Cereal Systems Initiative for South Asia
Phase III

— Building Resilience in South Asia's Cereal Systems —

Semi-Annual Report
September 30, 2018 to March 31, 2019

CSISA

Funded by

Partners

Contents

Abbreviations

2WT	two-wheel tractor
AAS	Agricultural Advisory Society
ACDI/VOCA	Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance
ACI	Advanced Chemical Industries
AIRN	Agriculture Inputs Retailers' Network
AIS	Agricultural Information Services
BARI	Bangladesh Agriculture Research Institute
BMGF	Bill and Melinda Gates Foundation
BRRI	Bangladesh Rice Research Institute
BWMRI	Bangladesh Wheat and Maize Research Institute
CABI	Centre for Agriculture and Bioscience International
CART	Classification and Regression Tree
CEO	chief executive officer
CGIAR	*formerly the* Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CNFA	Cultivating New Frontiers in Agriculture
CSISA	Cereal Systems Initiative for South Asia
CSISA-MI	CSISA-Mechanization and Irrigation
CSRD	Climate Services for Resilient
CSRD	Climate Services for Resilient Development
DAE	Department of Agricultural Extension
DAP	diammonium phosphate
DoA	Department of Agriculture
DSR	direct-seeded rice
FtF	Feed the Future
FY	fiscal year
GCAN	Gender, Climate Change and Nutrition Integration Initiative
GIS	geographic information system
GoN	Government of Nepal
ha	hectare
iDE	International Development Enterprises
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IRC	irrigated crops
IRRI	International Rice Research Institute

IWM	integrated weed management
JVA	joint venture agreement
KISAN	Knowledge-based Integrated Sustainable Agriculture and Nutrition project
N	nitrogen
NAMTRC	Nepal Agricultural Machinery Testing and Research Centre
NARC	Nepal Agricultural Research Council
NARES	National Agriculture Research and Extension System
NCE	no-cost extension
NDVI	Normalized Difference Vegetative Index
NGO	non-governmental organization
NSAF	Nepal Seed and Fertilizer project
PERSUAP	Pesticide Evaluation Report and Safer Use Action Plan
PMAMP	Prime Minister Agriculture Modernization Project
PQR	premium quality rice
RDC	Rice and Diversified Crops project
RFC	rainfed crops
SRFSI	Sustainable and Resilient Farming Systems Intensification in the Eastern Gangetic Plains
Std	standard
UIUC	University of Illinois at Urbana-Champaign
USAID	United States Agency for International Development
USG	urea super granule

Executive Summary

Intensive agricultural systems that include rice, wheat and/or maize as key crops are widespread throughout South Asia. The cultivation of these cereal crops constitutes the main economic activity in many rural areas and provides staple food for hundreds of millions of people. The decreasing rate of growth of cereal production in South Asia is therefore of great concern. Simultaneously, issues of resource degradation, declining labor availability and climate variability pose steep challenges for improving food security and rural livelihoods.

With the support of USAID and the Bill and Melinda Gates Foundation, the Cereal Systems Initiative for South Asia (CSISA) was established in 2009 with the goal of increasing the productivity and resilience of millions of farmers by the end of 2020. CSISA is led by the **International Maize and Wheat Improvement Center (CIMMYT)** and is implemented jointly with the **International Food Policy Research Institute (IFPRI)** and the **International Rice Research Institute (IRRI)**, in addition to numerous public and private sector partners. Operating in rural 'innovation hubs' in 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. CSISA supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills. In synergy with regional and national efforts, CSISA collaborates with many public, civil society and private-sector partners. The project has over time developed into a more comprehensive research for development program with a number of additional investments by USAID/Washington and the USAID Missions in Nepal and Bangladesh to deepen the overall scope and impact of CSISA's work.

This report focuses on the current third phase (2015–2020, CSISA III) of the 'base' or 'original' set of CSISA investments[1]. The third phase is focusing on USAID's support to activities in Nepal and Bangladesh, where CSISA is supporting partners in the public and private sectors to be better able to contribute to sustained change by addressing areas of systemic weakness (as described in the opening paragraph above). By addressing these areas and fostering new connections and collaborative efforts across the innovation system, CSISA is seeking to mainstream elements of its approach and to ensure a successful exit at the termination of Phase III.

BANGLADESH HIGHLIGHTS

- Raising healthy rice seeds can improve crop productivity and resilience to environmental stresses and transplant shock. Partnering with the NGO Agricultural Advisory Society, **CSISA showed healthy rice seedling videos to 59,015 farmers** in 794 village-level field screenings across 16 Feed the Future zone districts in Bangladesh in this reporting period. A follow-up survey conducted by the project during the early 2018/19 winter rice season found that **63% of the farmers who saw the videos had begun practicing at least three newly learned techniques** to raise healthy rice seedlings in their own fields.
- Fall armyworm is an invasive species and a global threat. It infests a wide range of crops, but favors maize. It first appeared in South Asia in India in mid-2018. By November 2018, the pest had migrated to Bangladesh and was found in the Feed the Future zone. In late 2018, the project translated and dubbed over farmer-educational videos on fall armyworm into Bengali. In December 2019, these videos were supplied on pen drives to 200 Department of Agricultural Extension

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

(DAE) officials to raise awareness. During the reporting period the project took emergency action and **CSISA worked with the Agriculture Inputs Retailers' Network (AIRN) to train 755 agricultural retailers on integrated pest management principles** for controlling fall armyworms. Starting in February 2019, the project along with the Agricultural Advisory Society (NGO) started an awareness raising and training program for farmers in maize growing districts, during which the above videos were shown and leaflets and infographics distributed. **13,057 (33% women) farmers had seen fall armyworm educational videos and participated in 238 informal trainings** by the time of reporting. Lastly, CSISA has begun collaborating with USAID's fall armyworm task force and is working towards the implementation of a trainers of trainers program for DAE staff in October 2019 prior to Bangladesh's main maize growing season.

- During the reporting period, the CSISA project refocused research activities to support gender justice and equity in rural development. The project, partnered with the Gender, Climate Change and Nutrition Integration Initiative (GCAN), funded by USAID/Washington and led by the International Food Policy Research Institute, released a **report on the gender and development implications of multi-crop reaper-harvester service provision in Bangladesh**. The report is available online and has important policy implications for addressing social norms in support of women's rural entrepreneurship and technology adoption in South Asia's smallholder dominated rural economies.
- The CSISA project continued its robust collaboration with the Bangladesh Maize and Wheat Research Institute (BWMRI) by issuing factsheets and running other awareness raising activities to encourage farmers to adopt crop management and variety recommendations to reduce the threat of wheat blast. Luckily, the comparatively cooler and drier climate during the 2019 wheat flowering stage limited wheat blast sporulation and disease spread in the FtF zone. The project continued to work with BWMRI and conduct collaborative research to verify agronomic control methods (cultivar mixtures and efficacy of foliar fungicides) to mitigate wheat blast yield loss, and to assist in developing an early warning system for wheat blast (collaboratively with the USAID funded Climate Services for Resilient Development [CSRD] in South Asia project). **Demonstrations were conducted with newly released blast resistant and zinc-enriched BARI Gom 33 wheat in collaboration with BWMRI** and the DAE, during which seed of this variety was distributed to farmers for multiplication.
- In partnership with the Bangladesh Rice Research Institute (BRRI), **CSISA is in the process of implementing adaptive research experiments on direct-seeded rice (DSR)** to identify agronomic methods and varieties that can help overcome some of the challenges associated with DSR. CSISA and BRRI scientists are implementing multi-locational experiments in farmers' fields to determine the agronomic and economic advantages of DSR established by broadcasting compared to drilled by machine and hand transplanted, and to identify suitable land types for DSR in Rangpur and Jhedeniah Divisions.
- To help identify how farmers can benefit from growing premium quality rice varieties, **CSISA has implemented research on ways to improve the flow of benefits from premium quality rice to farmers** that is now being implemented northern and southern Bangladesh. This includes (i) using qualitative and quantitative tools to assess the value chain to identify intervention points that could improve profitability to farmers and associated market actors, and (ii) supply-side factor research and testing the intensification hypothesis that farmers with access to markets are compelled to make use of improved agronomic practices.
- Integrated weed management (IWM) is both a challenge and opportunity for rice farmers. To help disseminate IWM principles, **the project partnered with the Agricultural Input Retailer's Network in late 2018 to train 250 input dealers on** identifying weed species, selecting herbicides for weed control, and on the use of knapsack sprayers, sprayer calibration and the

selection of agrochemicals considering human and environmental health. During the 2018/19 boro season, the project started new research with the Bangladesh Rice Research Institute (BRRI) to identify high yielding and weed competitive rice cultivars to strengthen the integrated weed management framework. The study will determine the ability of popularly grown rice varieties to compete with weeds under transplanted and direct-seeded rice at two locations with 14 high yielding rice varieties including three hybrids.

- In collaboration with the Agricultural Advisory Society (AAS) NGO and the Government of Bangladesh Agriculture Information and Communication Center (AICC), **an educational video on the benefit of early wheat sowing was shown to 116,000 farmers (76% male, 24% female).** The project also developed informational leaflets on early wheat seeding and **distributed 34,059 leaflets** to farmers to raise awareness about the benefits of the early seeding of wheat. Data collected at the time of wheat seeding from DAE record books and a telephonic survey of farmers who had attended video shows found that such **wheat farmers has seeded wheat earlier on over 4,523 ha** in CSISA's working locations.

NEPAL HIGHLIGHTS

- CSISA continues to provide **technical support and backstopping to the Prime Minister Agricultural Modernization Project (PMAMP),** an initiative run by the Ministry of Agriculture and Livestock Development (MoALD). PMAMP works with farmers in their fields to test the feasibility of direct-seeded rice sown by two- and four-wheel tractors in early season spring rice, an activity that assists PMAMP in achieving its rice production objectives.
- From 26-28 March 2019, the project invited **over 40 national and international delegates to observe the spread of large and small sized mechanized grain harvesting** machinery in farmers' fields in Rupandehi, Dang, Bardiya and Kailali districts in Nepal. The seminar shared lessons around the increasing numbers of mechanized grain harvesting choices for Nepal's farmers including large horsepower combine harvesters and the smaller self-propelled reapers and reaper binders. In addition, the project highlighted the **commercial success of the 3,000 two-wheel tractor reaper harvesters** that have been purchased in the Far West through the efforts of CSISA, the Department of Agriculture (DoA) and their private sector partners over the last four years.
- In CSISA Phase II and the early months of the current Phase III, the project introduced the use of mini-tillers for weeding the spaces between maize rows in Nepal. In early 2019, with the reestablishment of a project field office in Dang, the project organized a **two-day training on mini-tiller weeding operation and maintenance for 32 women members of the 16 custom hiring centers, which are managed by PMAMP** in the Dang Maize Super Zone.
- CSISA continues to use the Open Data Kit (ODK), a digital data collection tool that can be run on a smartphone or tablet, and that is being used to conduct farmer surveys, gather information on cereal crop management practices, machinery adoption and agronomic management trainings, in addition to farmer adaptation and adoption. Around **5,000 observations of farmer crop management** practices in CSISA working areas have been collected and stored on the server. Analysis indicates that **rainfall, fertility management and irrigation timing are key variables affecting rice yields**. Considering wheat, the application of machine learning analyses indicates that identified **sowing date, proper nitrogen application and weed management are the three most important drivers of wheat yield**. These results are being used to fine-tune CSISA's media and training materials to focus activities on the key interventions that can improve the productivity of the cereal systems in Nepal's Terai. The results were subsequently disseminated to PMAMP and other stakeholders during informational meetings and cross-learning sessions held in Province 5 and the Far Western Province in early 2019.

- With the collaboration with PMAMP being a project priority, **CSISA re-opened its field office in Lamahi, Dang in February 2019**. Project staff are now working to scale-out successful technologies like mechanized seeding and weeding through networks of provincial agriculture entities bodies agricultural knowledge centers (*krishi gyan kendras*) and local agriculture service centers. As a part of these efforts, the project demonstrated mechanized maize seed drills in Western Dang during the reporting period to the **Province 5 Minister of Land Reform, Agriculture and Cooperatives**.
- Meetings and discussions with PMAMP super zone members and the Department of Agriculture's Post Harvest Section led to **PMAMP procuring a mechanical dryer, which will be tested for efficacy in reducing aflatoxin** after the summer maize harvest in Dang Maize Super Zone.

POLICY REFORM HIGHLIGHTS

- The **CSISA project is now placing a greater focus on strengthening soil fertility management and fertilizer policies in Bangladesh**. The country is a net importer of urea, phosphate and potash fertilizers, importing as much as 70% of its total urea each year. In early 2019, the project began gathering and collating existing secondary data to chart the trends in applications over crops, seasons and regions. These trends will help identify the rates of application to document the extent of the over and under-application of key nutrients in various parts of the country, providing valuable insights for policy recommendations.
- CSISA continued collaborations with the Nepal Seed and Fertilizer project (NSAF), other USAID/Nepal Mission supported projects, the private sector, the Department of Agriculture and NARC to monitor and assess the impacts of the spread of mini-tillers for agricultural mechanization in Nepal's Midhills. The project's analysis revealed that **the use of mini-tillers increased rice productivity by 1,110 kg/ha (27%) in the Midhills,** and that **very small farms (≤0.25 ha) that adopted mini-tillers benefited the most in terms of rice productivity gains**. The study recommended a significant reduction in the price of mini-tillers to increase adoption in Nepal's Midhills.
- Additional collaboration with NSAF in Nepal yielded a **CSISA policy brief**[2] **on a willingness to pay for fertilizer study carried out on 600 farmers across Nepal's Midhills and Terai**. The results lead CSISA and NSAF to recommend i) a voucher program to provide support for increased access to fertilizer markets and quality fertilizers, ii) reducing the barriers to the private sector supplying fertilizers, and iii) the improved geographic targeting of appropriate fertilizer blends and types that respond to soil nutrient deficits.

Note: This report reflects a period during which project funding was uncertain and reduced, which led to delays and cut-backs in implementing planned activities. Although funding was supplied by USAID in late 2018 for the third fiscal year (FY) of activities, funds came more than nine months after their anticipated date. Funds were also 30% less than anticipated based on the CSISA Phase III proposal budget. This follows a 41% shortfall in the project's second year (FY 2017) of activities. As a result, most of the activities implemented by CSISA in Nepal and Bangladesh in FYs 2017 and 2018 were suspended or shrunk as the project was unable to retain all its staff. To date (May 2019), CSISA has received only 52% of the overall five-year planned budget, despite being half way through the third year of implementation of the five-year project. This report reflects this status.

[2] Please click on links to access the document in question

Context, Approach and Theory of Change

Since the food price crisis of 2007–08, agricultural research and development efforts in the developing world have received considerable public, private sector, and donor investment. In South Asia, attention has focused on the impoverished areas of the Eastern Indo-Gangetic Plains where cereals feed over half a billion people (Figure 1). Nevertheless, investments in agriculture have been less adept at supporting transformative change than originally anticipated. While progress has been made on addressing some of the systemic weaknesses that contribute to low rates of rural development and agricultural productivity, 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.

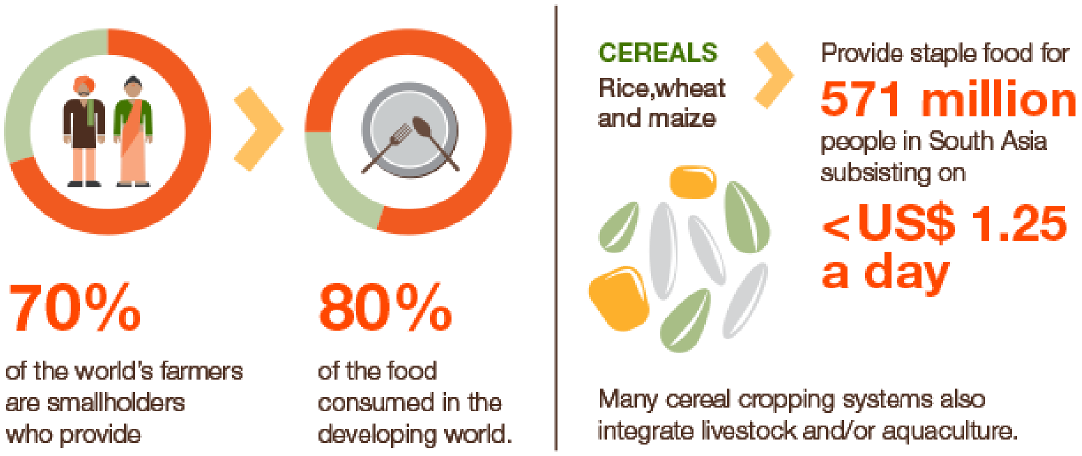


Figure 1: CSISA focuses on raising the productivity and resilience of smallholder farmers in South Asia's most important cereal farming areas

Layered onto these dynamics are the risks inherent in cropping in areas where weather patterns are erratic, water resources are poorly developed, heat stress is a binding constraint, and timely field operations are often compromised by a diminishing supply of rural labor. Despite these shortcomings and production challenges, there is considerable promise that the many individual strengths within the innovation system[3] in South Asia can be marshaled and coordinated to spur 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 project has developed into a program of investments in Bangladesh, India, and Nepal with a number of synergistic side-investments provided mainly by USAID's Missions in Bangladesh and Nepal (Figure 2).

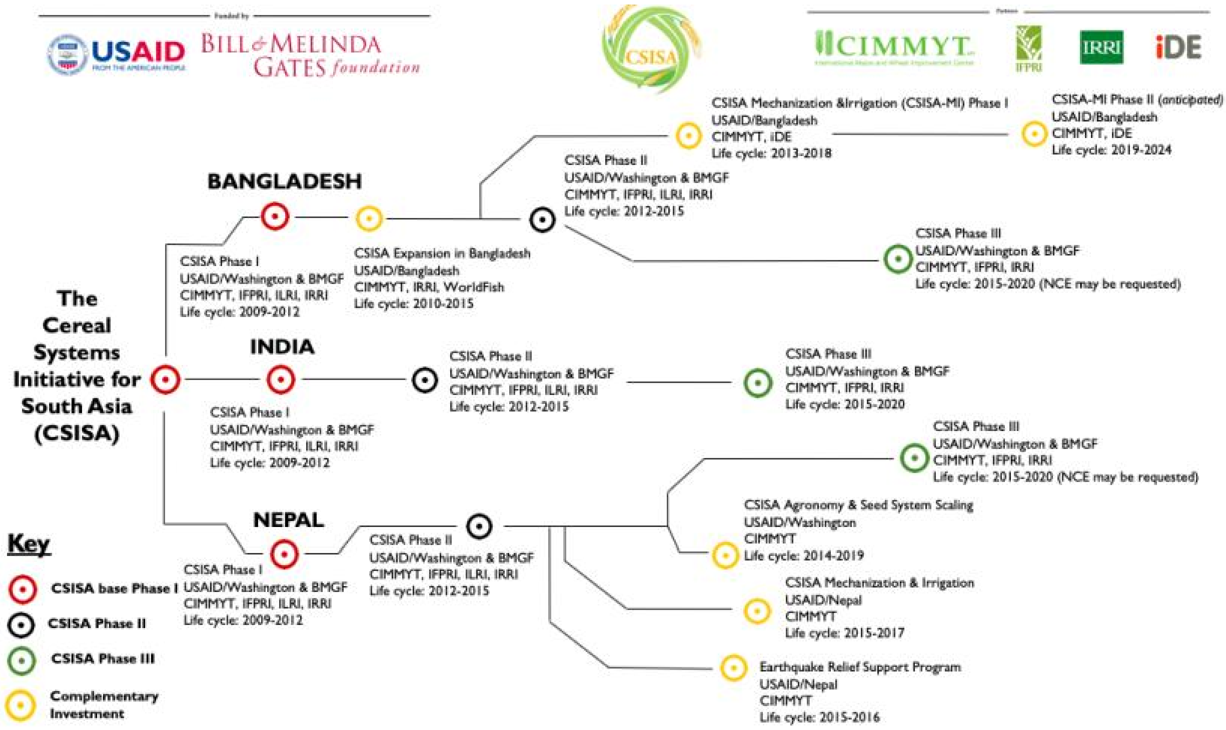


Figure 2: Evolution of USAID and Bill and Melinda Gates Foundation (BMGF) investments in the overall CSISA program in Nepal, Bangladesh and India since 2009 indicating core CGIAR and INGO partners

CSISA aims to use sustainable intensification technologies and management practices to enhance the productivity of cereal-based cropping systems, increase farm incomes, and reduce agriculture's environmental footprint.[4] As a science-driven and impact-oriented initiative, the project is positioned at

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

[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 out comes 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.)

the intersection of a diverse set of partners in the public and private sectors, occupying the crucial middle-ground where research meets development. 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.

1. Bangladesh – Achievements

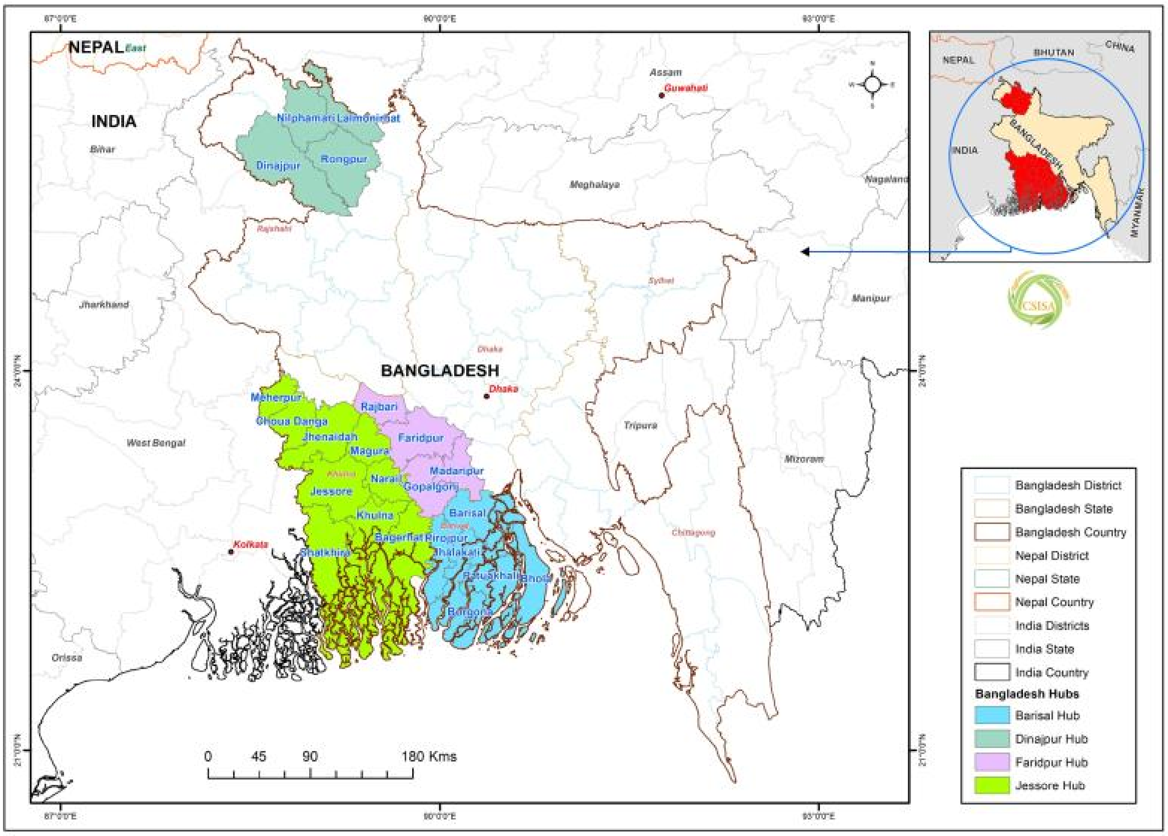


Figure 1.1: CSISA implements research for development activities in Bangladesh's USAID Feed the Future (FtF) Zone of Influence (south western Bangladesh) and in Rangpur Division (northern Bangladesh).

A. INNOVATION TOWARD IMPACT

A.1 Reducing risk to facilitate uptake of sustainable intensification practices

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

There is increasing interest in the dry direct-seeding of rice (DSR) in a number of Asian countries as it has the potential to reduce farmers' production costs by saving labor, tillage costs, and in some cases, scarce irrigation water. Where farmers are able to directly sow rice with starter irrigation, the crop is often more resilient to climatic stress as this practice alleviates the dependence of crops on erratic rainfall patterns. In Bangladesh, the scope for direct-seeded rice lies mainly in the pre-monsoon *aus* season (usually sown in April-May and harvested in July–August during the *kharif*-1.[5] This is because the lack of significant early season rainfall in this period enables farmers to sow by broadcasting and/or establishing the crop by sowing with a seed drill – most commonly attached to a two-wheel tractor in Bangladesh – after which starter irrigation can be applied to encourage germination. The crop can then grow to its mid-vegetative stage without being threatened by excessive flooding from the heavy rainfall

[5] See Figure 1.2 for the periods covered by the local terms for seasons and crops mentioned in this report (kharif, rabi, aus, boro, aman)

events that often cause problems for rice grown during the summer monsoon (kharif-II). However, there has only been limited adoption of direct-seeded rice by farmers.

The CSISA project[6] has been working since 2016 with National Agriculture Research and Extension System (NARES) partners, non-governmental organizations (NGOs) and private sector entrepreneurs (especially seed drill owners) in the aus season to promote the adoption of direct-seeded rice. This has entailed systematic research to address constraints to DSR as practiced in farmers' fields rather than in the research stations where most prior DSR work has taken place.

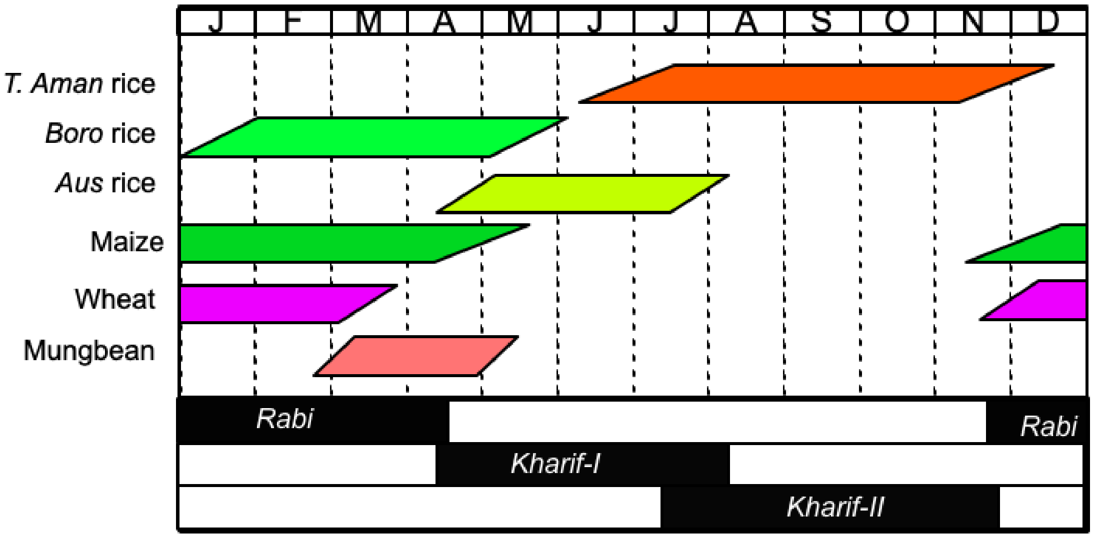


Figure 1.2: The major crops grown in Bangladesh discussed in this report, including the months when they are typically grown during the winter rabi, spring kharif-1 and summer monsoon kharif-II seasons

The scope, opportunities, and challenges of directly seeding rice, and the results of applied research conducted on this topic since the third phase of CSISA began in 2015 have been documented in previous semi-annual and annual reports, which are available in the CSISA report repository. In 2018, research activities on direct-seeded rice were not undertaken because of funding delays and shortfalls from USAID. CSISA's scientists did, however, continue to conduct research on DSR using data collected during the 2016/17 aus crop. Additional results will be presented in the 2018/19 annual report.

In the meantime, CSISA and its national NARES partners planned the following activities, which are primarily research-based and aim to identify ways to overcome constraints to practicing DSR. Field activities will begin at the start of the next reporting period from April 2019 and will continue throughout the 2019 aus season:

- *Performance evaluation study 1* – An on-farm performance evaluation of dry direct-seeded rice compared with transplanted rice is being carried out with the Bangladesh Rice Research Institute (BRRI). The aim is to (i) determine the comparative agroeconomic performance of direct-seeded rice (both broadcast and drilled by machine) compared to transplanted rice in different field types throughout the FtF zone and in the project's working locations in northern Bangladesh, and (ii) identify suitable land types and supportive market systems to advise extension and NGO partners on where to most appropriately target and promote DSR. This study will be conducted in Jashore, Faridpur and Dinajpur, which represent three distinct agroecologies in which special considerations for the deployment of DSR at scale will need to be overcome. In each of these locations, the

[6] Hereafter referred to as 'the project'.

project is working with 18 farmers who will lead the management of the comparative research trials representing Bangladesh's three key landscape positions (high, medium and lowlands), each of which are likely to affect DSR management requirements to achieve acceptable yields and economic performance.

- *Performance evaluation study 2* – Another study on the on-farm performance evaluation of rice cultivars for establishing direct-seeded rice will be conducted in 12 farmers' fields in Jashore district in partnership with the Department of Agricultural Extension (DAE). Six to eight high-yielding rice cultivars will be tested for their performance under machine-sown DSR, broadcast seeding and transplanting during the aus season. The goal is to identify suitable rice cultivars for direct-seeded rice cropping, so that the DAE can more effectively advise farmers interested in growing DSR.

Photo 1.1: Where the bottlenecks to carrying it out can be overcome, direct-seeded rice offers an efficient alternative to labor and energy intensive transplanted rice. This well-established directly sown rice crop in Bangladesh will soon enter its reproductive phase (V. Kumar/IRRI)

- *Linking to subsidies* – The project will link farmers with the DAE's aus rice seed subsidy program by facilitating direct-seeded rice establishment by mechanical seed drill, and by providing best management practice (BMP) guidelines for DSR where DAE is conducting promotional campaigns.

- *Training service providers* – Starting in the end of this reporting period, the project began one-day training events for service providers on establishing DSR with mechanical seed drills. These events build up the awareness of providers on basic agronomy and their technical competence for successful crop establishment.

- *Linking to service providers* – The project continues to link farmers with irrigation pump owners, local service providers and input dealers to overcome constraints to irrigation, machine sowing, and seed and weed control product supply to expand direct-seeded rice.

- *Field visits* – The project plans to facilitate field visits and field days to direct-seeded rice trials for policy makers. DAE staff, local service providers, input dealers and farmers will observe direct-seeded rice performance and share experiences on crop establishment, weed control, machine performance, and other issues.

- *Workshops* – The project will conduct several workshops for policymakers, researchers, DAE staff, local service providers, input dealers and farmers to review aus direct-seeded rice performance and formulate guidelines for upscaling direct-seeded rice in subsequent years.

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

Wheat blast is a fast-acting devastating fungal disease that threatens food safety and security in the Americas and South Asia. First officially identified in Brazil in 1984, the disease is now widespread in South American wheat fields, affecting as much as three million hectares in the early 1990s. In 2016, wheat blast crossed the Atlantic Ocean, and Bangladesh suffered a severe outbreak. In 2017, with project support, the Bangladesh Maize and Wheat Research Institute (BWMRI) released a blast-resistant wheat variety (BARI Gom 33) developed from CIMMYT breeding lines in Mexico. However, there are only limited supplies of the seed of this variety and thus the crops of farmers in Bangladesh and the region remain very vulnerable to the disease. The continued spread of blast in South Asia — where more than 100 million tons of wheat are consumed per year — could devastate regional grain markets and undermine smallholder farmers' abilities to sustain their families.

The CSISA project and its government and NGO partners are addressing wheat blast by issuing factsheets and running other awareness raising activities (Figure 1.3) that help farmers adopt crop management and variety recommendations to reduce the threat of wheat blast. These activities are strengthening the resilience of smallholder farmers by helping them mitigate the negative productivity consequences of the disease. Farmers are accordingly adopting recommended practices such as the earlier sowing of wheat to avoid maturity at times when blast is most likely, the use of blast resistant and tolerant varieties, treating seeds with fungicides, and, where economically and environmentally rational, spraying fungicides.

The comparatively cooler and drier climate during the 2019 wheat flowering stage limited wheat blast sporulation and disease spread in the FtF zone. The disease appears to have been contained to less than 100 hectares during the past year. However, blast is strongly driven by climate anomalies, and more humid or hot years are likely to see additional outbreaks. As such, the project is continuing to raise awareness on the biology and ecology of wheat blast among farmers, extension agents, and agricultural policy makers in South Asia.

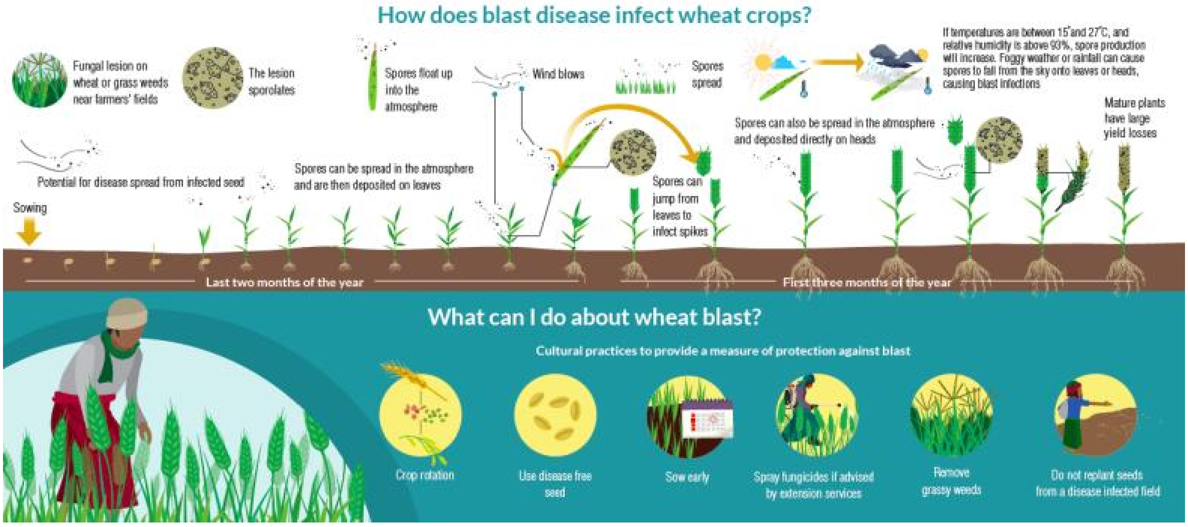


Figure 1.3: The CSISA project developed infographics like the one shown, which were printed in Bangla and English and distributed to farmers and extension agents throughout Bangladesh to increase awareness and understanding of the biology and ecology of wheat blast disease, and to provide insights on how to manage the disease. These infographics are available on [CSISA's website.]

In mid-January 2019, minor first blast infections were reported from Meherpur District in overly early seeded wheat. Four days of continuous rain from 24–27 February 2019 created a favorable environment for inoculum build up and sporadic minor infections were found in late seeded crops. The quantification of the overall impact of the infections are underway at the time of writing. More timely seeding within recommended dates help prevent infection by allowing the crop to avoid infection-permitting weather conditions. Each year, since 2016, additional sporadic minor infections have been found in new districts of Bangladesh, indicating the ongoing spread of the fungus and its adaptability to new environments. Outbreaks are likely to continue in future years now the disease is established.

In this reporting period, the project continued its collaborative research with i) the Bangladesh Wheat and Maize Research Institute (BWMRI) to verify agronomic control methods for wheat blast, and ii) with the USAID funded Climate Services for Development (CSRD) in South Asia project to assist in developing an early warning system for wheat blast. Demonstrations were conducted with newly released blast resistant and zinc-enriched BARI Gom 33 wheat in collaboration with BWMRI and the DAE during which seed of this variety were distributed to farmers for multiplication. (Photo 1.2). Additional project activities conducted with BWMRI are described below.

Photo 1.2: Showing the performance of several wheat varieties, including blast disease resistant BARI Gom 33, to farmers in a blast-affected area of Faridpur district in early 2019 (MA Arafat/CIMMYT)

Response of new wheat varieties to different seeding dates

Previous researcher designed and managed trials conducted by the CSISA project with BWMRI scientists at Jashore Regional Agricultural Research Station (RARS), indicated that wheat blast attacks existing cultivated varieties more vigorously when wheat is seeded late. This is largely because the climactic conditions (specifically higher minimum temperatures, humidity, fog and light precipitation) that favor wheat blast infection are more common late in the growing season. However, the blast sensitivity of newly released varieties under a range of environmental and cropping conditions has yet to be precisely quantified. Six varieties, including the susceptible BARI Gom 26 (grown as a control variety), were tested in experimental trials with five seeding dates (25 November; 5, 15 and 25 December 2018 and 5 January 2019) at research stations in the three different agroecological zones of Dinajpur, Jashore and Rajshahi.

These trials are being harvested at the time of writing and the results will be presented in the next report. The results from the same tests in 2017 and 2018 showed no blast infection of wheat sown on 25 November and 5 December, irrespective of variety, including the susceptible BARI Gom 26. Blast infections did however start to become apparent when wheat was sown from 15 December onwards, providing further evidence for the importance of early sowing to escape disease-conducive climactic conditions. The highest disease severity was found in the 5 January seeding of BARI Gom 26 (85.9%) compared to only 0.96% of the BARI Gom 33 wheat, 8.2% for BARI Gom 32 and 10.3% for BARI Gom 30. The results of this multi-year trial will be used to refine and formalize recommendations for how farmers can reduce the incidence of blast in their wheat crops, as well as to validate the disease prediction model and early warning system under development by the CSRD project.

Photo 1.3: (Left) CSISA staff explaining the wheat blast trials conducted with BWMRI to trainees and (right) mist irrigation in the cultivar mixture trial at Jashore where misting is used to stimulate infections and measure crop performance under high disease pressure (TJ Krupnik/CIMMYT)

Effect of cultivar mixtures on wheat blast caused by Magnaporthe oryzae pathotype Triticum

Many previous studies have reported that mixing different varieties of grain crops can reduce disease incidence and severity. In many cases, mixing cultivars can also increase yield. Such options open doors for the potential ecological management of diseases without fungicides. To explore options for cultivar mixtures to reduce wheat blast infestations, the CSISA project and BWMRI selected the three varieties of BARI Gom 26 (blast susceptible), BARI Gom 33 (which carries a wild wheat chromosome segment referred to as 2NS that confers blast resistance) and BARI Gom 30 to test in different seeding mixtures. Ten sub-plot treatments were prepared and sown in late November 2018 – three sole variety and six two variety mixtures with 33% + 66%, 33% + 33% + 33%, and 66% +33% cultivar seed densities.

Photo 1.4: Left: Well controlled leaf diseases in fungicide-applied cultivar mixture plots. Right: no disease control in plots without fungicide (DB Pandit)

The experiment was conducted in a split-plot design with five replications at Jashore Regional Agricultural Research Station. Main plots were divided into fungicide and non-fungicide treatments to further assess if cultivar mixtures can reduce relative yield losses when fungicide protected plots are compared to unprotected plots with high disease pressure (Photo 1.4). The experiment and replications were surrounded by three border rows of BARI Gom 26, and were sprayed with blast fungal inoculum at seven-day intervals starting from the late vegetative/early reproductive stage of the crop. Fungicide (Nativo 75WG) was sprayed by a trained professional applicator five days after each inoculation in the fungicide main plot. The whole experiment was subsequently put under mist irrigation (Photo 1.3 right), with misting stopped from 24 hours before to 24 hours after fungicide spraying. The recording of data from these trails is yet to be completed, with the wheat crop being harvested at the time of writing. The results will be presented in the 2018/19 annual report.

The CSISA and BWMRI partnership to implement the variety mixture trial and preliminary results were featured on national television in Bangladesh. They were broadcast to farmers across the country on 4 April 2019 edition of Bangladesh TV's *Mati-O-Manush* farming program (Figure 1.4).[7]

Figure 1.4: The project is collaborating with the Bangladesh Wheat and Maize Research Institute to conduct wheat cultivar mixture trials in Jashore to examine the potential of sowing mixed seed of different varieties for suppressing blast disease. Click the image to see the CSISA wheat pathologist Harun-Or-Rashid discussing this collaboration on *Mati-O-Manush*, the country's most watched agricultural TV program (Bangladesh Television)

Efficacy of foliar fungicides

Since the 2016/17 wheat cropping season, the CSISA project has supported the Bangladesh Agriculture Research Institute (BARI) and BWMRI to conduct three consecutive years of tests to identify high-performing, low-cost and low environmental toxicity fungicides for wheat blast under highly controlled research station conditions, with all fungicide application managed by trained professionals. Data recording for this year's trials is underway with full results to be presented in the 2018/19 annual report. The previous two years' results indicated that Nativo 75 WG (Tebuconazole 50% + Trifloxystrobin 25%) and Amistar Top 325 SC (Azoxystrobin 20%+ Difenoconazole 12.5%) were the most effective products for controlling wheat blast, although they are costly for most farmers. Information on these products was used by BARI and BWMRI to produce information leaflets for farmers, which have been distributed to farmers across wheat growing areas of Bangladesh over the past three years.

A2 Adding value to extension and agricultural advisory systems

A.2.2 Building precision nutrient management approaches around scaling pathways

[7] See 2 minute 14 seconds into the clip.

Although precision nutrient management has been an important component of project activities in Bangladesh, research under this activity was suspended in consultation with USAID during this reporting period due to funding delays and the lack of full fund transfer. However, project field staff continued to advise farmers, the DAE and agricultural input dealers on appropriate crop and nutrient management strategies through one-to-one interactions, at meetings and at farmer field days. In addition, project researchers continue to analyze data on precision nutrient management for maize collected in previous project years. Updates and results from these analyses will be provided in the 2018/19 annual report.

During the current reporting period, the project also engaged with a collaborating researcher and PhD student, Shah-Al Emran, now based at the Department of Crop Sciences at the University of Illinois at Urbana-Champaign, to independently analyze data from southern Bangladesh examining the effect of urea super granule (USG) deep placement on rice productivity. USG is a fertilizer technology that has been supported by the USAID/Bangladesh Mission in recent projects including those led by the International Fertilizer Development Center. Details of this research, which is now under review by a peer-reviewed journal, are given below:

This study evaluated the effects of nitrogen rate and source on the agronomic, economic, and environmental performance of transplanted and rainfed *aman* rice in Bangladesh's non-saline coastal areas. Data from 51 farmers who participated in previous trials distributed across two landscape positions described as 'highlands' (on which field inundation depth typically remains <30 cm) and 'medium-highlands' (inundation depths of 30–90 cm) were planted singly with varieties appropriate to each position (BRRI dhan 39 for highlands and the traditional variety Bhushiara for lowlands). Researcher designed, but farmer-managed dispersed plots were located across three district sub-units (Barisal Sadar, Hizla and Mehendigonj) to compare nitrogen (N) source (broadcast prilled urea or deep-placed urea super granules [USG]) at four N rates. Key results from this work were that:

- Rice grown on medium-highlands failed to respond with increasing N rates beyond 28 kg N ha^{-1}, indicating that little fertilization is required to maintain yields and profitability while limiting environmental externalities in CSISA's working areas in Barisal. In highland locations, clear trade-offs between agronomic and environmental goals were observed.
- To increase yields and profits for this improved variety, 50 or 75 kg N ha^{-1} was often needed, although these rates were associated with declining energy and increasing greenhouse gas (GHG) efficiencies.
- Compared to prilled urea, USG had no impact on yield, economic, energy and GHG efficiencies in medium-highland locations. USG conversely led to a maximum of 5.8% yield improvements at higher N rates in the highlands, while also increasing energy efficiency.
- Given the observed yield, agronomic and economic benefits of applying USG, these preliminary results suggest that farmers who can access labor for placement can consider use of USG at 50 kg N ha^{-1} to produce yields equivalent to 75 kg N ha^{-1} of prilled urea in highland landscapes in CSISA's working areas in Barisal.

These results underscore that when assessing sustainable intensification (SI) strategies for rice in South Asia's coastal zones, N requirements should be evaluated within specific production contexts (e.g. cultivar type within landscape position) to identify options for increasing yields without negatively influencing environmental and economic indicators.

B. SYSTEMIC CHANGE TOWARD IMPACT

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

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

Scaling-out information on better-bet agronomy

In the first half of 2018/19, the CSISA project continued to disseminate simple, easy to implement guides on the principles of raising healthy rice seedlings to increase yields, early wheat sowing, and wheat blast mitigation methods through development partners and extension workers. A total of 15,000 healthy rice seedling leaflets, 34,000 early wheat sowing leaflets and 700 wheat blast fact sheets were disseminated to farmers through the Agricultural Advisory Society (AAS). AAS is a collaborating NGO in the Feed the Future zone. At the same time, video shows on healthy rice seedlings and early wheat sowing were shown to farmers in 860 different villages across 19 districts (Photo 1.5). These informative videos disseminated important messages on healthy rice seedlings, early wheat sowing and the practical application of better bet agronomic practices and featured interviews with model farmers. Further details of the impact of these media campaigns will be provided in the 2018/19 annual report.

Photo 1.5: CSISA and AAS reached 64,000 farmers with a video on healthy rice seedlings and early wheat (October 2018–March 2019) (H Rashid/CIMMYT)

Healthy rice seedlings

With the resumption of partial funding in this reporting period the CSISA project restarted awareness-raising activities among farmers on the benefits of transplanting healthy rice seedlings to improve yields (Photo 1.6). A short informative video was shown in public places at the start of the 2018/19 boro season (in December through January) on easy-to-implement agronomic techniques and practices for raising healthy rice seedlings. As discussed above, the NGO AAS also conducted rural video shows on healthy rice seedlings that included question and answer sessions for farmers. Healthy rice seedling videos were shown to 59,015 farmers in 794 places across 16 Feed the Future zone districts in Bangladesh in this reporting period.

Photo 1.6: Encouraging farmers to use simple agronomic methods to raise healthy rice seedlings can increase rice crop productivity and resilience (Sudhanshu Singh?IRRI).

A follow-up survey was carried out March 2019 with 1,199 randomly selected farmers who had watched the healthy rice seedlings video since 2017 to assess what they had learned and how many were implementing recommended seedling raising practices during the early boro 2018/19 winter season. Sixty-three percent of the surveyed farmers said they had practiced at least three newly learned techniques to raise healthy rice seedlings. The most commonly used techniques were:

- filtering and selecting quality seed for use (93%);
- establishing seed beds under the correct solar radiation (light) and soil conditions (81%); and
- using raised beds with drainage channels to reduce flooding risk and injury to seedlings (80%) (Figure 1.5).

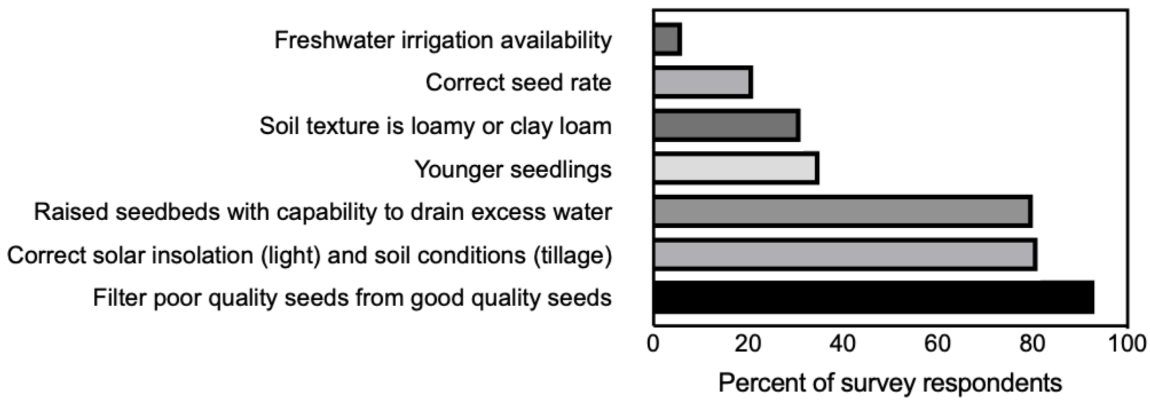


Figure 1.5: Follow up survey results with rice farmers who saw healthy rice seedling videos – proportion who had adopted better bet agronomic practices for raising healthy rice seedlings

Siting seed beds at places where fresh water is available for irrigation was, however, used by only 6% of surveyed farmers. This is probably because many districts in the Feed the Future zone are in coastal areas where fresh water is scarce in the dry season, and where soils have salinity constraints. Only 35% of the surveyed farmers were using younger (correct aged) seedlings. This is a crucial constraint as there is generally a strong relationship between increasing seedling age and declining yield. Given this important learning, the project plans to increasingly emphasize the importance of planting young seedlings in places where early season flooding is not a constraint. Despite room for improvement, almost all the farmers (99%) interviewed said they would continue to implement the most popular practices to raise healthy rice seedlings. Extrapolating these survey results to the wider population of rice farmers engaged with CSISA, indicates that farmers had applied healthy rice seedling techniques on 14,562 hectares of land in the Feed the Future zone in Bangladesh in this reporting period.

B.1.3 Winter rabi season development of fallow lands in coastal Bangladesh

Systems analysis highlights similarities between farmers and development experts for crop intensification efforts in coastal south-central Bangladesh

To meet the increasing demand for food production set against land and resource limitations, the Government of Bangladesh is seeking large-scale investments in agriculture and improved water resource management in its comparatively underdeveloped coastal region. Rainfed rice predominates in the monsoon season, after which farmers in these areas often practice dry winter *rabi* season land fallowing, or grow low-maintenance and low-yield 'opportunity' legumes using residual soil moisture. To meet national food security goals, the expanded use of canal and river water is being promoted to produce high-yielding cereals – particularly rice. However, many agricultural development initiatives, throughout the global south, narrowly focus on agronomic technology transfer. Less emphasis is placed on addressing the complex social, environmental, and market risks that can limit farmers' adoption of new crops and crop management practices, including irrigation.

Systematic studies of farmer decision-making conversely show that stakeholder perceptions, values and beliefs are important factors influencing the success or failure of agricultural development programs. Fuzzy Cognitive Mapping (FCM) is a semi-quantitative method to represent stakeholders' perceptions of complex socio-ecological systems.

Between late 2016 and late 2018, a collaboration between CSISA and the Farming Systems Ecology group of Wageningen University used fuzzy cognitive mapping to model farmers' perceptions of the prerequisites and development interventions needed in Bangladesh's coastal region to increase crop intensification. This exercise compared farmers' fuzzy cognitive maps with those generated by development practitioners, scientists, government officials, international donors, and NGO staff working in coastal Bangladesh. The maps were used to simulate the potential effects of development interventions (i.e. supportive market prices, infrastructure development, access to finance, and improved agricultural extension), as well as environmental factors (soil and water salinity), given each group's perceptions of the central coast's farming systems. Figure 1.6 shows the final integrated map.

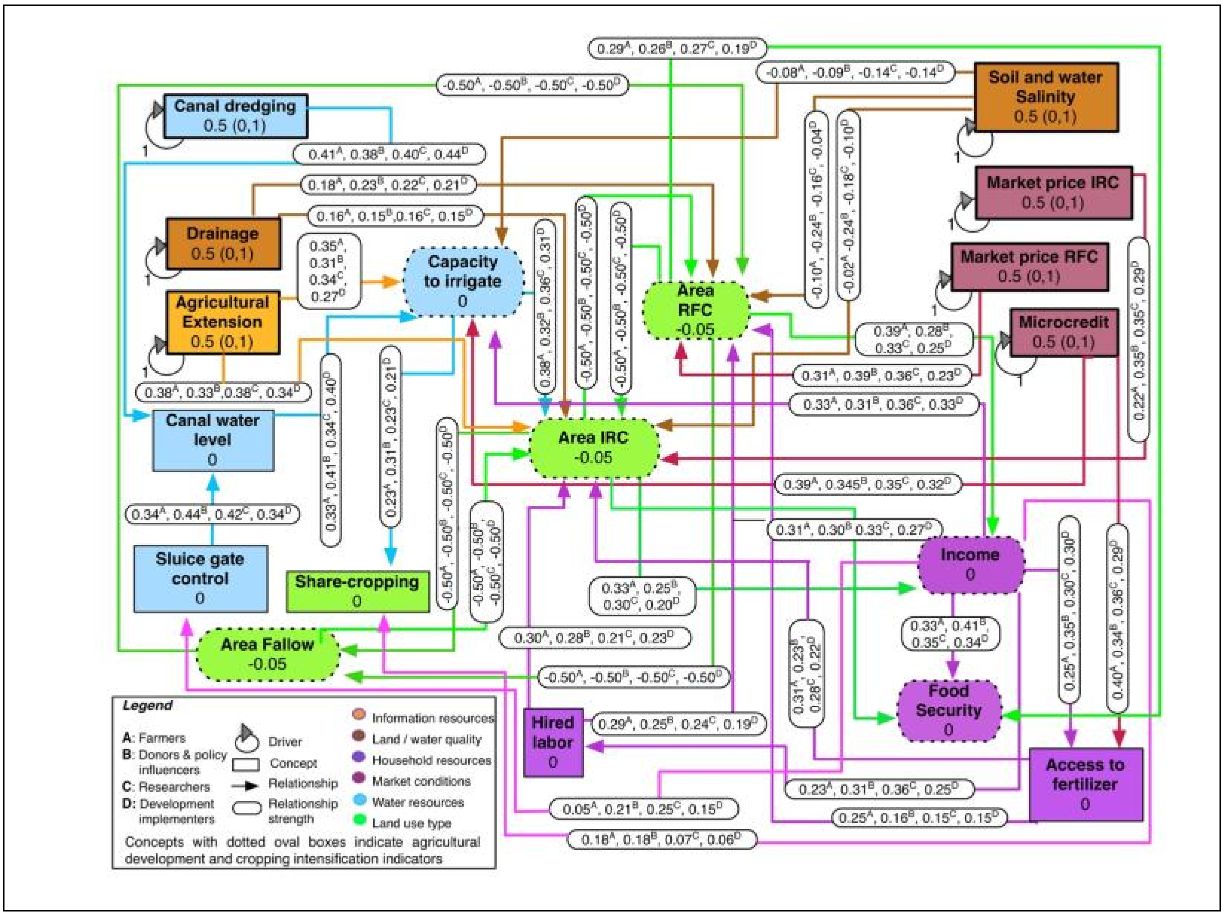


Figure 1.6: A fuzzy cognitive map of model farmers' perceptions of the prerequisites and development interventions needed in Bangladesh's coastal region to increase crop intensification.

Note to Figure 1.6: (A) farmers, (B) donors and policy influencers (C) researchers, and (D) development implementers were consulted to produce fuzzy cognitive maps of an average farm household and associated agricultural system in coastal Bangladesh. The mathematical equations underlying the map allow it to be used to simulate the potential impact of development interventions intended to intensify cropping systems. The concepts were grouped into color-coded categories based on the type of function they serve in the system: e.g. information resources, land and water quality, household resources, market conditions, and water resources. The system drivers, identified as external transmitter variables that are subject to natural or intentional intervention state changes, are indicated by looped arrows and outlined in black. Values in boxed concepts represent the baseline values. Note: RFC indicates rainfed crops and IRC irrigated crops.

This exercise showed similarities between farmers' and other stakeholders' perceptions. Most groups perceived increased agricultural extension availability and access to finance as positively influencing desirable crop productivity and income generation development goals. Scenarios, however, suggested negative effects from salinization and less consistent relationships between canal dredging, drainage, and market price interventions that might be necessary to substantially stimulate irrigated crop production and income generation.

These results to some extent contrast with the literature and development initiatives focused on the technical agronomic and engineering aspects of water management and agricultural development in coastal Bangladesh. This indicates the need to balance 'hard' engineering interventions with 'soft' system solutions – including improved extension programs and increased access to finance, to facilitate the transition to intensified irrigated cropping in Bangladesh's central coast.

Photo 1.7: Farmers are increasingly using mung beans to replace land fallowing in south Central Bangladesh. The photo shows farmers preparing to seed their fields with mung beans. CSISA is working to raise farmers' awareness of better-bet mung bean production practices (TJ Krupnik/CIMMYT)

From mid-2018 forward, the project began applying these results in interactions with partners involved in development and water management in Bangladesh's central coast by taking part in meetings and conferences related to water management in Bangladesh, and by advocating for an increased emphasis on so-called 'soft' interventions alongside interventions that maintain a focus on engineering activities and outcomes.

Cultivating farmers' potential by cultivating mung beans

In Bangladesh's central coastal areas, to the east of the Feed the Future zone, an increasing number of farmers are replacing winter land fallowing by cultivating mung beans (Photo 1.7). Mung beans offer a number of advantages to farmers including potential for high profits (several traders are now exporting mung beans grown in Bangladesh to Japan where they are used for fresh salad sprouts) and contributions to the improvement of soil quality. Mung bean is also a nutritious crop – 24% of this grain legume is protein. The project has responded to the opportunities offered by farmers' interests in this crop through the following supportive actions:

In this reporting period:

- 500 mung bean production booklets developed by CSISA in 2016 were distributed to farmers by partner organizations including the DAE and Embassy of the Kingdom of the Netherlands funded 'Blue Gold' project that works across the upazilas[8] of Patuakhali and Barishal districts.
- 350 farmers introduced improved agronomic practices, including mung bean sown in lines with mechanical drills, on 70 ha of their mung bean fields in Patuakhali.
- 162 kg of mung bean seed (BINA-7) were distributed to 34 farmers as quality seed and planted over 6 ha in Barishal district.

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

Rice is the staple food in Bangladesh, with total rice consumption of 35.2 million tonnes in 2018. The fast-growing population in the country (growth rate of 2.2% per year) is reflected in the increasing demand for rice (increasing rice consumption of 2.4% per year). The project works as a catalyst to expand premium quality rice (PQR) production in the Feed the Future zone. This activity can dramatically increase farmers' profits from rice farming by up to $200 per hectare. Project interventions have included raising awareness about premium quality rice varieties among farmers, facilitating links between private and government partners to assure the timely availability of seeds of these varieties, leveraging partners to train farmers on better-bet agronomy of these varieties, and organizing farmers into groups for collective marketing. However, a lack of funding in 2017/18 meant that the project was unable to this work in the 2017/18 winter boro rice season. The project did collect information from the Department of Agricultural Extension on the area of premium quality rice grown in the winter boro 2017/18 season. The varieties BRRI Dhan 50 and BRRI Dhan 63, which were introduced and popularized with project support in its second phase (2012 to 2015) and early third phase (2015 forward), were planted on 29,363 ha in the Barisal, Faridpur and Jashore hubs. These data indicate that premium quality rice has matured as an intervention, and that rice value chains have emerged to sustain farmers' continued cultivation of these varieties. Although the project cannot claim all the credit for these results, the project's pioneering research and popularization of these varieties alongside BRRI and DAE, and efforts to catalyze rice value chains in the private sector have had an important and lasting effect.

Some farmers have however commented that midstream actors (millers and traders) in the rice value chain benefit disproportionately due to less than ideal farm gate prices and the absence of specialized varieties to produce premium quality rice. As such, expanding market opportunities and the share of benefits from premium quality rice is likely to be more transferrable to farmers by introducing premium quality rice varieties. During the reporting period, CSISA worked to design research on ways to improve the flow of benefits to farmers that is now being implemented in northern and southern Bangladesh. Two specific activities are underway:

- A rapid value chain assessment: Qualitative and quantitative tools are being used to assess the value chain to identify intervention points that could improve profitability to farmers and associated market actors (Figure 1.7). The assessment is exploring the potential role of the private sector.
- Supply-side factors and testing of the intensification hypothesis that farmers with access to markets are compelled to make use of improved agronomic practices: CSISA is in the process of assessing the agronomic contributions to the productivity and supply of PQR and testing if value chain investments incentivize farmers to adopt PQR and better crop management.

The assessment is based on the FAO framework on Sustainable Food Value Chain Development (SFVCD), which considers value chain actors as those who produce or purchase from the upstream

[8] Upazilas are administrative sub-units of districts in Bangladesh.

level, add value, and sell to the next level along the value chain. The following deliverables will be reported on in the upcoming Annual report: 1) Identification of the constraints and value chain requirements for PQR, 2) preliminary insights into the quantify efficiency gain by improved agronomic practices/services, and 3) progress towards exploring the incentive or stimulus required for a better PQR production and supply system for Bangladesh.

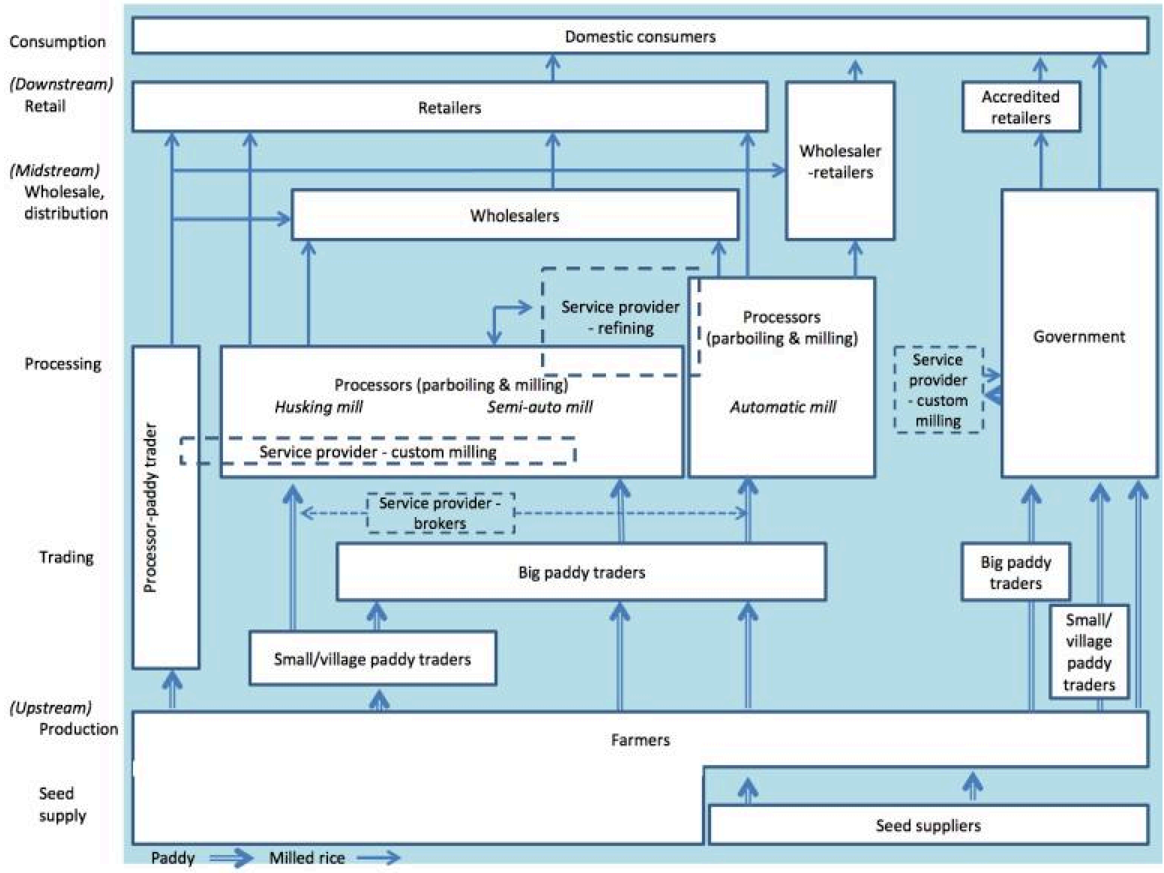


Figure 1.7 An example of a rice value chain and the flow of rice in Bangladesh (Custodio et al., 2016)[9]

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

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

With funding delays and cuts in the 2017/18 and 2018/19 fiscal years, CSISA was forced to suspend this activity. However, discussions with national research partners continued during this period and updates on any activities that may be resumed in the next six months will be provided in the 2018/19 annual report.

[9] Custodio, M.C., Demont, M., Laborte, A., Diaz, C., Ynion, J., Islam, R., Ceuvas, R.P., Paguirigan, N. 2016. Rapid value chain assessment and rice preferences of consumers, farmers and other rice value chain actors in Bangladesh. Report for TRB Project. Market Research Team, Social Sciences Division. International Rice Research Institute, Los Banos, Philippines.

C. ACHIEVING IMPACT AT SCALE

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

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

Funding shortfalls in the 2017/18 fiscal year and the significant delay in funding receipt thereafter (as detailed in the Executive Summary and Section 4) led to the project suspending on-farm activities on integrated weed management in the 2017/18 boro and 2018 aman seasons.[10] During 2017/18, project scientists had continued to analyze data gathered in the previous three seasons. The data was from 2016 on-farm aman experiments on different integrated weed management options for transplanted rice and farmer surveys on farmers' weed management practices, their knowledge gaps, predominant problematic weed species, and weed control costs. Preliminary results were reported in the 2017/18 annual report.

Photo 1.8: Echinochloa species are a major weed that constrain rice productivity globally and in Bangladesh (Unknown)

Since the 2018/19 boro season, project scientists have continued to analyze these data to better understand survey results and derive actionable weed management recommendations for incorporation into integrated weed management options.

In December 2018, the project also trained 255 input retailers in Dinajpur hub through the Agricultural Inputs Retailers' Network (AIRN) on integrated weed management principles. This training focused on identifying weed species, selecting herbicides for effective weed control, the use of knapsack sprayers, sprayer calibration, and the use of agrochemicals considering human and environmental health (see case study in Box 1.1). Preparations are underway to organize a workshop on integrated weed management in mid-2019 involving national partners from NARES, NGOs, herbicide companies, input dealers and private entrepreneurs to communicate the key results and actionable recommendations.

During the 2018/19 boro season, the project started new research with the Bangladesh Rice Research Institute (BRRI) to identify high yielding and weed competitive rice cultivars to strengthen the integrated weed management framework. The study aims to determine ability of popularly grown rice varieties to compete with weeds in the boro and aman seasons under transplanted rice and in the aus season under direct-seeded rice. The experiment under this study was established in the 2018/19 boro season at two locations with 14 high yielding rice varieties including three hybrids.

[10] Aman season rice is harvested in November or December.

Box 1.1: In Focus: Leveraging the private sector to deploy integrated weed management

Md. Motahar Hassan, a rural retailer selling seeds, fertilizers and herbicides, was in his shop in Jheneidah, Bangladesh, when a client, Saiful Islam, stopped in with a look of panic on his face. Islam was having trouble managing the weeds in his rice fields. He feared that he would have to spend a large amount hiring help to manually weed his field or face serious crop and income losses. Either way, he would lose money that could go to buy food for his family and send his children to school. Fortunately, Hassan identified a solution with support from the Agricultural Input Retailers Network (AIRN), an organization supporting private sector-led agricultural development in Bangladesh. The NGO was established by the Feed the Future Agricultural Input Project to enhance Bangladeshi farmers' knowledge and access to quality agricultural inputs.

With AIRN's help, Hassan took part in an integrated weed management training led by the CSISA project (see Photo 1.9). In addition to agronomic and environmentally-sound methods of mechanical and chemical weed control based on the principle of integrated weed management, Hassan learned how to identify different weed species. Importantly, the training taught him that overuse of the same type of herbicides can render them ineffective – valuable advice for many of his customers. "The training has been exceptionally fruitful as I have gained knowledge and practical skills on concepts that were previously unknown to me or my clients," said Hassan.

As most farmers seek advice from input dealers, trainings like this can have a large impact. AIRN has over 3,000 retailer members like Hassan across 19 districts in Bangladesh and has trained 1,450 input dealers using educational modules developed by CSISA since 2017.

> *"We have been working closely with USAID supported initiatives like CSISA through this collaborative effort. Input dealers are usually the first stop for advice for many farmers… Training in integrated weed management is a breakthrough and has helped our dealers give more responsible and quality advice to farmer clients, while reaching farmers through dealers and retailers at scale." – Khondkar Zunaed Rabbani, AIRN CEO.*

Because of advice from dealers like Hassan, and support from the private sector, more than 6,000 farmers across Bangladesh now use integrated weed management in their own rice fields. Data collected by CSISA shows that applying these principles pays dividends as farmers can save $57 to $78 per hectare using integrated weed management practices depending on the season.

Photo 1.9: Agricultural input dealers in Jheneidah, Bangladesh learn how to identify weed species and advise farmers on appropriate integrated weed management techniques through educational sessions organized by AIRN through CSISA (AIRN).

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

In its first two years (2015-2016), the project helped to scale-out the use of multi-crop reapers and two-wheel tractor-based seeding equipment in its working areas in northwestern Bangladesh. Activities were undertaken to complement the successful market initiatives undertaken in south Bangladesh's Feed the Future zone through the USAID/Bangladesh Mission-funded CSISA-Mechanization and Irrigation initiative. However, activities in the Dinajpur working area had to be cancelled in in the 2017/18 fiscal year due to budget delays and shortfalls. This unfortunately meant having to cancel joint venture agreement (JVA) contracts with several private sector partners and a leading micro-finance institution. At the time of reporting, the project has not been able to re-establish these partnerships, as private sector collaborators are reluctant to join hands with the project given ongoing uncertainty with respect to CSISA's ability to consistently support terms agreed in JVAs.

Identifying ways to overcome gender gaps in agricultural mechanization and services provision

During this period, the project refocused activities on research supporting its agenda for gender justice and equity in rural development. CSISA partnered with the Gender, Climate Change and Nutrition Integration Initiative (GCAN), funded by USAID/Washington and led by the International Food Policy Research Institute. The report, 'Gender and agricultural mechanization: A mixed-methods exploration of the impacts of multi-crop reaper-harvester service provision in Bangladesh' is available online and is summarized as follows:

Informal fee-for-service arrangements have positioned farmers in Bangladesh so they can access use of machinery to conduct critical time-sensitive agricultural tasks like land preparation, seeding, irrigation, harvesting and post- harvesting operations. However, both the provision and rental of machinery services are dominated by men, and by most measures, it appears that women have comparatively limited roles in this market and may receive fewer benefits. Despite the prevailing perception in rural Bangladesh that women do not participate in agricultural entrepreneurship, they do not necessarily lack the desire to be involved. Using a mixed methods approach involving a literature review, secondary data collection, focus groups and key informant interviews, and a telephone survey, the CSISA and GCAN team studied the gendered differences in women's and men's involvement in emerging markets for rice and wheat reaper-harvester machinery services in Bangladesh. The projects found that women benefit from managing and sometimes owning machinery services, as well as from the direct and indirect consequences of hiring such services to harvest their crops. However, a number of technical, economic, and cultural barriers appear to constrain female participation in both reaper service business ownership and in hiring services as a client. In addition, women provided suggestions for how to overcome the barriers that constrain their entry into rural machinery services as entrepreneurs. Men also reflected on the conditions they would consider supporting women to become business owners.

These findings have implications for addressing social norms in support of women's rural entrepreneurship and technology adoption in South Asia's smallholder dominated rural economies, and were presented on 7 May 2019 at a conference organized by GCAN in Dhaka with research and development partner stakeholders.

C.2 Managing risk and increasing resilience by coping with climate extremes

C.2.2 Early and resilient wheat for combatting heat stress

Wheat is the second most important food crop in Bangladesh and its consumption is increasing at 15% per year. However, the country produces only about a fifth of its needs and in 2017/18 imported six million tonnes of wheat. Bangladesh therefore needs to increase wheat production to avoid foreign currency expenditure in the purchase and import of wheat.

There is very limited scope to increase the area under wheat due to the continuing reduction in the area of arable land and competition with high value rabi crops. The best alternative option for increasing national wheat production is to increase yields. But Bangladeshi winters are short and warm causing heat stress during grain filling. Wheat yields decline remarkably when seeding goes beyond 30 November. As per the Bangladesh Wheat and Maize Research Institute (BWMRI), the optimum seeding time is 15–30 November. Wheat yields drop by 1.3% for each day's delay in seeding after this period.

Recent data collected by CSISA and BWMRI in newly established multi-locational experiments showed the highest yield to be from wheat sown in the 15–22 November period in Jashore region. Yields subsequently declined by 32 kg/ha/day. But in Dinajpur, yield was almost the same between 15 November and 6 December, after which it reduced by 22 kg/ha/day. This yield loss is due to high temperatures at grain filling that reduces grain weight and the number of grains per spike due to pollen sterility at temperatures above 32° C at flowering. Late seeded crops can also be damaged by storms and rain in late February to early March. This results in the crop being knocked over, reducing grain weight. Late seeded wheat also appears more susceptible to leaf blight, leaf rust and wheat blast diseases. As such, seeding wheat at the recommended time is one of the most important management practices for increasing wheat yields in Bangladesh.

Previous results from focus group discussions conducted early in the third phase of the project revealed that excessive soil moisture at seeding time is the number one cause of late wheat seeding followed by farmers' knowledge gaps on the benefits of early seeding. In 2016, CSISA began advising farmers, local service providers and government organizations and NGOs to mitigate the constraints of early wheat seeding. This is accomplished by advising on proper land selection for wheat, the timely transplanting of early aman varieties, using reaping and seeding machines and other ways to facilitate early wheat seeding through trainings, field days, workshops and meetings events organized by CSISA and the CSISA- Mechanization and Irrigation (CSISA-MI) project.

A short educational video on early wheat seeding was prepared in mid-2017 by the project. The video was then shown during this reporting period through a collaboration with AAS and the Government of Bangladesh Agriculture Information and Communication Center (AICC) to 116,000 farmers (76% male, 24% female) at 794 events. During the reporting period, information leaflets (Figure 1.8) on early wheat seeding were also prepared and printed by the project and 34,059 copies distributed to farmers to raise their awareness about the benefits of the early seeding of wheat. These activities have convinced many farmers and other concerned persons about the benefits of early seeding.

Data were collected after wheat seeding from Department of Agriculture Extension (DAE) record books and a telephonic survey of farmers who had attended video shows. This found that wheat seeding in 2017/18 had shifted earlier on over 4,523 ha in CSISA's working locations. Although this was less than the project's target of 8,000 ha, the reduced achievement came alongside a 15% reduction in the area under wheat in 2018/19 in the project's 20 districts compared to 2017/18. This reduction was due to the threat of wheat blast, reduced government subsidies for wheat, low grain prices and less economic returns than competing crops, mainly maize.

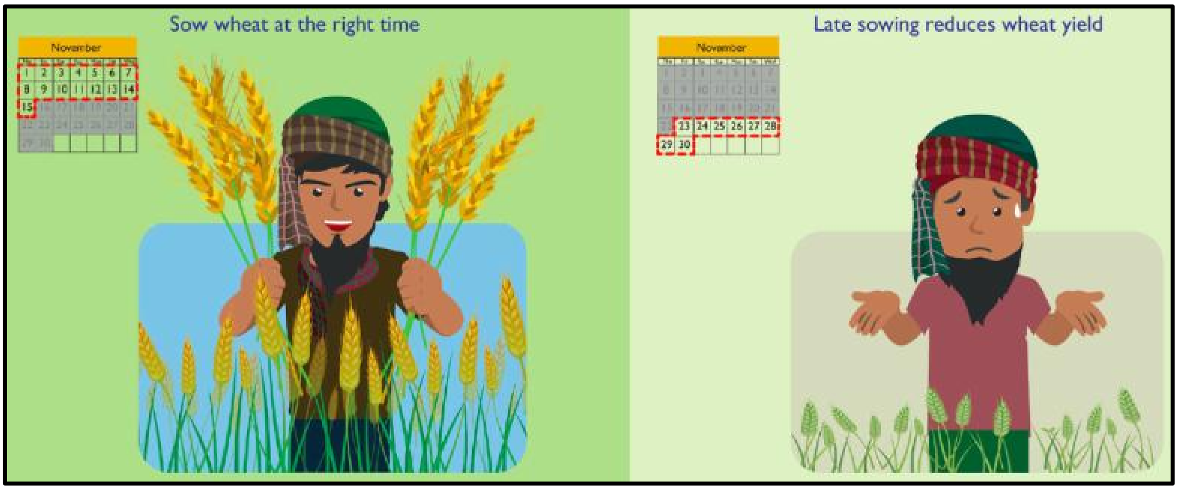


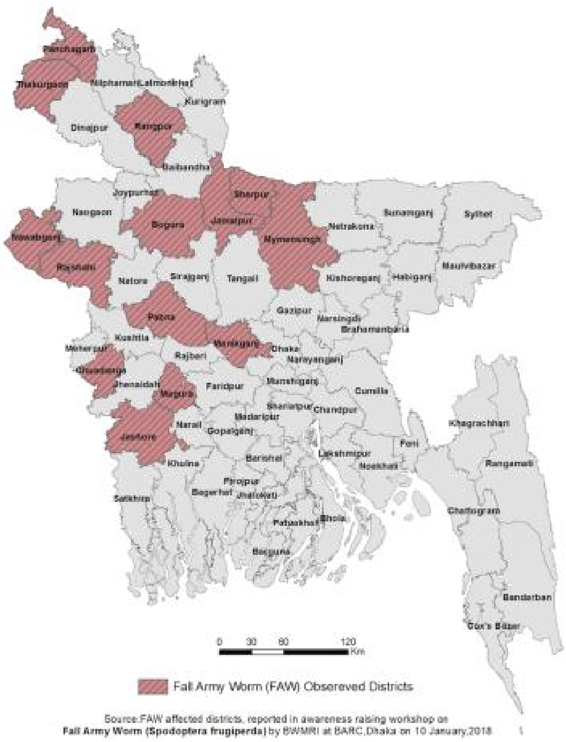
Figure 1.8: Working with partners in the national extension system, CSISA continues to raise farmers' awareness of the benefits of early wheat sowing, and to assist them to overcome constraints for timely planting. In 2018, CSISA developed and distributed these posters on early wheat sowing across its working locations in Bangladesh

C.2.3 CSISA leads the way in fighting back against the fall armyworm

The fall armyworm *Spodoptera frugiperda*, is a global threat to farmers. It infests a wide range of crops, but favors maize. It first appeared in South Asia in India in mid-2018. By November 2018, the pest had migrated and was found in 14 districts in Bangladesh in pheromone traps placed by the Bangladesh Agricultural Research Institute (BARI) in different areas and crops (Figure 1.9). Damaged maize was found in several districts, including CSISA working areas in the Feed the Future zone.

The fall armyworm has four stages of life – egg, larvae, pupae and adult moth. The crop is damaged by the larvae, which has six instars. The fourth to sixth instar can damage a crop overnight, and is very difficult to control. The insect thrives in warm temperatures and can complete its life cycle in 30-40 days in summer and 70-80 days in winter in Bangladesh. The adult insect can fly up to 100 kilometers during this part of its life cycle, and more in windstorms.

Although fall armyworm control was not in CSISA's workplan, maize production is integral to South Asian cereal systems. Of the cereals produced by smallholder farmers in Bangladesh, maize is the most rapidly increasing and profitable. Governmental policy aims to double national maize production over the next five years. In 2017/18, 3.9 million tonnes of maize was produced from 0.45 million ha with a national average yield of 8.7 t/ha. It is now the second most produced grain crop after rice replacing wheat. Still its production is less than needed. Two million tonnes of maize were imported in 2018.



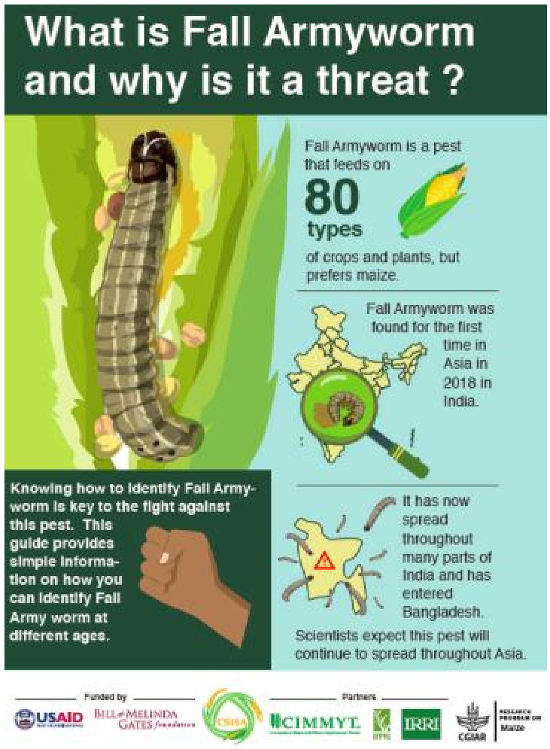


Figure 1.9: CSISA is a key partner in fighting the fall armyworm in Bangladesh. Left: Places where the worm was detected in 2018/19. Right: CSISA has trained 755 input dealers and raised farmers' awareness on fall armyworm threats using village video shows and Bangla language version infographics like the one above. Map: M. Khan

CSISA has responded to this emergency situation and is leading the way with the Bangladesh Maize and Wheat Research Institute (BWMRI) and Department of Agricultural Extension (DAE) in responding to fall armyworm. The project convened the first meeting to discuss fall armyworm with USAID, agricultural researchers and policy makers in late 2018 (as reported in the 2017/18 CSISA annual report). The project is now working to increase the resilience of maize farmers to this threat in collaboration with government organizations, NGOs and private sector partners. In late 2018, the project translated and dubbed over the following two informative videos into Bengali:

- *How to identify and Scout for Fall Armyworm* by Scientific Animations Without Borders
- *Fall Armyworm Life Cycle and Damage to Maize*, by the Centre for Agriculture and Bioscience International (CABI).

In December 2019, these videos were supplied on pen drives to 200 Department of Agriculture Extension officials to raise the awareness of field level officials and maize farmers on how to combat the new insect. In the same period, the project prepared a leaflet in Bengali in collaboration with CABI and BARI, which at the end of the reporting period was being printed to distribute to farmers. CSISA also developed four informational graphics on fall armyworm that are now being translated to Bangla and will be distributed to farmers and agricultural input dealers *en masse* during the remaining months of 2019. These infographics can be found in Appendix 3 and provide farmers with advice on the following topics:

- What is Fall Armyworm and Why is it a Threat?
- What is Fall Armyworm and how can I Scout for it in my Field?
- What is Fall Armyworm and How Does it Grow?

- What should I do if I Find Fall Armyworm Damage?

In addition, during the reporting period the project took emergency action and worked with AIRN to train 755 agricultural retailers on integrated pest management principles in controlling fall armyworm. As retailers are often farmers' first point of contact for pest management advice; trainees learned how to identify the insect, the symptoms of their presence and means of control, prioritizing preventive measures by crop management and bio-pesticides. Starting in February 2019, the project and AAS also started an awareness raising and training program for farmers in maize growing districts, during which the above videos were shown and leaflets and infographics distributed. By early April, 13,057 maize farmers had participated in 238 video show trainings (33% female). Lastly, CSISA has begun collaborating with USAID's fall armyworm task force and is working towards the implementation of a training of trainers program for DAE staff in October 2019 prior to Bangladesh's primary maize growing season.

Photo 1.10: Fall armyworm damage on an early vegetative stage maize crop in the Feed the Future zone of Bangladesh (TJ Krupnik).

It must however be strongly noted that, while CSISA can assist in leading the initial efforts to fight back against fall armyworm, this topic was not part of the project's initial workplan and given budget shortfalls, CSISA may not be best placed to continue in-depth work on this topic. Given the size of the threat posed by fall armyworms, a dedicated project that tackles the pest through a series of well-planned integrated pest management actions is urgently needed. Given CIMMYT's leadership in maize and the fall armyworm, additional funding for this purpose is urgently needed to properly address the emerging crisis.

2. Nepal – Achievements

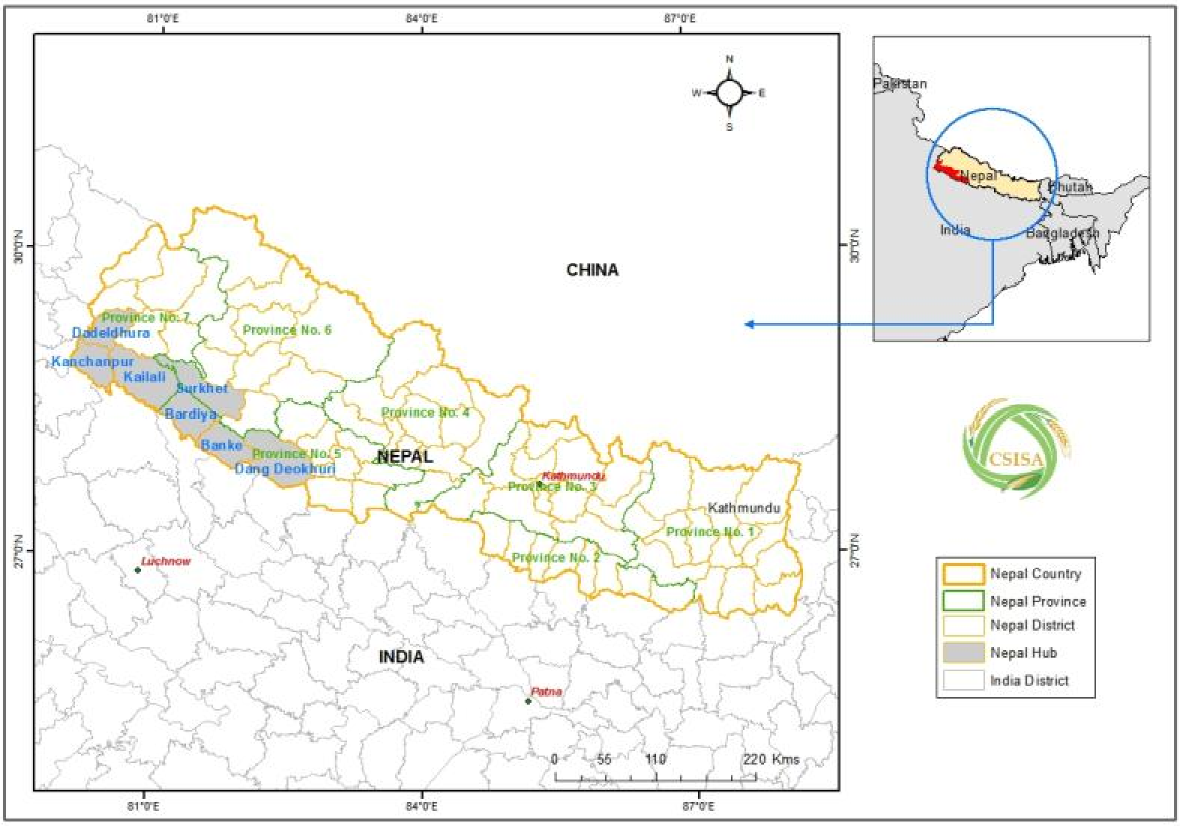


Figure 2.1: In Nepal, CSISA focuses its efforts on the Feed the Future zone in Provinces 5 and 7 (shaded in grey)[11]

A. INNOVATION TOWARD IMPACT

A.1 Reducing risk to facilitate uptake of sustainable intensification practices

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

Growing rice is becoming more costly for farmers in the CSISA project's working areas in Nepal. This is due mainly to the increasing cost of wage labor due to the widespread out-migration of working age men from rural areas. This has resulted in lower profit margins for rice cultivation and yield penalties as farmers cannot find labor in time for crop management and inter-cultural operations. To address the problem of the high cost of cultivation, the project is working to evaluate and encourage farmers to experiment with adapting and adopting direct-seeded rice (Photo 2.1), which reduces the labor required for establishing seedling nurseries, uprooting seedlings and transplanting rice. However, the adoption of direct-seeded rice in Nepal requires the use of mechanical seed drills attached to two or four-wheel tractors. It is almost impossible for smallholder farmers to invest in buying these expensive seed drills and tractors without support. To increase smallholder farmers' access to these seed drills, CSISA works with a model of entrepreneur to farmer service provision in Nepal's Feed the Future

[11] Note: Province 7 is now officially called Sudurpashchim Province or the Far Western Province

Zone of Influence. More than 100 seed drills have been purchased and are now being used for seeding in the project's working areas. However, despite the benefits of growing direct-seeded rice, the adoption rate of this method remains low and is concentrated in a few areas in the Feed the Future zone. To understand the reasons and associated constraints, the project plans to carry out a diagnostic survey on the limited adoption following the rice harvest in mid-2019.

Photo 2.1: A farmer examining the growth of line-sown spring direct-seeded rice at early tillering stage in a farmer's field at Rajapur, Bardiya district (Salin Acharya/CIMMYT)

Opportunities for direct-seeded rice with the Prime Minister Agricultural Modernization Project

The government's main strategies to replace rice imports with domestically-grown rice are to increase rice productivity and expand the area of land on which rice is grown. Nepal imports about $386 million of rice per year from India. The Prime Minister Agricultural Modernization Project (PMAMP) is a large project run by the Ministry of Agriculture and Livestock Development. One of its main foci is improving rice production by closing the gap between the actual and attainable yield (the yield gap) for the main monsoon season (June/July – September/October). PMAMP is also focusing on expanding the area of spring season rice.

Several rice super zones (blocks in excess of 1,000 ha), rice zones (500 ha), rice blocks (100 ha) and rice pockets (10 ha) have been identified as areas for PMAMP interventions. CSISA is working with PMAMP in these areas to close the yield gap. It is providing technical support to PMAMP officials in rice super zones, zones, blocks, and pockets. In late 2018, recognizing the project's role in guiding the sustainable intensification of rice growing, PMAMP added two new super zones in the Feed the Future zone. PMAMP's attention is currently aimed at expanding the area under spring rice, with special interest in direct-seeded rice following consultations with CSISA.

Photo 2.2: Testing the establishment of spring direct-seeded rice by 2WT seed drill in coordination with Bardiya Rice Super Zone, Rajapur (Kalika Chaudhary, RSZ Tech)

Farmers experience several problems related to seedling mortality to establish directly seeded spring rice. By interacting with CSISA, PMAMP staff have recognized that the main challenges to establishing direct-seeded spring rice are the reliability of irrigation, seed drill calibration and assuring seed germination. Since the seeding time starts from March/April, the details of project interventions on addressing these challenges will be provided in the next reporting period. During the reporting period, CSISA has assisted PMAMP officials through technical planning for the spring rice season.

To make spring rice more profitable while reducing labor costs, the project is supporting PMAMP to promote climate resilient approaches to growing rice. Direct-seeded rice is a low cost and resource-conserving technology; although limited research has been carried out to address the unique challenges associated with spring DSR in Far Western Nepal. CSISA also plans to collaborate with PMAMP to verify the performance of direct-seeded spring rice in farmer's fields under their own management in the coming season. Data with cost benefit and yield analysis will be shared in the upcoming annual report.

Photo 2.3: The CSISA team in Nepal works with national partners to evaluate and overcome constraints to the direct seeding of rice in the Feed the Future zone. Above: CSISA team members assisting a service provider to directly sow rice in lines as an alternative to the time and labor-intensive manual transplanting (Unknown)

Since the project's second phase, CSISA has also been working to improve the technical and agronomic performance of summer season direct-seeded rice as a cost-effective rice growing technology in Banke and Bardiya districts (Photo 2.2). Besides developing a number of seed drill service providers, the project has attracted other organizations and projects to promote the technology. Among them PMAMP's Bardiya Rice Super Zone (Rajapur) is promoting spring rice in an area where most farmers transplant rice manually and very few practice mechanical methods of crop establishment. Spring direct-seeded rice has not yet been tested and is likely to require agronomic adjustments before it is ready for out-scaling. Therefore, at the time of reporting, CSISA is coordinating with super zone officials to establish a number of direct-seeded rice technology trials in farmers' fields (Photos 2.2 and 2.3). Testing commenced with seeding by a two-wheel tractor seed drill (Photo 2.2.) on three dates spanning February and March 2019. Trials compared the yields and costs of i) machine drilled direct-seeded rice, ii) puddled direct-seeded rice of pre-germinated seeds by drum seeder, iii) seedlings transplanting manually and iv) seedlings transplanting mechanically.

B. SYSTEMIC CHANGE TOWARDS IMPACT

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

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

Using digital surveys and big data insights to drive agronomic priority setting and messaging

The Open Data Kit (ODK) is digital data collection tool that can be run on a smartphone or tablet. CSISA is using the kit to conduct farmer surveys, gather information on cereal crop management practices, and to track machinery adoption, trainings on agronomic management practices and farmer adaptation and adoption. The project in Nepal and Bangladesh has created ten Open Data Kit forms to capture data along with GPS latitude and longitude in real time. Around 5,000 observations of farmers' crop management practices in CSISA working areas have been collected and stored on the server. Most project-related datasets from Bangladesh and Nepal on rice and wheat crop management practices have been analyzed. These geotagged datasets allow researchers to examine factors that contribute to agronomic performance by combining surveys with secondary datasets including soil characteristics and weather data.

Photo 2.4: Data enumerators from CSISA Nepal surveying a farmer using the Open Data Kit on electronic tablets to rapidly collect and store data (Unknown)

During the reporting period, CSISA started to expand the use of these digital data collection tools at the provincial level in collaboration with government agencies including Nepal's main agricultural university (at Rampur, Chitwan) and PMAMP. Two major objectives under these partnerships are to train university students and provincial government personnel on using digital tools while implementing scientific sampling for crop cuts and surveys, and for tracking the spread of the use of farm machines across project sites. The following text discusses some of the analyses conducted so far using these data collection approaches, and clarifies how data-driven insights can be used to provide actionable recommendations aimed at improving crop performance and resilience in Nepal's FtF zone.

Rice yield and profit gaps

During the reporting period, CSISA staff worked to analyze crop cut survey data collected through CSISA Phase III and the CSISA Scaling project in the summer rice seasons in 2017 and 2018. These rice diagnostic crop-cuts and production practice surveys showed that rainfall variability, fertilizer and irrigation management were the major factors affecting yield in the region. Further analysis indicated that rainfall, fertility management and irrigation timing were the most important variables determining overall yield variability in rice yields. The average nitrogen (N) application rates in the CSISA working districts were found to be 72 kg/ha, which is 28 kg/ha lower than the recommended rate of 100 kg/ha, indicating scope for improvement by farmers. Partial dependence plots of the rice response of the nitrogen, phosphorus, potassium, and irrigation number are presented in Figure 2.2.

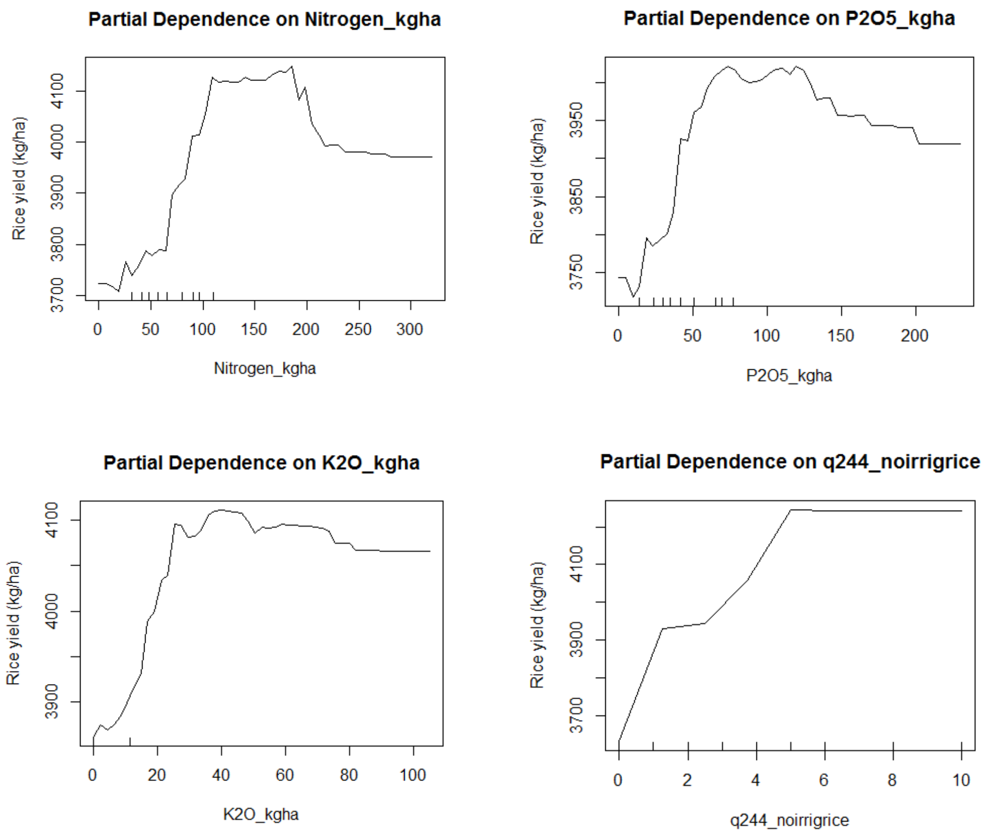


Figure 2.2: Response of nitrogen (N), phosphorus (P_2O_5), potash (K_2O), and number of times of irrigations on the rice yields in CSISA working districts determined using machine learning to digitally analyze collected farm survey data

The project's analysis also showed higher rice yields when up to 110 kg/ha of nitrogen was applied, after which a plateau and then decline was observed. Moreover, the average phosphorus (P_2O_5) application rate in CSISA working districts was around 47 kg/ha. Although this rate is close to the recommended rate, rice yields tended to be greater when 70 kg/ha was applied. This indicates that better nutrient management has the potential to enhance rice productivity in the region, and provides data that can be used to interact with PMAMP officials to reconsider current recommendations. Interestingly, almost 87% of surveyed farmers had not applied any potash (K_2O) fertilizer. Average potash application was only 3.5 kg/ha while rice yields were highest when 40 kg/ha was applied. The analysis indicates that an additional 36.5 kg of potassium per hectare can enhance rice productivity by 300 kg/ha, even if farmers do not change other management practices. This indicates that the proper application of potassium is important to enhance rice productivity in the region.

Spatial variation in rice crop management practices in CSISA working districts

Rice crop management practices vary in the project's working areas. During the reporting period, the project analyzed production practices data from the previous rice crop cut surveys and identified locations where rice yields were lowest for subsequent project intervention. Analysis uncovered three different types of yield groupings in the project's working districts. The third cluster was located in areas to the south and southwest of Butwal (Figure 2.3). This location tended to have the highest observed yields with better crop management practices implemented by farmers.

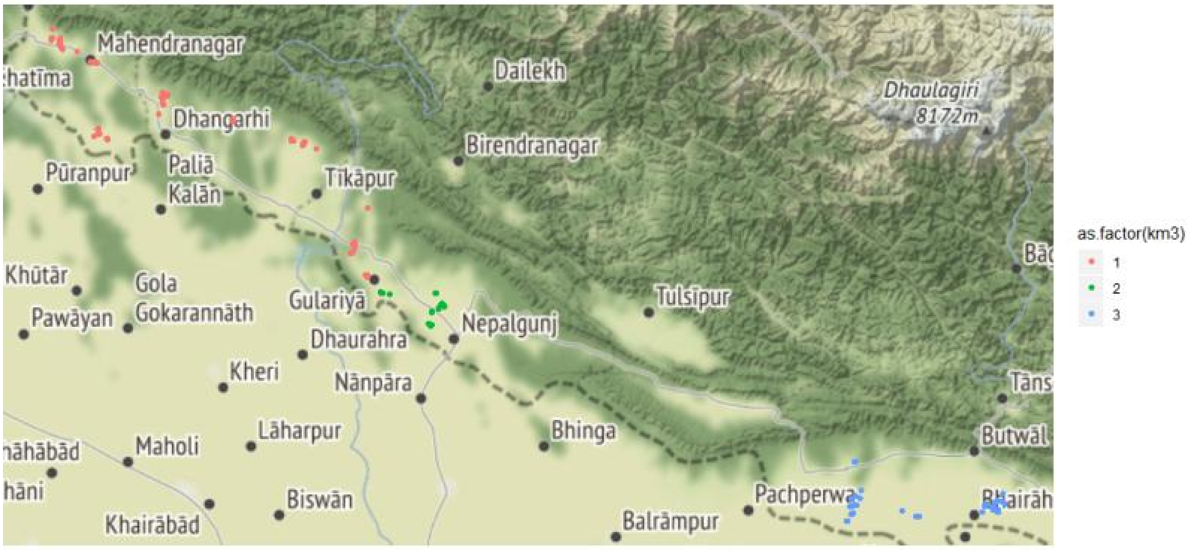


Figure 2.3: The three clusters (from k-means clustering) indicating three basic categories for the management practices for rice cultivation in the CSISA working districts in Nepal Terai

The first group was identified in in Kanchanpur, Kailali and Western Bardiya, and the second grouping to the west of Nepalganj. Both locations tended to have lower yields and poorer crop management practices. Farmers in these groups tended to apply less macronutrients and irrigated their rice crops less frequently. The latter practice undermines the resilience of the crop when less than normal rainfall occurs. Farmers in these locations also transplanted older seedlings. which could explain the lower productivity. Table 2.1 gives the mean values of the yields and associated parameters for these farmers, disaggregated by group.

Why are these grouping important? Through analyses such as these, it is possible to identify where CSISA can intervene with PMAMP to promote the use of improved and resilient agronomic practices for summer rice production. Data from this preliminary analysis are being scrutinized further at the time of reporting, and will be presented to PMAMP officials in Kathmandu and Kanchanpur, Kailali and Western Bardiya prior to their summer rice season activity planning.

Table 2.1: Spatial variations in crop management practices for rice cultivation in CSISA working districts (mean values). *N* indicates number of farmers surveyed.

	Group 1 (*N*=469)	Group 2 (*N*=254)	Group 3 (*N*=329)	All farmers (*N*=1,052)
Rice yields (kg/ha)	3,462	3,282	4,938	3,894
Farmyard manure applied (kg/ha)	3,850	2,070	1,796	2,572
Nitrogen applied by farmers (kg/ha)	60	63	96	73
P_2O_5 applied by farmers (kg/ha)	40	34	68	47
K_2O applied by farmers (kg/ha)	1.9	1.2	7.3	3.5
Zinc applied by farmers (kg/ha)	0.9	0.2	1.2	0.8
Number of times irrigated	1.5	1.1	2.2	1.6
Seedling establishment time (Julian days of year)	160	164	174	166
Transplanting time (Julian days of year)	189	190	201	193
Harvesting time (Julian days of year)	298	303	318	306

Closing rice yield gaps through better-bet agronomy

Rice productivity in Nepal is about 3.5 tonnes/ha on average, although mean yields in the FtF zone fall far below. The good news is that there are good opportunities to close the yield gaps in these areas. During the reporting period, CSISA scientists conducted further analysis the rice-crop cut datasets collected earlier in mid-summer 2018 to identify the major drivers of standing crop biomass measured as the Normalized Difference Vegetative Index through remote sensing, which is correlated with yielding ability, and to validate these values at the field level.

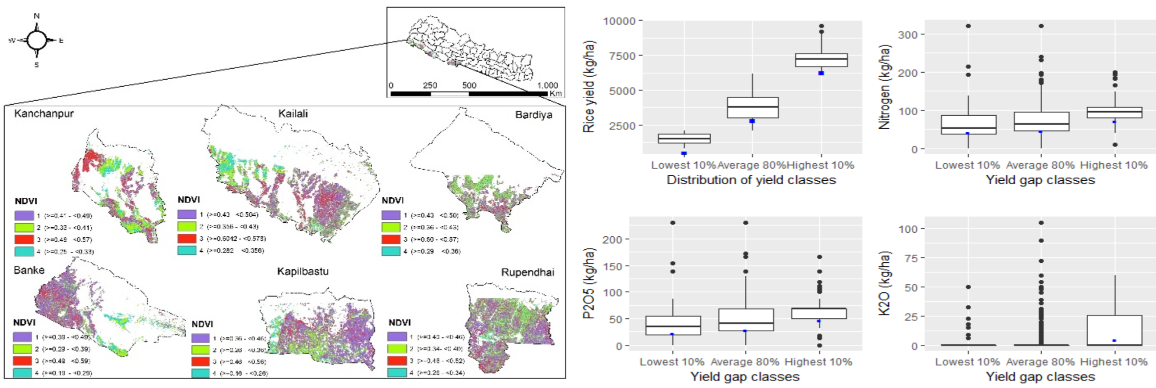


Figure 2.4: The satellite-derived NDVI values stratification and yield gaps based on elite farmers (top 10%), average farms (middle 80%), poor farmers (bottom 10%) and the fertilizer application rates across these classes

This analysis is important as mid-season yield estimation can assist the project and partners in PMAMP to identify areas that are lagging behind desired productivity levels, after which corrective actions can be taken by farmers. Analysis of the data showed that the top quartile of farmers yielded almost 7.5 tonnes/ha of rice, indicating that substantially higher yields can be achieved in the project working areas. Fertilizer application rates were identified as the most important driver of yield followed by number of irrigations. The top 10% of farmers had higher yields because they applied more nitrogen, phosphorus and potassium to their rice relative to their counterparts. These farmers were the same ones as those with the higher Normalized Difference Vegetative Index (NDVI) values as identified using remote sensing. While environmental and profitability outcomes of these observations deserve further scrutiny, the analysis is valuable in that it provides evidence that NDVI can be used to help identify farmers that could benefit from mid-season advisories on improved agronomy to reduce the risk of yield loss due to sub-optimal management (Figure 2.4).

Wheat yield and management gaps

In collaboration with PMAMP, CSISA conducts periodic crop-cut yield assessments and production practice surveys to understand management practices used by farmers in project working areas. These surveys provide crucial data to help focus project activities and respond appropriately with agronomic interventions that can help raise farmers' productivity. During the reporting period, the CSISA science team continued to analyze survey data to identify the major drivers of wheat productivity in Nepal's Terai. The results show an average wheat productivity of 2.5 tonnes/ha. While disaggregating the data by the highest and lowest wheat yielding farmers, the top 10% yielding farms harvested 4.5 tonnes/ha of wheat, the bottom 10% a third of this amount (1.5 tonnes/ha) and the medium 80% 2.5 tonnes/ha (Figure 2.5). The agronomic management practices of the top 10% of farms are potential entry points for improvement by other farmers who comprise the middle 80% of those surveyed.

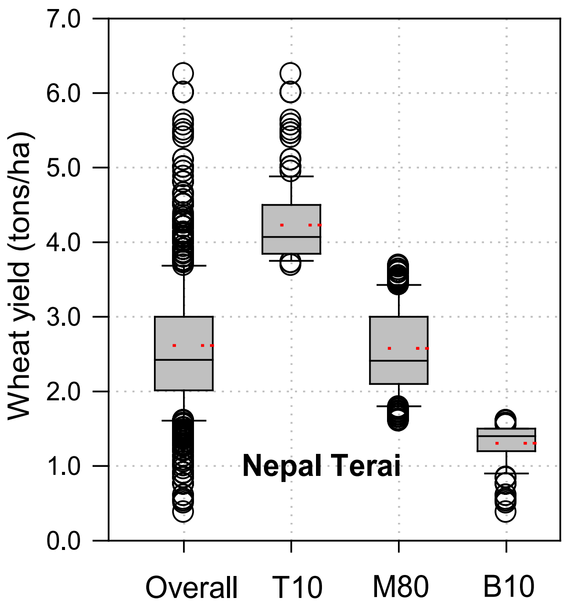


Figure 2.5: The wheat productivity of all farms (*N*= 1,684), top 10% farmers (T10), middle 80% farmers (M80) and bottom 10% of farmers (B10) (source: 2018 diagnostic survey data)

During the reporting period, the CSISA team used novel machine learning techniques to further analyze the data. Figures 2.6 and 2.7 show different types of classification models that identify the major wheat productivity drivers in the region. The two models sequentially:

- highlighted sowing time as the most important predictor for wheat productivity in Nepal's Terai, confirming and justifying CSISA's work to encourage early wheat sowing as a key intervention;
- identified the pathways for attaining sustainable production in Nepal's Terai under farmers managed field conditions; and
- identified proper nitrogen application and weed management as the three most important drivers for wheat yield.

These results were subsequently disseminated to PMAMP and other stakeholders during meetings and cross-learning sessions in Province 5 and the Far Western Province in early 2019. The research team is now assessing the economic and environmental consequences of these methods, and investigating if the same results hold true for male and female-headed households.

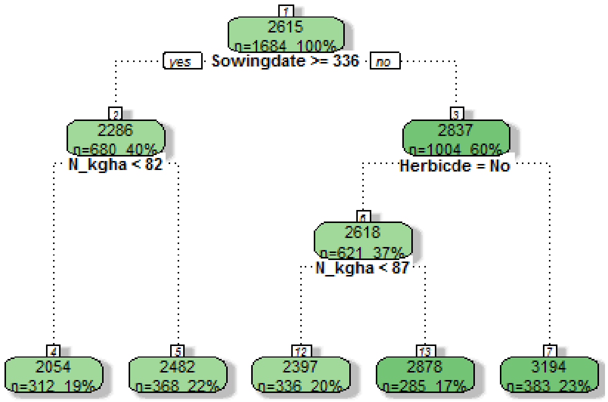


Figure 2.6: The results from the application of the recursive partitioning decision tree analysis to predict the most important productivity drivers of wheat in the Nepal's Terai

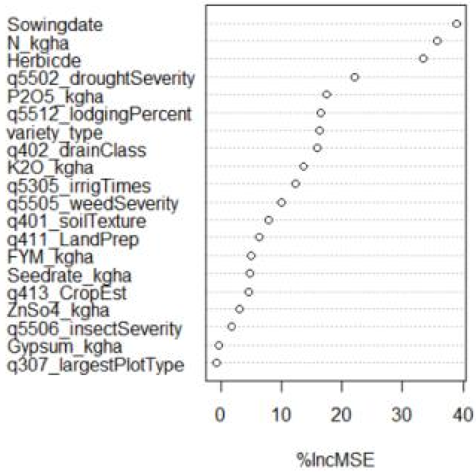


Figure 2.7: The results from the application of the recursive partitioning CART decision tree to predict the most important productivity drivers of wheat in the Nepal's Terai

The results of the 2018 crop cuts and production practices survey also confirm that farmers in Nepal's Terai can also take advantage of growing longer duration varieties of wheat. The adoption of such varieties coupled with early sowing may enable wheat plants to escape the terminal stress that results in decreased productivity. The 2018 survey results show a gain of almost 0.5 tonnes/ha when long duration wheat varieties are grown by farmers who sow early (Figure 2.8).

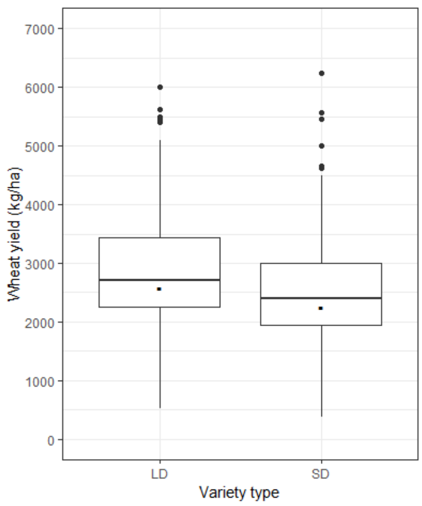


Figure 2.8: The adoption of long duration (LD) varieties of wheat can increase yield by almost 0.5 tonnes/ha compared to short duration (SD) varieties

Photo 2.5: Early wheat sowing and the use of long-duration varieties helps farmers achieve highly-productive farming systems in Nepal's Terai (TJ Krupnik/CIMMYT)

Photo 2.6: Maize is an important crop for farmers in Nepal's Terai. Fact sheets and manuals produced by CSISA are guiding farmers to improve crop productivity (Unknown)

Don't forget the small things! Expanding farmers' use of better-bet agronomy through production tips

Easy to understand factsheets and manuals on the basics of improved agronomy are prized by farmers in Nepal. These media promote awareness and the use of best production practices. During the reporting period, the project produced and printed the following resources:

- 2,000 copies of user manuals for resource-conserving agricultural machinery
- 1,000 copies of a maintenance manual for rice and wheat reapers
- 1,500 leaflets informing farmers how to improve mung bean productivity
- 2,000 leaflets on how to use mechanical seed drills
- 2,000 leaflets informing farmers how to improve maize production and increase returns on investments.

These media have been distributed by CSISA team members directly to farmers and also PMAMP super zone offices, farmer cooperatives, seed companies, agro-vets and FtF partner projects.

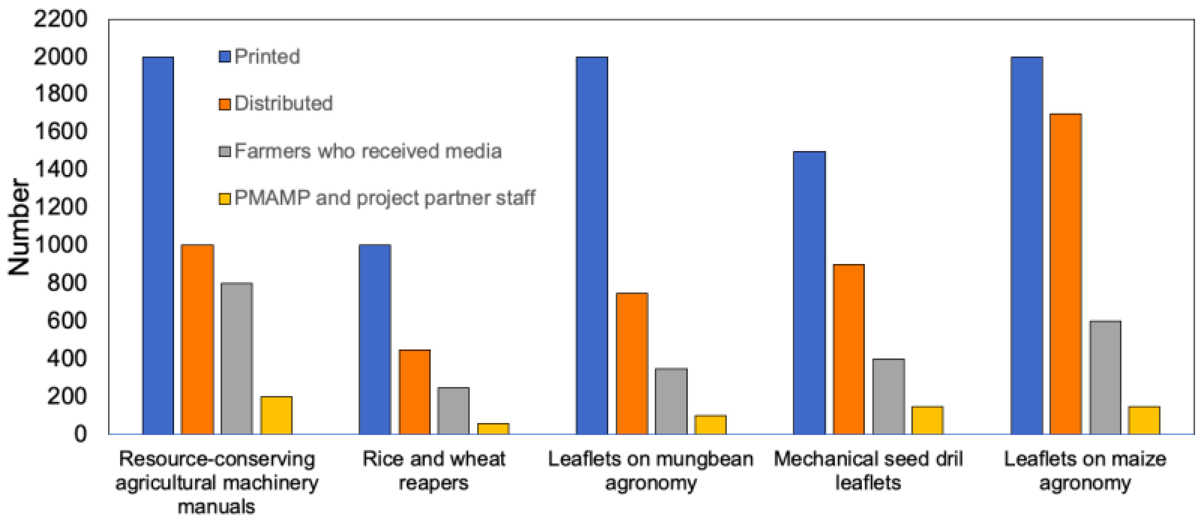


Figure 2.9: Status of the distribution of the project's manuals and production tips and estimate of farmers benefitting from receipt of media in CSISA working areas during the reporting period

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

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

Nepal's very low level of maize productivity demonstrates the large potential for increasing productivity. Where appropriate, the use of hybrid maize has the potential to increase productivity in Nepal's Midhills, which is the major domain for maize production in the country. However, the adoption of hybrid maize in the project's working districts has been limited due to restricted domain specific registrations. Concerns are also often raised that hybrid seed can lock farmers into needing to repurchase seed year after year, although data collected by CSISA indicates that hybrid maize can significantly raise both productivity and incomes, the latter more than sufficient to permit re-investment in seed while providing considerable additional income for farming families. In 2015, the project assisted its national partners to expand the domains of registered hybrid maize varieties to the western part of the country where they were previously unregistered. Specifically, the project played the major role in expanding the domains of the most prominent maize varieties into the FtF zone.

The project conducted surveys to assess the impacts of adopting hybrid maize on maize productivity in the Midhills, where maize is primarily used for household consumption. During the reporting period, CSISA scientists analyzed the complete dataset and found that adoption increased productivity by 1,937 kg/ha and per-capita expenditure on food purchases of households by $11. The latter represents a 5% increase in farmers' ability to purchase food. It also showed that hybrid maize non-adopters could have increased their maize productivity by 951 kg/ha and per capita food expenditure by $22, if they had planted hybrid over open-pollinated maize. The study concluded that food insecure households with less than six months per year of food self-sufficiency and farms of less than 0.3 hectares in size stand to benefit the most from planting hybrid maize in the Midhills. Government policies that support the rapid diffusion of hybrid maize would likely have a considerable positive impact on maize productivity and rural livelihoods in Midhills Nepal; as such, CSISA is working to disseminate this information to national development partners at the time of reporting.

Gender perspective on mini-tiller weeder expansion

In CSISA Phase II and the early months of CSISA Phase III, the project introduced the use of mini-tillers for weeding between maize rows. In early 2019, with the reestablishment of a project field office in Dang, the project organized a two-day training on mini-tiller weeding operation and maintenance for 32 women members of the 16 custom hiring centers managed by PMAMP in Dang Maize Super Zone (Photo 2.8).

Photo 2.7: Left: A woman trainee trying to start a mini-tiller during the training in Dang. Right: Trainees learning to operate mini-tiller weeders at the training (Sagar Kafle/CIMMYT)

During the training, a third of participants were able to start the engines and operate them independently while the others were able to operate the machines after getting help to start them. The project plans to follow up with trainees and help increase the number of women service providers.

Addressing the threat of aflatoxin

During the reporting period, CSISA team members participated in the 'Feed the Future Innovation Lab for Nutrition Scientific Symposium: 25 Years of Progress for Nepal', held on 27–29 November 2018 in Kathmandu. The project delivered presentations on the availability and scaling-out of the use of grain drying options and ii) pre- and post-harvest management techniques to reduce aflatoxin contamination in maize. The presentations highlighted the activities of CIMMYT and its project partners and the promotion of potential dry chain technologies and agronomic management practices to reduce aflatoxin fungus on maize.

Meetings and discussions at the symposium led to the formation of an informal network by the project with PMAMP super zone members and the Department of Agriculture's Post Harvest Section for follow-on in-depth discussions on the topics discussed at the symposium. As a result of the network's formation, PMAMP has decided to go ahead with procuring and testing a mechanical dryer for spring rice and has provisionally indicated that the dryer will be tested for reducing aflatoxin on the summer maize harvest in Dang Maize Super Zone.

Seizing opportunities for collaboration and impact with the Prime Minister Agricultural Modernization Project

Farm mechanization initiatives are at the heart of PMAMP, which encourages farmer groups and cooperatives to establish custom hiring service centers. CSISA collaborates closely with PMAMP and has been particular influential in introducing and technically backstopping machinery appropriate for the small field sizes and limited resource endowments of most of Nepal's rice, wheat and maize farmers. This collaboration was strengthened through the thematic forums held in the Far Western Province and Province 5 on wheat, rice, maize in in 2018, and through the day-to-day integration of PMAMP and CSISA activities on farm mechanization. The forums helped PMAMP's zones and super zones introduce the promotion of scalable technologies in their periodic plans.

At the strategic level, CSISA also challenges and encourages PMAMP officials to consider crop diversification and systems approaches to integrating agronomic and value chain interventions. From the initial focus on prioritized cereals, officials in PMAMP's zones and super zones have started to take more of a systems approach to agricultural development. For instance, in the reporting period Jhapa Rice Super Zone expanded its mandate and began disseminating resource-conserving technologies like zero tillage wheat alongside its regular activities. Further, every PMAMP area is focusing on the machinery in the custom hiring centers that

Photo 2.8: A demonstration of mechanized maize seeding in Province 5 (Jyoti Rai/CIMMYT)

can be used on multiple crops and for multiple purposes. Dang Maize Super Zone has, for example, started supporting the use of zero tillage maize planters and mini-tiller weeders based on the project's recommendations.

The project continued to support the zones and super zones to implement their regular activities. It helped Kailali Wheat Super Zone, Bardiya Rice Super Zone and Dang Maize Super Zone to organize machinery and agronomy training, field days, farmers visits, awareness raising through media campaigns, demonstrations and the on-farm verification of technologies. The project also provided technical backstopping to Kapilvastu and Jhapa Rice Super Zones and other PMAMP areas.

With collaboration with PMAMP being a project priority, CSISA re-opened its field office in Lamahi, Dang in February 2019 to bolster the scaling activities in coordination with Dang Maize Super Zone. Project staff are working to scale-out successful technologies like mechanized seeding and weeding through networks of provincial agriculture entities bodies agricultural knowledge centers (*krishi gyan kendras*) and local agriculture service centers. Particularly in Dang, there is a huge potential for spreading mechanized seeding and weeding technologies in summer maize in the west of the district. In March 2019 the project began collaborating with Dang Agriculture Knowledge Center to extend project-promoted technologies through Province 5's Smart Agriculture Village (*Smart Krishi Gaun*) program. As part of these efforts, the project also demonstrated mechanized maize technology in Western Dang during the inauguration of the Smart Agriculture Village Program in the presence of the Province 5 Minister of Land Reform, Agriculture and Cooperatives.

C. ACHIEVING IMPACT AT SCALE

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

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

The project plays a targeted and catalytic role to support stakeholders interested in integrated weed management (IWM) in rice and other cereal crops in Nepal. IWM combines the use of multiple techniques to control weeds in farmers' fields, for example by rotating crops, mechanical weeding, the use of weed suppressive and tolerant genotypes, and where necessary and economically rational, herbicides. While weed growth depends on many factors including the density of the weed seed bank, cropping practices, soil types and the means of seed dispersal, the first step in IWM is to develop a sound knowledge of the most problematic weed species.

Photo 2.9: CSISA works to address the weed management concerns of maize, wheat and rice farmers. Above: A farmer showing the roots of *Phalaris minor*, a problematic weed of wheat (TJ Krupnik/CIMMYT)

In mid and late 2018, the project developed and supplied posters of weeds of rice and wheat crops for agricultural input dealers to display in their stores. The posters were displayed in these stores as most farmers will initially seek pest management advice from these dealers. This pilot initiative is helping farmers to identify weeds and appropriate mitigating measures, including using the right herbicides if and when necessary (Photo

2.9). The initial response has been positive and the project is planning to deploy the activity at a larger scale by integrating weed species information with tailored IWM approaches.

A short 2018 survey of weeds in the rice fields of 100 Mid-Western and Far Western farms, conducted during the reporting period, found that the most problematic weeds included *Echinochloa crusgalli*, *Echinochloa colona*, *Cyperus rotundus* and *Cyperus iria*, although they had different frequencies that appear to be related to environmental and cropping system factors. In addition:

- *Echinochloa crusgalli* was more prevalent in the lowlands than *Echinochloa colona,* which was widespread in upland rice producing areas;
- *Cyperus rotundus*, one of the world's most problematic weeds, was prevalent in upland rice but occurred only negligibly in lowland fields; and
- *Cyperus iria* was a common problem across all environments and crop management systems (Figure 2.10).

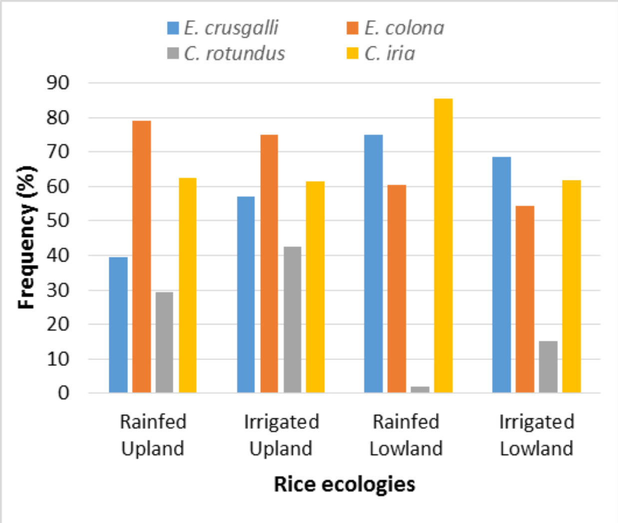


Figure 2.10: Frequency of problematic weed species present in rice fields, 2018 CSISA survey, Mid-West and Far West

Technical advice to agrovets on integrated weed management in wheat

Photo 2.10: Demonstration of safety and security measures for spraying herbicides in wheat, Kanchanpur (Unknown)

Weed management is critical at the different stages of growth of wheat in order to achieve acceptable yields. Thirty percent or higher yield losses can occur if weeds are not properly managed. The scarcity and expense of labor in Nepal's Terai is resulting in a gradual shift from manual to chemical weed control. Farmers are also finding it difficult to control *Phalaris minor*, a problematic weed of wheat (Photo 2.9). This is mainly due to their lack of knowledge of the appropriate herbicide.

In late 2018, project staff interacted with and trained agrovets and several farmer cooperatives and farmer groups to identify problematic weed species and carry out appropriate IWM techniques, including the safe and environmentally considerate application of least toxic and PERSUAP[12] approved herbicides. As a result, nearly 500 farmers have begun to more appropriately manage weeds in their wheat fields (see Photo 2.10). In November 2019, CSISA also demonstrated the safe application of herbicides to agrovets. These training and demonstration

[12] PERSUAP = Pesticide Evaluation Report and Safer Use Action Plan

activities were conducted in coordination with Kanchanpur Agricultural Knowledge Center and the Kailali Wheat Super Zone in the Far Western Province.

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

Scaling mechanized wheat seeding through service providers

Nepalese agriculture is predominantly dominated by smallholder farmers who have low purchasing capacity and little access to labor- and cost-saving technology or equipment. The project has been working for several years to promote a service provision model to make scale-appropriate seed drill machinery available to farmers on an affordable fee-for-services basis (Photo 2.11). This activity also serves as an entry point for the improved agronomic management of crops; for example, by assisting farmers to sow wheat in lines rather than by broadcasting. This technique improves crop density, makes intercultural operations like weeding much easier, and tends to result in less within-field yield variability. During the reporting period, in the Mid-West and Far West, the project continued to train seed drill service providers to correctly calibrate seed and fertilizer drills for cereal and pulse sowing. The project has also helped link service providers with machinery traders and government offices to make them familiar with one another and to encourage a rural service provision economy. The project also continued to play an advisory role to the PMAMP-supported custom hiring centers and to provincial governments by informing them about seeders and how they can be used for multiple crops.

Photo 2.11: RCT Agro Machinery and Engineering Workshop, Kanchanpur, Nepal has supplied a seed drills after identifying a raising demand for its use among local farmers (Subash Adhikari/CIMMYT)

The average service provider earns $250 to $300 profits per season seeding wheat. Nepal's Feed the Future zone now has nearly 200 seed drill service providers providing line sowing, and about 1,500 farmers are hiring them regularly to mechanically seed their fields

Photo 2.12: A farmer places seed in the hopper of a two-wheel tractor operated mechanical seed drill prior to line sowing by a service provider in Kailali, Nepal (Pradip Chaudhary/CIMMYT)

Photo 2.13: A CSISA field research technician, counting the number of tillers in wheat sown by a 4-wheel tractor drawn seed drill, Banke, Nepal (Lokendra Khadka/CIMMYT)

Understanding adoption dynamics to fine-tune zero-tillage wheat business models

The availability of zero tillage services is a core part of CSISA's theory of change for more sustainable crop establishment. CSISA's support and awareness building has led to about 200 seed drills being available in the Terai, many of which can be used for zero tillage. However, most drills are used for crop establishment following prior plowing, and only a relatively small group of seed drill service providers have focused strongly on zero tillage seeding. This raises important research questions on why zero tillage has not accelerated in Nepal as it has in other CSISA working areas such as Bihar and the Punjab in India. In response, during the next six months the project will interview service providers who own zero tillage seed drills to identify the constraints and catalysts for their livelihoods and businesses. The results will be used to inform CSISA scaling strategies and refine its theory of change as it pertains to zero tillage service provision. The same methodology (semi-structured interviews with quantitative and qualitative components) will be applied in CSISA-India and the Australian funded 'Sustainable and Resilient Farming Systems Intensification' projects for joint learning and strengthening national and regional implementation strategies. The results will be presented in the 2019 annual report and a peer reviewed academic publication in 2020.

Building relationships across countries to facilitate access to appropriate harvesting equipment: Traveling seminar on cereal crop harvesting

From 26-28 March 2019, the project hosted over 40 national and international delegates to observe the spread of large and small sized mechanized grain harvesting machinery in farmers' fields in Rupandehi, Dang, Bardiya and Kailali districts in Nepal (Photo 2.14). The seminar shared lessons around the increasing numbers of mechanized grain harvesting choices for Nepal's farmers including large horsepower combine harvesters and the much smaller self-propelled reapers and reaper binders. In addition, the project highlighted the commercial success of the 3,000 two-wheel tractor reaper harvesters that have been purchased in the Far West through the efforts of CSISA, the Department of Agriculture and their private sector partners over the last four years.

Photo 2.14: Participants in the traveling seminar on cereal crop harvesting gather in the field to observe and discuss the affordability and technical utility of rice and wheat reaper-binders (Dakshina Vedachalam/CIMMYT)

On the final day of the seminar, experts from Bangladesh, Sri Lanka, India, Vietnam, China, Nepal's Department of Agriculture and CSISA Bangladesh presented their experiences. Participants then brainstormed and advised on machinery and institutional-based solutions, including rice and wheat residue management (particularly rice straw burning) and machine-based maize harvesting options that are not yet present in Nepal. An expected outcome is that the project and its partners, having seen the success of the two-wheel tractor reaper harvesters in Nepal will redouble their efforts to promote these machines. The seminar showed participants how agricultural mechanization in Nepal offers all sizes of farmers multiple, scale-appropriate machinery solutions and can be held up as a model for other developing nations to learn from.

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

Additional purchases of two-wheel tractor attachable reaper-harvesters in the 2019 wheat season brought the number of operational reapers to over 3,000 in CSISA's working districts (Photo 2.15). As previously reported, sales of two-wheel tractor reaper harvesters remain strong in the Far West, although the rate of growth has slowed. According to importers, sales started picking up in 2018 in the eastern Terai where there are fewer of these machines.

In late 2018, two more two-wheel tractor reaper importers also opened in the FtF zone – DKAM Traders and Naya Tulsi Traders, both in Tikapur. The presence of five importers in the Far West means that reaper prices remain competitive there. However, various subsidy programs from central and provincial governments and projects such as the Rani Jamara Kulariya Irrigation Scheme (which in 2018 offered 50% subsidies to 150 farmers to buy reapers), are likely to depress sales as farmers delay purchase with the hope of accessing a subsidy. The project is therefore discussing with government partners how fair prices can be offered to accelerate farmers’ access to crucial equipment without distorting the overall machinery market.

Lastly, importers are also reporting that sales of self-propelled reapers, which have been sluggish for the past 5–6 years since their introduction, have also begun to increase.

Photo 2.15: CSISA’s ongoing efforts have led to mechanical rice and wheat reaper sales increasing dramatically in the last few years. Above, wheat is harvested by a self-propelled reaper in Province 5 (TJ Krupnik)

Wheat straw reaper-bailers can improve livestock feeding practices

The project ran a straw reaper-bailer demonstration in Jhalari, Kanchanpur on 11 March 2019 in collaboration with RCT Agro-machinery and Engineering Workshop (Photo 2.16). Journalists from Jhalari FM radio, technicians from PMAMP offices in Belauri municipality, farmers, and students from Krishnapur Technical College attended. This event exposed farmers to new machinery options for their crops and promoted the use of wheat residue for livestock feed instead of being burned off. CSISA is now encouraging farmers to experiment with reaper-bailers through demonstrations conducted in partnership with machinery dealers. It is also partnering with local FM radio stations to broadcast the names and contact details of service providers and the benefits of bailing straw.

Photo 2.16: Students from Krishnapur Technical College, a journalist and farmers observing a straw reaper-bailer demonstration at Jhalari, Kanchanpur, Nepal in March 2019 (Subash Adhikari/CIMMYT)

Expanding evidence of farmer demand for mini-tillers in the Midhills: Second stage of data analysis

Smallholder farmers in Nepal face acute labor shortages due to the out-migration of many men of working age leading to many farmers not accomplishing crop cultivation and inter-cultural operations on time, thus affecting crop productivity. The situation is aggravated by rising rural wage rates. The adoption of scale-appropriate farm mechanization can attenuate these problems.

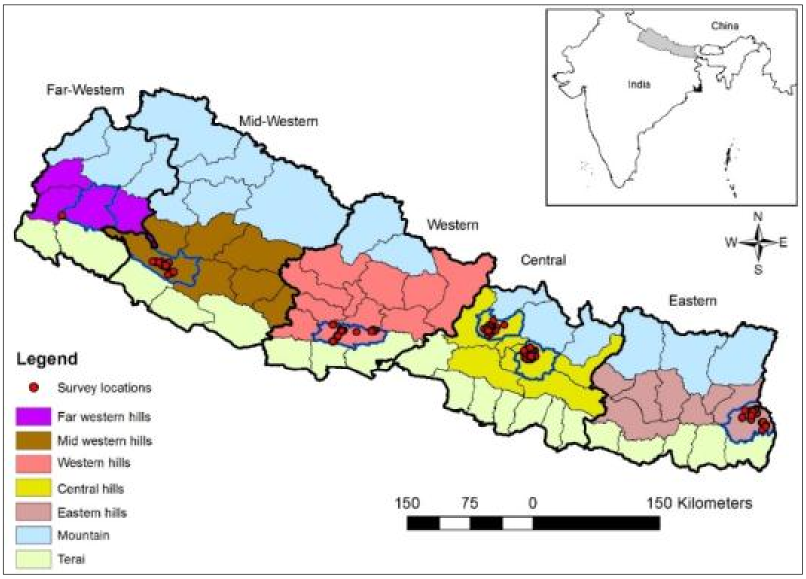


Figure 2.11 Map of areas in Nepal's Midhills where the willingness to pay for mini-tillers was assessed

Preliminary analysis of data from the surveys on farmers' willingness to pay for mini-tillers were discussed in the 2017/18 annual report. The survey collected data from where CSISA had worked in Phase II plus the project's additional investments such as the Earthquake Recovery Support Program (Figure 2.11). Mini-tillers are small (5-7 horsepower) tractors that are primarily used for agricultural land preparation but can be used for other purposes by attaching small seed drills. Mini-tillers are appropriately sized for the small terraced fields in Nepal's Midhills. While the traditional market for mini-tillers remains Nepal's central hills, new sales there are now mainly replacing older tillers. Importers report new sale areas opening up in the eastern hills and some new sales in the Terai. The results of the study were finalized and in this reporting period.

The key overall results of the survey were that:

- farmers who faced difficulties in finding labor and had to pay higher labor charges were more willing to pay more for mini-tiller technology; and
- draft animal ownership was negatively associated with the willingness to pay.

The results also showed a large variation in 'willingness to pay' across socio-economic groups and locations:

- Overall, the amount farmers were willing to pay for buying or hiring in a mini-tiller was substantially less than the average market price. This indicates the need to increase awareness of the benefits of the machine and to work closely with the private sector for appropriate and persuasive targeted advertising.
- Farmers in the Eastern and Mid-Western hills were willing to pay close to the market price, while farmers in the Western, Central and Far Western hills were only willing to pay a much lower amount. The implications of this finding are similar to the above point.
- The farmers in the highest farm size quartile were willing to pay a higher price for mini-tillers than farmers with very small farms.

The study further found that:

- regression results suggested that mini-tiller non-adopters could increase their rice productivity by

1,250 kg/ha (26%) if they adopted; and

- very small farms (≤0.25 ha) that adopt mini-tillers benefit the most in terms of gains in rice productivity.

A major initial recommendation is that governmental policies that subsidize the purchase of mini-tillers should focus on small-sized farmers willing and able to also act as service providers, as they appear to be the group that stand to benefit most from mechanized land preparation by mini-tiller.

Table 2.2: Estimated willingness to pay (in NPR) for mini-tillers across different farm size quartiles across Nepal's Midhills

	Overall farms		Bottom quartile sized farms		Top quartile sized farms	
	Mean	**Std error**	**Mean**	**Std. error**	**Mean**	**Std. error**
Eastern hills	47,575	1,120	34,472	1,889	50,555***	1,193
Central hills	35,691	535	31,131	863	38,588***	1,096
Western hills	38,595	868	35,928	1,110	43,394***	1,672
Mid-west hills	45,464	1,257	37,029	1,870	47,707***	1,622
Far Western hills	35,450	2,207	–	–	39,582	3,134
Overall Midhills	38,193	435	32,483	697	43,712***	751

Notes: *** indicates significantly higher than the smallest 25% of farms at 1% level of probability. Average exchange rate $1 = NPR 104 in survey year.

Ongoing collaboration with the Nepal Agricultural Research Council's agricultural machinery centers

The following progress was made in the reporting period under the project's ongoing collaboration with NARC's agricultural machinery testing and promotion centers, which are both based at Nawalpur in the Terai.

Agricultural Machinery Testing and Research Center – NARC's continued, strong 'buy in' for supporting the Nepal Agricultural Machinery Testing and Research Centre (NAMTRC), which was established with CSISA's support in 2018, continued as construction began in October of a main office building and officer quarters, which should be finished by June 2019. The project arranged a visit and facilitated collaboration between the center and a University of Manchester group on the testing of pumpsets. To help jumpstart machinery testing at the center, the project placed an agricultural engineer intern there in March 2019. The intern will also support collaboration between the project, NAMTRC and NARC's Agricultural Implement Research Center (AIRC), Birganj on AIRC's new research project, which is following up on the CSISA project's earlier work on a two-wheel tractor shallow tube well drilling attachment.

Agricultural Machinery Promotion Testing and Research Center – Training activities at the Department of Agriculture's Agricultural Machinery Promotion Testing and Research Center (AMPC) have yet to start as the federal budget for multiple lead service provider and mechanic trainings were delayed until the next fiscal year. In the meantime, the project assisted the center in December 2018 to run a brief training of trainers program on how to operate laser land levelers, during which half a hectare of fields inside AMPC were leveled. The project agreed in February 2019 to assist the center to prepare its training hall and workshop facility and to provide two training of trainer events prior to the center starting its main training program in 2019/20.

C.2 Managing risk by coping with climate extremes

Understanding and coping with monsoon variability

The increasing variability of monsoon rainfall obstructs farmers' efforts to synchronize their cropping with the climate, specifically precipitation but also temperature patterns. The resulting desynchronization causes yield losses, which are a major hindrance to the sustainable intensification of rice cultivation. This means that choosing the right starting point of the cropping system – i.e. planting dates for rice – is of key importance for the sustainable intensification of the rice-wheat systems in the Eastern Gangetic Plains, to which Nepal's Terai belongs. Previous project research through household surveys and field trials shows that the early planting of rice has the potential to increase system yields and profitability. Late planting, in contrast, results in several negative cascading effects such as the impacts of late droughts in rice and terminal heat stress in wheat. As part of a regional effort, including work in the Indian side of the Eastern Gangetic Plains, the project is working to identify spatially explicit entry-points for early rice planting for different farm types.

Surveys and focus group discussions have been deployed by CSISA scientist to collect data on farmers' perspectives on early planting and are currently being analyzed. The survey was carried out in mid- to late-2018 by Anton Urfels, CSISA consultant and PhD Student at Wageningen University. Resulting data are now being fed into a regional gridded crop modelling exercise to examine the implications of transplanting date and the pre-irrigation of monsoon season rice crops to shift transplanting earlier in the season. Although similar analyses have been previously undertaken, they have tended to be conducted for point-locations. The new analysis is unique in that it will result in maps of potential yield across the Terai and also in Bihar where CSISA operates. These maps will further serve as discussion support tools for future meetings with CSISA project partners and governmental collaborators with respect to development interventions that increase rice production resilience to climate change and variability.

Project scientists are currently preparing the modelling framework, and have finished initial test runs. Additional work is underway to set up regionally explicit analyses on optimal and socially viable rice planting dates, the latter point being crucial as socioeconomic considerations may limit farmers' ability to transplant, despite agronomic advantages. Ultimately, these tools, data and analyses will help build decision support systems to assist farmers with deciding when to plant rice and to help them synchronize their cropping systems with the climate system. This will allow farmers to better cope with monsoon variability and minimize negative cascading effects caused by late rice planting, thus enhancing the resilience, productivity, and profitability of rice-based cropping systems in Nepal's Terai.

3. Policy Reform – Achievements

D. POLICY REFORM

D.1 Seed Systems

Bangladesh

Phased down – Activities around seed system policy reform were phased down in this reporting period due to transitions in the CSISA project's leadership within the International Food Policy Research Institute (IFPRI) and project funding uncertainties as described in the Executive Summary and Section 4. However, the project continued to maintain close relationships with seed system partners in Bangladesh, including IFPRI's Bangladesh Policy Research and Strategy Support Program and Agricultural Policy Support Unit, the main CGIAR centers with offices in Dhaka, the national research system and the donor community. 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. The project is awaiting guidance from USAID on this matter.

Nepal

Assessing varietal turnover gaps – In Nepal, the project entered into a collaboration with the USAID/Nepal Mission supported and CIMMYT-led Nepal Seed and Fertilizer project (NSAF) to determine the demand and supply gaps that need filling to bring about systemic policy change on varietal turnover. In late 2017, CSISA initiated discussions with national research partners to carry out a discrete choice experiment among Nepalese farmers to better assess the specific varietal traits that farmers desire in cereals seeds with the aim of assessing farmers' demands for seed quality and the timely availability of seed. The intention is to provide a better understanding of the ground-level issues and provide evidence to advise the Government of Nepal on policy and regulatory options under the Nepal Seed Vision 2020. The Nepal government intends to reduce the subsidy burden on the exchequer by replacing universal seed subsidies with a targeted voucher system. However, no further activities were undertaken on this activity due to revised project priorities and funding limitations as described in the Executive Summary and Section 4.

IFPRI is currently undertaking a similar assessment on varietal turnover in India, in regions bordering the south of Nepal, and is well placed to formulate strategies for regionwide activities to promote varietal turnover if continued funding is available. To this end, in mid-2019, IFPRI will participate in a seed summit organized by the project and NSAF to discuss seed varietal turnover in the region and ways to address the demand and supply gaps related to the adoption of advanced varieties in Nepal.

D.2 Scale-appropriate mechanization

Bangladesh

Impact of protective policies – In 2017, the project had engaged in determining the potential impact and tradeoffs associated with the Government of Bangladesh's policies to support and protect domestic agricultural equipment manufacturers, such as customs duties and tariffs, credit facilities and other support mechanisms. The project had also characterized the status of the agricultural machine industry and the spread of agricultural machines throughout Bangladesh, including the nature of the trade barriers to importing agricultural equipment. This task also attempted to understand the sensitivity of the supply and demand of machinery and service provision arrangements to price changes, and changes in government revenue resulting from changes to trade policies. This exercise identified important data gaps that restrict the project's ability to develop a complete picture – such as the lack administrative data on specific machines and data on supply and demand elasticities for relevant agricultural machines. It became apparent that the project needed to invest a significant amount of staff time and resources to complete the analysis. However, continued work on this activity beyond December 2017 proved difficult considering uncertain project funding as described in the Executive Summary and Section 4.

Nepal

Due to funding uncertainties as described in the Executive Summary and Section 4, the project halted its direct policy work on scale-appropriate mechanization in 2017. Staff transitions within the project and the IFPRI team due to funding uncertainties also hindered the project's ability to contribute to this workstream. Efforts were therefore redirected towards soil fertility management and fertilizer market work, which emerged as more relevant workstreams in light of the project's new priorities.

In spite of the changed focus, the project team's interest and expertise on mechanization leads to its continued engagement with partners to determine the potential for experiments around scale-appropriate mechanization in Nepal through other USAID grants and other donors.

Impact of the spread of mini-tillers – CSISA continued research collaborations with NSAF and other partners including the private sector, the Department of Agriculture and NARC to engage, monitor and assess the impacts of the spread of mini-tillers on mechanizing agriculture in Nepal's Midhills. Key findings are emerging from a survey completed in 2018 that investigated the impacts of and demand for mini-tillers by farmers in seven Midhills districts. The results of the first study suggest that a significant proportion of farmers were willing to buy mini-tillers, with a larger proportion willing to hire-in mini-tiller services. While limited labor availability, increasing labor prices and associations with cooperatives and access to credit were related with increased demand for hiring in and buying mini-tillers, unsurprisingly the more draft animals a farmer owned reduced their willingness to hire in or buy a mini-tiller. The study recommended a significant reduction in the price of mini-tillers to increase adoption in Nepal's Midhills.

D.3 Soil fertility management and fertilizer markets

The CSISA project is placing a greater focus on strengthening soil fertility management and fertilizer policies in Bangladesh and Nepal. Bangladesh is a net importer of urea, phosphate and potash fertilizers, importing as much as 70% of its total urea each year. The demand for fertilizers is rising, but declining soil quality and the poor management of fertilizer application remain a concern.

Also, the cost of fertilizers for farmers is highly subsidized and accounted for about 45% (69,360 million taka or $823 million) of the agricultural budget in 2014–15, as per allocations to the Ministry of Agriculture, Ministry of Livestock and Ministry of Food. In 2017–18, subsidies for fertilizer and other agriculture inputs amounted to 60,000 million taka ($712 million), accounting for 43% of the agriculture budget allocation and 0.26% of national gross domestic product (GDP).[13]

Even after subsidies, expenditure on fertilizer by farmers exceeds 10% of the total value of rice output. However, the often imbalanced application of fertilizer affects crop yields, farmers' profits, soil health and the environment. The constraints on the balanced application of fertilizers urgently need identifying

[13] Bangladesh Economic Review 2018, Ministry of Finance, Bangladesh

as little information is available on this subject. In late 2018, the project prepared a baseline assessment of the scale and intensity of over and under-application of nutrients in Bangladesh. In early 2019, the project began gathering and collating existing data from the Bangladesh Integrated Household survey (BIHS), the Bangladesh Institute of Development Studies (BIDS), the Household Income and Expenditure Survey (HIES) of the Bangladesh Rehabilitation Assistance Committee (BRAC) and other IFPRI projects. Using these data between April and September of 2019, the project will chart the trends in applications over crops, seasons and regions. These trends will help identify the rates of application to document the extent of over and under-application of key nutrients in parts of the country. The factors that determine application rates and barriers to balanced nutrient application will then be mapped out, which could identify demand and supply constraints for fertilizers. This should enable the drawing of policy recommendations to encourage more balanced fertilizer use.

Photo 3.1: A farmer in Jhedeniah, Bangladesh broadcasting urea on his boro rice (TJ Krupnik/CIMMYT)

Nepal

The project's collaboration with NSAF continued to expand the knowledge base and insights on government policy concerns on establishing internal manufacturing systems to support the demand for fertilizers, a portion of which is currently met by grey markets around the India-Nepal border.

Willingness-to-pay study – In 2019, in collaboration with NSAF, CSISA provided survey design consultation and technical and analytical support to carry out a willingness-to-pay study with 600 farmers across Nepal's Midhills and Terai. The study sought to identify the price variants and other bottlenecks in the availability of urea and diammonium phosphate (DAP) fertilizer. It investigated the latent demand for quality fertilizers and timely availability. The main study findings were as follows:

- Farmers in the Terai valued urea and DAP more than what they pay for them in the market, while the Midhills farmers valued DAP less than its cost in the market.
- The total intrinsic value for fertilizers was typically less than the actual market price under the current situation in which farmers incur travel and other transaction costs and the quantities and qualities of fertilizers are uncertain.
- The study also found that relaxing travel and certainty constraints could increase the value farmers put on fertilizer – especially in terms of yield gains.

The second point indicates that an argument can be made that these farmers rely heavily on subsidies. There is thus a need for continued support, at least in the short to medium term, to ensure that farmers can avail of adequate supplies and do not reduce the already low levels of fertilizer application on their crops. The study report recommends that:

- a well-designed voucher program could provide the requisite support for increased access to fertilizer markets and quality fertilizers;
- reducing the barriers to the entry of the private sector in supplying fertilizers would also improve farmers' access to fertilizers; and
- an appropriate targeting mechanism is needed to enhance marginal and smallholder farmers' access to fertilizers.

As the private market for fertilizers develops and increased competition for providing quality and timely fertilizer emerges, farmers are expected to be able to avail the benefits of using vouchers provided by local administrations. The value of vouchers could be determined by the amount of subsidy the government is willing to provide per kg of fertilizer.

As the fertilizer market becomes stronger and competition increases, it should become easier and less costly for farmers to travel to acquire needed fertilizer supplies and to encourage uniform high-quality fertilizer supplies. In turn, less of the total value of fertilizers will be accounted for by travel and transaction costs, and more will be attributed to its intrinsic value. Over time, then, it is not difficult to imagine a scenario where government support to farmers is reduced if not wholly eliminated.

The study findings were presented to stakeholders including USAID on 21 March 2019 and published in March 2019 in a study report (IFPRI discussion paper) and a CSISA policy brief.[14] The project team aims to hold further discussions with key policymakers in Nepal, with support from NSAF to share these results and inform the Nepal government's design of a voucher system and efforts for the development of stronger supply chains across the country.

In August 2019, CSISA and NSAF will host a regional meeting to bring together expert academicians, researchers and policymakers from India, Bangladesh and Nepal to deliberate on fertilizer supply policy reform.

D.4 Agricultural risk management

Bangladesh

Due to staffing changes in the CSISA-IFPRI team and the uncertainty of project funding, future activities on this component were suspended in in 2017/18 to ensure that the efforts of the current team focused on their areas of expertise, i.e., soil fertility management. Given the project's efforts to generate evidence for risk management alternatives in the region, the project is well-placed to undertake relevant analysis if there is continued interest and funding from other partners and policymakers.

Nepal

Owing to funding uncertainty, no further activities were undertaken on agricultural risk management. Additionally, internal staffing changes within the CSISA-IFPRI team led to future activities on this component being suspended in 2017/18 to ensure the efforts of the current team focused on their areas of expertise.

[14] Click on links to access internet copies of the report

4. Challenges Faced During the Reporting Period

CHALLENGES ACROSS COUNTRIES

The flow of funds and the amount received continue to be uncertain for CSISA. This has led to delays and cut-backs in planned activities including as described in the text for almost all of CSISA's work packages in Bangladesh, Nepal, and especially on policy reform. The project is currently operating with FY 2017/18 funds, which came more than nine months after their anticipated date. Funds were also 30% less than anticipated. As described in the 2017/18 annual report, this led to a significant reduction in staff that continues to slow the project. Importantly, although funds were received in the latter half of 2018, they followed a 41% shortfall in the project's second year (FY 2017) of activities. As a result, most of the activities implemented by CSISA in Nepal and Bangladesh in FY 2017 and FY 2018 were significantly reduced. To date (May 2019), CSISA has received only 52% of the overall 5-year planned budget, despite being half way through the third year of implementation of the five-year project.

CHALLENGES IN BANGLADESH

As discussed in Section 1.C.2.3, the appearance of fall armyworm in Bangladesh has caused some re-organization of CSISA activities to respond to this serious threat. Although fall armyworm was not initially part of CSISA's initial workplan, maize production is crucial to the project's objectives to increase productivity and resilience in South Asia's cereal systems. Although CSISA has been able to adapt reactively and lead initial efforts to mitigate the risks posed by fall armyworm, this topic was not part of the project's initial workplan. Given the overall budget shortfalls and delays, CSISA is not necessarily best placed to continue in-depth work on this topic. Rather, given the size of the threat posed by fall armyworms, a dedicated project is urgently needed to tackle the pest through well-planned integrated pest management actions. Considering CIMMYT's leadership in maize and the fall armyworm in sub-Saharan Africa in partnership with USAID, additional funding to combat the threat of fall armyworm in Bangladesh, and also in Nepal where it is expected to spread during the summer of 2019, is urgently needed.

In addition to fall armyworm, and as described in section 1.C.2.2, a reduction in national wheat land area in Bangladesh due to the threat of wheat blast, reduced government subsidies for wheat, low grain prices and less economic returns than competing crops, meant that the project achieved only 4,523 ha of early sown wheat compared to its 8,000 ha target in 2018/19.

CHALLENGES IN NEPAL

Activities in Nepal have been significantly challenged due to funding delays and shortfalls as described above. In addition, an ongoing challenge faced by the project in this reporting period was the uncertainty and the lack of permanent governmental agricultural staff working in Nepal's newly formed provinces. The government's new federal constitution, which was promulgated in 2015, began to take full effect in 2017 through to the end of 2018 with the election of the three new tiers of government – federal, provincial and local governments. Each of these levels continues to sort out their relative responsibilities, and the devolution of responsibilities from central government has meant that provincial and local governments are intended to be more responsible for supporting farmers than under the previous Ministry of Agriculture and district agriculture offices. The project continues to engage closely with governmental partners during this transition period, but has in a number of cases suffered as plans have been made that had to be later abandoned due to provincial and district level staff changes and modifications to governmental priorities.

5. Additional Information

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

USAID/Bangladesh Mission

In Bangladesh, the CSISA Phase III Project Leader regularly updates the USAID/Bangladesh Mission staff under the Office of Economic Growth with regards to ongoing activities at formal and informal meetings. CSISA is also regularly consulted by the Mission for information on cereal-based cropping systems, agricultural mechanization and appropriate agricultural development investments. Notable consultations continue to include requests for information and ideas on improving gender mainstreaming in agricultural development, in addition to the solicitation of ideas for future investments. Most recently, CSISA cooperated with the USAID/Bangladesh Mission in coordinating and supporting USAID's response to fall armyworm in Bangladesh, as described in Section 6.2.3.

USAID/Nepal Mission

CSISA continued to engage with the Nepal mission in the following areas during this reporting period:

- The provision of technical advice and extension media to the KISAN II project (USAID-Nepal's flagship Feed the Future program) on staple crop management and private sector development while supporting Nepal's agricultural development strategy.
- Shared technical insights into challenges and opportunities confronting the sustainable intensification of lentil production in Nepal to USAID-funded projects, i.e., NSAF and KISAN II.

Feed the Future partners

CSISA Phase III also directly collaborates with the following Feed the Future projects:

- **Rice and Diversified Crops (RDC) Project:** The ACDI/VOCA led RDC project 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-III provides regular technical advice to RDC and is working to convene a national meeting on Integrated Weed Management with RDC during summer 2019.
- **Cereal Systems Initiative for South Asia – Mechanization and Irrigation (CSISA-MI) project**: CSISA-MI emerged out of CSISA's ongoing efforts in the USAID/Bangladesh Mission-funded CSISA expansion project (2010–15), and during CSISA Phase II. It continues to be strategically aligned with the broader CSISA Phase III program in Bangladesh, and is led by CIMMYT in partnership with International Development Enterprises (iDE). CSISA-MI is a five- year project (July 2013–September 2018)[15] that focuses on unlocking agricultural productivity through increased adoption of agricultural mechanization technologies and services. The CSISA-MI Project Leader participates in the overall cross-country CSISA Management Committee. The CSISA Phase III Project Leader Coordinator also maintains a position on the leadership committee of CSISA-MI and regularly contributed to strategy.
- Although it does not fall under the Feed the Future program, CSISA's wheat blast research

[15] SCISA-MI has a one year no cost extension to September 2019 when a second phase is under consideration.

activities on disease forecasting and modeling are also strategically aligned with the USAID-Washington funded **Climate Services for Resilient Development (CSRD) project**, which falls under the Global Climate Change Office Bureau for Economic Growth - Education and Environment. Strategic alignment with CSISA is assured as the CSRD Project Leader is now also the CSISA Phase III Bangladesh and Nepal Project Leader.

- The **Nepal Seed and Fertilizer (NSAF)** project, a $15 million USAID-Nepal initiative, was a direct outshoot of progress made by CSISA on seed systems and integration soil fertility management. CSISA staff collaborate deeply with NSAF on scientific and operational matters. The lead of CSISA, Andrew McDonald, acts as the senior advisor for NSAF.
- **The KISAN project**, part of USAID's global Feed the Future initiative, is a five-year project which facilitating systemic changes in the agricultural sector including: (i) greater climate-smart intensification of staple crops and diversification into higher value commodities; (ii) strengthening local market systems to support more competitive and resilient value chains and agricultural related businesses and (iii) improving the enabling environment for agricultural and market systems development. KISAN reaches hundreds of thousands of farmers, who have been exposed to CSISA information, materials, and technologies through this partnership.

Project Sub-Contractors

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

- **Agricultural Advisory Society** (**AAS**): The NGO AAS works to put more wealth in the hands of small and poor farmers by improving their agricultural skills and capacities and by demonstrating ways in which they can better manage their available resources. The purpose of the 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 19 districts of the country.
- **Agricultural Input Retailers' Network** (**AIRN**): AIRN formed as a result of CNFA led efforts a previous USAID/Bangladesh Mission funded agricultural inputs project. Partnering with CSISA, AIRN is training inputs dealers on the principles and practices of integrated weed management and to combat fall armyworm.
- **The Bangladesh Research Institute (BRRI):** Under this agreement, BRRI assists with:
  - implementing on-farm trials of new premium quality rice varieties in 6 upazilas in three CSISA hubs to identify best-bet premium quality varieties in terms of yield and farmers', millers', and traders' preferences;
  - on-farm performance evaluations of integrated weed management options to increase yield and profits in farmers' fields;
  - on-station trials to develop and fine tune the mat nursery method of raising rice seedlings for manual transplanting; and
  - organizing additional on-farm trials and collecting crop cut data.

Appendix 1: CSISA III Key Leadership Staff

Name	Role	Institution	Address	Phone	Email
Timothy Krupnik	Senior Scientist (Systems Agronomy) and Regional Strategic Team Lead for Sustainable Intensification in South and Southeast Asia. CSISA Project Leader (Nepal and Bangladesh).	CIMMYT	Dhaka, Bangladesh	+88 0175 556 8938	t.krupnik@cgiar.org
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Name	Role	Institution	Address	Phone	Email
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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 inputs into the development of extension materials, approaches and policy, 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.	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 policy, 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. CIMMYT has signed a sub-grant agreement with BWMRI to continue research on wheat blast and other subjects.
Bangladesh Rice Research Institute (BRRI)	Development, validation, and refinement of technologies and new research methods, boosting scaling capacity	Innovation towards impact	With a network of regional research stations and strong input into the development of extension materials, approaches and policy, and being integrated in the Ministry of Agriculture, BRRI also provides leveraging opportunities to mainstream sustainable intensification innovations in the Government of Bangladesh's National Agriculture	The International Rice Research Institute (IRRI) maintains a formal partnership MoU with BRRI. BRRI collaborated with CSISA in Phases I and II continuing in Phase III. Funding for BRRI's research partnership was on hold in 2018 due to fund unavailability, but it was restarted in 2019

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
			Research and Extension System.	with funds from USAID.
Department of Agricultural Extension (DAE)	Extension and scaling	Achieving impact at scale	The DAE has over 13,000 field extension agents across Bangladesh. The department collaborated with CSISA Phase II and the USAID/Bangladesh Mission funded CSISA Expansion project in Bangladesh in the Feed the Future zone and Dinajpur hub. The sensitization of DAE agents on sustainable intensification technologies and approaches provides opportunities for reaching and raising the awareness of farmers, with sustainability through messaging after Phase III ends.	CSISA continues to collaborate with DAE on an informal and synergistic basis despite funding cuts. The volume of activities reduced due to the project's inability to support large field campaigns and collaborative meetings with DAE. CIMMYT has been working with DAE through other projects – Climate Services for Resilient Development (CSRD) and wheat blast. Also, as part of CSISA III activities, the DAE works with CIMMYT to disseminate better bet agronomic practices. DAE is spreading messages on early wheat sowing and fighting wheat blast developed by CIMMYT, BARI and BWMRI.
Agricultural Information Services (AIS)	Production of extension materials for DAE use	Achieving impact at scale	AIS 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 continues on an informal basis. In Dinajpur, AIS supported CSISA III activities by conducting village level video showings and trainings on healthy rice seedlings and early wheat sowing.
Bangladesh Private Sector				
Janata Engineering	Development and sale of scale-appropriate machinery	Achieving impact at scale	Domestic production and import of sustainable intensification scale-appropriate machinery and sales through the private sector	Established relationship through a commercial joint venture agreement. However, the agreement was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA. CSISA has

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
				however maintained active discussions with this partner, and could re-establish relations if clear funding timing and commitments are provided by USAID.
Metal Pvt. Ltd	Development and sales of scale-appropriate machinery	Achieving impact at scale	Domestic production and import of sustainable intensification scale-appropriate machinery and sales through the private sector	Established relationship through a commercial joint venture agreement. However, the agreement was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID. CSISA has, however, maintained discussions with this partner, and could re-establish relations if clear funding timing and commitments are provided by USAID.
Rangpur Foundry Limited (RFL)	Development and sales of scale-appropriate machinery	Achieving impact at scale	The import of sustainable intensification scale-appropriate machinery and sales through the private sector	Established relationship through a commercial joint venture agreement. However, the agreement was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID. CSISA has, however, maintained active discussions with this partner, and could re-establish relations if clear funding timing and commitments are provided by USAID.
Advanced Chemical Industries (ACI)	Sale of scale-appropriate machinery, fungicides, weed control products and seed. IRRI works with ACI to produce a range of hybrid and open-	Achieving impact at scale	The import of sustainable intensification scale-appropriate machinery and sales through the private sector, along with a range of chemical and cereal seed products.	Established this relationship through a commercial joint venture agreement. However, the agreement was terminated in 2017 due to funding uncertainties and fund transfer delays to CSISA from USAID. CSISA has, however, maintained

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	pollinated rice seeds			discussions with this partner and could potentially re-establish relations if clear funding timing and commitments are provided by USAID.
NGOs				
Agricultural Advisory Society (AAS) - project subcontractor	Facilitates village screenings of training films and conducts follow-up studies	Achieving impact at scale	The project worked with AAS in Phase II and CSISA-Bangladesh to reach 110,000 farmers with village training video screenings accompanied by question and answer sessions to raise awareness among farmers on scale-appropriate machinery and associated crop management practices. During CSISA III, AAS is working with the project 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 farmer trainings on core CSISA topics.
Agro-Input Retailers Network (AIRN) Project subcontractor	Trains input dealers and retailers	Achieving impact at scale	AIRN was awarded two sub-grants in the current year: i) for training AIRN dealers on the principles and practices of integrated weed management and iii) equipping them to combat fall armyworms.	Partnering with the project, AIRN trains input dealers on the principles and practices of integrated weed management and fall armyworm control.
Universities				
Department of Crop Sciences at the University of Illinois at Urbana-Champaign (UIUC)	Strategic research on precision nutrient and rice crop management	Innovation towards impact	The CSISA Project Leader is an active academic committee member for Shah-Al Emran, a Bangladeshi PhD student at UIUC. Emran is working towards the production of two manuscripts using CSSIA data.	Ongoing successful partnership.
Wageningen	Strategic research on	Innovation	Strategic high-end research capacity to assist in the	Formally established working relationship

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
University	farmer decision making processes and the intensification of fallows	towards impact	analysis of farmer decision-making processes on intensification decisions	with CIMMYT for research deliverables to support 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 an 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, though not discussed in detail in this report.
Bangladesh Agricultural University	Capacity development in high-quality research, research on fall armyworm	Innovation towards impact	Bangladesh's largest agricultural university, with influence over the next generation of young scientists, many of whom go on to work in BARI, BRRI and the DAE	Relationship with Phase III continues on an informal basis. Increased collaboration on fall armyworm is underway at the time of reporting.
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 technologies in northern Bangladesh. The ACIAR funded SRFSI is scaling up these activities. CSISA is supporting NARC and other SRFSI partners to spread its technologies.	Active for more than 3 years
Cereal Systems Initiative for South Asia – Mechanization and Irrigation (CSISA-MI	CSISA-MI aims to transform agriculture in southern Bangladesh by unlocking potential productivity through irrigation, small-scale	Achieving impact at scale	CSISA-MI, led by the International Maize and Wheat Improvement Centre (CIMMYT), in partnership with iDE under the Feed the Future (FtF) Initiative. The project developed and trained local agricultural service providers (LSPs), created an agricultural mechanization value chain and	Active for more than 5 years since CSISA Phase II

Partner	Partnership objective	Alignment with themes	Leveraging opportunity	Status of partnership
	agricultural machinery and agricultural services provision. CSISA III supports CSISA-MI in that CSISA-MI is aligned with the overall CSISA portfolio and the CSISA-MI Project Leader participates in the overall CSISA Management Committee.		scaled-out agricultural machinery services across the FtF zone. Through private sector dealers and manufacturers, Axial Flow Pumps (AFP), Power Tiller Operated multi-crop Seeders (PTOS) and harvesters were introduced for which farmers receive these mechanized services at a reasonable cost, for improved productivity. CSISA Phase III leverages this project by aligning its themes with geographies where LSPs have emerged, particularly with respect to fallows development through irrigation, reapers to facilitate rapid rice harvesting and early wheat sowing, and directly sown rice.	
Rice and Diversified Crops (RDC)	RDC is led by ACDI-VOCA and is working to i) improve food security through systemic changes that increase rural incomes, ii) increase farm productivity and iii) increase participation in profitable market systems	Achieving Impact at Scale	The USAID Feed the Future Bangladesh Rice and Diversified Crops Activity (RDC) 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. RDC will reach its goals through facilitative interventions (targeted technical assistance) that create scalable market system impacts, ultimately benefiting rural households with the added value of expanding opportunities for women and youth. 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.	Active for more than 2 years

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 new Agriculture Development Strategy (ADS, 2015–2035) was approved by the Government of Nepal in late 2015. CSISA acts as a technical partner to shape the loan and investment programs associated with the strategy, which may exceed $100 million.	Active and sanctioned by CIMMYT's host country agreement
Nepal Agricultural Research 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 of all state recommendations; their endorsement and the ownership of emerging sustainable intensification technologies.	Active and long-standing
Department of Agriculture (DoA)	Front line extension and support to farmers, service providers and the private sector	Achieving impact at scale	CSISA assists in improving the quality of extension messaging and works to deepen linkages to the private sector.	Active and long-standing
Provincial governments	To strengthen provincial level policies and provincial government support for agricultural development activities	Achieving impact at scale	Provincial governments are the middle tier of government under the new federal constitution and have a large degree of independence. They have important policy making and oversight roles on agricultural development. In this reporting period the project engaged and supported the Province 5 and Far Western Province governments.	Active and new
Local governments	To strengthen local government support for agricultural development activities	Achieving impact at scale	Local governments are the local tier of government under the new constitution. They have a significant role in implementing agricultural development in their areas and are important stakeholders that the project seeks to engage.	Active and new

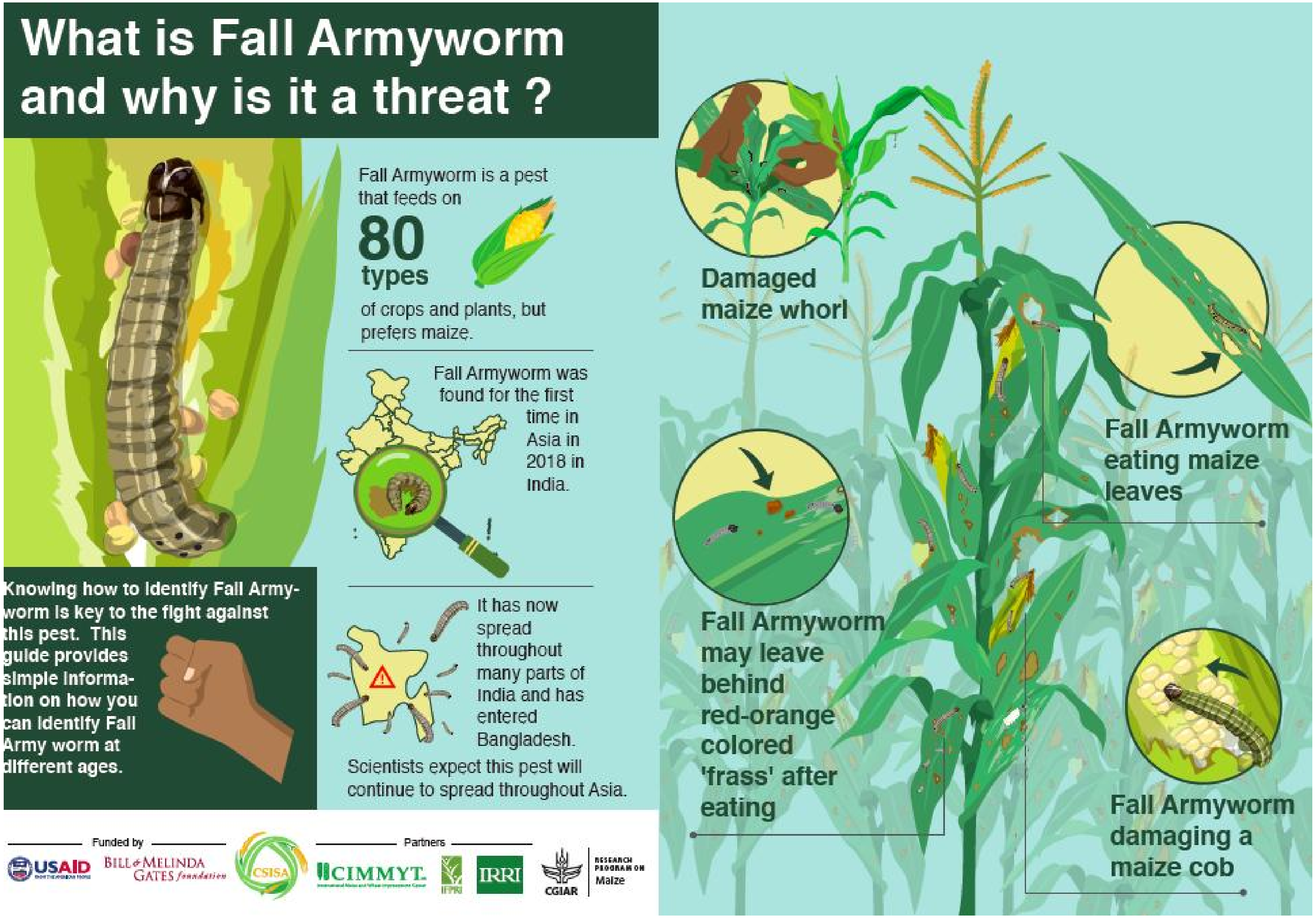
Nepali private sector				
DKAM (farm machinery importer and dealer)	Introduction and market development of reaper-harvesters in Dang (Province 5)	Achieving impact at scale	The rapid expansion of investments in scale-appropriate machinery and support for emerging service provision markets.	New in this reporting period
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.	New in this reporting period
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 with the help of CIMMYT to create an enabling environment and policy dialogue for scale-appropriate mechanization in Nepal	Systemic change towards impact	Important voice for the private sector with GoN as Agriculture Development Strategy support programs take shape.	Active since 2014

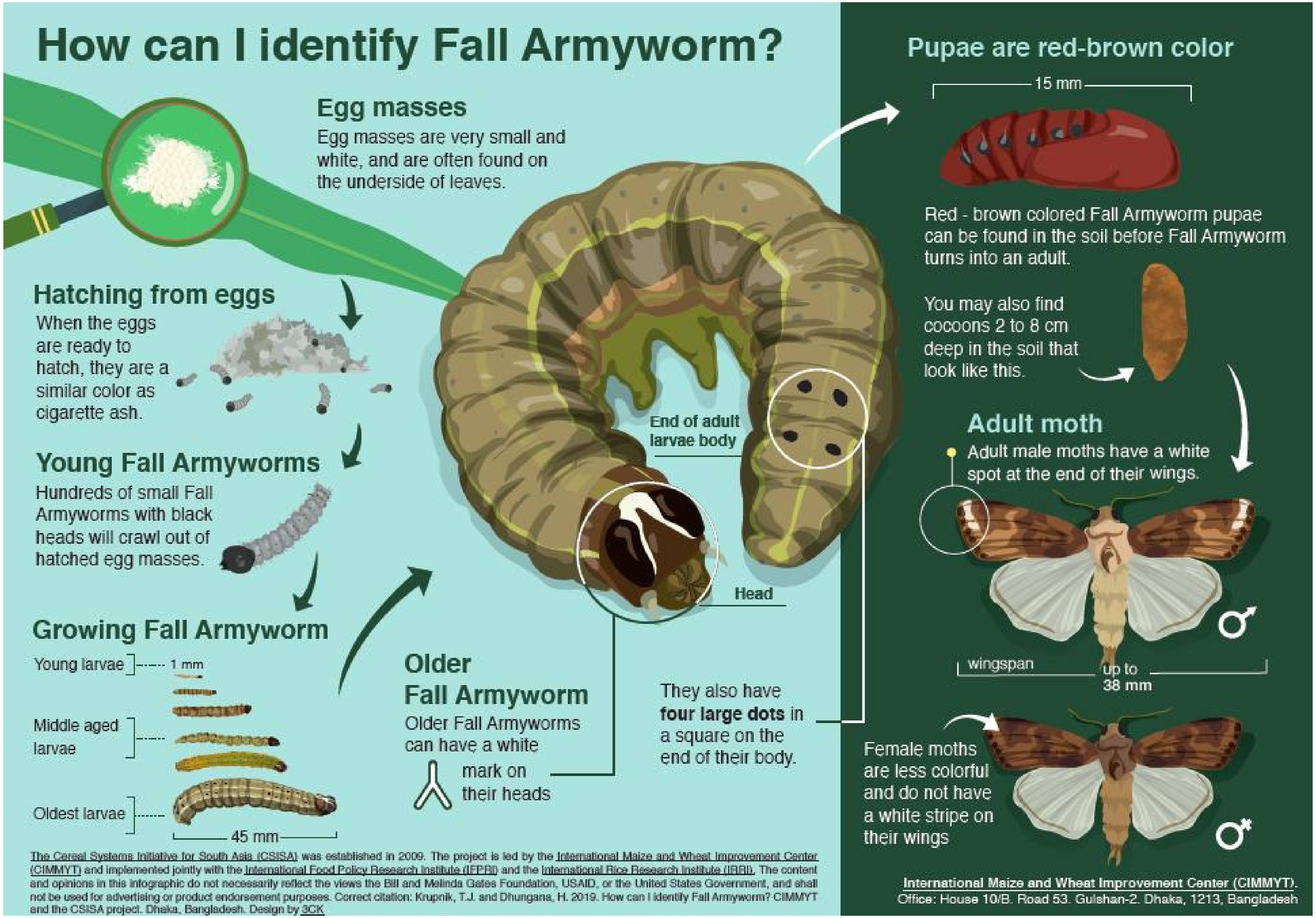
Seed Entrepreneurs Association of Nepal (SEAN)	Trade association strengthened with the help of CSISA to create an enabling environment and policy dialogue for seed system strengthening for small and medium seed enterprises in Nepal	Systemic change towards impact	Important voice for the private sector with GoN as Agriculture Development Strategy support programs take shape. Provided inputs to studies on maize hybrids in Nepal	Active and long-standing
Universities				
Manchester University	Collaboration on irrigation and hydrology research to support sustainable irrigation use in the Terai	Innovation towards impact	Field survey design, implementation, data analysis, and development of reports, papers and presentations for partners.	New in this reporting period
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 studies with CSISA	Established, but 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 the formulation of new research questions.	Active
Projects				
Knowledge-based Integrated Sustainable Agriculture and Nutrition (KISAN) II	Strategic partnership to co-support the large-scale deployment of extension information and technologies	Achieving impact at scale	KISAN II is a five year, $ 32.7 million project which will facilitate systemic changes in the agricultural sector including: (1) greater climate-smart intensification of staple crops and diversification into higher value commodities; (2) strengthening of 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. KISAN reaches hundreds of thousands of farmers meaning they are exposed to	Active for more than 3 years

			CSISA information, materials and technologies.	
Nepal Seed and Fertilizer Project (NSAF)	Strategic partnership to co-support the large-scale deployment of extension information and technologies	Achieving impact at scale	The USAID Nepal-funded NSAF project ($15m for 2016–2021) focuses on the applied science-to-development continuum, including market facilitation to expand private sector-led fertilizer and seed sales. CSISA is disseminating the better-bet technologies at scale through NSAF's networks.	Active for more than 3 years
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 for more than 3 years
CSISA Agronomy and Seed Systems Scaling	Strengthening scaling efforts related to best practices for agronomy and improved seed systems for smallholder farmers.	Achieving impact at scale	CSISA-Nepal Agronomy and Seed Systems Scaling aims to address these constraints by (1) strengthening seed systems so farmers have timely access to improved varieties and hybrids for pulses, wheat and maize; (2) targeting geographic niches and identifying management practices that enable cropping system intensification through the cultivation of lentil and mungbean; (3) recommending best management practices for wheat, including scale-appropriate mechanization technologies that help farmers plant early and avoid terminal heat; (4) facilitating market development for small-scale technologies that enable precise nutrient management; and (5) supporting the expansion of the private sector for sustainable intensification technologies into the Mid and Far West, including the availability of 'spares and repairs,' and expanding the number of service providers so that farmers in rural areas can gain affordable access to new technologies. CSISA Phase III leverages this project by supplying research information, technologies	Active for more than 3 years

			and recommendations that can be scaled-out through this project.	

Appendix 3: Fall Armyworm Infographics Developed by CSISA During the Reporting Period




How can I identify Fall Armyworm?
Egg masses
Egg masses are very small and white, and are often found on the underside of leaves.
Hatching from eggs
When the eggs are ready to hatch, they are a similar color as cigarette ash.
Young Fall Armyworms
Hundreds of small Fall Armyworms with black heads will crawl out of hatched egg masses.
Growing Fall Armyworm
Young larvae
1 mm
Middle aged larvae
Oldest larvae
45 mm
Older Fall Armyworm
Older Fall Armyworms can have a white
mark on their heads
End of adult larvae body
Head
They also have **four large dots** in a square on the end of their body.
Pupae are red-brown color
15 mm
Red - brown colored Fall Armyworm pupae can be found in the soil before Fall Armyworm turns into an adult.
You may also find cocoons 2 to 8 cm deep in the soil that look like this.
Adult moth
Adult male moths have a white spot at the end of their wings.
wingspan
up to 38 mm
♂
Female moths are less colorful and do not have a white stripe on their wings
♀
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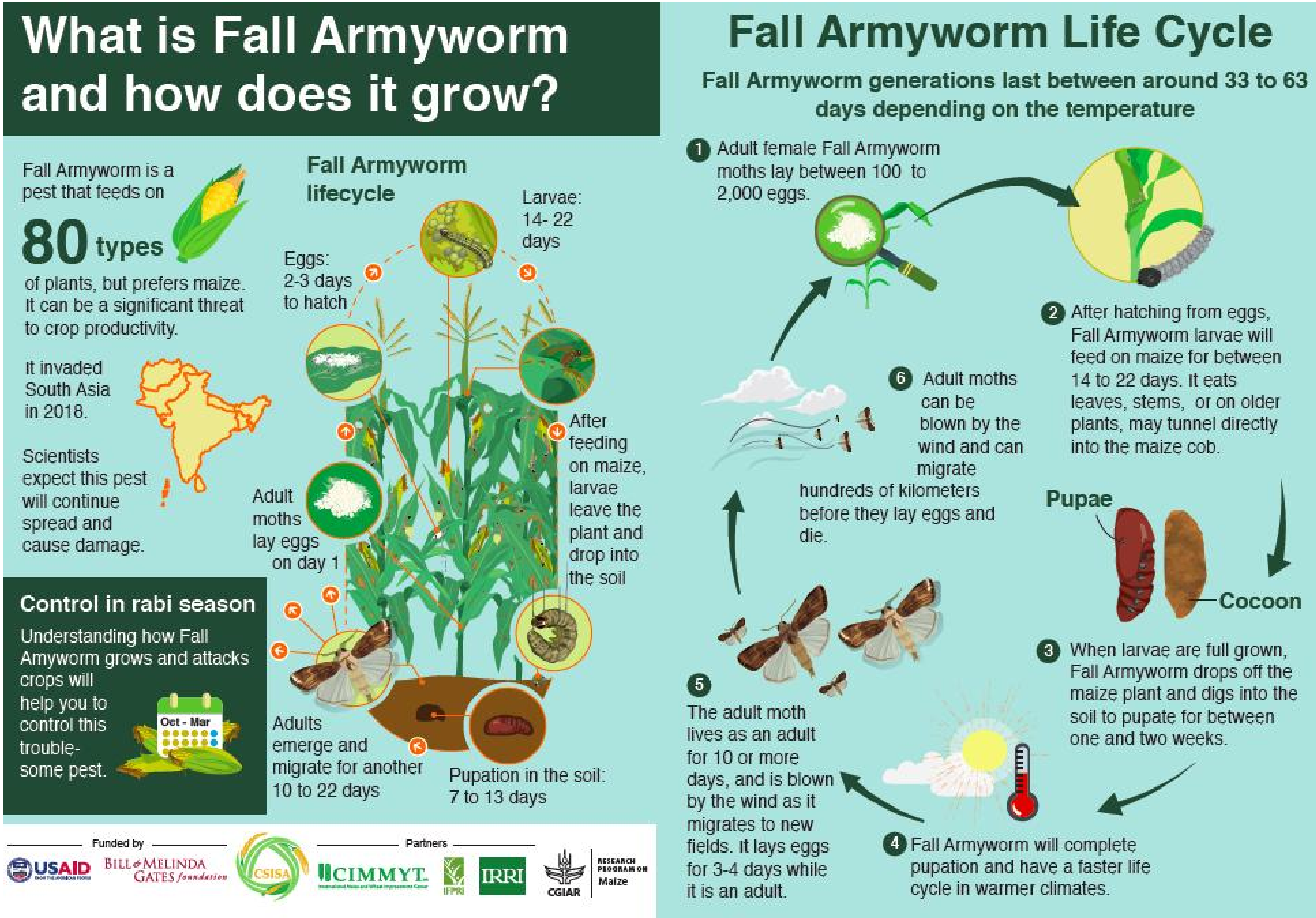

What is Fall Armyworm and how does it grow?
Fall Armyworm is a pest that feeds on
80 types
of plants, but prefers maize. It can be a significant threat to crop productivity.
It invaded South Asia in 2018.
Scientists expect this pest will continue spread and cause damage.
Fall Armyworm lifecycle
Eggs: 2-3 days to hatch
Larvae: 14- 22 days
After feeding on maize, larvae leave the plant and drop into the soil
Adult moths lay eggs on day 1
Adults emerge and migrate for another 10 to 22 days
Pupation in the soil: 7 to 13 days
Control in rabi season
Understanding how Fall Amyworm grows and attacks crops will help you to control this trouble-some pest.
Oct - Mar
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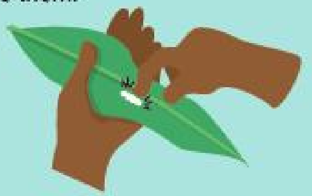
Fall Armyworm Life Cycle
Fall Armyworm generations last between around 33 to 63 days depending on the temperature
1 Adult female Fall Armyworm moths lay between 100 to 2,000 eggs.
2 After hatching from eggs, Fall Armyworm larvae will feed on maize for between 14 to 22 days. It eats leaves, stems, or on older plants, may tunnel directly into the maize cob.
Pupae
Cocoon
3 When larvae are full grown, Fall Armyworm drops off the maize plant and digs into the soil to pupate for between one and two weeks.
4 Fall Armyworm will complete pupation and have a faster life cycle in warmer climates.
5 The adult moth lives as an adult for 10 or more days, and is blown by the wind as it migrates to new fields. It lays eggs for 3-4 days while it is an adult.
6 Adult moths can be blown by the wind and can migrate hundreds of kilometers before they lay eggs and die.

How can you control Fall Armyworm at different stages of growth?

Look for egg masses. They are usually on the bottom of leaves. Crush them when you see them.

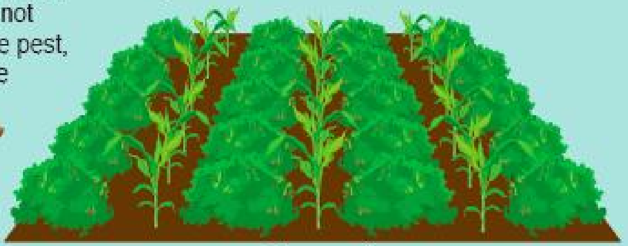


Fall Armyworm is most successfully controled when it

less than
10 days old
so scout your field early and often.

If you regularly inspect your fields, larvae can be picked off plants and crushed with your hands. This will not completely control the pest, but will help to reduce populations.

Intercropping can help confuse Fall Armyworm and reduce infestation.



Intercropping

If you have irrigation, you can flood your field with a few centimeters of water when Fall Armyworm is pupating in the soil. Pupae will drown and die. Irrigation works best when all farmers in an area flood at a similar time. This reduces populations over a large areas where maize is grown and helps many farmers benefit by reducing area-wide pest levels.

Conserve spiders and other insects that are parasitic and lay their eggs inside Fall Armyworm eggs and also larvae. These spiders and insects are friends of farmers and will kill Fall Armyworm for you.

Insecticides should only be applied by a certified pest control specialist after you have consulted with an extension agent. Use insecticides only after all other pest management techniques have been attempted and failed. Remember, insecticides will also kill beneficial insects like spiders and parasitic wasps, so use them only as a last resort.

If you use insecticides, be sure to spray egg masses or larvae. They may be hiding under leaves or in the maize whorl.

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What is Fall Armyworm and how can I scout for it in my field?

1. Begin scouting your field soon after maize has emerged. Fall Armyworm prefers to feed at night. For this reason, scouting very early in the morning is best.

2. Check plants for damage from Fall Armyworm.

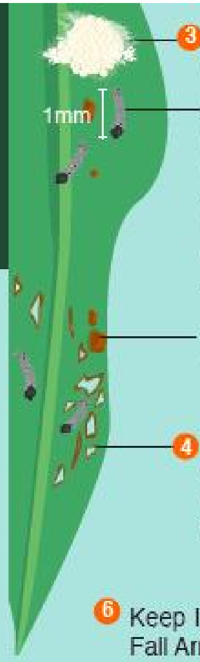
Fall Armyworm is a serious pest that can feed on over

80 plants

but prefers to eat maize.

Fall Armyworm is now found in South and South East Asia and requires careful management to avoid crop damage.

By counting the number of maize plants with signs of damage, you can decide how to protect your crop.



3. Egg masses are small and white colored.

Newly hatched and young larvae are about between 1 mm long. They grow to up to 45 mm as adults. **You will have more success in controlling Fall Armyworm when they are young.**

Larvae also leave behind waste when they feed.

4. Leaf damage from young Fall Armyworm looks like small windows or pinholes chewed into leaves.

5. Older larvae bore diectly into maize cobs, but it is very hard to control them at this stage.

6. Keep looking at least every 10 days for signs of Fall Armyworm damage.

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CSISA

Partners: CIMMYT, IFPRI, IRRI, CGIAR, RESEARCH PROGRAM ON Maize

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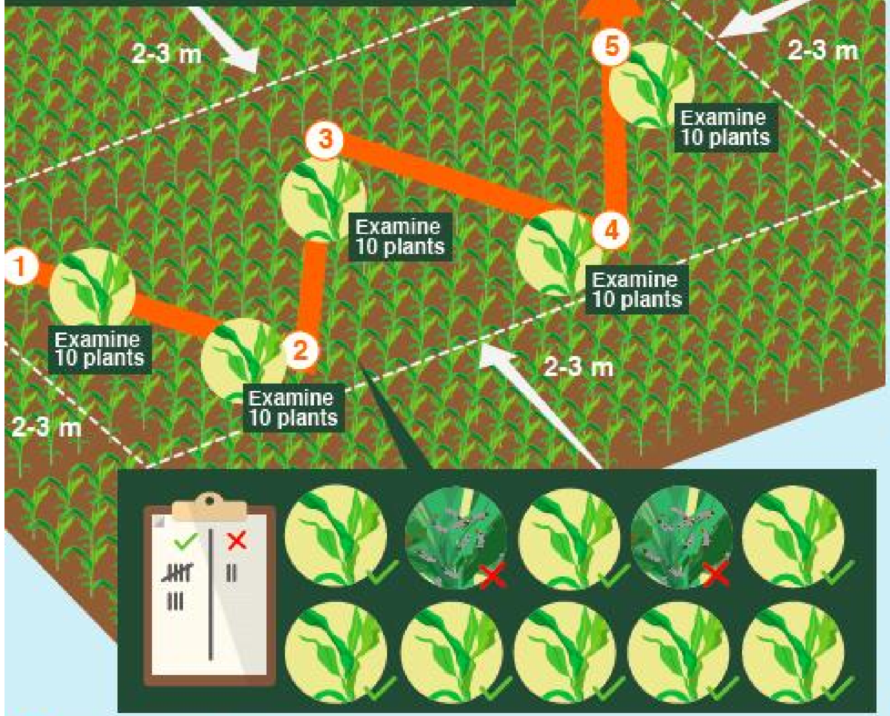
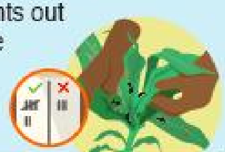
7 Look for signs of Fall Armyworm damage in 5 different places in your field.



8 Stop in 5 places that are not on the sides of the field as shown in the image above.

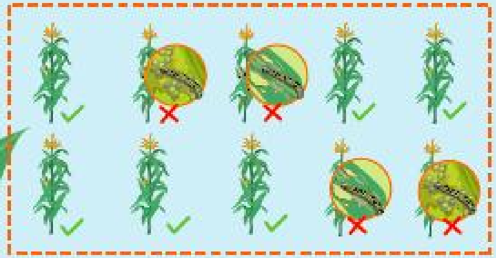
10 Write down how many plants have Damage. Also record the number of plants that do not.

9 In each of the 5 places in your field, carefully examine 10 plants for signs of new Fall Armyworm damage. Next, count up the total number of plants out of 50 that have signs of new damage.

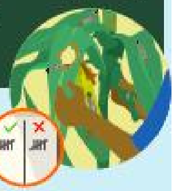


If **more than 10 out of 50** young plants out have signs of fresh Fall Armyworm damage, consult with an extension agent or CIMMYT for pest management advice.

11 When maize is older, examine the top three leaves or cobs for signs of Fall Armyworm damage.



If **more than 20 out of 50** older plants have counted have fresh Fall Armyworm damage, consult with an extension agent or CIMMYT. Be sure to only count plants with new damage.

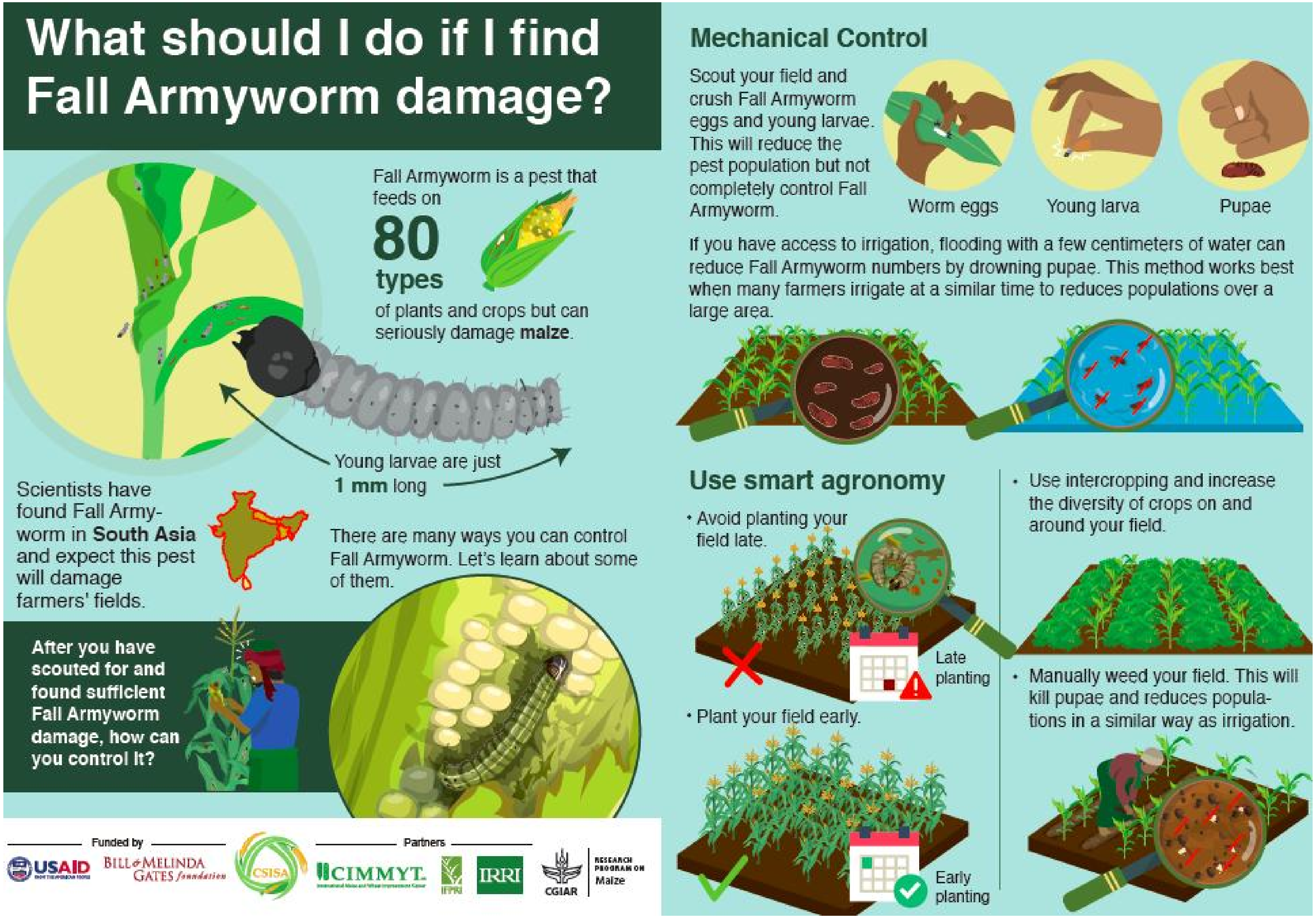


12 If you have found enough Fall Armyworm damage in your field, consult with an extension agent for advice.

More than 10
young plants out of 50 plants surveyed.

More than 20
older plants out of 50 plants surveyed.

13 Ask the extension agent if it you have enough Fall Armyworm damage to justify use of insecticides. Only use insecticides as a last option.If rain is forecasted in the coming days, spraying may not be needed. But if you do choose to spray, only use insecticides that minimize environmental damage and risk to human health.


What should I do if I find Fall Armyworm damage?
Fall Armyworm is a pest that feeds on
80 types
of plants and crops but can seriously damage maize.
Young larvae are just 1 mm long
Scientists have found Fall Army-worm in South Asia and expect this pest will damage farmers' fields.
There are many ways you can control Fall Armyworm. Let's learn about some of them.
After you have scouted for and found sufficient Fall Armyworm damage, how can you control it?
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IFPRI
IRRI
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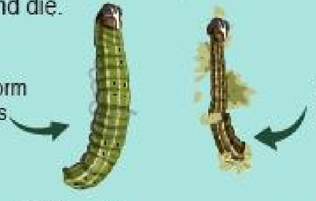
RESEARCH PROGRAM ON Maize
Mechanical Control
Scout your field and crush Fall Armyworm eggs and young larvae. This will reduce the pest population but not completely control Fall Armyworm.
Worm eggs
Young larva
Pupae
If you have access to irrigation, flooding with a few centimeters of water can reduce Fall Armyworm numbers by drowning pupae. This method works best when many farmers irrigate at a similar time to reduces populations over a large area.
Use smart agronomy
• Avoid planting your field late.
Late planting
• Plant your field early.
Early planting
• Use intercropping and increase the diversity of crops on and around your field.
• Manually weed your field. This will kill pupae and reduces popula-tions in a similar way as irrigation.

Biologically-based insecticides

- Biologically-based insecticides include Bt, and Baculovirus-based biopesticides. *Spodoptera frugiperda* multiple nucleopolyherovirus is also effective and has a low-risk of killing beneficial insects. It makes Fall Armyworm sick and die.



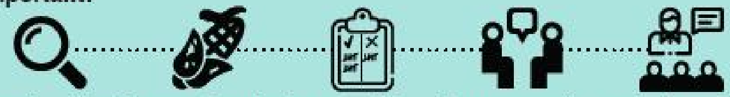
- Before spraying pesticides, let spiders, ants and parasitic insects work for you! Spiders and some wasps can kill Fall Armyworm. These insects are farmers' friends and will kill Fall Armyworm for you.

- Encourage parasitoids that will lay eggs in Fall Armyworm egg masses and also in their larvae. When eggs hatch, they kill Fall Armyworm.

- Spiders, ants, and many other insects will eat eggs and larvae of this pest.

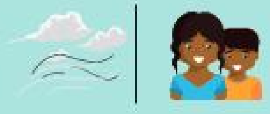
Chemical control

Important!



You should **only use chemical control** if you have properly scouted your field, identified Fall Armyworm damage, and consulted with an extension agent or qualified advisor. Insecticides should only be applied by a trained professional.

Spraying before you have scouted and identified or Fall Armyworm in your field is expensive and unlikely to be effective.



Never spray pesticides when it is windy or when people or children are near your field.

Insecticides are a last resort to use after you try mechanical, agronomic, and biological control methods.

Store insecticides in a locked box outside your home. Keep insecticides out of the reach of children.

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