Polderings

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Working together for a resilient agri-food system in coastal Bangladesh

Photo by: Mahabub Rahman

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Project partners

Managing editors

Sudhir Yadav
Manoranjan Mondal
S.V. Krishna Jagadish

Language editing

Lanie Reyes
Mary Ann Batas

Layout

Grant Leceta
Nisar Ali

Please direct comments and inquiries to:
Sudhir Yadav (s.yadav@irri.org) and S.V. Krishna Jagadish (kjagadish@ksu.edu)

Past issues of Polder Tidings can be viewed on this link https://www.irri.org/siil-polder

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Contributors

Chayan Kumer Saha
Bangladesh Agricultural University

Guy C. Jones
Blue Gold Program

Ignacio Ciampitti
Kansas State University

Kitty Bentvelsen
Blue Gold Program

Manoranjan Mondal
International Rice Research Institute

Md. Monjurul Alam
Bangladesh Agricultural University

Mohammed Mainuddin
The Commonwealth Scientific and Industrial Research Organisation

Nurul Siddiquee
ACDI/VOCA

P.V. Vara Prasad
Kansas State University

S.V. Krishna Jagadish
Kansas State University

Sudhir Yadav
International Rice Research Institute

Managing risks for a resilient agri-food system: A holistic approach

Sudhir Yadav, Manoranjan Mondal, S.V. Krishna Jagadish, and P.V. Vara Prasad

Photo by: Mahabub Rahman

The global agri-food systems face many challenges and interconnected risks such as climate change, biotic and abiotic stresses, land and natural resource degradation, market volatility, policy, and political environment and regional conflicts, among others. These changing scenarios and challenges can have negative impacts on Bangladesh, which is vulnerable to these conditions.

In recent years, Bangladesh has been exploring potential approaches and pathways to sustain its food security and feed its fast-growing population while addressing the adverse effects of climate change. Meeting the sustainable development goals of decreasing hunger and poverty in mind, the country has been investing substantial efforts to solve these challenges. Intensifying and diversifying agriculture, especially in the country's coastal areas, has emerged as one of the priority areas to ensure a sufficient and sustained future food supply.

A lot of evidences show the potential for diversifying production systems and improving land productivity in the coastal zone. Unfortunately, around 1.7 million farming households still grow only one low-yielding, long-duration traditional rice crop in the wet season.

Similarly, for the dry season, researches show that it is possible to grow many other crops aside from rice in polders such as maize, sunflower, mungbean, watermelon, spinach, mustard, potato, okra and sesame. Many of these studies, however, have not factored-in the risks and resilience of the production system with improved agricultural technologies. In response to this research gap, a study was done through the Sustainable Intensification Innovation Lab- Polder project (SIIL-Polder) to highlight the stability of new production systems (Fig. 1). The research evaluated five cropping systems, which are improved varieties of rice-maize (R-M); rice-mungbean (R-MB); rice-sunflower(R-S); traditional varieties of rice-mungbean (R_{Trad}-MB_{Trad}); and traditional varieties of rice-fallow (R_{Trad}-Fallow) for three cropping years (2016-2019). Those three years have very distinct weather conditions.

Overall, the improved rice-maize and rice-sunflower systems were the highest yielding and productive cropping systems, followed by the improved rice-mungbean. The traditional rice-fallow system was the least productive. In a high climate-risk year, however, rice was the only crop with positive net income, and the traditional systems had a relatively higher net income than the improved agricultural production systems. In an average opportune year, maize had the highest net income, and all improved rice-based cropping systems had a relatively higher income than traditional systems.

Risk and resilience are particularly important considerations for designing an agri-food production system. However, resilience is not only about coping against climatic events, it is also about the intrinsic ability to maintain or regain a stable state. In the coastal zone, a traditional way of growing rice can be deemed as resilient as it can stand against all potential risks; but, its low productivity consequently poses challenges to sustain food security.

Along with drivers for change, the introduction and adoption of a new production system depend on the biophysical, social, environmental, institutional and market demands (Fig. 2). The state of each of these parameters can trigger a change in decisions of transition to a new production system. For example, the success of sunflower as a potential dry season "crop" in the coastal polder zone depends on timely

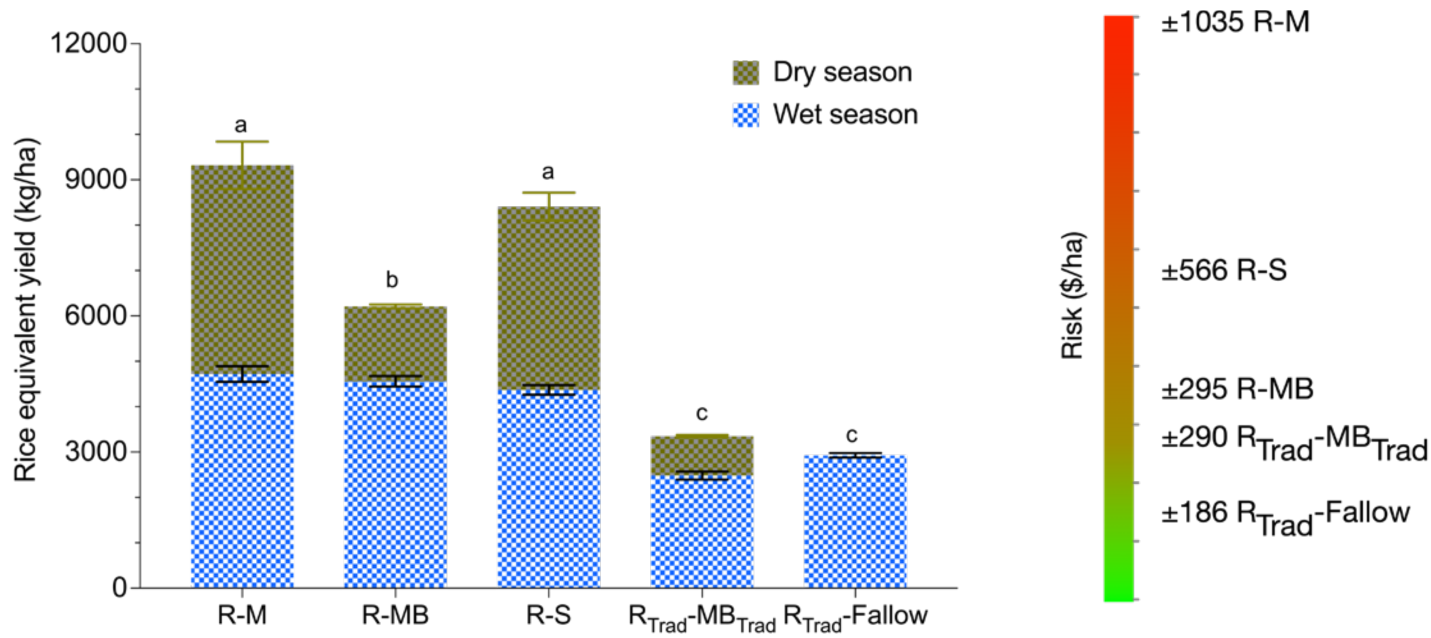

Figure 1. Performance of different cropping system in terms of yield (left) and associated risk (right). Adapted from Assefa et al., 2021[1].

drainage and harvesting of aman rice, planting window, seeding and intercultural operation for its cultivation. However, for achieving resiliency, one needs to look at the entire system, value chain, including production, market demand, required skills, infrastructure, social network, and institutional capacity.

In developing pathways to achieve resilience and averting potential risks, we should understand the core interest around resilience. Are we targeting to develop the resilience of sunflower-based agri-food system or is it the resilience of farmers' livelihood? Although both of these approaches are interlinked, they do not necessarily follow the same trajectory. The next question is resilience to what? Are we targeting sunflower to be resilient to climate, market price, market demand, yield, or a combination of a few of these aspects? A clear understanding will help us monitor the progress and gaps in assessing resilience. Also, it is necessary to know the actors and institutions to define the "for whom" dimension of resilience. Along with producers, it is critical to understand the role and interest of the other players in the value chain. Lastly, it is equally essential to determine and define the aspects "to what" we want to build resilience.

Aside from introducing potential innovations to intensify and diversify agri-food system in the coastal zone of Bangladesh, one should understand what it requires to build resilience. Resilience is not a technocentric concept; thus, a systemwide viewpoint is needed to address this multi-faceted necessity. Bangladesh is one of the top ten most climate-vulnerable countries. The coastal zone of Bangladesh is also a home for the poorest among the poor, which further highlight many environmental, social, human, and economic challenges in introducing a new production system. Understanding these constraints as well as the system capacity of the country to adapt and transform can surely help assess and pick appropriate strategies and pathways to enhance resilience.

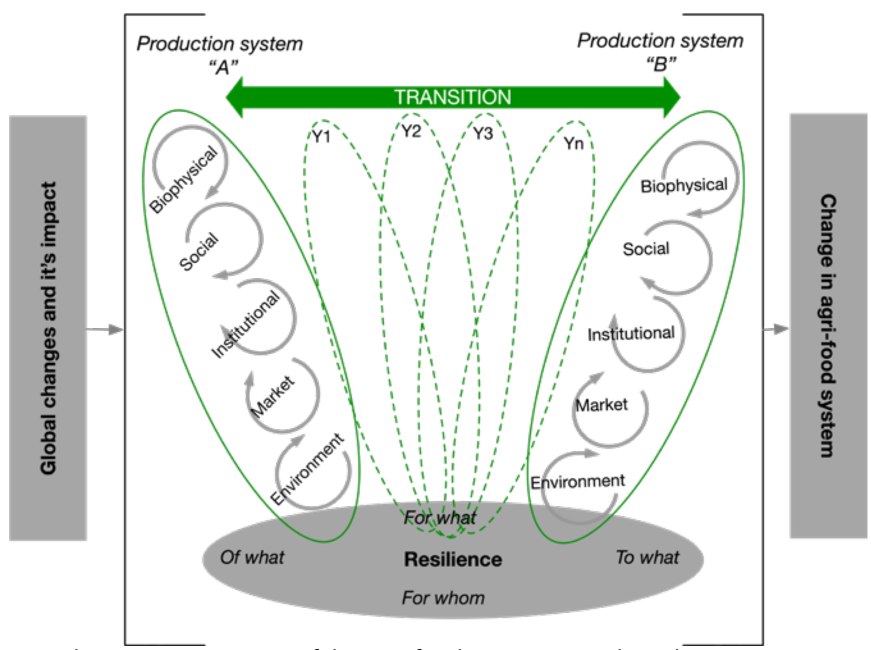

Figure 2. The transition process of the agri-food system towards resilience.

1 Assefa, Y., Yadav, S., Mondal, M.K., Bhattacharya, J., Parvin, R., Sarker, S.R., Rahman, M., Sutradhar, A., Prasad, P.V.V., Bhandari, H., Shew, A.M., Jagadish, S.V.K., 2021. Crop diversification in rice-based systems in the polders of Bangladesh: Yield stability, profitability, and associated risk. Agricultural Systems 187, 102986 DOI: https://doi.org/10.1016/j.agsy.2020.102986.

Intensifying farming in salt-affected areas in Bangladesh and India

Mohammed Mainuddin

Photo by: Author

The coastal zone of the Ganges delta is vital for food security, biodiversity conservation, fisheries production, and climate change adaptation and mitigation. Due to its low elevation, the delta is highly vulnerable to flooding from rising sea levels. Within this low-lying deltaic region, large areas known as "polders" have been enclosed and protected from seawater flooding by human made earth embankments, which protect inhabited and cropped land. These areas are disadvantaged by poverty, food insecurity, environmental vulnerability, and limited livelihood opportunities.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia has been leading the research project, "Cropping system intensification in the salt-affected coastal zones of Bangladesh and West Bengal, India" since 2015. The project has been funded by the Australian Centre for International Agricultural Research (ACIAR) and Krishi Gobeshona Foundation (KGF) of Bangladesh in partnership with Murdoch University of Australia, Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI), Institute of Water Modelling (IWM), and Khulna University from Bangladesh, as well as ICAR-Central Soil Salinity Research Institute (CSSRI), Bidhan Chandra Krishi Viswavidyalaya (BCKV), and Tagore Society for Rural Development (TSRD) from West Bengal, India. The project aimed to sustainably raise the cropping intensity and productivity in the coastal zones of the Ganges delta, particularly in the dry (Rabi) season, through integrated soil, water, and crop management. In Bangladesh, the project covered three selected polders, including Amtali, Barguna and Dacope, Khulna and Gosaba Island in West Bengal, India.

Lessons learned

1. Surface water, groundwater, and salinity interaction models for the polders can be assisted in simulating scenarios such as saline groundwater pumping for drainage and climate change impact.
2. Adaptive research along with crop modeling can fast-track assessment and simulation of crop response to management change and environmental drivers in the coastal zone.
3. Several new high-yielding and short-duration varieties of Aman rice such as BRRI dhan87, BRRI dhan77, and BRRI dhan76 for Bangladesh are suitable, profitable, and preferred by the farmers. These varieties yield half to one ton higher than existing varieties per hectare; 15–20 days shorter, which allows early sowing of Rabi crops; and provide more than 50% higher net benefit.
4. Growing Aus rice (BRRI dhan48) in the Kharif-I season is feasible (the average yield is more than four tons per hectare) and profitable in Bangladesh. Farmers can grow Aus

rice in the coastal area to intensify their cropping system, an option that is becoming popular for them. Boro rice varieties (BRRI dhan67, BINA dhan10) were introduced in the project sites in Bangladesh and was found highly suitable (average yield is more than 6 tons per hectare), profitable (net benefit above 40,000 Taka per hectare) and adopted by the farmers.

5. In Bangladesh, several new crops such as foxtail millet, English spinach, barley, garlic, along with sunflower, maize, mustard, pumpkin, among others were suitable and profitable for cultivation. The optimum sowing time, establishment methods (zero tillage, dibbling, transplanting, use of machiner), management practices (use of mulch, fertilizer rate and application, spacing, intercropping) and conjunctive use of fresh water and saline water for irrigation for some of the suitable crops were developed.
6. Zero tillage (ZT) potato cultivation is a breakthrough technology of the project, which has been taken up by the farmers in Gosaba rapidly. ZT potato was also successful at Dacope.
7. Several suitable and profitable cropping patterns have emerged based on this research over the last five years for the study areas. Some of the highly profitable cropping patterns for Bangladesh sites are Aman rice-sunflower/maize-Aus rice, Aman rice-Boro rice, Aman rice-Aus rice, Aman rice-spinach/mustard/garlic/ZT potato- Aus rice, among others.
8. Local capacity building is key to sustain the changes. Sixteen PhD students are collaborating with the project (four in Australia, who are ACIAR scholarship grantees through the project; ten are in Bangladesh, who received funding by KGF; and the other two are in India).

Challenges and opportunities

Much remains to be done to increase the resilience of this system by mitigating risks and increasing crop productivity through best management practices. Over the last five years, untimely heavy rain has fallen during the Rabi season. So, further research is needed to design and assess the most effective forms of drainage, including the possibility of sub-soil drainage to lessen the risk of crop failure, or delayed sowing due to heavy rainfall in the early Rabi season. Also, the relative tolerance of Rabi season crops to waterlogging and flooding during crop establishment needs further studies.

Within the coastal zone, the cropping intensification options vary according to land type. Thus, it is critical to identify packages of resilient technologies suited to a region and its characteristics. A key element of this process is to address the issue of risk inherent in wider adoption of our technologies, particularly the risks associated with variable climate and environments. ACIAR continually supports the country through a follow-on project titled, "Mitigating risk and scaling-out profitable cropping system intensification practices in the salt-affected coastal zones of the Ganges Delta." This project started on 1 November 2020 and will be implemented for four years.

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Photo: A bumper crop of potato in coastal zone

Growing more quality fodder in stressed lands

A look into a multistakeholder approach in solving fodder crisis in southwestern polders in Bangladesh.

Nurul Siddiquee

Photo by: Author

Livestock plays a crucial role in the agricultural economy in Bangladesh. It contributes 13.4% to the country's agricultural gross domestic product. It is the livelihood of the rural households who raise livestock for profit and for their food such as milk and meat. The 2019-20 report by the Department of Livestock Services (DLS) says that ten years ago (fiscal year 2010-11), the country produced only 2.9 and 1.9 million metric tons for milk and meat, respectively. The production has increased to 10.6 million metric tons for milk and 7.6 million metric tons for meat. Despite this gain in production, increased livestock productivity is being hindered by many problems.

In Bangladesh, livestock production is heavily influenced by agroecological zones. These areas differ significantly from north to south. A lack of adequate year-round quality forage/feed is one of the main constraints for livestock production, particularly in the polders in the southwest region. This region has less land, has natural calamities, and poor soil conditions because salinity limits fodder production.

While a fair amount of cut-and-carry trade goes on for crops such as forage sorghum and oats—the amount is not enough to meet the demand in the polders. Rice straw is abundantly available there, and it is accepted as the basic cattle diet when no green forage is available; but the nutritional value of untreated rice straw is meager and with poor digestibility. Thus, cattle suffer from a severe shortage of good quality forage, leading to low milk and meat yields.

The Feed the Future Livestock Production for Improved Nutrition (LPIN) is enhancing livestock productivity for increased income and consumption of livestock products by improving farmers' access to high-quality inputs such as fodder, feed, better livestock management techniques, and primary animal healthcare services.

Through an agreement in 2016, the LPIN and The Norman Borlaug Institute for International Agriculture (Borlaug Institute) at Texas A&M University (TAMU) worked together to strengthen the capacity of Bangladesh Livestock Research Institute (BLRI) and DLS to conduct research on forage production on saline- and flood-prone areas in the southern coastal region in Bangladesh.

The aim was to identify and develop saline-tolerant perennial forage and legumes for the year-round availability of forage for dairy and beef cattle.

The Borlaug institute carried out a needs assessment of the forage research and development capabilities of BLRI. Based on that study, LPIN supported BLRI in developing new forage materials, scaling-up production, and training farmers to establish and manage forage production systems. In March 2017, twelve BLRI staff received advanced training on fodder production from the Borlaug Institute and initially tested nine varieties of high-yielding, saline-tolerant fodder such as German, Sweet Jumbo, Jumbo gold, Para, Napier- 3, 4 and Super Napier- hybrid or Pakchong, which are appropriate for southwestern polders.

LPIN also supported BLRI to establish fodder nurseries showcasing all these varieties at the local DLS offices, from where the farmers in the polder areas can access fodder cuttings. This initiative facilitated the distribution of cuttings of a high-yielding Pakchong variety of fodder from the BLRI, Jashore campus. This ensured the distribution of fodder cuttings among farmers in polder areas. With LPIN facilitation, BLRI and DLS distributed 623,210 fodder cuttings to 1,370 farmers including those in polders in 2020.

To further improve access to fodder for farmers in remote areas in the polder, the LPIN worked with BLRI to develop the capacity of local entrepreneurs on fodder cultivation and dissemination. The plots of these entrepreneurs showcased proper fodder processing techniques using locally available materials. Also, these served as trial plots for BLRI to validate their research efforts in the "Feed the Future "areas. Now, the LPIN has trained 98 fodder entrepreneurs (28 of which are females) in the polders of Khulna and Satkhira. All in all, the entrepreneurs grew an improved variety of fodder in 5.3 hectares of fallow land.

Through these entrepreneurs, the LPIN increased the availability of fodder as well as fodder seeds and cuttings to surrounding farmers. The initiative engaged with 363 fodder entrepreneurs (108 were women), who cultivated an improved fodder on 25.4 hectares of land. This is not only supplying these farmers with fodder to feed their cattle, but it is also enabling them to be fodder entrepreneurs who earn money by selling surplus fodder and cuttings. In an LPIN 2020 survey, the fodder entrepreneurs earned $272 per month by selling fodder to an average of 68 clients per month.

Moreover, Livestock and Nutrition Activity highlights the role of the private sector in expanding fodder technology dissemination during the lean period. To ensure that farmers have access to required fodder and forage materials in both wet and dry seasons, LPIN has collaborated with a network of private sector partnerships (BRAC Dairy) to promote fodder that can thrive during the dry season, such as sorghum, among the farmers in the polders to ensure a year-round supply. LPIN also has been working with large-scale silage processors to scale-out and market silage in polder areas. Silage is a high-quality alternative to fodder for smallholder farmers during the monsoon season and in salinity-prone areas.

Through LPIN's efforts in working with the private sector and in building capacity of the actors in the fodder market, the farmers benefit by having sufficient availability of quality fodder in the future. Providing entrepreneurs access to fodder cuttings from government agencies helps increase the fodder productivity as well as the growth of fodder seed and cuttings business. In the end, this will make forage readily available, sustainable, and profitable in polder areas.


Photo by: Author

A Bangladeshi farmer gather fodder for cattle feed.

Popularizing farm machinery in the polder zones of Bangladesh

Chayan Kumer Saha and Md. Monjurul Alam

Photo by: Mahabub Rahman

Mechanization has boosted up paddy production in Bangladesh. The country is the third largest producer of paddy in the world and produces enough to feed its people. Unfortunately, its agricultural land is decreasing by half percent (around 38 thousand hectares) per year due to urbanization and industrialization. By 2030, on-farm laborers shall have been reduced because of the continuing migration of laborers into the industrial sector.

To feed millions of people in the future, production needs to be expanded and intensified—a tough task to do without mechanization. Tilling, irrigation, pesticide application, and threshing operations are mostly mechanized, and transplanting and harvesting are also gaining its ground for mechanization in the northern and northeastern areas of Bangladesh. However, in the southern delta and coastal zones of Bangladesh, mechanization is lagging as well as challenging. More than one million hectares of land in these areas are within polders, which are vulnerable to rising sea level and flooding. This compels farmers to grow only a single crop making agricultural productivity in these zones low.

Paddy production has become expensive for farmers due to the high cost of wages resulting from labor shortage, especially during seed planting or transplanting and harvesting. Using traditional postharvest practices, farmers can incur paddy losses at around 14 % at the farm level.

The Bangladesh Agricultural University, in partnership with the USAID Sustainable Intensification Innovation Lab (SIIL), Kansas State University, and the University of Illinois, is implementing the Feed the Future project entitled "Appropriate Scale Mechanization Innovation Hub (ASMIH)-Bangladesh" to make smallholder farmers in the southern delta of Bangladesh resilient. The project focuses on suitability, scalability, and sustainability of appropriate scale technologies, capacity building, and women and youth engagement. Results from the ASMIH-Bangladesh project showed that the use of seed planting, transplanting, and harvesting machines could save at least half (50%) of the costs compared with manual farming. Mechanization can increase the cropping intensity with efficient operational time management. The research findings indicated that use of combine harvester (from reaping to threshing) can save losses up to five percent. The Postharvest Loss Reduction Innovation Lab (PHLIL)-Bangladesh project showed that BAU-STR dryer and hermetic storage technologies could save losses up to two percent and five percent in postharvest drying and storage, respectively. These kinds of technologies can be adapted in the polder zones by overcoming existing challenges.

Another SIIL initiative in the region, "Pathways of scaling agricultural innovations for sustainable intensification in the polders of coastal Bangladesh (SIIL-Polder) project," is scaling out and evaluating pragmatic and feasible farming ways for a more efficient use of land and water resources. The ASMIH-Bangladesh project has already identified technologies, and has developed training modules, business modules and technology profiles. Through these outputs, and active collaborations with ASMIH-Bangladesh, the SIIL-Polder project is making appropriate farm machines popular in the polder areas. The Government of Bangladesh has approved a mega project worth around USD360 million for popularizing and disseminating appropriate agricultural machinery for transplanting, harvesting, and drying, among other farm operations. The government will provide 70% subsidy on the machines in haor (low-lying area) and coastal areas; and 50% to the rest of the areas in Bangladesh. The subsidy would undoubtedly help popularize the use of appropriate machinery. But, to increase the success in machinery adoption in the polder zones the farmers and communities should be aware on the benefits of farm machines and how to operate them through field days and fairs, capacity building of operators, local workshops, demonstrations, as well as women and youth engagement. The donors, government agencies, and private sectors working in polder areas need to work closely together in making mechanization popular and increase the cropping intensity in the polder communities of Bangladesh.

A training for operators on how to use a reaper machine in polder areas is conducted during a collaboration activity between the SIIL Polder project and ASMIH-Bangladesh project.

Photo by: Mahabub Rahman

ASMIH-Bangladesh team conducting hands-on training on use of reaper in collaboration with SIIL-Polder project.

Mini-tillers: the promise of small machines in the coastal polders of Bangladesh

Manoranjan Mondal, Sudhir Yadav and S.V. Krishna Jagadish

Photo by: Mahabub Rahman

Bangladesh is dominated by a rice-rice production system that provides food security for the nation. But diversified farming systems are needed for better nutrition and income in a farming community. Due to its agroclimatic conditions, the country can diversify its farming only during the dry season (December–May). Without enough rainfall, farmers rely on irrigation in those months for their crop production to be successful. Fortunately, Bangladesh is blessed with good quality groundwater and it has intensified cropping in the dry season in most of the central and northern regions. The scenario is quite different in southern Bangladesh, especially in the polders of the climate-vulnerable coastal zone, where most lands lie fallow or uncultivated in the dry season mainly due to lack of good quality irrigation water.

The farmers cannot grow dry-season crops (popularly known as rabi crops) on time in the coastal polders because the soil is very wet during the initial weeks of the dry season. The farmers must wait for about two months after the rice harvest for the soil to dry out before starting their field activities. Often, the late-established rabi crops (late February) are damaged by premonsoon rains and cyclones in May, when the crop is close to maturity. Thus, the farmers incur huge losses almost every year.

One way for farmers to sustainably intensify and diversify cropping in the dry season is by judiciously using residual fresh water in the soil after the monsoon. Although the topsoil dries out quickly after tillage, the soil moisture in the lower layers remains readily available for crop growth and development almost throughout the rabi growing season. Therefore, using residual soil moisture could help farmers successfully grow crops in the dry season even without irrigation.

The Sustainable Intensification Innovation Lab- Polder project (SIIL-Polder) has shown that maize and sunflower can be established by dibbling (zero tillage) on moist soil after the harvest of wet season (aman) rice. The early planting allows better use of the residual moisture. However, later in the season, the dry soil often cracks and ruptures roots and inhibits crop growth and productivity. It is also difficult to apply fertilizer and manage weeds if the soil is not tilled and dry.

Shallow tillage using mini-tillers solves these problems by pulverizing the soil between crop rows and break capillaries and thus, tilling slows down the drying of the soil. The farmers can easily incorporate fertilizer and control weeds through tillage. However, mini-tillers are not readily available in the coastal zone of Bangladesh.

In response, the SIIL-Polder project worked together with a local mechanic (Mr. Krishna Pado Mondal, proprietor of Bhai Bhai Engineering Workshop, Koiya Bazar, Batiaghata, Khulna), who is experienced in downsizing machines. The result of the collaboration was a 60-cm wide mini-tractor, resembling a small version of a power tiller. The Mechanic bought a 5-hp diesel engine and other accessories from a local market and took help from a blacksmith to prepare the blades or tynes of the mini-tractor. He made the main chassis and other accessories to develop the prototype (Photo 1).

The project has developed a semi-mechanized cropping practice for the dry season using this mini-tiller in the polder zone. In this method, seeds of maize and sunflower (and any row crop) are sown manually by dibbling (zero tillage) on wet soil after rice harvest within the second half of December. This allows the farmers to take advantage of the residual soil water during the initial growth and development of rabi crops. When the soil is ready for tillage, about a month after sowing and when the crops are 15–30 cm tall, a farmer can plow the topsoil in-between rows with the mini-tractor Moreover, the rabi crops established by dibbling on moist soil in the third or last week of December can be harvested within April, before the start of the the cyclonic season.

In contrast, under conventional practice, the emergence and growth of the late-established (third or last week of February) rabi crops are generally poor and uneven due to lack of soil moisture as most stored water in the soil evaporated while waiting for ideal conditions to carry out tillage. As a result, these crops usually mature by the end of May, significantly increasing the chances of a crop being damaged by premonsoon rains or cyclones.

The walking type mini-tiller proved effective in intercultural operations such as incorporating fertilizer and managing weeds in wide-spaced (more than 60 cm) row crops grown in the dry season. As the power tiller is widely used for land preparation in Bangladesh, this mini-tiller can be popularized once it is fully tested, manufactured, and made available in the local markets. The mini-tiller is easy to operate and easy to move as it is light. This small machine can attract the interest of the poor, landless women, and youths and develop themselves as service providers of mechanized intercultural operations in the dry season.

A locally manufactured and scale-appropriate machine for efficient farming is promising in growing dry-season crops that are climate-resilient and cost-effective in the polders of the coastal zone of Bangladesh.

Photo 1. Mr Krishna P. Mondal, a local mechanics fabricated a prototype mini-tiller.

Pooling digital solutions for a more resilient farming

Ignacio Ciampitti

Photo by: Mahabub Rahman

Funded by the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL), the Digital Tools, Geospatial and Farming Systems Consortium (DGFSC) has been recently formed to improve the resilience of smallholder livelihoods by using digital geospatial tools.

DGFSC will integrate system models to quantify the impacts of innovations, which builds a new era on Predictive Agriculture across five domains (productivity, economics, environment, social, and human condition) of the Sustainable Intensification Assessment Framework (SIAF).

The consortium will target the main innovations and technologies in relevant farming systems identified in the past years of the SIIL project. Cutting-edge digital tools and datasets, as well as resilient innovative technologies, will be leveraged to help farmers, researchers, and policymakers have informed decisions. For technology transfer, the project will focus on extension practitioners and stakeholders, who are assisting smallholder farmers.

To achieve the goal of this project, DGFSC will develop and integrate a series of models and remote sensing data products for the agropastoral and cereal-root crop mixed farming systems in Senegal and rice-based and fodder-crop farming systems in Cambodia and Bangladesh and deliver these to the SIIL Geospatial Consortium actors in the field".

Smallholder farmers in the coastal polder zone of Bangladesh, for example, will benefit greatly from the consortium. They face severe environmental challenges, including floods during the wet season, drought and salinity during the dry season; and storms throughout the year. And, the negative impact of climate change makes it even more challenging for them to adopt any new technology that will help them intensify and increase resilience of their farming systems in the polders.

Thus, reliable, tailor-fit decision-support tools are critical and should be a priority. This is where necessary data play a vital role in helping these resource-poor farmers to have resilient cropping systems and livelihood. With regards to digital solutions, the SIIL project in Bangladesh focuses on the following essential steps:

- Use field data on salinity that are collected at polder-scale to characterize both temporal-spatial variations.
- Integrate the data with geospatial layers related to altitude and topography.
- Explore association with past productivity data to establish more uniform management zones in the polder.
- And, evaluate the right combination of management and crop options to improve yield stability across the year and secure not only productivity for smallholder farmers, but also improve the overall food security (see infographic).

Then, these information are shared with local extension agencies and farmers for routine use—without skipping out capacity building in the agenda of digitalization.

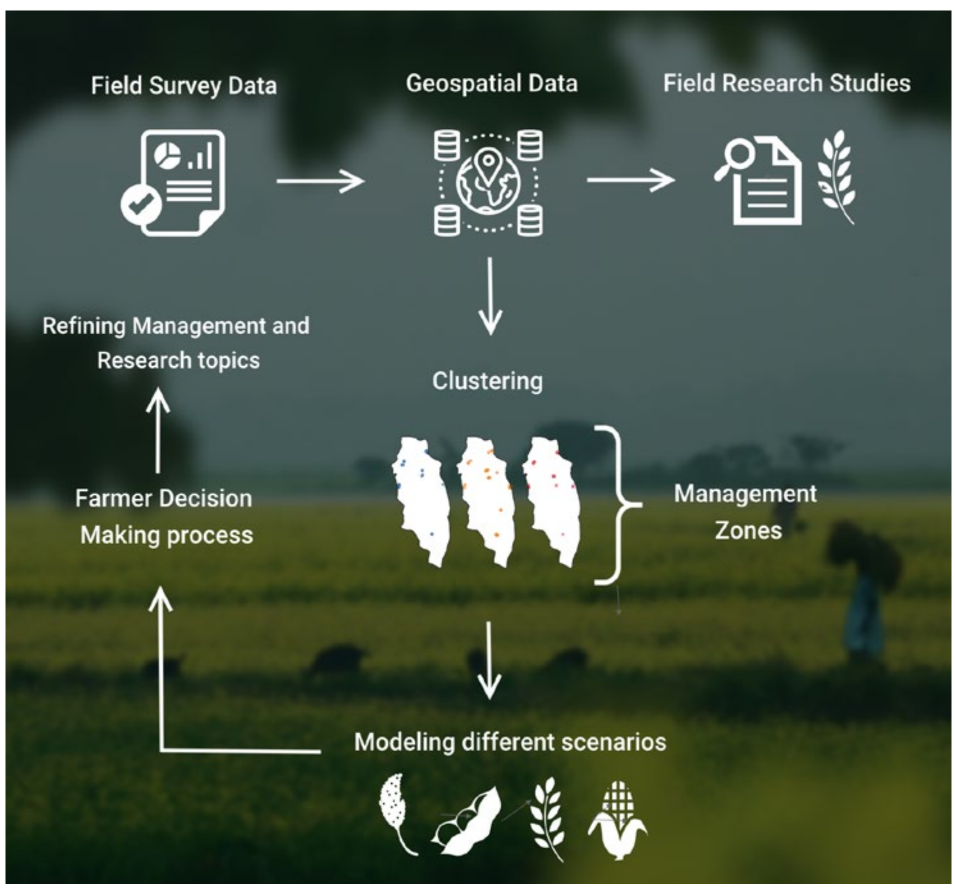
SIIL is managed by the Kansas State University (KSU) and is funded by the U.S. Agency for International Development as part of Feed the Future, the government's global hunger and food security initiative. Through the leadership of Dr. Ignacio Ciampitti from KSU, the researchers in the consortium include Jason Neff from the University of Colorado-Boulder; Paul West, James Gerber, Zhenong Jin, and Kathryn Grace from the University of Minnesota; Amirpouyan Nejadhashemi from the Michigan State University; and Molly Brown from the University of Maryland. These researchers and some industry partners such as Corteva Agriscience, Microsoft, Descartes Labs, and aWhere are the founding members.

The members also collaborate with teams from Senegal, Cambodia, and Bangladesh, as well as with other consortia such as SOILS, Policy, and Mechanization. Moreover, the consortium will seek opportunities to train undergraduate and graduate students in the targeted countries on data science.

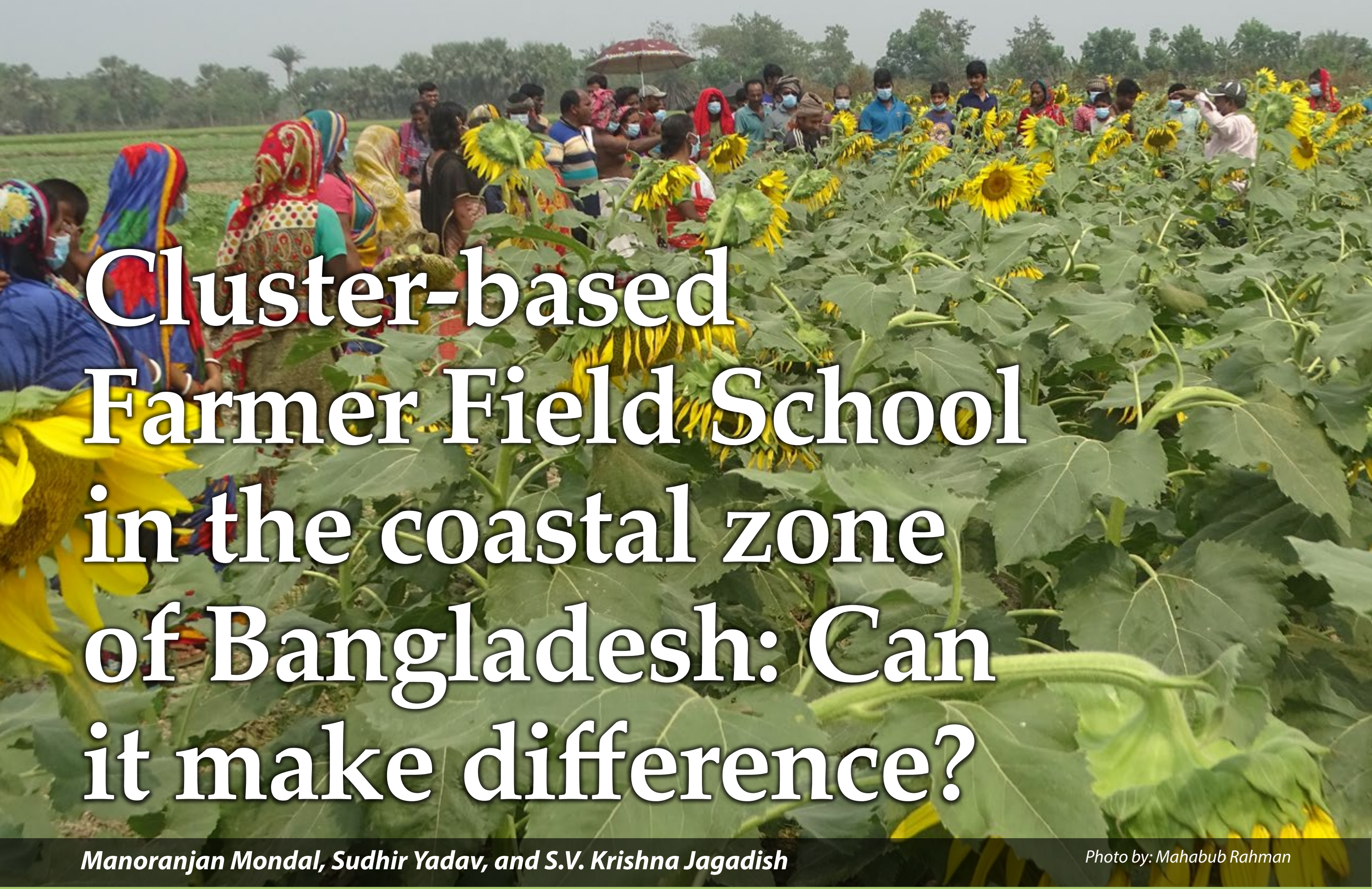
The consortium will use high-resolution geospatial resources that can be applied across a range of tools by the consortium partners and students in the future. The DGFSC will work with the partners to explore a simplified interface to easily access data. Each partner can access the information via GPS location, via the raw grids, customized grids for the users' own tools, or in an online portal where the data can be viewed and interacted with such as an ESRI webapp.

As the consortium project progresses, the focus will be to test this initial data visualization activity with partners in targeted countries, gather feedback, and refine the approach. This iterative development will let the consortium deploy our data at low cost and build access points utilizing user input throughout this project.

Our team strongly believes that the development of new data products can positively impact smallholders and help them better adapt to emerging environmental and market pressures.



Schematic of potential land use pattern using crop modelling and geospatial tools



Cluster-based Farmer Field School in the coastal zone of Bangladesh: Can it make difference?

Manoranjan Mondal, Sudhir Yadav, and S.V. Krishna Jagadish

Photo by: Mahabub Rahman

Bangladesh has achieved self-sufficiency in rice using green revolution technologies. But with a population of 160 million that continues to grow at 1.2% annually, the country faces enormous challenges to maintain food self-sufficiency. In addition to its increasing population, rapid urbanization is reducing the share of cropland, which is decreasing every year. The cropping intensity and productivity in Bangladesh are already high. There is little scope to further increase food production, except on the underutilized coastal zone lands, especially 1.2 million hectares of arable lands in the polders of the coastal zone of Bangladesh. The agricultural environment in the coastal zone is generally termed as "high risk" and most farmers adopt "low investment" risk aversion strategy and ultimately get "less production."

The polder lands are deprived of the technological advancement in agriculture despite significant investment from the government, nongovernment, development partners, and international organizations. The main reason probably is the adoption of "one-size-fits all" scaling approaches or the "replicating" of technological innovations from other regions without tailoring to fit to unique socio-organizational and hydrological conditions of the coastal zone, especially the polder ecosystem of coastal Bangladesh.

Many approaches are adopted in agricultural technology dissemination across the globe. Among them, the Farmer Field School (FFS) model has been widely adopted in Asia especially in Bangladesh. The key features of the FFS model include the primary learning, which starts at a crop field and lasts for a full cropping season; the meeting place is close to the learning plots; the FFS educational methods are experiential, participatory, and learner-centered; and are generally done involving between 25 and 30 farmers of a village. The FFS approach enhances the knowledge and skills of a group of farmers sporadically chosen from a village (geographical area) to improve productivity and farm income on a seasonal basis but not focused on year-round cropping and farming system. Since FFS is focused on geographical boundary, hydrology is not considered as one of the determinants for technology dissemination. It is broadly assumed that an individual farmer can successfully adopt agricultural innovations without any linkages with other community members.

Since the hydrology of the coastal zone is different from other parts of Bangladesh and is mainly governed by the lunar tidal phenomenon, it is practically impossible for an individual farmer in this zone to adopt agricultural innovations managing huge volume of tidal river water entering through the sluice gates of the polder ecosystem without community's cooperation to manage irrigation and drainage for successful cropping within its catchment generally consisted of several villages, either whole and/or part of the villages. This is the complexity distinguishing the polder ecosystem of the coastal zone with other parts of the country. Such hydrology demands community coordination for wide-scale adoption of improved agricultural technologies for higher productivity and improved livelihood of the coastal polder ecosystem.

On one hand, Water Management Organizations (WMOs) is formed by the Bangladesh Water Development Board (BWDB) for in-polder water management operating the sluice gates synchronizing with the tidal phenomenon of the coastal river systems. On the other hand, FFS is formed by the Department of Agricultural Extension (DAE) involving 25–30 farmers sporadically chosen from a village, who has practically no control over or influence on sluice gate operation. This is a key factor hindering wide-scale adoption of improved agricultural technologies and innovations in the coastal polder zone. Therefore, a Cluster-based FFS (CFFS) approach is required for technology dissemination in the coastal zone, particularly in the polder ecosystem. The distinguishing features of the CFFS model over the present FFS model is the synergies among practices as well as institutional efforts for dissemination of technologies.

Farm clustering based on hydrology (using a sluice gate as command area), synchronized crop management practices including choice of crops, varieties, irrigation and drainage scheduling can be achieved by empowering and engaging the farming communities and community leaders (from WMOs) within the farming cluster.

SIIL-Polder staff engaging with community using Cluster-based Farmer Field School extension approach.

In Phase 2, the SIIL-Polder project is implementing this CFFS approach in scaling the rice-maize and rice-sunflower cropping system innovations in partnership with the national agricultural extension (DAE) and water development (BWDB) systems of the government, civil societies (Shushilan) and private (ACI) sector partners who have the mandate and capacity to deliver at scale and sustain delivery of the improved cropping systems through improved water management at catchment level of the sluice gates in the polder ecosystem (Fig. 1). In this model, the WMOs are empowered on improved in-polder water management synchronizing with the tidal phenomenon and crop growth stages for adoption of improved agricultural production systems and climate-resilient management practices involving all the farmers in a cluster of land areas instead of forming separate FFS groups.

Successful demonstration of CFFS model in partnership with the public and private sector extension agents might be an eye-opening step to influence the farming community, community leaders involved in water management (WMOs), agricultural technology dissemination personnel (DAE, Shushilan, ACI) and the policymakers to adopt appropriate policies necessary to scale agricultural innovations through modified technology dissemination model (CFFS) across the coastal polder zone of Bangladesh. Thus, food and nutritional security and livelihoods of the eight million polder communities will be improved and the country could achieve SDG 1 (no poverty) and SDG 2 (zero hunger) within the time frame.

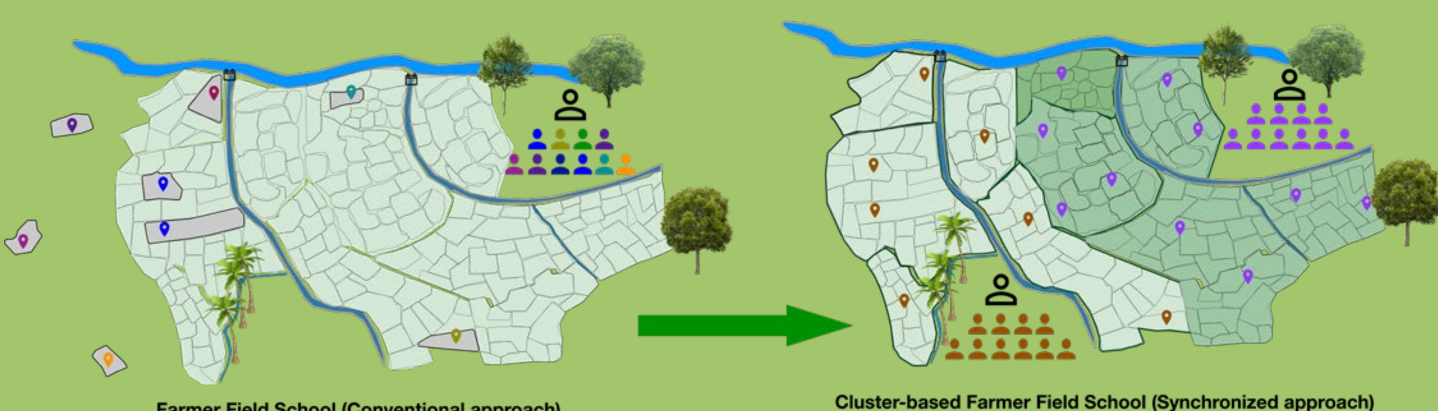


Fig. 1. A schematic diagram of water management and cropping in polders of the coastal zone.

Blue Gold Program: Bridging the gap for participatory water management

Kitty Bentvelsen and Guy C. Jones

Photo by: Authors

The coastal zone of Bangladesh contains 139 polders that protect about 1.2 million hectares including poor and disadvantaged communities. Cropping is mostly by traditional practices, and farming systems are less intensified than in other parts of the country. Agricultural development is a primary driver for poverty reduction in rural areas. Bangladesh is among the top ten most climate-vulnerable countries in the world, with the low-lying coastal polders particularly vulnerable. Flood protection to safeguard investments and reduce the risks for farmers, and water management infrastructure to increase productivity and cropping intensities, are both prerequisites for improving livelihoods in these climate-vulnerable communities.

The Blue Gold Program (BGP), which was implemented from 2013 to 2021, invested in infrastructural, institutional and agricultural development. Jointly funded by the Government of Bangladesh and the Government of the Netherlands, BGP worked in 22 polders in the southwestern and south-central coastal zones, with a gross area of about 120,000 hectares and a resident population of around 800,000. The program aimed to reduce poverty and improve food security through water management as the main enabling factor for increased and diversified agricultural production.

The key interventions areas of BGP were: (i) the rehabilitation of 330 km polder embankments and the associated regulators and sluices that protected 120,000 hectares from tidal flooding and salinity intrusion; and (ii) community empowerment through the formation and strengthening of 511 Water Management Groups (WMGs) and 35 Water Management Associations (WMAs), and developing working linkages between them and Local Government Institutions (LGIs). The third intervention was to build farmer capacity to raise their agricultural productivity and farm income using the opportunity provided by improved water management. This was done through Farmer Field Schools and demonstration trials. In the course of the Blue Gold Program, in-polder water management as a pre-condition for enhancing agricultural production became more evident, leading to initiatives such as community-led agricultural water management (CAWM) and small-scale water management infrastructure. This was complemented by linking the community with agricultural extension providers, input suppliers, and other market actors.

Program outcomes

- reduced occurrence of water logging, flooding, and droughts, which enables improved agricultural production and overall economic development in the polder;
- higher cropping intensities and profitability due to improved water and crop management practices, use of quality inputs, and efficient market linkages;
- empowered water management organizations;
- higher demand for labor meant increased opportunities for (landless) men and women; and
- improved resilience of polder communities due to greater production and higher and diversified incomes, and reduced risks for natural disasters, including better preparedness.

Lessons learned

- The water management organizations (WMGs and WMAs) developed by BGP greatly helped in bridging the gap between community members and the LGIs, especially the Union Parishads. This enabled WMGs: to operate sluice gates to relieve waterlogging and facilitate in-polder water management; to arrange the collective purchase of inputs and/or collective sales of produce that increased farm profitability; to mobilize labor to protect or repair embankments when river erosion threatened to breach embankments resulting from floods, sea surges or cyclones; and to raise awareness at the start of the COVID-19 pandemic. Thus, the waterlogging, flooding, and drought environments in the polders were considerably improved which in turn contributed to increased cropping intensity and productivity.
- Building partnerships for water management takes time. Although community-led water management has enhanced in-polder water security and economic development, water management organizations (WMGs and WMAs) cannot operate in isolation. Partnerships are needed to sustain economic advantages from water management, for example, through the support and cooperation of LGIs (in particular, Union Parishads) for the permanent removal of blockages in drainage canals, resolving conflicts between farmers and fishing communities, or agreeing modalities for the funding of operation and maintenance of polder water management infrastructure.
- To increase and sustain the scope of the achievements of Blue Gold, the working modality by which community representatives and local government institutions discuss and resolve water management issues in coastal polders needs to be formalised and operationalised, using the 2018 Water Rules.
- The effective engagement of government agencies in water management and agricultural development and private sector organisations in market development helps to sustain community participation in in-polder water management. One of the responsibilities of these agencies is to ensure that the infrastructure is robust, fully functional and able to be maintained and operated by WMGs, particularly the gates in the hydraulic structures - which allow the control and regulation of water flows, a precondition for in-polder water management.

- **Next steps**

To strengthen the national framework for water sector governance, Blue Gold recommends three main elements for the way forward:

1. Institutional capacity for participatory water management should be strengthened through stakeholders' participation in planning, design, construction, and management of polder infrastructure, and in increasing the national budget for maintenance of polder infrastructure reflecting local needs and opportunities.
2. Consultations result in better solutions. Thus, consultations with local stakeholders in planning and construction of polder infrastructure must be more systematic. This process helps strike a right balance between swiftness and fairness and builds trust among the communities.
3. Partnerships for integrated and participatory water management should be built at all levels. The WMGs and WMAs flourish when they work together with LGIs, government agencies, and the private sector. And progressive water management organizations are more likely to contribute to overall agricultural development for food security in the polder zone of Bangladesh.

Bangladeshi farmers sharing the knowledge gained through farmers field school with their peer groups during the field day

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