integrating impact models and sectors (pSIMS) and the APSIM crop model. The model is currently being deployed as part of a study that aims to assess the impact of different planting strategies on yield patterns, resilience and water use, with an initial focus on rice.

Most farmers in the Terai currently wait for the monsoon rains to establish preparations to plant their rice crops. Late planting, however, exposes rice to a low temperature that are detrimental to crop development and has cascading effects when rice is harvested late and wheat is subsequently also planted late. This exposes wheat to high temperatures that reduce yield in the summer. Preliminary results suggest that if farmers have complete information about the start of the monsoon season (enabling them to grow their nurseries on time and prepare inputs and main fields for transplanting with the first significant rains), they can achieve potential rice yields of 8,000 kg ha^{-1} (and more in some cases). At the same time, their potential wheat yields are also increased. In addition, such early planting can increase system stability to shocks: the increased preparedness is of additional value in years with late monsoon onset, as this pushes the system further towards the critical threshold of temperature-related stresses to crop growth. However, such early planting also requires timely access to irrigation and other inputs, highlighting the importance of range of considerations that development agencies should focus on for farmers to achieve the best yields.



Above: *Simulated potential rice yield for Banke district in kg/ha.*

Building linkages between local governments and advances in regional climate forecasts

Monsoon patterns and onset are notoriously hard to predict. Nevertheless, recent advances in earth system sciences and climate dynamics have significantly improved our understanding of the monsoon and skills in forecasting its onset. Several actors, such as the European Centre for Medium-Range Weather Forecasts (ECMWF), are constantly improving operational datasets to support seasonal forecasts, including monsoon forecasts for South Asia. Currently, the International Centre or Integrated Mountain Development (ICIMOD) supports the ongoing development of a regional and country-specific drought outlook and seasonal climate forecasts. CSISA has already informally partnered with ICIMOD in the previous reporting period to inform outreach strategy for advisories related to climatic factors such as timely plantings and irrigation deployment. In the next step, CSISA is collaborating with local Agricultural Knowledge Centers[6] to develop outreach strategies that can be put into place. These partners currently lack the expertise and capacity to interpret the results of model outputs and seasonal forecast systems as they remain relatively technical and require domain knowledge for interpretation. Given the significant value these can provide for local partners, CSISA has organized a meeting with ICIMOD to strengthen further cooperation between ICIMOD's drought outlook and seasonal forecasts and local organizations. At the virtual meeting on 16 March 2021, ICIMOD and CSISA discussed potential collaboration avenues. They agreed to host a capacity-building workshop for local government partners to be trained on ICIMOD's regional forecasts' interpretation and use. Participants agreed that CSISA will facilitate these linkages and contribute agronomic expertise as part of the translation process from model output to specific crop management advisories. Further details on this work will be provided in the 2020-21Annual report.

[6] There are 52 Agricultural Knowledge Centers in Nepal, established by the Ministry of Agriculture Land Management, Agriculture and Cooperative (MoLMAC) to disseminate up-to-date agricultural information to the farmers and implement agriculture program of Provincial Ministries.

3. Policy Reform – Achievements

D1. SEED SYSTEMS

Bangladesh

As described in previous semi-annual and Annual reports, CSISA's activities in Bangladesh around seed system policy reform were phased down due to transitions in the project's leadership within IFPRI and project funding uncertainties, as described in the Executive Summary and 'Challenges Faced During the Reporting Period' sections of previous CSISA reports. Nevertheless, CSISA, continues to maintain 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 from the project of other key personnel with expertise in seed systems, the proposed study with PIM has been put on indefinite hold.

Nepal

Assessing varietal turnover gaps

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. CSISA had planned to engage with the IARI incubation center to understand if a similar public-private model can be replicated in Nepal. This however would require in-person discussions and visits to assess the situation in Nepal as well as facilitate interaction between stakeholders from partner organizations in Nepal and IARI. However, as reported on in previous reports, the Activity has not yet been able to initiate work on this due to the COVID-19 lockdown and travel restrictions in both countries. The Activity is now exploring the possibility of organizing a virtual session with relevant stakeholders, using online communication platforms to discuss the work done by IARI and deliberate upon the potential for replicating a similar model in Nepal. Further information on this work will be provided in the Annual report submitted in of October of 2021, though the second surge of COVID-19 in Nepal is expected to further delay these efforts. Further details on this work will be provided in the 2020-21 Annual Report.

D2. SCALE-APPROPRIATE MECHANIZATION

Bangladesh and Nepal

Due to funding uncertainties, in 2017 the project halted its direct policy work on scale-appropriate mechanization in Nepal and Bangladesh. Staff transitions within CSISA 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.

But with renewed interest and improved funding availability, during this reporting period policy research activities around scale-appropriate mechanization in Bangladesh are now being pursued again. CSISA had planned to undertake a process evaluation around subsidy and credit policies, and programs for agricultural equipment in Bangladesh. However, given the COVID-19 travel restrictions, and the associated ethical concerns and risks of carrying out primary data collection, the planned study may not be feasible in the 2020-21 activity year. Instead, CSISA's researchers are now using secondary data sources such as the Bangladesh Integrated Household Survey (BIHS) datasets for all three rounds (2011–19) to assess the penetration of agricultural machinery in Feed the Future (FtF) and other districts in Bangladesh. The analysis would also seek to understand how machine ownership and the cost of land preparation has evolved over the years. The findings from this analysis will be used to prepare a policy brief and/or journal article. Further details on this work will be provided in the 2020-21 Annual Report.

D3. SOIL FERTILITY MANAGEMENT AND FERTILIZER MARKETS

During October 2020-March 2021 reporting period, CSISA continued policy work around soil fertility management and fertilizer policies in Bangladesh and Nepal from the previous reporting period. Due to COVID-19 restrictions, these efforts were limited to desk-based research using secondary data, as described below.

Bangladesh

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

During the reporting period, the policy research team analyzed previous year's data and information on fertilizer prices and policies in South Asia. There was drastic reduction of non-urea fertilizer prices from 2008 onwards which continued till 2012, following the fall in international fertilizer prices. This 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 more appropriate and 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[7]. However, there had 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.

To facilitate better understanding of whether this price change translated into changes in farmer-level use of fertilizers and if farmers were able to reap the benefits of this massive increase in subsidy, CSISA, in the previous reporting period, had analyzed different data sources covering

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

the period of price change to assess its impact on fertilizer use. This included 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 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. 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.

While there were differing results across the three datasets, the findings corroborate the economic intuition of increase in demand and use as prices fall. According to secondary data sources, urea use in Bangladesh followed the price pattern, as it plummets with the price increase until 2012, though it then increases with the fall in price post-2012 until 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. 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. The decline in MoP prices continued until 2011 before it stabilized. VDSA data conversely shows opposite results compared to the BIHS 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.

In the current reporting period, the findings from this analysis are being used to prepare a policy brief and/or journal article. An interactive stakeholder workshop drawing attention to the need for evidence generation and extension to encourage balanced fertilizer application by farmers in Bangladesh is planned for the later part of the year, depending on the COVID-19 scenario and associated regulations and travel restrictions. As a contingency plan, we are also exploring the possibility of organizing a virtual conference in case organizing the conference in Dhaka as planned earlier is not possible. Further details on this work will be provided in the 2020-21 Annual Report.

Nepal

Re-examining smallholder farmers' willingness to pay for spreader in the rice-wheat cropping systems in Nepal.

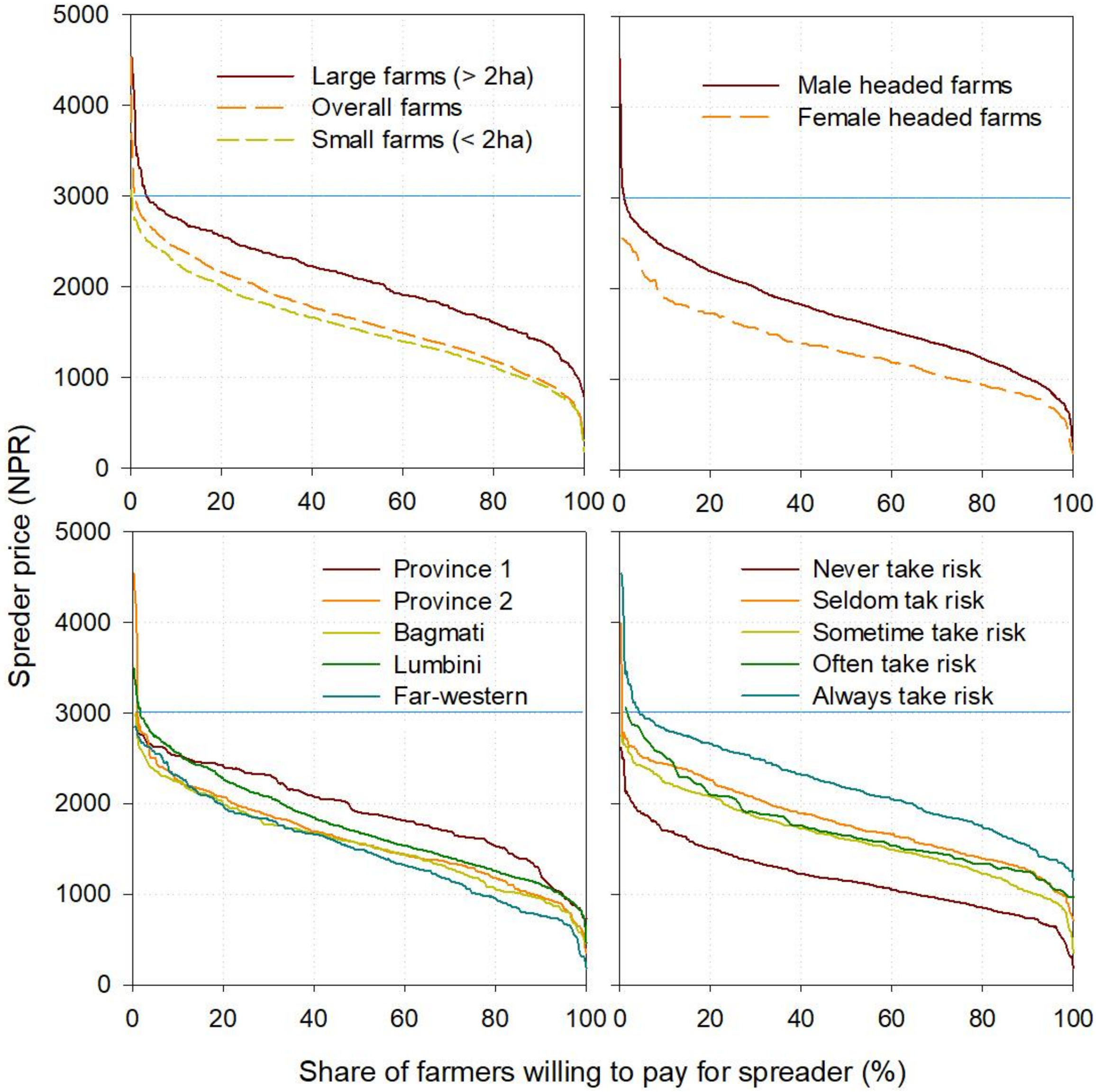
Smallholder farmers in Nepal are constrained by the lack of timely availability of fertilizers and several other agricultural inputs. Farmers generally do not get the required amount of inorganic fertilizers on time, as fertilizer in Nepal is imported, and distributed to the farmers through different cooperatives. Farmers generally consider fertilizer a scarce resource and apply it efficiently. However, the traditional method of fertilizer application by hand-broadcasting (especially for urea and DAP) is widespread.

Above: *A farmer spreading fertilizer (urea) using a hand-operated small-scale spreader (Photo: Subash Adhikari/CSISA).*

With broadcasting by hand, over- and under-application of the recommended dose of fertilizer is likely to take place. While over-application creates environmental problems and waste of resources, under-application leads to soil nutrient mining. To overcome such inefficient methods of fertilizer application, CSISA introduced a gender-friendly spreader (see photo, left). The spreader is hand-operated, and using it distributes the fertilizer and seed uniformly across the plot. This reduces the patchy crop standing and minimizes within-field yield variability. CSISA introduced this cost-efficient technology in FTF ZOI in 2014. Initially, however, farmers found the cost (USD 80) prohibitive. CSISA worked with multiple partners, including NAMEA (Nepal Agricultural Mechanization Entrepreneurs Association) and a manufacturer in China, and introduced a more cost-effective spreader, at around USD 25. However, many farmers are unaware of this technology. To identify the potential demand for this affordable and gender-friendly spreader, in early 2020 CSISA conducted a study on Terai farmers' willingness to pay for the spreader and the data was analyzed during this reporting period.

The study uses an auction followed by contingent valuation methods to identify the potential demand for the spreader in Nepal Terai. The study uses existing market price of $25 (~NPR 3000) as an initial market price for bidding. A total of 1,569 famers were considered in the sampling frame for the study. Several demand curves across farmers size, gender, geographic locations, and farmers risk bearing categories are generated. The results show that at the existing market price only 2% of the farmers showed their willingness to pay for the spreaders at the initial auction. However, during the follow-up bids, we observed the heterogeneity in demand for the spreaders. Large farms owing land holdings >2 ha of land area have the higher demand than the small farms (who cultivate on <2 ha of land). This indicate that despite being small and cheap technology, only large farms were willing to pay the current market price for this technology. On average, the large farms were willing to pay 33% lower than the average market price, while small farmers were willing to pay 50% lower than the market price. These results suggest that farmers may require a support mechanism to initially

adopt this technology. A similar result across household's gender cohorts was observed, where male headed households were willing to pay higher than the female headed households, although for both categories average willingness to pay was lower than existing market price. Moreover, a spatial difference in demand for this spreader was also detected; farmers in the province 1 were willing to pay higher than the farmers in the Far-western provinces. Finally, risk bearing farmers were willing to pay higher price for the reaper than the risk averse farmers. These demand curves highlight the potential role of public and private sectors to identify potential entry points to target the technology and develop the markets, however, as willingness to pay is at this point low and will likely require policy intervention and smart subsidies to further kick-start the market and spur adoption.



Above: *Demand curves for the spreaders in the rice-wheat cropping systems in Nepal Terai. The blue line shows the average market price of the spreader.*

Manual hand crank fertilizer spreaders as an alternative to broadcasting: What service markets exist?

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 spreaders introducing farmers to it using a mix of extension and financial incentives.

A social-experiment study conducted by CSISA with 300 farmers in Province 7 of Nepal in the summer of 2019 addressed both these components. The data indicated the average uptake of spreader service was low, at 18%. It is important to note however that CSISA has not typically concentrated on spreader services, but has rather encouraged use of the spreaders by farmers in their own fields. This study was conversely conducted to investigate the potential possibility of encouraging a service provision economy for spreaders, though our results indicate that such services are unlikely to be viable in comparison to farmers' own use in their own fields.

The findings however did highlight some important topics that need to be addressed in development initiatives. It was found that fertilizer usage is lower among women agricultural decision-makers than their male counterparts by around 24 kg hectare^{-1}, on average, in the survey population. Agricultural cooperative membership was the major determinant of fertilizer access and appears to increase use of fertilizers by 36 kg ha^{-1}. The research team is now finalizing a CSISA research note based on the findings from this study and will share this with the immediate peer group soon for their feedback.

D4. AGRICULTURAL RISK MANAGEMENT

Nepal

Examining risks and extension options for Fall Armyworm mitigation in Nepal

In response to the threat posed by Fall Armyworm (FAW) in Nepal, in the previous reporting period (April 2020 to September 2020), CSISA carried out an experiment in Dang district, Province 5 in Nepal to explore the effectiveness of phone-based 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 IPM approaches appropriate for FAW. This is a new workstream in the CSISA project, added due to the emergent threat posed by FAW.

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

The objective of this workstream was to measure the effectiveness of the differing information mediums in improving farmers' knowledge of FAW and related IPM messages. The experiment was carried out in two treatment arms and 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 auto-recorded voice call, along with the same four weekly SMS reminders. All the experimental arms were administered using a knowledge test, comprising 10 questions on FAW identification, scouting and mitigation, at both baseline and endline, 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 where over 5,000 maize farmers were surveyed. As 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 endline survey covered 2,304 farmers; 70% of these respondents were female agriculture decision-makers.

For the voice call system and SMS delivery, CSISA partnered with Viamo, Inc.. The phone call intervention was conducted with the help of trained enumerators from the Institute for Integrated Development Studies (IIDS), which also undertook data collection for both 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.

The baseline and endline surveys were conducted over telephone using SurveyCTO supported computer-assisted telephone interviewing (CATI) features. Baseline data was collected between May–June 2020. The experimental intervention treatments were rolled out in tandem with the baseline data collection, from June–July 2020. The endline data collection was from the last week of August to the second week of September, 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.

The experience of operationalizing an experiment remotely over phone and conducting phone-based surveys, especially with a relatively large group of women respondents, have helped in gaining meaningful and critical insights. The learnings from this experience have been shared on various platforms so far while some more are in the pipeline for the coming months. These have been covered as part of IFPRI South Asia Region's COVID-19 blog series[8], SurveyCTO blog on conducting phone surveys[9], and other IFPRI events[10]. The work was also presented as part of the Women and Gender in Development Conference 2021 organized by Virginia Tech[11], the online training programme organized by ICAR-IARI (March 2021) on "Analytical techniques for impact assessment of agricultural technologies & policies" and the online training workshop on

[8] https://www.ifpri.org/publication/just-call-away-learnings-phone-surveys-india-and-nepal

[9] https://www.surveycto.com/case-studies/ifpri-covid19-phone-surveys/

[10] Gupta, Shweta and Alvi, Muzna. Hello, can you hear me? Impact of speaker phones on responses in phone surveys during COVID-19. Working Paper. Presented at IFPRI RISE.

[11] Poster presentation on "Not just a call away: Reaching women through phone surveys in India and Nepal" http://view.ceros.com/ifpri/a-phone-call-away-web/p/1

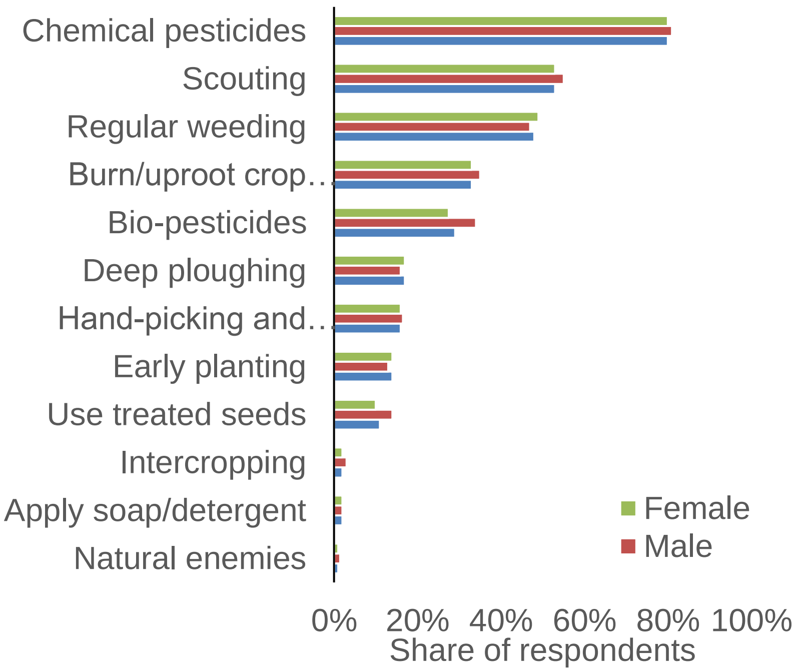
"Advances in tools and techniques for policy research" organized by AERA and IFPRI (December 2020).

One of the major methodological findings from conducting phone surveys was the widespread use of speakerphone by female respondents. We found that this use of speakerphone not only violated respondent privacy and precluded the inclusion of sensitive questions in the survey, but also affected responses to other seemingly innocuous questions on intra-household decision-making. The behavior of putting the phone on speaker can also be partially explained in terms of the participant's trust in the enumerator, as we find speakerphone use to be lower when women are matched with the same enumerators in the second round. Our findings have important implications for the design and analysis of phone survey data. Our early insights on this have been very impactful, and several other organizations including Michigan State University and World Bank included questions on speakerphone use in their own COVID-19 survey modules.

Preliminary results from the FAW experiment

More than 80% of respondents in the baseline survey had heard of FAW and around 33% had heard FAW awareness messages that had been broadcast on the radio. Nearly 15% of respondents reported that they experienced FAW infestation of their maize during *kharif* 2019, while a higher proportion (39%) reported any kind of pest infestation in maize during that period. The primary sources of information for farmers to manage pest infestation include agrovets (53%), other farmers (45%), own knowledge (36%) and mass media (25%).

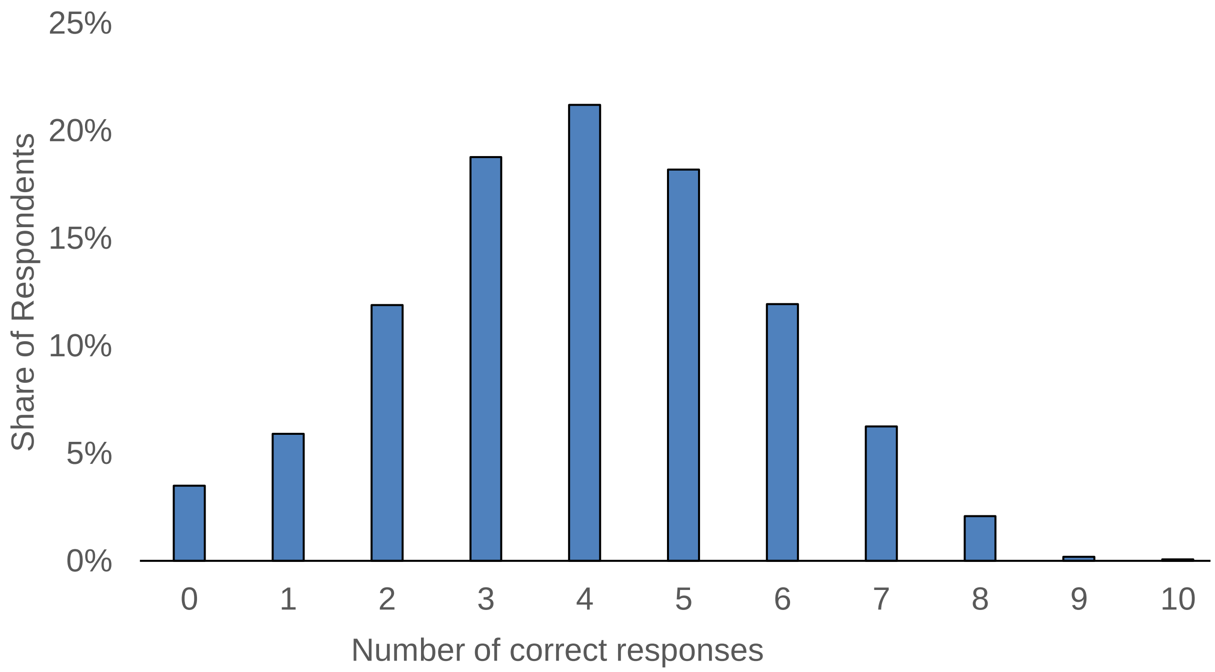
Among those who had suffered any kind of pest infestation in maize earlier, only 16% stated that they had recorded the level of pest infestation in their crop before deciding upon the type of control measure that needs to be implemented. However, around 53% of respondents could remember scouting as one of the practices that should be used to protect maize plants from any kind of pest infestation, although their use of this technique was low. Applying chemical pesticides (80%) was the most commonly reported control measure. Considering percentages, more men than women recalled the use of treated seed and biopesticides or neem-based pesticides as recommended practices to protect against pest infestation in maize. This indicates a major need for



Above: *methods/practices to protect maize plants from pest infestation* extension services to better inform farmers how to scout and the importance of observational information to make appropriate spray or no spray decisions.

Of the 10 questions in the knowledge test on FAW identification, scouting and mitigation, only about 21% respondents could answer more than 5 questions correctly. The mean score for respondents in the control group was 3.95; it was 4.07 and 4.05 in treatment groups 1 and 2, respectively. The mean test scores across all groups increased by the endline; however, we are yet to analyze the differential impact of the interventions.

In addition to providing key information on FAW and its management, the endline results from the experiment are being analyzed to determine the effectiveness of phone-based extension interventions. The results from this experiment will be disseminated among all relevant stakeholders in the form of discussion paper, research note, and journal article. CSISA will also engage in conversations with regional stakeholders to facilitate cross-country dialogue on effective extension approaches for promoting knowledge and adoption of IPM solutions. The findings will help in communicating to the policy makers the impact and feasibility of deploying ICT tools to aid agriculture extension systems in the country, particularly in times of crisis. As social 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. 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.



Above: *Distribution of correct responses on FAW knowledge test during baseline survey.*

Impact of COVID-19 among maize farmers in Nepal

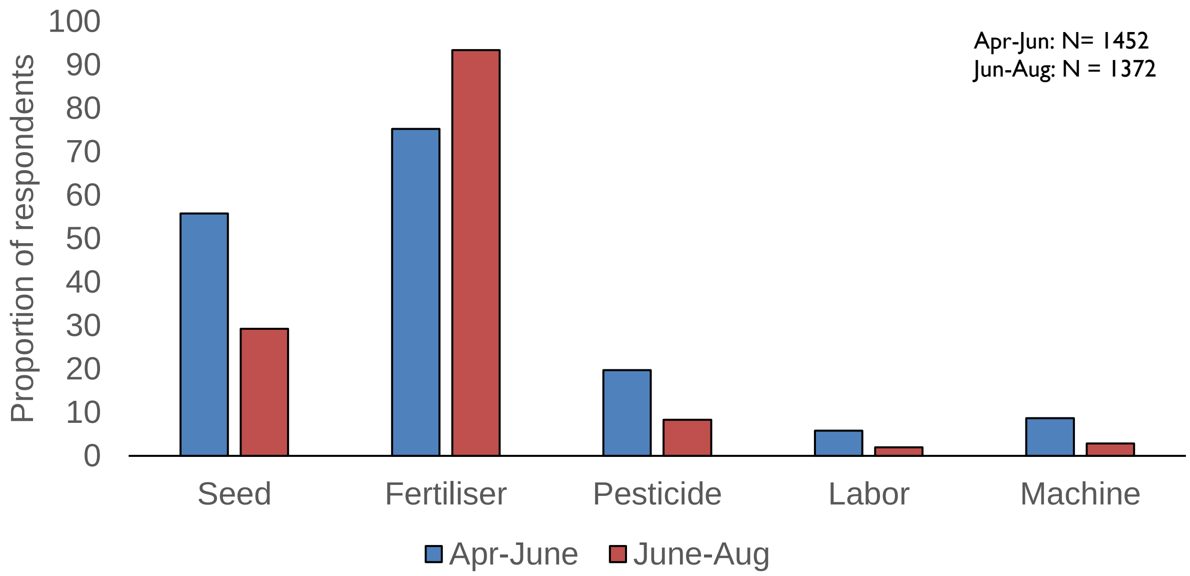
Implication of COVID-19 lockdown on agriculture extension. Agrovets (agricultural input retailers) emerged as the most relied-upon source of information for over 53% of respondents before the lockdown, followed by the use of social networks or other farmers, and their own knowledge/past experience. After the lockdown and social distancing norms, we observe a decline in the number of respondents relying on agrovets and an increase in reliance on social networks. There was also an increase in the proportion of respondents obtaining mass media (radio, newspaper, television, IVR, internet) post the lockdown. Female respondents reported higher reliance on other farmers while more male farmers reported agrovets and governmental agencies as sources of information after the lockdown.

The change in the information sources and availability of timely and quality extension services had a bearing on farming activities as well. Around 29% of our respondents reported that the overall quality of agriculture information had worsened post the lockdown. Conversely, 35% respondents stated that their farm suffered due to their inability to access timely information.

Impact of COVID-19 lockdown on access to agriculture markets and farming inputs.

The baseline survey captured the market conditions faced immediately after the lockdown (coinciding with the wheat harvest), and the endline survey covered the market conditions for crops (primarily maize) which were harvested in and around August 2020. Many farmers in our sample practice farming for self-consumption and basic food security. Of the farmers who had harvested crops before the baseline survey, only 55% reported selling their produce in the market. Of these, 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. During the second round of data collection, fewer farmers reported selling crops as they were still in the process of harvesting maize when the endline survey was conducted. Of the farmers who sold summer maize, 67% reported obtaining lower prices than the previous year and 15% reported facing difficulties in selling the crops. Farmers reported persisting issues of lower prices, lack of transport, and movement restrictions as lockdown was being reimplemented across the country around that time.

Farmers' curtailed access to markets did not only affect the sales of farm produce but it also bore consequences for further sowing plans and the livestock sector. For the crops sown after lockdown commenced (April–June 2020), 54% of 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 and mobility restrictions. Around 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%). Around 29% farmers continued to face issues with seed procurement, citing lack of variety and higher prices as major difficulties.

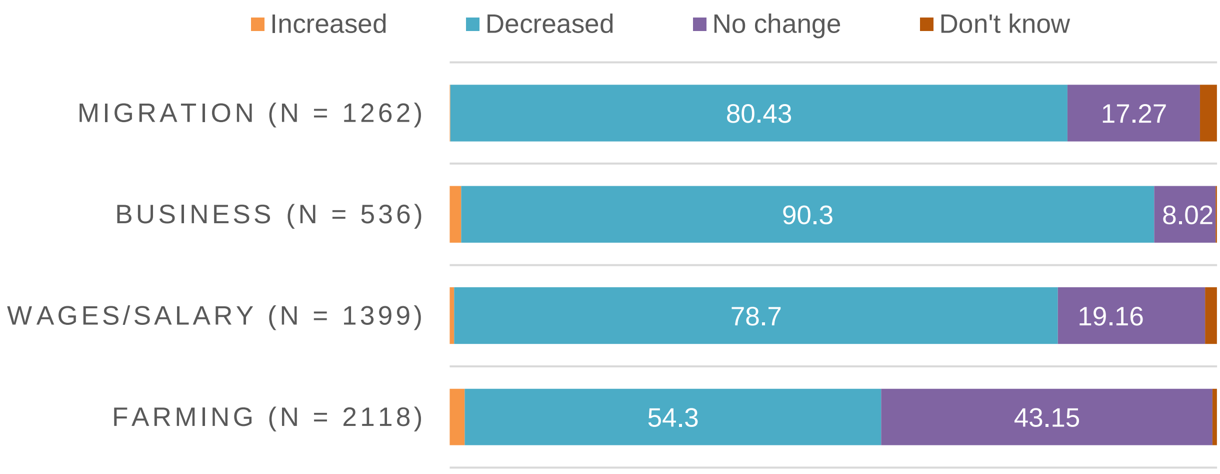


Above: *proportion of respondents who faced difficulties in input access for crops post lockdown (April–June 2020) and summer crops (June–August 2020)*

Economic impact and coping strategies adopted by farmer households following the COVID-19 lockdown.

Farmers covered in the study have diversified income portfolios to cope with the economic stresses associated with the COVID-19 crisis. Over 78% of 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. Around 46% respondents indicated remittances as a source of income for their households. Respondents reported a clear fall in income from remittances, wages/salary and business following the COVID-19 lockdown in Nepal. Over 80% of respondents indicated that remittance income had declined (17% reported no change). Immediately after the lockdown began, there was a halt on the movement of migrants outside the country and many were unable to make their way back to Nepal. Over 90% of respondents who depended on business for income generation, indicated having had a decrease in income. Among all activities, farming income was reported to be the least affected by the highest proportion of farmers.

Respondents were also asked about their monthly household incomes during the two survey rounds. While 26% respondents reported no income from mid-April 2020 to mid-May 2020, 30% respondents reported no income from mid-July 2020 to mid-August 2020. The impact of the COVID-19 lockdown is still being felt as 9% respondent farmers had no monetary income for both periods.



Above: *impact of COVID-19 lockdown by income source*

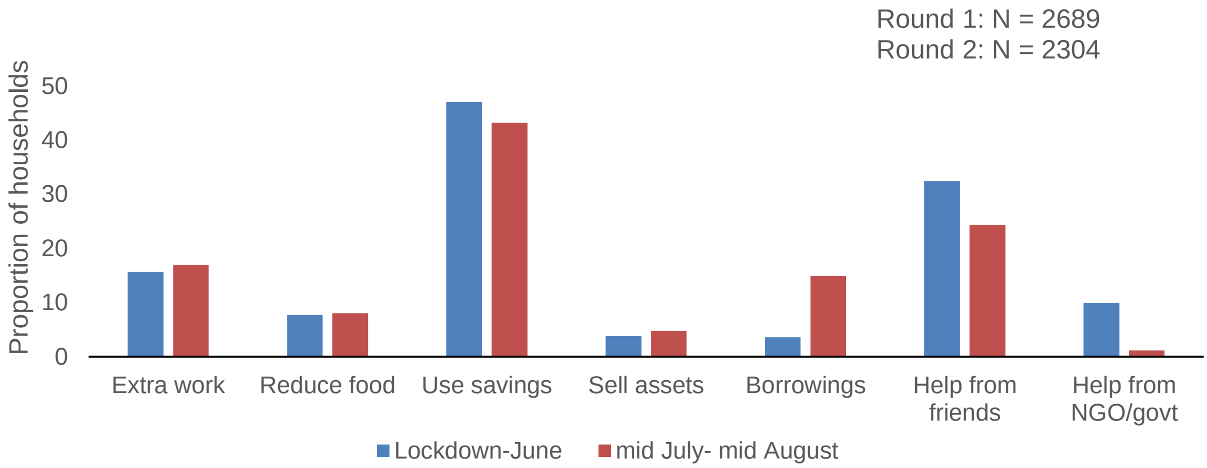
After lockdowns were lifted, over 70% of respondent households had to use at least one coping measure to deal with the economic impact. The most common coping strategies were to use their savings, seeking help from friends, relatives and neighbors, and using less expensive food items. Around 47% respondents reported using their savings in the first round which reduced marginally to 43% in the second round. Farmers also sought help from NGOs and the government, and friends and relatives. In the first round of data collection, respondents' food consumption choices were also affected as 25.5% reported using less expensive food items. The time period coincided with agriculture harvest which may have helped households avoid immediate food insecurity. However, even in the second round, 32% of respondents reported having reduced expenditure on food items. This shows the prolonged effect of the lockdown on food security of these households.

These findings highlight the need for policy action to ensure food and income security, especially among marginalized farmers. Lack of access to markets and reduction in both farm income and remittances is likely to reduce investments in agriculture inputs, further trapping farmers in a cycle of low output and productivity. The impacts are exacerbated by the mass reverse migration and loss of remittance income, which is the single most important source of income for the country.

These findings on the impact of COVID-19 on maize farmers in Nepal was presented at the "6th International Conference on South Asian Economic Development" organized by the South Asian University, New Delhi in February 2021. The impact of the pandemic on women's access to agriculture extension was published in the "Agricultural Systems" journal in 2021[12]. A blog on the impact of COVID-19 among women farmers in Nepal was published in July 2020[13]. These

[12] https://www.sciencedirect.com/science/article/pii/S0308521X20308969?via%3Dihub.
[13] https://www.agrilinks.org/post/covid-19-challenges-equity-insights-rural-nepal-and-senegal.

findings are also being used to prepare a journal article. Further details on this work will be provided in the 2020-21 Annual Report.



Above: *coping strategies used by households to deal with income loss during lockdowns in Nepal in the 2020 first wave of COVID-19.*

4. CSISA Nepal Impact Study

Overview

In order to understand and measure changes in farmer livelihoods due to technological interventions introduced by CSISA in Nepal, in early 2020 the Activity initiated an empirical impact evaluation. The objectives of this 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. This report presents research results addressing how inclusive these technologies are and whether there is a need for additional social targeting in extension and scaling efforts. The impact assessment methodology that CSISA is using has been developed and iteratively revised, and improved in a process that included a detailed review of literature, field visits, detailed discussions with Activity personnel, and examination of available datasets and reports.

Methodological background

By the end of 2020, the team of CSISA evaluating scientists (who were not involved in the implementation of CSISA's other research or development activities) had completed the village census and estimated technology diffusion rates. However, due to COVID-19 and related travel restrictions and risks, the household survey has been postponed until 2021. In 2020, a complete list of CSISA interventions and intervention areas was first generated through discussion with project personnel. To estimate the reach of these technologies, a rural household census was 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

The Activity conducted the household census in each of the 50 wards within a period of two months (February–March 2020), and collected the basic farmer information alongside technology adoption details. The questionnaire coding was carried out by the survey agency, using CAPI software (Surveybe). The questionnaire was revised and finalized based on suggestions from CSISA researchers. The enumerator training was held in the first week of February in Kathmandu, Nepal. The census questionnaire was discussed in detail, and the investigators requested to clarify the terms used and functions of various farm machinery. CSISA's scientists gave a comprehensive presentation on the questionnaire and used visuals to explain the technical details of various technologies. Discussions were carried out regarding the procedure to edit, save, re-edit the data, collect GPS coordinates, and 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. Consent was recorded on the tablet through a YES/NO answer. The major findings of the census data are presented in the last CSISA report (April-October 2020).

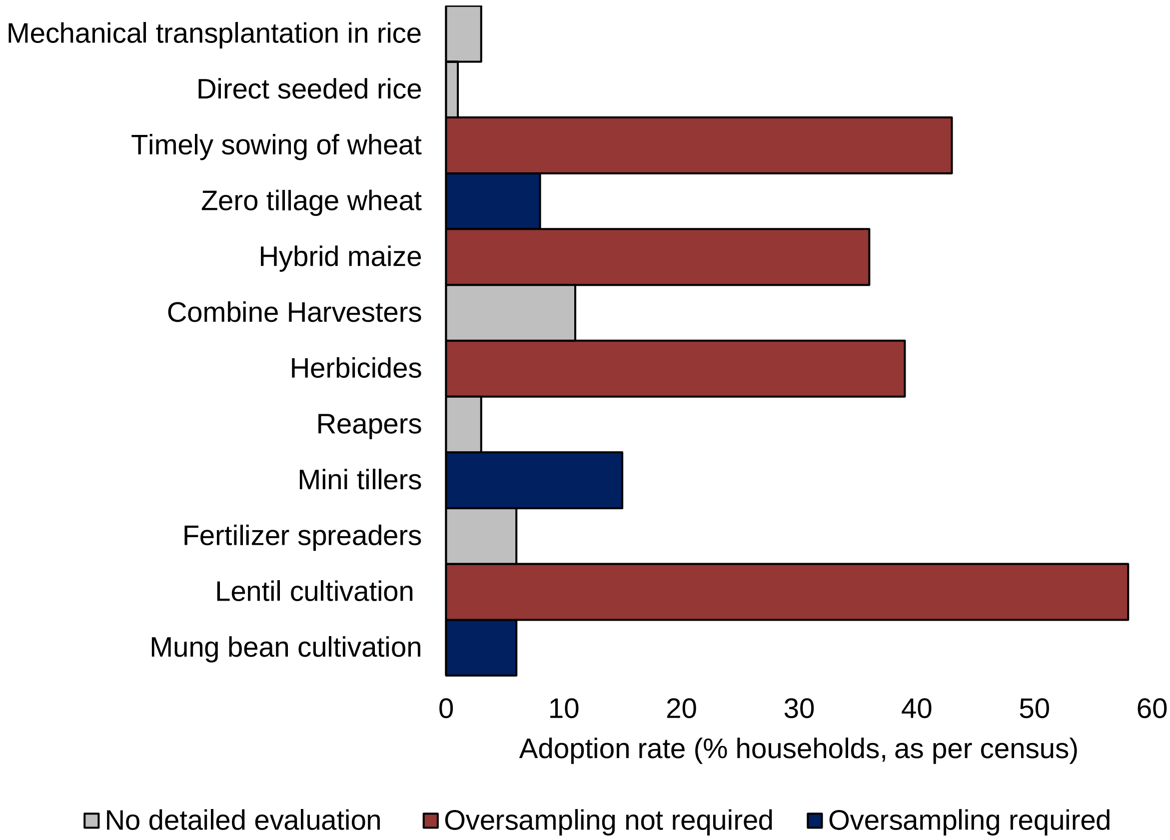
Household survey preparation

Between October 2020 and March 2021, the evaluation team was involved in three main activities: (1) identification of the technologies to be evaluated and review of the relevant literature, (2) development of a household survey questionnaire, and (3) the selection of a survey firm and field assistant (consultant) to carry out the activities. The details are given below.

Technology identification for impact evaluation. According to the census, a large share of households in the study area adopt several technologies. For them, no oversampling is required to obtain a sufficient number of adopters in the household survey for impact evaluation. These technologies are (a) lentil cultivation, (b) chemical herbicides, (c) hybrid maize, and (d) timely sowing of wheat. However, for some other promising technologies, the diffusion rate is low at the time of the survey, requiring oversampling to obtain a sufficient number of adopters for impact assessment. These technologies are (a) mung bean cultivation, (b) mini tillers, and (c) zero tillage in wheat.

Development of questionnaire. During the last six months, the Activity developed a questionnaire for the household survey (to interview both male and female household heads) with the following sections: (a) general household and farm information, (b) technology awareness and adoption, (c) information on randomly-selected plot and input application, (d) technology evaluation, (e) women's empowerment in agriculture index (WEAI) details, (f) household assets, and amenities, and (g) dietary diversity, food security and food consumption. The questionnaire will be tested and revised during the next six months before implementing in the field. The sampling frame will be developed simultaneously. About 50% of the households will be randomly selected, 20% from random women-headed households, and 10% each from adopters of the three technologies that require oversampling (mung bean cultivation, mini tillers, and zero tillage wheat).

Selection of survey firms. During the last six months, the Activity carried out discussions with several survey firms based on the Terms of Reference (ToR) prepared according to the household survey activities, and elicited quotations from three firms to conduct household surveys in Nepal Terai. From the three we selected the firm L-1 and conducted detailed discussions about the scope of work. At the time of writing, a consultancy contract is being developed, although surveys may have to be suspended due to the second wave of COVID-19 in Nepal.



Above: *Technology adoption rate and need for oversampling for impact evaluation.*

Note: “No detailed evaluation” pertains only to the current impact study and not for CSISA Nepal as a whole.

5. CSISA COVID-19 Resilience in Nepal

The CSISA-COVID-19 response Activity is an 18-month (July 2020–December 2021) buy-in from the USAID/Nepal Mission. Its aim is 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.

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

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

1.1 Gather information and generate data on evidence of labor availability and cost dynamics, and challenges that farmers face in the COVID-19 crisis and post-crisis period

Objective I Work Package I targets districts that experienced negative economic impacts as a result of the onset of the pandemic in the FtF Zone. During the reporting period, and in order to generate data that can be used for adaptive management and improved targeting, CSISA began conducting telephone panel surveys (on a monthly basis) of farmers to understand the effect of the COVID-19 crisis on labor costs for key agricultural activities including those that can be partially or fully mechanized (inclusive of land preparation, crop establishment, irrigation, harvest and post-harvest services). Data collected also include comparison to pre-COVID 2019 labor costs for the same activities, in order to approximate the impact of the pandemic on rural labor costs and associate them with opportunities for machinery services providers to more effectively decide on charge costs for farmer-clients hiring services. Data are also regularly being collected from 105 machinery service providers in the FtF zone to monitor typical charge costs. Full analysis and interpretation of these data will be provided in the 2020-21 Annual Report.

1.2 Turn problems into solutions by identifying return migrants poised to become rural entrepreneurs

The objective of Work Package I Activity II is to identify at least 100 return migrants who can be supported to become service providers. Crucially, at least 35% of these individuals will be younger than 29 years of age. Returned migrants were identified as a key group in need, as Nepal experienced large-scale mass re-migration from India as workers who had been employed in India were forced to return to Nepal when the pandemic began.

The activity began this work by collecting data on returnee migrants. This was accomplished through two mechanisms (a) broadcasting of radio jingles encouraging returnee migrants to come forward and contact CSISA if they were interested in participating in programs aimed at becoming a machinery service provider, and (b) through snowball telephone sampling in which CSISA researchers called farmers and requested information on known returnee migrants. This yielded a list of more than 450 potential returnee migrants who could participate in Activity 1.2. These migrants were further screened for their business acumen and knowledge of service provision entrepreneurship opportunities using a simple psychometric test that was administered following initial orientation meetings with a sub-set of approximately 200 returnee migrants.

This filtering yielded a list of high-potential returnee migrants that demonstrated the drive and sufficient business knowledge to engage in rural entrepreneurial services provision as an agricultural machinery owner. In addition to these candidates, the Activity identified potential other return migrants on an opportunistic basis in Dang, Kanchanpur, Banke and Kailai districts. The activity then engaged these return migrants in additional trainings and worked with them to select agricultural equipment for which they could apply for loans from banks, or through enrollment in the Government of Nepal subsidy scheme supporting machinery dealers to offer equipment at reduced incentive prices. Importantly, each of the trainings included information on how to maintain COVID-19 safety as part of machinery services provision businesses.

Many banks, however, were initially reluctant to loan to returnee migrants. This is because they were perceived as (a) higher-risk clients that could flea in the event of loan default, (b) lack of adequate collateral for loans, and (c) because banks rarely lend for agricultural machinery, and when they do, they tend to implement a policy in which loanees must have a verified residence within a 3 km diameter area of the bank branch extending the loan. The latter is another risk and transactions cost reducing measure on the part of banks, so they do not have to expend considerable time, money, and effort locating defaulting clients. Finally, (d) many banks indicated that machinery can breakdown easily, and when not repaired, loanees may not be able to generate business to repay their debts. These criteria, however, are clearly constraints to engaging returnee migrants as service providers.

In order to tackle this challenge, CSISA worked during the reporting period closely first with Muktinath Bikas Bank Ltd. (MNBBL), and then later with Nabil Bank, MegaBank, and Century Commercial Bank, to develop risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery. In order to reach agreements, high-profile coordination meetings were held following COVID-19 safety guidelines. A key example was the meeting with CSISA and the MNBBL field office team was conducted on 22 March, 2021 at Nepalgunj, Banke with the objective of strengthening coordination among the MNBBL and CSISA teams and speeding up loan disbursement to migrant workers. A total of 19 participants from 12 branches in all five districts participated in this program, which was very successful in clarifying the agricultural machinery service provision business model and key machinery types and its attachments that project is popularizing.

Through such meetings, agreements were reached with MNBBL for (a) CSISA providing returnee migrants applying for loans with repair kits and training in how to maintain and trouble-shoot machinery malfunction, (b) and through the provision of a loan security fund in which CSISA provided funds to buy-down the initial interest rates for loans associated with machinery purchase, and (c) by assuring returnee migrants were sufficiently trained in business skills and linked to farmer clients wishing to purchase machinery services. Transactions with farmer clients were also (d) informed by business models that were developed by the Activity and provided to returnee migrants during the loan application process, in order to generate maximum amounts of revenue from farmer clients and to optimize seasonal opportunities for services provision following loan securement.

To increase linkage and coordination with financial institutions offering access to appropriate finance for machinery loans, the Activity is also in the process of courting partnerships with Mega Bank Ltd and Shine Resunga Development Bank, as a result of which the process of signing an

MoU has been initiated with Mega Bank to allow its 'Kisan Credit Card' to be utilized as a means of lending for the purchase of farm machinery.

While it took time to navigate these challenges and come to agreements with these banks, the process is beginning to yield impact, and is anticipated to be a more sustainable model of assuring meso-level finance to bank clients who are considered to be part of risker lending portfolios from the standpoint of banks in Nepal, particularly return migrants, At the time of writing, 32 returned migrants had purchased machinery and entered into rural entrepreneurial business service farmers as a result of CSISA's interventions. Of these, 23 were from Banke, 8 in Dang, and 1 in Kailali. The range of machinery purchase ranged from irrigation pumps (nearly half the returnee migrants purchasing machinery), mini-tillers, power-tilers with attachable trailers or reapers, four wheel tractors, self-propelled reapers, and wheat threshers and combined rice mills. Further details on these and additional returnee migrants who have become machinery service providers as a result of these efforts will be provided in the 2020-21 Annual Report.

1.3 Link potential service providers to machinery dealers and financial services

During the reporting period, return migrants identified in Activity II who received loans were linked to nearby machinery dealers by leveraging CSISA's established databases of business involved in agricultural machinery trade and supply in the Terai. The Activity offered technical and business coaching on which types of machinery have the largest potential service provision 'watersheds' in target areas while emphasizing affordability and durability of equipment. An English version of key machineries identified that fit well into rice-what and rice-maize cropping systems, which are among the most common crop rotations practiced in the Terai, that the Activity worked to popularize among banks and returnee migrants is provided in Annex 3.

In addition, CSISA also worked with established machinery dealers to develop a 'service provider and sub-dealer pilot learning program', that was very successful. In total, 17 returnee migrants with an interest in agricultural machinery and services provision were selected by 13 agricultural machinery dealers that collaborate with CSISA. Following the signature of MoUs between the Activity and machinery dealers, and contractual agreements with the Activity and returnee migrants, these return migrant were supported by the Activity with two months of salary work in machinery dealer shops in high-priority districts. During this time, CSISA also provided basic training on business management and sales, and they also learned about the machinery detailed in Annex 3 through their practical employment in the machinery dealer's showrooms.

The target for this work was to enroll and support 15 returnee migrants, and the Activity exceed this target by two people. The machinery dealers that participated in this program included Krishi Solution in Banke, Swostik Traders in Bardiya, Quality Agro Suppliers in Bhurigaun, Karnali traders in Bardiya, Aayeshaa Power Tiller Mermat Kendra in Joshipur, NB Krishi Auzaar Kendra, in Kailali, RTC AgroMachinery and Engineering Workshop in Kanchanpur, RK traders in Kanchanpur, and Swargadwari Trade Link, Surya Traders, and Kishan Trade and Link, the latter three in Dang.

1.4 Cooperatively develop business models and link emerging entrepreneurs to provide essential services to farmers in COVID-19 affected areas

In Activity 1.4, CSISA works with return migrants entering into the machinery services provision to develop business models through which they can profitably offer land preparation, planting, irrigation or harvesting and post-harvest services to farmers in COVID-19 impacted areas while also reducing overall production costs for farmer clients. During this reporting period, two business orientation training sessions were conducted for the returned migrant workers in Kailali, Banke and Dang districts. The major aim of this orientation was to motivate and prepare participants to adopt farm machinery service provider businesses, and prepare them to connect with banks to access finance. The training was conducted using a participatory approach, involving all participants in group discussion, presentation and sessions. A visit to local dealers was organized to provide participants with firsthand information on various machinery types, and interaction with the bank representative was also arranged, to boost participant confidence on dealing with the bank to access loans. A total of 23 returned migrant workers participated in the training organized on 26–27 February, 2021 in Kailali. In Banke on 1–2 March, with 23 returned migrant workers participated in training, and in Dang on 4–5 March, with 17 participants.

In addition, two days of business management skill training was delivered to the newly enrolled service providers of Banke district. A total of 19 service providers participated in this training conducted from 23–24 March, 2021, which covered various important aspects of business management (planning, organizing and controlling), and helped equip newly enrolled service providers with the various required to manage a service provision business. Lastly, sales skill training was delivered to 17 interns who have been appointed to work as sales representatives for dealers in five districts as described in Activity 1.3 above. This was a three-day training conducted from March 23-25, 2021. Main objective of this training was to equip the participants with essential knowledge and skills required to be an excellent sales person.

1.5 Beating back break downs through the deployment of COVID-19 safe mobile mechanics

The number of weeks during the calendar year in which machinery service providers can assist farmers for land preparation, planting, and harvesting services is limited. This is a consequence of the tight-time windows within the calendar that farmers need to focus their work on within the confines of agricultural seasonality. As such, any breakdown in machinery can have significant negative consequences. In response, CSSISA is working to overcome lost work days for machinery services providers – who are increasingly crucial during the COVID-19 pandemic – by assuring that mechanics are (a) well trained, (b) are available in the service watersheds of machinery service providers, and particularly new service providers who are retuned migrants, and (c) assuring that mechanics are equipped to assist machinery service providers using COVID-19 safety protocols.

To this end, and during the reporting period, CSISA created an inventory of 190 mechanics spanning the working districts that the COVID-19 Resilience Activity is working in within the FtF Zone. 62 of the these mechanics were trained in the principles of COVID-19 safety, and on how to best repair land preparation equipment. Personal protective equipment was distributed to all of these mechanics and four additional staff working under the mechanics. Safety kits included gloves, masks, and disinfectants that were to be used before and after machinery repairs. In addition, training and PPE were provided for six irrigation pump mechanics in these same locations. Follow up studies indicated that the majority of mechanics were able to operate and provide repair services when and where needed, even during lockdown periods.

WP 2: 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 targets districts where there are fewer numbers of agricultural cooperatives that can be mobilized as business clusters for service providers, but where the number of return migrants was large following the first wave of the pandemic. CSISA will works to develop new service providers and will also leverage established service providers to provide COVID-19 safe agricultural machinery services. CSISA also partners with MoALD in this Work Package to advise on 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. Examples of advice for appropriate machinery can be found in Appendix III.

2.1 Track the availability and movement of agricultural machinery in the FtF zone and advise government, development partners, and machinery owners on how to channel services to locations where they are most needed

Nepal benefits from a relatively high concentration of reaper-harvesters and farmers' knowledge of, and demand for harvesting services. In addition to reapers, combines are also increasingly popular for rice and wheat, both of which can experience significant yield losses if left too long in the field because of social distancing or a lack of available labor prevent harvesting. Similarly, land preparation and planting equipment popularized by CSISA is gaining traction.

Activities conducted under 2.1 forces on (a) assisting partners to track machinery availability through telephone surveys and assist in targeting machinery services provided by PMAMP through development partner initiatives and service providers themselves, to areas in COVID-19 affected high demand districts. (b) CSISA is also working to assess demand for mechanization and irrigation services against the willingness and ability of machinery owners to serve farmer-clients in the context of the COVID-19 crisis. Resulting data generated by Activity I are being used PMAMP and agricultural policy makers on effective COVID-19 response and methods to assure timely, affordable and rapid land preparation, planting, irrigation, harvesting and post-harvest for farmers. This is done through CSISA's regular interactions with officials at the district, provincial, and federal levels of government. Examples include national-level presentations on appropriate machinery for spring rice establishment held on August 28, 2020, and the supply of suggested machinery lists for the MoALD and KISAN-II backed Joint Rice Implementation Program (JRIP) that was transferred from CSISA to these partners on July 28, 2020 and April 18, 2021.

In addition, CSISA is one of the members of District Project Implementation Committee formed by the JRIP in each project implementing district including Dang and Kapilvastu. In Dang, CSISA participated in three consecutive meetings chaired by the head of AKC-Dang after 23 January 2021 to technically backstop the project. Likewise, three consecutive meetings in AKC-Kapilvastu after the first meeting on 11 October 2020 were also attended by the CSISA representatives. In the meetings, CSISA provided technical information on reliable machineries that are fit for the purpose based on cropping pattern dynamics, land suitability, market availability of machines/spare-parts and potential to adoption and scale up. Firstly, scale-appropriate machines were identified through intensive discussion among the members of the committee and finalized. It was agreed that the small-scale machines like power tiller attached- and self-propelled reapers and seed drills which contribute in resource-conservation are to be promoted.

Rice transplanters and rotavators were given less priority for the support schemes as the former's adoption rate in terms of efficient utilization is much lower in Nepal[14], while rotavators can reduce soil quality and undermine the natural resource base that agriculture relies on. As stated in JRIP guidelines, CSISA responded effectively in partnership and supported by preparing machinery specifications of selected machines to facilitate the machinery support scheme (See Appendix III). This technical support was provided after several meetings and trainings at central and provincial level with KISAN II, MoAD's CCDABC and MoLMAC-Lumbini Province.

Above: *Service provider logbook cover.*

One of the key outputs that came during the reporting period for this activity was the development of record keeping books for machinery service providers. CSISA worked with service providers for a range of equipment to collaboratively design a format that could be easily understood and used to help service providers keep better track of their activities. These logbooks are also of additional value when service providers apply for new bank loans, as they demonstrate the business savviness (and hence ability to more responsibly pay back loans) of service providers and have been helpful in assisting in gaining loan approval from financial institutions.

Lastly, business management training for custom hiring centers (CHCs) and individual service providers were conducted on 28th September 2020 by CSISA and KISAN cooperatively as part of the CSISA COVID-19 Resilience Activity. The KISAN team organized this event and the CSISA team provided the training content. Several individual machinery service providers and CHC representatives participated in this training program. The training aimed to help the participant effectively manage the machinery so that they can provide the renting services and make mechanization services lucrative. Participants developed their theoretical and hands-on technical skills and knowledge on minimizing the potential risk and covering the payback period

[14] A research report on the causes of low rice transplanter adoption will be completed by the end of July 2021, and published by CSISA.

of machines in a short period. Since rice harvest season was approaching soon, the training focused mainly on rice harvesting machinery.

The trainings also oriented participants towards methods of establishing "renting-out service charges" by considering investment in the machines and the amount of business they must create to break even on their investments in machinery. The discussion from this training suggested that individual service providers can set service charges for any new machinery and manage the staff and their machines effectively. However, follow-up training will likely be required to support CHC representatives to effectively set services charges associated with operating large charges and become more effective in managing CHCs. Part of the later issue of low effectiveness of CHCs representative is due to the subsidy-driven approach for the CHCs, making them less risky and less innovative. The training on business management of machinery services can be found in the following link (Business management training presentation).

2.2 Link harvesting equipment owned by PMAMP, or by farmers' cooperatives, and individual service providers to farmers demanding services in COVID-19 affected districts

In Activity 2.2, CSISA makes use of its established networks and information generated in Activity 1 to actively link land preparation, crop establishment, and harvesting equipment service providers to farmers demanding services – particularly for the remaining wheat crop and for the *Kharif* season rice crop – in a COVID-19 safe way. During the reporting period, CSISA prepared its partners for COVID-19 safe and socially distanced harvesting operations and also launched a voucher scheme to assure that farmers in COVID-19 impacted areas who have not previously utilized mechanization services could benefit. Outcomes from this voucher scheme – which is ongoing at the time of reporting but appears to be very promising – will be provided in the 2020-21 Annual Report. The sections below therefore concentrate on work that was done by CSISA to prepare partners to meet farmers' machinery needs in a COVID-19 safe way.

Machinery specifications and service provider training in support of PMAMP

During the reporting period, CSISA played a supportive role in devising machinery specifications required by different governmental and non-governmental organizations including PMAMP-PIU-Dang, CCDABC (Chandragadhi and Sundarpur farms), Ghorahi sub-

***Above**: Trainers describing the laser land leveler working mechanism, Sundarpur, Kanchanpur, November 2020. (Photo: Lokendra Khadka/CSISA)* metropolitan wards 14 & 15, Dang's Agricultural Knowledge Center, JRIP/KISAN II, Dangisharan Rural Municipality, Rice Block Program run by Harit Kranti Agriculture Cooperative and Suryodaya Agriculture Co-operative in farm machinery used for commodities including maize, rice and mustard. Trainings on land preparation were prioritized, along with seeding equipment in preparation for the winter cropping season.

Specifications were provided for farm machinery including four- and two-wheeled tractors and their respective tillage and seeding attachments, mini-tillers and rice transplanters, and post-harvest equipment such as the combine rice mill, maize grits/flour mill and grain dryers, and irrigation equipment including a pump set and electric motor. The Activity also supported the inspection and quality confirmation of newly purchased machines in Dang to ensure quality items were delivered from suppliers. The technical support that CSISA has provided to different organizations has played a conducive role in strengthening the machinery supply chain, especially in resource-conserving machinery technologies such as seed drills, laser land levelers and mini-tiller weeders.

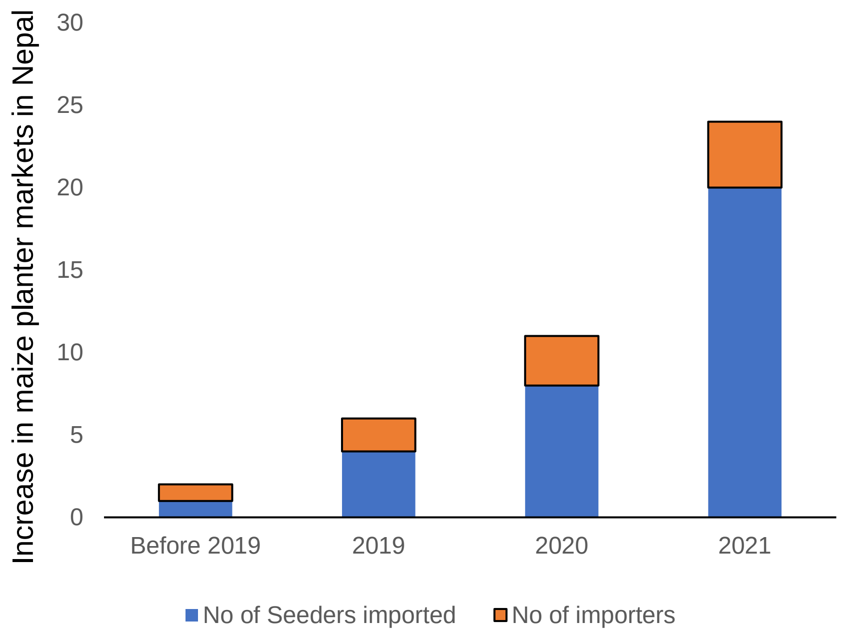
CSISA also played a facilitative role in strengthening the capacity of custom hiring centers managed by farmers' groups and supported by PMAMP, as well as individual entrepreneurial services. On an individual coaching basis, CSISA trained twelve machinery operators of custom hiring centers in the operation, calibration and adjustment of farm machinery including the maize planter, mini-tiller weeder, jab planters and threshers. These re all machines that PMAMP and Dang's Agricultural Knowledge Center provide subsidy incentives for purchase. Similar technical support on the effective operation of seed drills was provided to the technicians of machinery dealers Surya Traders, Swargadawari Trade Link and Lumbini Seed Company. Also during the reporting period, 11 new precision maize planters procured by the custom hiring centers were tested and demonstrated jointly with Dang Maize Super Zone. PMAMP and CSISA are expected to accelerate the initiative of expanding the area under maize and increasing productivity, while at the same time making the maize crop highly commercial and fully mechanized.

Above: *Power tiller owners participating in training to operate and calibrate a two-wheel tractor operated seed drill, Harit Kranti Custom Hiring Center supported by PMAMP, Dang. (Photo: Sagar Kafle/CSISA)*

Similarly, on 20 Nov 2020 CSISA enhanced the capacity of individual entrepreneurial service providers of seed drills and laser land levelers who were not part of PMAMP's custom hiring centers, by providing hands-on training to a total of 10 government machinery operator staff and custom hiring center technicians in Sundarpur, Kanchanpur. The training was a jointly organized by Sundarpur Agriculture Development Farm and RCT Agro Machinery and Engineering Workshop.

Training topics covered the operation of multiple seed drills to sow maize, mung bean and wheat, and how to use laser land levelers. Participants learned the basics of seed drill calibration and operation, and gained knowledge of the seed metering systems of different types of seed drill. They also learned about the specifics of laser land levelers, including different components and their linkage mechanisms. Details the outcomes of these trainings will be reported in the 2020-21 Annual Report.

Machinery market development during and in response to the COVID-19 crisis



Above: *Growth in markets for mechanized maize planters in Nepal over time.*

To achieve sustainable market development and the adoption of scale-appropriate technology, CSISA is engaging private agro-machinery dealers lead in farmer field days and other technology promotional events. During the reporting period, CSISA supported NB Krishi Auzaar Kendra, Kailali, to demonstrate its seed drill for zero-tillage wheat sowing (9 November 2020) through the project's network of cooperatives and farmers groups. After selling eight machines last year, NB Krishi Auzaar Kendra recently procured ten seeders and sold two new seed drills in their area just after the demonstration. Shantinagar Agriculture Cooperative in Kailali also purchased the multi-crop seed drill and developed a skilled service provider to operate the machine on behalf of their cooperative. With this seed drill, the cooperative has provided machine aided sowing services for 10 ha of wheat, 30 ha of maize, and 20 ha of mung bean within their own and neighboring cooperatives. CSISA also provided technical supported to the cooperative's new custom hiring center in the preparation of technical information for a radio jingle to advertise their business.

An additional importer of the maize seed drills, D-Kam Microsystem Pvt. Ltd, from Tikapur, Kailali, entered into formal business establishment with CSISA's technical support and business advising during the reporting period. The importer's proprietor consulted with CSISA staff during the lockdown period (in May 2020) after which, and with technical feedback and support from CSISA, imported eight seed drills to sell. This new dealer establishment will assist local people with maize cultivation, thereby contributing to reducing the COVID-19 impact.

2.3 Improve service providers' access to emergency mechanic's services in COVID-19 impacted districts

Regardless of the quality of agricultural machinery, break-downs and service interruptions are inevitable. For this reason, machinery service providers assisting farmers during the relatively short time-windows in the agricultural calendar allotted to land preparation, planting, irrigation, harvesting and post-harvest need rapid access to support from mechanics. Activity III responds by linking competent mechanic repair services to equipment operators who may provide services in COVID-19 affected areas who may be unfamiliar with local options for spares and repairs.

The original goal of Activity 2.3 was to assist mechanics in the provision of movement permission passes within and across districts, in the event of continued social distancing and movement restrictions during lockdowns in the reporting period from October – March (2020-2021). As Nepal was not in lockdown during this period, Activity 2.3 did not need to be implemented. Instead, the CSISA team focused on more general training to mechanics and assurance that mechanics were prepared and able to provide COVID-19 safe services, as described in Activity 1.5 of Work Package I.

2.4. Improve service providers' access to emergency mechanic's services in COVID-19 impacted districts

This activity works to demand and facilitate access to machinery services for very poor and women farmers in locations impacted by the COVID-19 crisis. Because details of the work conducted in Activity 2.4 focused on access to mechanical harvesting services for the winter wheat crop, which would otherwise be harvested by labor gangs that could increase the risk of COVID-19 transmission, outputs and outcomes from this Activity will be provided in the Annual 2020-21 report. A the time of writing, CSISA was in the process of implementing a specialized voucher scheme targeting women and marginalized groups, including very poor farmers, to facilitate their first ever experience with hiring services for harvesting. This smart-phone based digital voucher scheme, and its impacts, will be described in detail in the Annual Report.

OBJECTIVE II: 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 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-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, an 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 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 the 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 to 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 is informed by detailed background research, literature review, and multi-stakeholder dialogue and co- t. 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 the capacity of Nepali stakeholders over time.

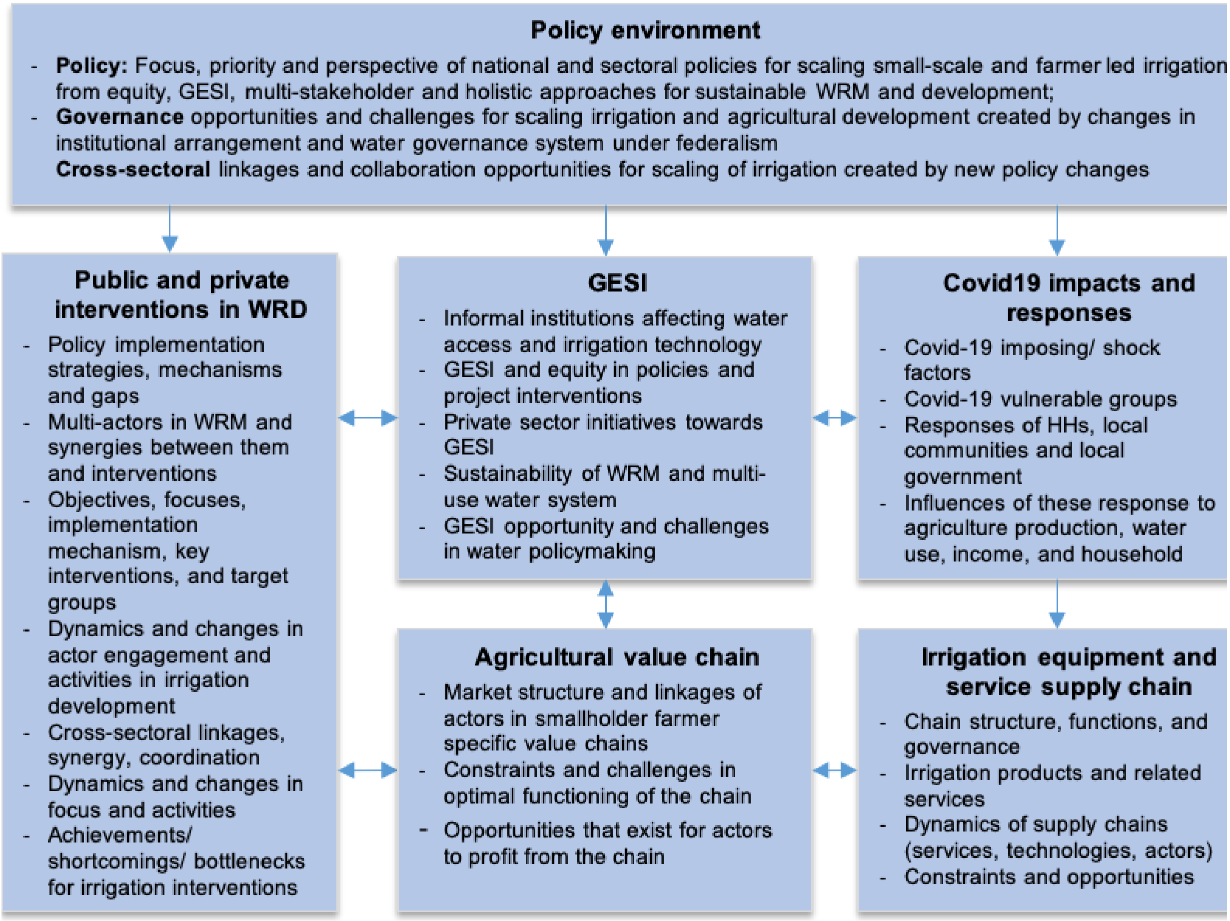
WP 1: Towards a systemic framework for sustainable scaling of irrigation in Nepal

1.1 Develop a sustainable groundwater use framework to support conjunctive use as a response to water access challenges in Nepal

Activity I focuses on the biophysical aspects of irrigation development with an emphasis on hydrology. A comprehensive review and analysis of available secondary data and literature with specific focus in the FtF ZoI of the Terai was completed in the reporting period titled 'Towards Conjunctive Use of Surface Water and Groundwater Resources as a Response to Water Access Challenges in the Western Plains of Nepal'. In addition to generating information that can be used for model scenario analyses as described in Objective II Work Package III, this review synthesizes information that can be feed into policy and support for irrigation-related investments by the public and private sectors. The insights generated from this report are being combined with the other activities in Work Packages I, II III and IV to inform relevant policies to support sustainable private and public investments in irrigation.

1.2 Understanding systemic barriers, socio-economic and institutional challenges, and opportunities in scaling water access and irrigation technologies

The limited use of ground and surface water in Nepali agriculture remains largely related to various socio-economic, policy, institutional, investment and gender and social inclusion challenges faced by rural communities. Where these challenges are not systemically analyzed or understood, major opportunities are missed to strengthen water and irrigation access aimed at agricultural development in Nepal. These challenges have likely been exacerbated by the COVID-19 crisis, and by the necessary national policies put into place to prevent further infection.



Above: *Analytical framework for scaling irrigation development in Nepal.*

As such, this Work Package uses a systems approach to assess a range of relevant topic influencing irrigation development, including the broader policy environment, public and private sector interventions in water management, gender and social inclusion, value chains, irrigation machinery and services, and the implications of COVID-19 on irrigation development.

Using the framework shown above, the study aimed at assessing opportunities, and barriers for scaling sustainable and inclusive farmer-led irrigation development in the Feed the Future Zone of Influence (FtF ZoI) region in Western Tarai from a qualitative social science perspective. Irrigation development does not take place in a vacuum, irrigation practices are continuously shaped and reshaped by a multi-faceted range of drivers stretching from farmers livelihoods and aspirations, via economic arrangements of different scales including supporting sectors and markets, to the political economy of water resources management and international trade arrangements. Making irrigation work, therefore requires the application of an integrated lens for analysis to understand and pinpoint critical bottlenecks in the rural innovation systems for irrigation development and management.

To achieve this, the research has looked at six key interconnected dimensions that influence scaling of irrigation development in Nepal's diverse societies, livelihoods, and political economy:

- Lasting drivers in the FtF ZoI and Covid-19 related impacts and responses

- Policy environment, including governance
- Agricultural value chains
- Irrigation equipment and service supply chain
- Public and private sector interventions in water resources development
- Gender and social inclusion in policies, agricultural value chains, irrigation equipment supply chains and public and private sector interventions

The research broadly based on extensive review of scientific and grey literature, including over 50 policy and programs documents of the governments and development partners in Nepal, 16 telephone interviews with the private sector, farmer group associations and agricultural cooperatives, provincial officials and policymakers, and reflections of stakeholders on the opportunities and challenges of the water sector to capitalize on the power of water in national development planning.

The recognition of water management and irrigation development being crucial to the country's agricultural and economic growth provides an opportunity of the new federal PPP legislations to stimulate private sector investment in irrigation supply chains, agricultural value chains (VCs) and also multiple use systems. However, the current policy frameworks remain biased towards large-scale infrastructure and economic growth instead of inclusive growth. Hence, subsidies for agro-inputs are not pro-poor or women and largely fall in the hands of better-off farmers. Furthermore, the overlapping roles and responsibilities across the three levels of government and sectoral line ministries complicates the role out of agricultural and water management interventions in the water-agricultural and energy sector. Hence, the lack of coordination among ministries and stakeholders has led in the past to poor scaling of available irrigation and agricultural technologies.

For many of the agricultural VCs, access to timely and quality fertilizer remains a serious bottleneck. Furthermore, poor access to roads and transport facilities, lack of (cold) stores and poor market linkages increase post-harvest losses. Similar challenges in the irrigation supply chains are observed as in the VCs. The reliance of imported raw material for domestic manufacturing significantly increases costs as well as the unreliable land ports and road conditions which hamper the importation of equipment. This together with the political instability with neighbor countries results in steep price increases of irrigation equipment such as pumps. Transportation and market disruptions because of covid-19 only aggravated the situation leading to price surges for vegetables and equipment, declined harvests of wheat and reduced income for farmers as well as remittances from migrant workers. Given the fast-growing local demand there is an opportunity to strengthen local manufacturing companies. The USD 6.6. billion under the Green Recovery Plan in building resilience to climate, covid-19 and other shocks provides an opportunity to strengthen agri-businesses and local manufacturing of equipment in a pro-poor and inclusive way, creating jobs for women, returning migrants and youth affected by covid-19. Especially the recent Industrial Enterprise-related policies and acts on VCs, PPPs, business and finance give priority to smallholders, youth, tenant and marginal farmers. Multi-stakeholder partnerships which provides services support and strengthen capacity of female extension agents, entrepreneurs will be key given the cultural norms in the Tarai which restrict interaction between women and men outside kinship circles.

For farmer-led irrigation development to thrive, there is a need to address issues of land tenancy as these prohibit borehole investments and electricity access and stability. As tenancy rights are barely protected, investments in borewells under an irrigation service scheme is less likely to happen if formal tenancy contracts are absent. Introducing shared solar irrigation pump (SIP) systems and wells supporting a sharing equipment-rental market at community level might be an alternative. However, upfront investment costs in SIPs remains relatively high and the 60% subsidy programs fail to reach the poor and the most vulnerable. Limitations to the subsidy schemes is the requirement of a land ownership certificate, a recommendation letter from the local government and a minimum land size of 1 ha, preventing smallholder farmers, women and youth from reaping the benefits of SIP. As irrigation development remains predominantly infrastructure focused the implementation of gender and inclusive principles haven been relatively limited when it comes to irrigation development and in particular the role out of financing mechanisms, irrigation supply chains and services and VCs. However, women are emerging as role models and entrepreneurs leading 30% of firms including agri-businesses. There is an opportunity to use private-sector extension to overcome some of the current challenges in human capacity and knowledge on GESI in governmental institutions tasked to implement irrigated agricultural programs. Mainstreaming GESI in the private sector by partnering with I/NGOs could offer an opportunity to achieve GESI outcomes at the project-implementation level as women's social networks are key to technology adoption.

Learning from these insights the following five objectives are essential to *improve incomes, nutrition, health, knowledge in the FtF ZoI through sustainable and inclusive scaling of FLI development:*

- ***Enable a supportive policy and institutional environment and governance mechanisms for the scaling of sustainable and inclusive FLI development along irrigated agricultural value chains and public and private investment:*** This includes supporting an environment for private sector partnership, domestic agro-irrigation input manufacturers, regulation of markets for cheap Indian agriculture, fertilizer agri-businesses and strengthening of technical and human capacity in sanitary and Phyto-sanitary implementation; revision of fertilizer and subsidy policies and strengthening of GESI tools and transformative approaches.

- ***Capitalize upon private sector investment into irrigation equipment and input supply chains:*** Develop financing modalities that help de-risk private sector investment to entire frontier markets especially micro-irrigation, bottom of pyramid market financing. Strengthen scaling partnerships between private sector, local governments, operating Technical and vocational education Training (TVET) institutions. Support domestic manufacturers and create an enabling environment for more domestic agro and irrigation input businesses to grow (e.g. revising raw material taxes those required for irrigation equipment, engaging with private sector to establish input factories). Invest in essential infrastructure such as cold stores and collection centers to enable stallholder produces to effectively reach bigger markets.

- ***Enhance adaptive interventions to support small-scale irrigation and farmer-led irrigation development:*** It is essential to emphasize that scaling FLI development requires bundles of irrigation technologies, agronomic practices, extension services, financial and market services as well as corresponding actions to reach scale of the locally driven, bottom-up, effective and efficient climate smart agriculture, sustainable water resources use and gender and social inclusion. Implement best-fit of bundled irrigation and agronomic practices with financial and market services, cold storage and entrepreneurial activities to enhance return of investment for smallholder farmers and agri-businesses and lower investment risk. Support scaling of solar-powered irrigation pumps (SIPs) technologies for water access for multiple use, including WASH in areas with unreliable electricity access. Addressing access of poor women, smallholders and vulnerable groups requires innovative end-user financing which could include farm-equipment leasing, group-distribution models or integration of irrigation investment with agricultural-related inputs.. Support local governments to pilot and implement frameworks for decentralized water and land management as a sustainable solution to water security, environmental conservation and equitable development outcomes. This also includes the training of local services providers for operation and maintenance.

- ***Supporting collaborative scaling ecosystem in responding to dynamics and driving changes needed for scaling FLI development:*** Establish inclusive and sustainable financing ecosystem for public and private sector investment. Promote 'multi-stakeholder partnerships approach for scaling' to strengthen resource leverage, harmonized irrigation investment, market system development, evidence-based policymaking and knowledge development, and local capacity building. Strengthen partnerships with research organizations as a knowledge broker to address information and innovation gaps to support the niche, reach and accelerate functions of scaling is essential. This also includes capacity building of sectoral staff, water user associations and farmers collective to promote climate smart agricultural development.

- ***Transform the irrigation and agricultural development system:*** Systemic barriers that hinder transformative changes in the irrigation, private sector and agricultural value chain sectors can be addressed through the facilitation of policy processes in local, provincial and federal levels on inclusive and sustainable FLI development scaling approaches. This supports evidence-based policy and capacity development of the government, CSOs and private sector on multi-use water resources management. Create and operate multi-stakeholder dialogue (MSD) platforms, dialogues, and knowledge forum (national and subnational level) which connects private sector actors, government, cooperatives and association of water user groups to discuss barriers and opportunities for scaling small-scale/farmer-led irrigation. An investment into Research for Development (R4D) programs to design, implement and learn from 'sustainable and transformative irrigation development in the FtF ZoI is essential to develop local capacity on inclusive agri-businesses, and strengthen local policy implementation.

During the reporting period, a comprehensive literature review and series of interviews with focus groups and key stakeholders was undertaken to address these issues. At the time of writing, the report is in its final stages of being completed and laid out by a graphic designer.

WP 2: Preliminary development of a digital groundwater monitoring system to inform sustainable irrigation development and management strategies

2.1 Identify groundwater wells appropriate for spatially accurate groundwater monitoring

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. Work Package II responds to this crucial information gap through two associated activities to develop and pilot a preliminary groundwater monitoring system.

Above: *Installing an offline data logger for groundwater level monitoring.*

As part of the Nepal Digital Groundwater Monitoring Pilot, CSISA and the Groundwater Resources Development Board (GMRDB) of Nepal cooperatively developed a sampling framework for adequate testing of the data collection methods and devices. The team started by surveying the existing monitoring wells which the GWRDB is currently collecting data from. These wells have largely been installed as part of a UNDP supported project in the 1980s and comprise the key monitoring network for the GWRDB. In each districts there a total of 20 shallow monitoring wells (<80m) and an additional four deep monitoring wells (>80m). The basis for the siting of these wells is not directly known and COVID restrictions made document recovery through personal travel impossible. However, the GWRDB confirmed that these wells have been installed as part of a wider project to characterize the groundwater resources suggesting that substantive investigation in appropriate siting had been conducted. However, with an increase in irrigation water use, the adequacy of the current network remains unknown and was earmarked as a key concern that the project will aim to address.

Working with the existing monitoring network, the project had to identify the best locations for installing the offline data loggers that will be collecting groundwater levels and a 12 hourly temporal resolution. Given that the pilot area exhibits a North-South topological gradient that also guides river morphology, a perpendicular cross-sectional sampling strategy was chosen for installing the offline loggers within the more evenly distributed network of shallow monitoring wells. This approach was documented in the groundwater monitoring protocol which has been co-developed and endorsed with the GWRDB. Slight modification on the planned selection wells had to be accepted due to some shallow wells not being amenable to installation of the offline loggers, for which the closest neighboring well was chosen.

2.2. Set up and kick-start a digital groundwater monitoring system

After an online inception workshop and initial stakeholder consultation with participants from a wide variety of background on 14th of October – CSISA immediately started to implement the pilot on the ground. With the well selection in place, the next step of the groundwater monitoring pilot was to train the GWRDB staff on the procedures for data collection. In January and February 2021, CIMMYT staff organized several field days with the GWRDB for training. Since the chief of the GWRDB office, Surendra Maharjan, in the pilot area was replaced by Krishna Upadhya.

Above: *Groundwater Development Board staff learn how to install dataloggers.*

The project experienced slight delays as and required an additional training session to update the new GWRDB staff on the activity and data collection methods. However, the new chief of the GWRDB office provided excellent support and displayed avid engagement in the activity, securing swift start of data collection and knowledge transfer. The training sessions were held according to the Training of Trainers Manual that was co-developed and endorsed by CSISA and the GWRDB and further improved based on the experience of the training. The manual is now ready to be used for future trainings with the current monitoring approaches – but designed as a living documents that can be updated as the approach is being refined and learnings emerge. Unfortunately, the deployment of online loggers has been delayed due to a technical fault in the loggers from ONSET, which had to be re-ordered and COVID caused delays in the production and import of the OTT pressure level sensors. They, however, have recently arrived and COVID save installation is under way. To finally kick-start the digital groundwater system CSISA organized an online workshop on the 23rd of February to which the project invited key critical stakeholder and individuals that showed interest during previous stakeholder discussion. The workshop started with Krishna Upadhyaya informing stakeholders about the progress of the activity – sparking a vivid discussion on the potential use cases and need of stakeholders. Arranging the science-policy interface for the translation of these data into policy guidelines and enabling better coordination of stakeholders at the district level some of the most critical discussion points.

These discussions were followed by a brief presentation of current prototype of the Dashboard by which was welcomed with interest by stakeholders who appreciate the open-data approach requested that these should be used to collaboratively update the knowledge on groundwater characteristics in Nepal's Terai. Stakeholders further remarked that for policy and decision makers monitoring system requires a policy framework for guiding the development of maps of groundwater abstraction risks and potential. Lastly, the data collectors themselves shared their experience and overcoming issues of digital literacy and reward of being able to contribute directly to better water management while improving their workflow. However, they remarked that in the future it would be easier to collect data through phone and not tablets as these are more difficult to carry on a bicycle.

Above: *The inception workshop for the digital groundwater monitoring system.*

WP 3: Provide local, district and provincial level assessment of sustainable water use and development options including risks of unintended consequences at a watershed (and basin) scale and communicate assessments effectively through trainings and workshops

Along with high-yielding crop varieties and broad use of fertilizers, expansion of irrigation has provided a non-negotiable foundation for agricultural intensification and food security in South Asia since the 1960s. Irrigation, however, 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, costs and reliability, and the diverse incentives 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 pumpsets. Despite dramatic area expansion in Nepal (*n.b.* more than 70% of our 3,000+ surveyed rice fields across the Terai are irrigated), it is generally recognized that many regions 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 while also extending access to households who do not have affordable access. Nevertheless, the benefits of irrigation intensification are not uniform in time and space; policy makers, development practitioners, and farmers need better guidance on optimal 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 potentially influenced by a host of factors including soil type, landscape drainage characteristics, rainfall distribution, planting dates, crop variety characteristics, and higher order interactions among these factors. In complex production environments like in the Terai of Nepal, big data and advanced machine learning analytics are opening new avenues for untangling the influence of these factors in order to identify circumstances where there are significant opportunity for irrigation-led sustainable intensification. Towards this goal, this workstream combines data from two sources: 1) digital soil maps produced by the USAID-funded *Nepal Seed and Fertilizer* project, and 2) a large-*n* (>3,000) landscape diagnostic survey of rice production fields collected from the 2016 and 2020 harvest season by the USAID-supported CSISA. The field survey data were collected from 14 Terai districts, with all districts covered by the FtF 'zone of influence' captured by the survey. .

3.1 Generating insights into targeting irrigation-led sustainable intensification with machine learning analytics

Sub-Activity 1: Construct machine learning-based prediction models for rice productivity

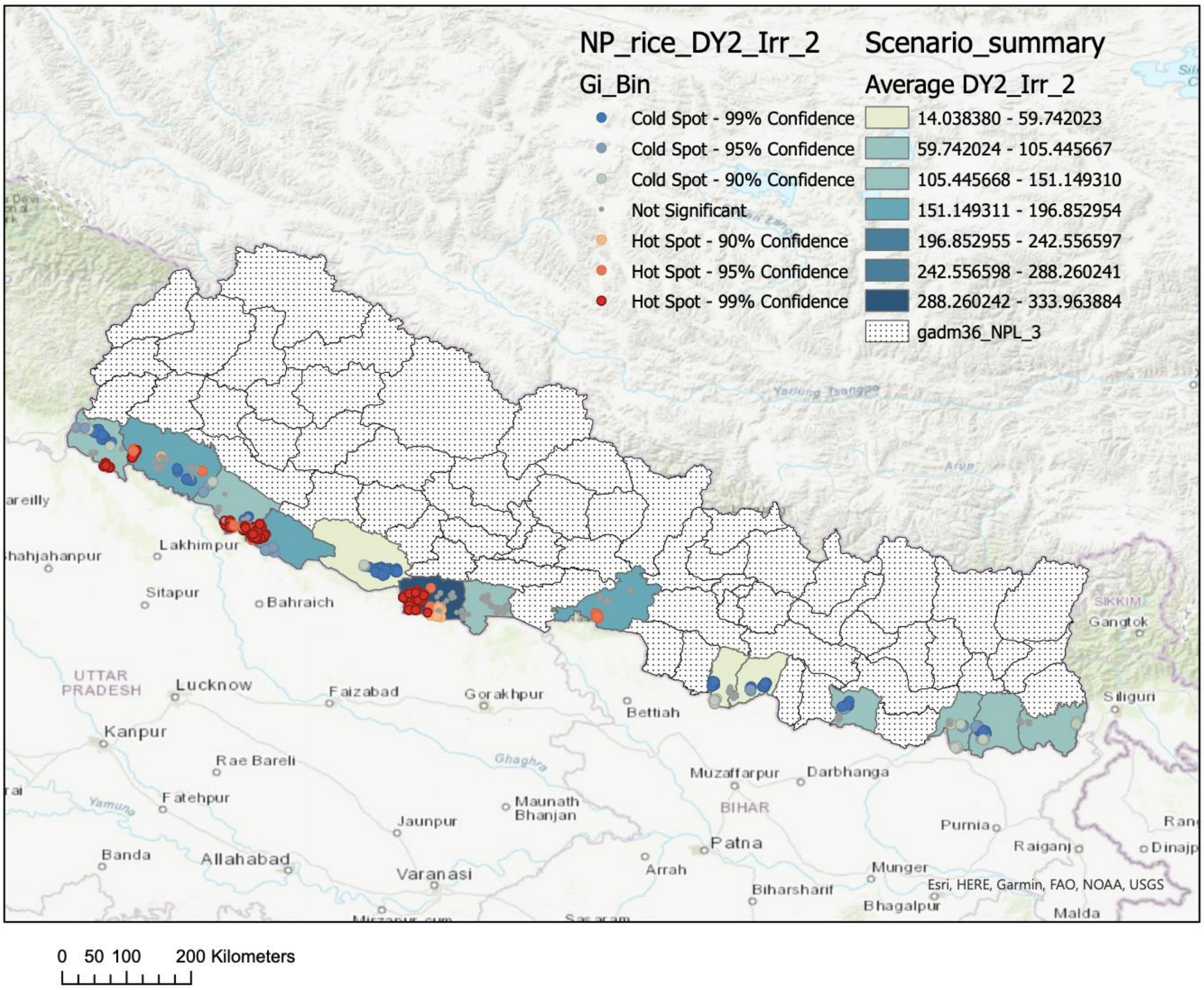
A Random Forest (RF) model was constructed to predict rice yields as function of soil and agronomic management factors (r2 = 0.736, RMSE = 676 kg ha^{-1}). In descending order of importance, the top seven model predictors are show to the left. Among these seven, three factors (soil texture - % sand, planting date, and irrigation number) are strongly associated with field hydrology and crop water stress. In contrast to adjacent rice growing areas in India, irrigation intensity explains less contemporary yield variation because, in general, irrigation utilization is low with an average of only 2 irrigation events per rice season.

Predictor	SS	Variable importance	Portion
Sand	565102859		0.2249
Organic matter	404270919		0.1609
N fertilizer	379820779		0.1511
Transplant date	376688252		0.1499
P fertilizer	344333258		0.1370
Irrigation #	257458276		0.1024
Cultivar	185417051		0.0738

Above: *The random forest machine learning model constructed to predict rice yields as function of soil and agronomic management factors.*

Sub-Activity 2: Scenario analysis to understand the spatial distribution and causal factors associated with responses to increased irrigation

With the RF model developed in Objective 1, we then ran a set of hypothetic scenarios to simulate how individual fields would likely respond to increased irrigation (shown below). A high degree of response heterogeneity was observed between districts, with the western Terai generally anticipated to have higher productivity gains. Hot spot analysis suggests that Kapilvastu, western Banke, and Bardiya Districts are likely to significantly and consistently benefit from increased irrigation. Our analysis also explores the field characteristics that are associated with responsiveness to irrigation and has identified prior rice yield levels (i.e. < 3.3. t ha^{-1}), soil texture, and past irrigation practices as strong candidates to help guide field level advisories. As an additional step, we explored how investments in soil health (i.e. N and P fertilizers) may influence the value of intensified irrigation for rice. Results suggest that the expected benefits of irrigation will more than double if modest levels of complementary investments in fertilizer are used conjunctively.



Above: *Simulation responses to increased irrigation in the Terai region of Nepal; reds indicate higher response, blues lower.*

Sub-Activity 3: In areas predicted to be highly responsive to increased irrigation, implement additional field diagnostic surveys that highlight opportunities and constraints that farmers may face in intensifying irrigation.

At the time or writing, this sub-activity is the planning phase with feasibility contingent on COVID-related staff mobility and general travel restrictions.

3.2 Integrated crop and hydrological set-up and scenario analysis for sustainable irrigation development

Using insights from Objective I Activity I and II, as well as the data-driven modeling work described above, Work Package 3.2 integrates data sources to develop modeling scenarios that can provide integrated assessments of (s) field, watershed, and basin-level water balances, (c) existing crop productivity estimates, and (c) economic performance of existing farming systems. This is accomplished using SWAT, a basin-scale physically based model which is used to estimate changes in climate, land use and land management on water, soil and nutrients. APEX is a biophysical model which analyzes the productivity and water/nutrient balance of farming systems. FARMSIM, conversely, is a Monte Carlo socio-economic model that assesses the economic and nutrition impacts of different alternative farming systems. The three models applied in an integrated manner, are referred to as an Integrated Decision Support Systems (IDSS), and are widely used by the Texas A&M University led FtF Innovation Lab for Small Scale Irrigation. These tools are beubg used to assess the impact of different farming systems on agricultural production, environmental sustainability and income and nutrition at different geographic scales.

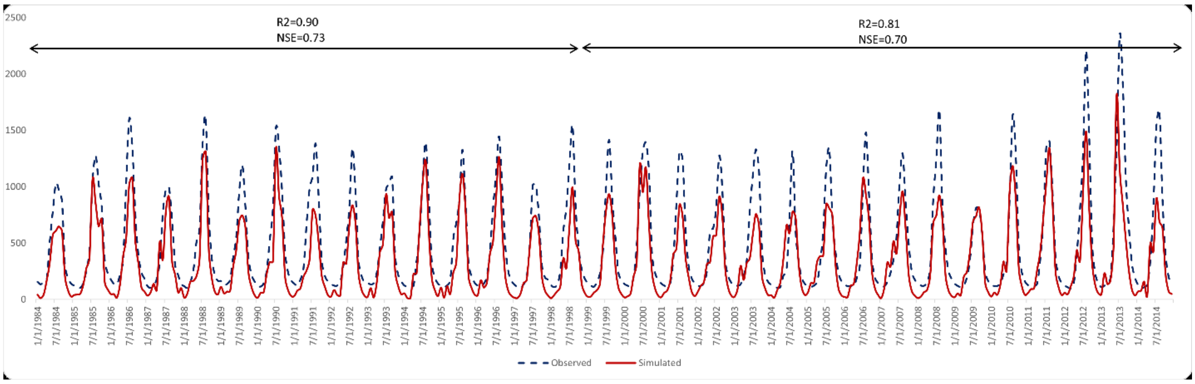
The key research questions being addressed through this work include the (a)what is the scope is for ground and surface water irrigation development in Lumbini and Sudurpashchim provinces? (b) What best-bet crop and cropping systems combinations are suited to irrigation development from both an agronomic 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? (c) What the potential 'safe operating space' for irrigated (ground water, surface water, and conjunctive use) development in Lumbini and Sudurpashchim provinces, 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? (d) What locations might be 'best-bet' for future irrigation development in consideration of the medium-term effects of climate change?

These questions are aimed to assess the optimal water use that ensures maximum agricultural production, income and nutrition while without causing significant negative environmental externalities. In doing so, this Activity is working to provide inference on the potential implications of different irrigation development pathways for individual farmers, farmer cooperatives, and water user's associations.

During the reporting period, and although COVID-19 posed challenges for travel, the following activities were implemented through virtual settings:

- **Establishment of key technical staff:** Texas A&M University (TAMU), whose researchers are expert in SWAT and IDSS, engaged a post-doctoral research fellow, Dr. Avay Risal, who is a Nepali national to work on the project. The post-doc and other TAMU researchers regularly participated in meetings with CIMMYT, IWMI and other stakeholders.
- **Data preparation:** TAMU identified and prepared data, including landcover, soil, and climate datasets needed to run SWAT. Landcover data layer for entire study area was prepared combining crop mask for a range of cereals, pulses, and horticultural crops. These are supplemented with available land use data. The soil database for Nepal was prepared using ISRIC global soil database and Rawls and Saxton (2006) Pedotransfer function.

Precipitation data for the study areas was extracted and reformatted from the global precipitation grid data (Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) using a Python code and weather generator tool. The other climatic variables for the stations within the watershed were collected from the partners and prepared as required by the SWAT model.



***Above**: monthly stream flow (simulated and observed) during the calibration and validation periods at the Asarghat river gauging station.*

- **Model setup and calibration:** At the time of reporting, the SWAT model was setup for three watersheds (Babai, West Rapt, and Karnali) using different sets of soil and climatic data to identify the best available dataset for further analysis in the project. Based on the initial modeling results, however, the two different soil datasets provided more or less similar streamflow at watershed outlets. Initial streamflow calibration for one of the study watersheds (i.e. Karnali Watershed) was conducted at four streamflow gauging stations (at Asarghat, Banga, Chisapani, and Rimna monitoring stations). Evaluations of the model simulations using the coefficient of determination and Nash-Sutcliff Efficiency (NSE) indicated reasonable model performance. For example, the R^2 and NSE values at the Banga monitoring station were 0.90 and 0.73, respectively, during the model calibration periods, and 0.81 and 0.70 at the model validation period. Monthly simulated and observed streamflow also showed reasonable agreement. Work is ongoing to extended beyond these watersheds and set up the model to conduct scenario analyses that will be generated in the second half of the 2020-2021 reporting period.

3.3 Integrated crop and hydrological set-up and scenario analysis for sustainable irrigation development COVID-19 response at the local, district and provincial levels

Based on a series of meetings with the CSISA, the Activity developed preliminary scenarios during this reporting period. The calibrated and validated SWAT model will be used to assess the impact of the scenarios on crop production and environmental sustainability (especially impacts on groundwater level, as the source of irrigation is largely from the groundwater reservoir) at the local, district and provincial levels. Scenarios will be based on water resource availability, crop rotation and diversification, irrigation system, and implication of agricultural best management practices. The model derived from different scenarios will be integrated into a framework for sustainable and inclusive irrigation development in the Activity area.

In the second half of the 2020-21 activity year, a workshop (will be held with public and private sector stakeholders from the provincial and local levels to generate preferred scenarios for model analysis depending on the priorities of USAID, the Government of Nepal, development partners, and the private sector. At the time of reporting, activities were underway to prepare for this workshop, which will be held virtually due to COVID-19 travel restrictions and risk, in addition to governmental guidelines that ,limit in-person gathering size. Telephone surveys of farmers and farmer groups are underway in preparation for the workshop, which will be reported on in the 2020-21 Annual Report. Based on the work above, model scenarios generated by the IDSS tools will be conducted. Scenario analysis with the SWAT model provides large scale information about land and water resources potentials to inform Work Package 4.

WP 4: Sustainability framework for irrigation development in Nepal's Feed the Future Zone completed

4.1 Move towards self-reliance through training and communication of research insights

Work Packages I, 2, and 3 closely involve stakeholders in (a) selection of scenarios for irrigation and multi-use water resources development assessments, and (b) in interpretation and fine-tuning of model scenario outputs, respectively. Activity 4.1 is focused on complementing these efforts through capacity building. Key actions taken during the reporting period include the following:

- Following a call for competitive applications and proposals by candidates that was posted in various newspapers and job advertising websites. A shortlist of 19 candidates was made, and after an intensive interview process, two early-career scientists, one male, one female, both youth, were selected for a long-term training internship. These interns are now formal members of the CSISA team and are actively contributing to IDSS modeling through 1:1 coaching and direct participation in the research outlined in Activities II and III. The goal of this work is to provide thorough on-the-job coaching, technical support, and practical learning will position these early-career scientists to contribute in the long-term towards resilience-enhancing and sustainable irrigation development, while also positioning them as leaders in water resources management and agricultural research.
- The TAMU postdoctoral research fellow, Dr. Avay Risal, will visit Nepal in April 2021 to deliver SWAT training to the early career researchers (selected through an open call), as well as CSISA and GWRDB staff. The training will be provided from 19–30 April, 2021. Dr. Avay will also conduct seminars on the Integrated Decision Support System (IDSS) at Institute of Engineering, Pulchowk campus, Tribhuvan, Nepal. He will meet with

Activity teams from CSISA to review modeling progress, data requirements and next actions, including model set-up, parameterization, calibration, validation and scenario analysis. The Activity has also planned participation in stakeholder workshops to discuss and finalize modelling scenarios is during Dr. Avay's visit.

4.2 Iteratively develop and complete a sustainability and scaling framework for inclusive irrigation development in Nepal's Feed the Future Zone

Conducted in close dialogue with public and private sector stakeholders, this activity is the ultimate product of Objective II and will identify plausible and equitable irrigation and water development pathways for Nepal's Feed the Future Zone. This activity is working to develop a Nepal-specific sustainable and inclusive scaling framework for irrigation development to: (a) cooperatively identify high-potential locations for public and private sector interests and incentives to overcome systemic barriers and strengthen sustainable water governance, thereby working to increase farmer's resilience and de-risk private sector agricultural investments. Such efforts also link the IDSS model setups and run analyses to incorporate learnings on the policy implications of changes in farming practices that result from the COVID-19 crisis and other stresses. This work will also (b) initiate regular multi-stakeholder dialogues to support sustainable irrigation and agriculture development.

Activity 4.2 builds on all prior Work Packages and Activities in Objective 2 of the CSISA COVID-19 Resilience Activity. As described above, the necessary work needed to prepare to begin Activity 4.2 was undertaken during the reporting period. Activity 4.2 itself is scheduled to commence from April of 2021 forward, and as such, details on progress will be provided in the 2020-2021 Annual Report.

6. Challenges Faced During the Reporting Period

CHALLENGES IN BANGLADESH AND NEPAL UNDER CSISA III

As reported in the last Annual Report, COVID-19 has caused significant modifications in workplans and activities in Bangladesh, even outside periods of formal lockdown. Staff mobility completely ceased and alternate work modalities were implemented throughout the reporting period in both Nepal and in Bangladesh. All in-person training programs, demonstrations, video shows and other field related programs were postponed or modified to include small groups of less than 10 people only in open air settings. Staff attended office only on a rotational basis and all meetings were moved to virtual platforms. As reported in the Annual Report last October, CSISA continued to remain appropriately cautious in engagement with partners in any other way than through virtual meetings. A number of key staff in both Nepal and in Bangladesh also experienced COVID-19 infections, though have now recovered. A number of staff however lost family members, which took a toll on their ability to work effectively due to mental and emotional duress. At the time of writing, both Bangladesh and Nepal were also entering into a second wave of COVID-19, indicating that these challenges are likely to continue for some time. Further detail on the implications of COVID-19 in the USAID/Nepal Mission buy-in are provided below.

Challenges specific to the CSISA-COVID-19 response and resilience activity

Objective I

- Screening and identification of potential returned migrant workers has remained a challenging and time-consuming task. A majority of migrant workers contacted preferred to find a fixed job or other business, including work in the agricultural sector such as poultry or goat raising, and high-value vegetable farming.
- Despite all the efforts from the activity to enable the vulnerable migrant workers to purchase required machinery and link with multiple banks, the perceived high risk for banks to lend in this sector and the high cost of processing and managing these loans has led banks to demand extraordinary levels of documentation and collateral. This is interfering with access to credit for potential service providers in rural communities.
- A majority of farm machinery types in the past have been promoted in villages through various subsidy programs. Many of the returned migrant workers interested to take up farm machinery service businesses are hesitating to invest, expecting some subsidy in the near future.

Objective II

- The challenges encountered related to data and COVID-19. The activity team found a lack of reliable hydrological data at multiple stations in the working areas (lack of recent hydrologic observation data and lack of reliable hydrologic data at seasonal river gauges). In addition, communication among different project partners has been limited through the lack of in- person engagement and the time zone differences for virtual meetings. More specifically, COVID-19 reduced the potential for in person workshops for scenario development among different stakeholders and project team members at local, provincial, and federal level, and virtual workshops conducted at different level were not as effective as in person. Therefore, the scenarios are not yet finalized at the time of writing.

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 Activity**. 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 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, (5) support the development of a Bangladesh standing multi-threat pest emergency taskforce, and (6) 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 1 October 2019. It has three main objectives, namely, to (1) increase the competitiveness and efficiency of domestic and private sector-led agricultural machinery manufacturing, assembly, use and servicing, (2) enhance institutional capacity for agricultural mechanization through the development of a skilled and youth workforce, and (3) facilitate the 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

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

manufacture of agricultural machines and spare parts. 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.

- **The Nepal Seed and Fertilizer (NSAF) project** (2016–21) is a USD15 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: (1) greater climate-smart intensification of staple crops and diversification into higher value commodities, (2) strengthening local market systems to support more competitive and resilient value chains and agricultural related businesses, and (3) 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 Feed the Future Nutrition Innovation Lab**. The FtF 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 of the Lab and conducts research in close partnership with several US university partners. CSISA collaborates with the Nutrition Innovation Laboratory in the analysis of survey data and modeling of the intrahousehold nutritional status implications of agricultural development interventions in Bangladesh.
- **The Feed the Future Sustainable Intensification Innovation Lab (SIIL)**. 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 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 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 DAE, under the Ministry of Agriculture, is to provide eco-friendly, safe, climate resilient and sustainable productive good agricultural practices while sustaining natural resources, to ensure food security as well as commercial agriculture, with a view to accelerating the country's socioeconomic development. DAE's mission is to provide efficient, effective, decentralized, location-specific, demand-responsive and integrated extension services to all categories of farmer, supporting them to access and utilize better knowhow to increase sustainable and profitable crop production. CSISA collaborates widely with DAE on a range of initiatives and activities in Bangladesh, detailed in this report.
- **University of Manchester, UK**. Since 2019, CSISA has collaborated in a research capacity with Dr Tim Foster, lecturer in Water-Food Security at University of Manchester to optimize the technical and social acceptability of irrigation in the Terai of Nepal.
- **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 chapters 2 and 3. Please see Appendix 2 for more details on project subcontractors and key partners.

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Appendix 2: Project Subcontractors and Key Partners

BANGLADESH

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Government of Bangladesh				
Bangladesh Agricultural Research Institute (BARI)	Development, validation, and refinement of technologies and new research methods, boosting scaling capacity	Innovation towards impact	With a network of regional research stations and strong input into the development of extension materials, approaches and 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.
Bangladesh Rice Research Institute (BRRI)	Development, validation, and refinement of technologies and new research methods, boosting scaling	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, BRRI also provides leveraging opportunities to mainstream sustainable intensification innovations in the	The International Rice 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.

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	capacity		Government of Bangladesh's National Agriculture Research System.	
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 Activity in Bangladesh in the Feed the Future zone and Dinajpur hub. The sensitization of DAE agents to 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 Activity continues to collaborate with DAE informally and synergistically, despite funding cuts. The volume of activities was reduced in the reporting period due to the Activity's inability to support large field campaigns and collaborative meetings with DAE. CIMMYT also worked with DAE through CSRD and USAID/Bangladesh mini-grant on wheat blast that closed in September 2019. As a part of project activities, DAE works with CIMMYT to disseminate better bet agronomic practices. In this period, DAE spread messages developed by CIMMYT, BARI and BWMRI on EWS and fighting wheat blast, fighting back against FAW 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 screenings and training on healthy rice seedlings and early wheat sowing in 2020. The Activity is exploring further opportunities to work with AIS to disseminate better bet practices among farmers.
Bangladesh Meteorological Department (BMD)	Conduct collaborative research and development activities related to weather, agro-climatology and	Achieving impact at scale	BMD provides clientele services related to weather and climate to more than 100 national and international organizations. It has a network of meteorological stations across the country, and BMD-generated weather forecasts are used in the	BMD completed a sub-grant during 2017–19. After completion, the collaboration continues under the Memorandum of Understanding signed on September 15, 2019.

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	climate services, and undertake programs for strengthening the capabilities and dissemination of useful research findings, advisories and technologies within Bangladesh.		field of agriculture by GOs and NGOs to provide agro-meteorological advisory services to farmers.	
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.
The 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.
Advanced Chemical	Sale of scale-appropriate machinery, fungicides, weed	Achieving impact at	Import of sustainable intensification scale-appropriate machinery and sales through the private sector, along with a range of chemical and cereal	The commercial joint venture agreement with this firm was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Industries (ACI)	control products and seed. IRRI works with ACI to produce a range of hybrid and open-pollinated rice seeds	scale	seed products.	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 other biological products against the invasive pest Fall Armyworm	Achieving impact at scale	There are 10+ activities (ToT for sales team, video development and screening, promotional material development and disbursement, crop consultant program, IPM championship program, educational and marketing campaign, dealers, retailers and farmers training, advertisements such as those put out by road shows) included in the agreement, aimed at rapid commercialization of the product.	The 1:1 matched fund agreement with this company started on August 2020 and will continue till June 2021.
Syngenta Bangladesh Limited	Awareness raising to assist in the rapid commercialization of Fortenza 60FS (Cyntraniliprole) 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 June 2021.
Auto Crop Care Limited (ACCL)	Commercialization of safe and less toxic	Achieving impact at	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

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	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.	scale		(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 subcontractor)	Facilitates village screenings of training films and conducts follow-up studies	Achieving impact at scale	The Activity worked with AAS in Phase II and CSISA-Bangladesh to reach 110,000 farmers with village training video screenings accompanied by 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.	AAS works under project sub-grants to conduct village-level video shows and on training farmers on core CSISA topics. In the previous 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	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

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
			threat of fall armyworm.	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 Crop Sciences, University of Illinois at Urbana-Champaign (UIUC)	Strategic research on precision nutrient and rice crop management	Innovation towards impact	The project leader is an active academic committee member for Shah-Al Emran, a Bangladeshi PhD student at this university. Emran is working towards the production of two manuscripts using CSISA data.	Ongoing successful 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.

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
Projects				
Sustainable and Resilient Farming Systems Intensification in the Eastern Gangetic Plains (SRFSI)	Extending CSISA technologies to areas of northern Bangladesh	Achieving impact at scale	CSISA's experiences in scaling up resource conserving technologies in Bangladesh are an asset 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.	Active partnership since 2014
Cereal Systems Initiative for South Asia – Manufacturing Systems Activity (CSISA-MEA)	CSISA-MEA will support Bangladeshi manufacturing firms to (1) develop well-structured business cases that describe the business problem and opportunities to be addressed, (2) articulate alternative solutions, (3) identify potential costs and benefits, and (4) 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: (1) larger companies with dealership networks that will adopt a business model to assemble machines from parts made by smaller companies (OEM-supplier network), (2) larger manufacturing firms venturing into the domestic manufacture, assembly and/or spare parts production of more complex agricultural machines, such as combine harvesters, (3) all sized firms that will domestically manufacture a wider range of spare parts as a means to reduce dependency on expensive imported parts, and (4) 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	Active since 2019

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
			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 direct-seeded rice aligning with CSISA MEA Objective 4.	
Rice and Diversified Crops (RDC) Activity	RDC is led by ACDI-VOCA and is working to (1) improve food security through systemic changes that increase rural incomes, (2) increase farm productivity, and (3) 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 USD100 million.	Active and sanctioned by CIMMYT's host country agreement
Nepal Agricultural Research Council (NARC)	Strategic and applied research on sustainable intensification technologies, crop diversification, and crop management practices	Innovation towards impact	NARC is responsible for providing the scientific basis for all state recommendations, their endorsement and the ownership of emerging sustainable intensification technologies.	Active and long-standing
Provincial government	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 government	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-	Achieving impact at scale	The rapid expansion of investments in scale-appropriate machinery and support for emerging	Initiated in first half of project year 2018/19

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	harvesters in Dang (Province 5)		service provision markets.	
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
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	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

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	seed enterprises in Nepal			
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
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 USD20 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 (USD 15m for 2016–21) 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

Appendix III: Priority agricultural machineries suitable for service provision and encouraged by the Activity for bank loans in rice-wheat and rice-maize cropping systems in Nepal's Feed the Future Zone.

Priority Machineries list for Rice-Wheat Cropping System.

1. Power Tiller
2. Minitiller
3. Tractor
4. Diesel Engine Pumpset
5. Self-Propelled Reaper
6. Trailer
7. 2WT operated Reaper
8. Rice Mill
9. Rice Thresher
10. Wheat Thresher
11. Harrow

Priority Machineries list for Rice-Maize Cropping System.

1. Power Tiller
2. Minitiller Weeder
3. Tractor
4. Diesel Engine Pumpset
5. Self-Propelled Reaper
6. Trailer
7. 2WT operated Reaper
8. Rice Mill
9. Rice Thresher
10. Maize Sheller.
11. Maize Planter

Summary on the Prioritized Machinery for Rice-Wheat Cropping System.

S.N.	Name of Machinery	Price per machine (NRs)	Estimated number of Machinery in Ftf Zone	Average capacity of each machinery per day in Ha	Life span of the machinery in years (estimated)	Machinery Use cost (NRs/h)	Pay Back Period in Years	Operational requirements
1	Power Tiller (2WT)	200000	9000	1.3	10	500	2.25	No
2	Mini tiller (diesel)	80000	1000	0.8	5	600	0.48	No
3	Tractor (4WT)	1500000	10000 above	4	20	1200	4.31	No
4	Diesel Pumpset	35000	10000 above	1	15	300	0.8	No
	Electric Pumpset	20000		0.3	10	100		No
5	Reaper (Self-Propelled)	160000	200	1.2	8	600	2.2	No
6	Trailer (2WT)	80000	5000 above	-	15	600	0.33	2WT
	Trail (4WT)	250000	10000 above	-	15	1250	0.5	4WT
7	Reaper (Two Wheeled Tractor Mounted)	50000	1835	1.6	5	600	0.45	2WT
8	Rice Mill							No
9	Rice Thresher (Four Wheeled Tractor Operated)	335000	10000 above	4	15	1500	2.4	Tractor
10	Wheat Thresher (4WT operated)	250000	10000 above	4	15	1500	1.6	Tractor
11	Harrow (tilling equipment for 4WT)	65000	10000 above	4	15	1200	0.24	Tractor

Summary on the Prioritized Machinery for Rice-Maize Cropping System.

S.N.	Name of Machinery	Price per machine (NRs)	Estimated number of Machinery in Ftf Zone	Average capacity of each machinery per day in Ha	Life span of the machinery in years (estimated)	Machinery Use cost (NRs/h)	Pay Back Period in Years	Operational requirements
1-9	Same as above							
10	Maize Sheller (electric)	15000		4	5	100	1.23	No
11	Maize Planter (4WT operated)	200000	20 above	4	15	1500	1.8	Tractor

Power tiller (PT)

- Machine cost: - NRs 200000.
- Machine field capacity(ha/day): 1-2 ha depending upon field conditions and operator
- Machine service cost (NRs/ha on average): NRs3000
- LSP profit for service (NRs/ha on average): NRs 1100
- Number of days per year that each machine can be used for: 60 days per year (two seasons in a year)
- Time required for LSPs to break even on investments in the machine: 2.26 years

Mini-Tiller (MT) (Though this machine in general not used for service provision it is most essential for commercial vegetable farmers):

- Machine cost: - NRs 80000.
- Machine field capacity (ha/day in average): 0.8 ha
- Machine service cost (NRs/ha on average): NRs 6000
- LSP profit for service (NRs/ha on average): NRs 3416
- Number of days per year that each machine can be used for: 60 days per year (two seasons in a year)
- Time required for LSPs to break even on investments in the machine: 0.49 years

Tractor, four wheeled (4WT)

- Machine cost: - NRs 1500000.
- Machine field capacity (ha/day in average): 4 ha
- Machine service cost (NRs/ha on average): NRs 2400
- LSP profit for service (NRs/ha on average): NRs 740
- Number of days per year that each machine can be used for: 60 days per year (two seasons in a year)
- Time required for LSPs to break even on investments in the machine: 4.31 years

Diesel Engine Pump sets

(Those who have electricity might buy electric pump sets)

- Machine cost: - NRs 35000 for 5hp pump.
- Machine field capacity(ha/day): 0.5-1ha.
- Machine service cost (NRs/ha on average): NRs 2400, 8 hours a day.
- LSP profit for service (NRs/ha on average): NRs 1450/ha.
- Number of days per year that each machine can be used for: 30 days per year (two seasons per year)
- Time required for LSPs to break even on investments in the machine: 0.79 year

Reaper (Self-propelled):

- Machine cost: - NRs 160,000
- Machine field capacity(ha/day): 1.2
- Machine service cost (NRs/ha on average): NRs 4650, 8 hours a day.
- LSP profit for service (NRs/ha on average): NRs 2416/ha.
- Number of days per year that each machine can be used for: 40 days per year (two seasons per year)
- Time required for LSPs to break even on investments in the machine: 1.4 year

Trailer

- Machine cost: - NRs 80000 for 2WT Trailer.
- Machine field capacity(ha/day): not applicable
- Machine service cost (NRs/ha on average): not applicable but NRs 600/h.
- LSP profit for service (NRs/ha on average): not applicable but NRs 373/h.
- Number of days per year that each machine can be used for: 80 days per year (8 hours per day) considering eight months per year with at least 10 days per month.
- Time required for LSPs to break even on investments in the machine: 0.34 year

Reaper (Power tiller operated/mounted)

- Machine cost: - NRs 50,000
- Machine field capacity(ha/day): 1.6
- Machine service cost (NRs/ha on average): NRs 3000,
- LSP profit for service (NRs/ha on average): NRs 1726/ha.
- Number of days per year that each machine can be used for: 40 days per year (two seasons per year)
- Time required for LSPs to break even on investments in the machine: 0.45 year

Rice Mill (Electric/Diesel operated)

- Machine cost: - NRs
- Machine field capacity(ha/day):
- Machine service cost (NRs/ha on average): NRs
- LSP profit for service (NRs/ha on average): NRs.
- Number of days per year that each machine can be used for: days per year (two seasons per year)
- Time required for LSPs to break even on investments in the machine: year

Rice Thresher (4WT operated):

- Machine cost: - NRs 335000.
- Machine field capacity(ha/day): 4
- Machine service cost (NRs/ha on average): NRs 3000
- LSP profit for service (NRs/ha on average): NRs. 1145
- Number of days per year that each machine can be used for: 30 days per year (one season per year)
- Time required for LSPs to break even on investments in the machine: 2.43 year

Wheat Thresher (4WT operated):

- Machine cost: - NRs 250000.
- Machine field capacity(ha/day): 4
- Machine service cost (NRs/ha on average): NRs 3000
- LSP profit for service (NRs/ha on average): NRs. 1300
- Number of days per year that each machine can be used for: 30 days per year (one season per year)
- Time required for LSPs to break even on investments in the machine: 1.6 year

Electric Maize Sheller

- Machine cost: - NRs 15000
- Machine field capacity(ha/day): 0.5
- Machine service cost (NRs/ha on average): NRs 1600.
- LSP profit for service (NRs/ha on average): NRs 890.
- Number of days per year that each machine can be used for: 30 days per year (8 hours per day) considering one season per year.
- Time required for LSPs to break even on investments in the machine: 1.12 years

4WT operated Maize Sheller:

- Machine cost: - NRs
- Machine field capacity(ha/day):
- Machine service cost (NRs/ha on average): NRs
- LSP profit for service (NRs/ha on average): NRs.
- Number of days per year that each machine can be used for: days per year (8 hours per day) considering two seasons per year.
- Time required for LSPs to break even on investments in the machine: year

Disc Harrow (4WT operated):

- Machine cost: - NRs 65000.
- Machine field capacity(ha/day): 4
- Machine service cost (NRs/ha on average): NRs 2400
- LSP profit for service (NRs/ha on average): NRs. 1140
- Number of days per year that each machine can be used for: 60 days per year (8 hours per day) considering two seasons per year.
- Time required for LSPs to break even on investments in the machine: 0.24 year

Maize Planter (4WT operated):

- Machine cost: - NRs 200000.
- Machine field capacity(ha/day): 4
- Machine service cost (NRs/ha on average): NRs 3000
- LSP profit for service (NRs/ha on average): NRs. 1375
- Number of days per year that each machine can be used for: 20 days per year (8 hours per day) considering one season per year.
- Time required for LSPs to break even on investments in the machine: 1.8 years

CEREAL SYSTEM INITIATIVE FOR SOUTH ASIA - CSISA III

WWW.CSISA.ORG

The Cereal Systems Initiative for South Asia (CSISA) was established in 2009 with a goal of benefiting more than 8 million farmers by the end of 2022. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI), the International Rice Research Institute (IRRI) and the International Water Management Institute (IWMI). 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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