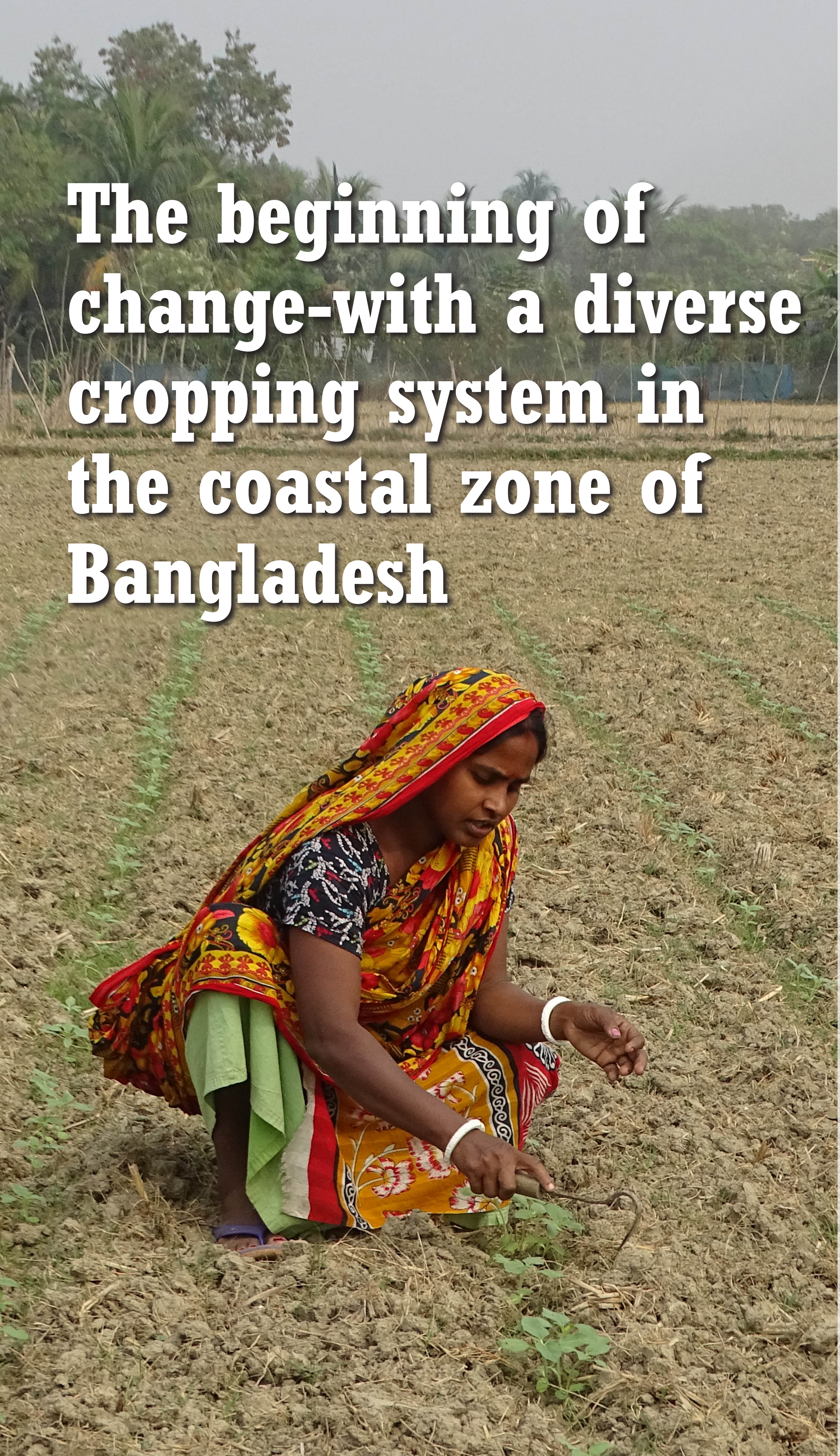
The beginning of change-with a diverse cropping system in the coastal zone of Bangladesh



Polder Tidings
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Foregoing fallow: Improving productivity of polders in Bangladesh

By Sudhir Yadav, Manoranjan Mondal, and Krishna Jagadish

Bangladesh faces enormous challenges in maintaining food self-sufficiency for its growing population. With declining agricultural land, there is little scope to further intensify agricultural production, except in the underutilized 1.2 million hectares of land in the polders of the coastal zone. In general, more than 50% of the polder area remains fallow during the dry season, mainly due to high soil salinity and lack of fresh water.

Most farmers in the polders cultivate a single low-yielding rice crop in a year, which is sometimes followed by low-yielding dry-season crops. In the last four years (2013-2016), dry-season crops in the polders were damaged by rainfall and cyclonic storms coinciding with crop maturity during May. As a consequence, large stretches of land are left fallow, with animals grazing the left-over rice stubbles from the aman season. The need, therefore, is urgent, to develop appropriate—productive, profitable, and resilient—production systems that will sustain and benefit the polder communities.

Why managing rice for a diverse cropping system is important

The primary source of irrigation in the region is the tidal river. In the medium-saline zone, river water remains fresh in the aman season. The water starts to become saline in January, although it remains moderately saline until the end of February. This brings an opportunity to grow a dry-season crop early in the season. Early planting of the dry-season crop and managing water properly in wet-season rice are both components of rice management. As of now, these are not well coordinated to allow uniform planting and harvesting.

Historically, farmers in the polder region drain their field in November-

December and harvest their crop of traditional rice in December-January. The field remains too wet for a month or so, and farmers generally cannot grow dry-season crops until mid-February. Most of the time, the dry season before crops are destroyed by pre-monsoon rains prior to maturity, with most of these failures tracking back to the inability of the polder farming community to coordinate the aman-season rice crop. Collective action by the community is the entry point for adoption of modern agricultural technologies in the polders of the coastal zone. High-yielding varieties (HYVs) of rice provide an opportunity to harvest in late November. This scenario is conditional and is only possible if the community agrees to take a collective decision to grow HYVs within a catchment area and then drain water from the paddy fields on time.

The Water Management groups (WMG) holds the key to empowering the community toward taking the necessary steps to achieve this goal of sustainably managing natural resources in and around them.

Introducing small-scale mechanization—an interface for foregoing fallow

The turnaround period from aman to the dry season in the polders is generally very long, which results in significant loss of residual soil moisture that would otherwise be sufficient to grow a pulse or oilseed crop. Plowing followed by broadcast of seeds is traditional practice, but as the fields remain too wet, farmers generally plow their land around mid-February. Use of small machinery like the power tiller-operated seeder (PTOS) can potentially bring the opportunity to plant crops early, with minimum tillage. It also allows for multiple operations (e.g., tillage, seeding, and basal fertilizer application) in one go, thus helping cut labor costs. Use of machines with a service provision model also opens opportunities for generating extra income and attract youth in agricultural.

IRRI

A diverse system keeps risks down

The SIIL-Polder project has engaged the community to introduce suitable crops (short duration, high yielding, and high value) in the dry season. Project focus are:

- Early harvest of wet-season rice and, thus, early dry-season crop establishment.
- Tapping of residual moisture by early seeding of the crop with PTOS.
- Mitigating temporal increase in salinity or effects of cyclonic storms.
- Diversifying crops to minimize the risk of failure.

Other potential opportunities are the temporal availability of fresh water during the dry season, which can be 'stretched' through the capture and storage of non-saline river water in canals within the polders. Cultivation of high-yielding and high-value salt-tolerant crops in the dry season and the use of supplementary irrigation could potentially help address the problems of low productivity and food insecurity in the polder communities.

From November 2016 to February 2017, a recall and actual monitoring surveys were conducted among 200 farmers in Polder 30. The survey sought to document rice yield and identify farmers' crop choice for the dry season of 2016-2017.

Results revealed that most of the farmers (41.3–52.5%) left their land fallow in the previous dry season (2015-2016). However, adoption of HYVs of rice allowed for early harvest and, consequently, farmers who grew the HYVs were able to bring a larger area under various crops in the 2016-2017 dry season.

The results also pointed to the importance of rice management in the aman season to open up opportunities for growing dry-season crops much earlier than traditionally practiced. Farmers who cultivated HYVs of rice also opted to diversify their crops to minimize risk. Most of them planted mungbean, sesame, sunflower, and okra in the dry season of 2016-2017. A similar and independent story in the Blue Gold Program also reported on the potential of diverse systems in the dry season through management of rice and community water.

Cropping patterns	% farmers who cultivated different *rabi* crops in 2016-17	% farmers cultivated different *rabi* crops in 2015-16
Climate-resilient high yielding varieties of rice (SIIL intervention area)		
Rice-sesame	23.9	30.7
Rice-mungbean	32.3	14.7
Rice-okra	15.4	10.7
Rice-sunflower	14.4	6.0
Rice-maize	4.5	0
Rice-HYV rice	3.5	2.7
Rice-sweet gourd	5.0	0
Rice-other crops	2.5	0
Rice-fallow	28.4	41.3
Traditional rice (outside of SIIL project intervention)		
Rice-sesame	17.5	30.0
Rice-mungbean	12.5	5.0
Rice-okra	7.5	12.5
Rice-sunflower	0	0
Rice-HYV rice	0	0
Rice-vegetables	0	0
Rice-fallow	70.0	52.5

Community-led water management: Learnings from the Blue Gold Program

By Shorab Hossain, Ashraful Islam, and Judith de Bruijne

The Blue Gold Program (BGP) has been working intensively to improve water resources management infrastructure across 22 coastal polders in Bangladesh. The program has been supporting work to strengthen the main polder embankments to improve water safety, re-excavating major canals, and repairing main sluices to improve drainage, flushing, and water-storage capacities of the polders.

At the same time, it is helping build capacity of water management organizations (WMOs) for the operation and maintenance of water management infrastructure and for improving homestead, crop production and market orientation.

BGP is funded by the governments of Bangladesh and the Netherlands, and is being implemented in collaboration with Bangladesh Water Development Board (BWDB) and Department of Agricultural Extension (DAE).

Community water management as entry point

As part of agricultural production and food security objectives, the BGP works closely with national and international agencies including the International Rice Research Institute (IRRI) to improve the agricultural production system in the region. The project has seen the success of community water management (CWM) through IRRI activities in Polder 30.

In 2015, IRRI and BGP worked with partners to focus on the identification of water management units inside the polders as part of internal polder water management strategies.

The approach was to drain out water twice: while topdressing with urea, and two weeks before harvesting of aman rice. The approach also involved encouraging WMOs to plan for and manage water management units within the catchment area of a sluice gate.

The interventions helped (A) increase the area planted to HYVs of rice, (B) synchronize planting and harvesting time and other collective actions, and (C) facilitate early establishment of dry-season crops.

BGP's upscaling approach

After a year of joint implementation of CWM with IRRI and other partners, outcomes proved transformational and BGP started to outscale to other polders and catchments. In the upscaling initiative, BGP incorporated some lessons learned from the pilot and developed a four-point strategy:

1. Sustainable internal polder water management (IPWM) by catchment-level water management planning, implementation, operation, maintenance, and monitoring by WMOs, with the support of relevant stakeholders.
2. Intensive technical and agronomic guidance throughout the year to motivate WMO members toward ensuring they can independently synchronize cropping, gain expertise in agronomics of improved varieties, and adopt modern crop production technologies and on-farm water management practices.
3. Coaching of WMO members to initiate collective action for developing marketing strategies, networking with suppliers and output sellers, and establishing linkages with local government institutions (LGIs) and other actors.
4. To a limited extent, co-funding of agricultural inputs and internal water management infrastructure.

The upscaling initiative is led by the WMOs, supported by the BWDB, DAE, and Union Parishad (UP) and facilitated by the BGP Technical Assistance team.

WMOs are self-mobilized and are established independently in their area for water management and economic activities. They make inventories of their own farms as well as select and synchronize cropping patterns through coordinated actions.

Despite their limited capacity, BWDB field staff has provided critical support in selecting sites, making suggestions on minor water resource management interventions, and motivating the WMOs.

DAE field staff have been facilitating special CWM-Farmer Field School (FFS) training activities for all involved WMO members—both men and women—on the use of crop technologies, on-farm water management, and market-related topics.

UPs provided support during the process of site selection and helped resolve internal conflict.

IRRI, for its part, provided good-quality BRRI dhan52 seeds for the farmers as well as technical advice.

The CWM approach bringing change in the region

Ashim Roy, from Gopipagla in Polder 22, is one of the farmers who joined BGP's CWM upscaling initiative. Roy was initially sceptical of the promoted technologies under CWM. After attending the FFS sessions, however, he set out to grow BRRI dhan52 and eventually reported a yield of 7.2 tons per hectare.

All farmers involved in the CWM initiative reported yields of more than 5.2 tons per hectare—significantly higher than the usual reported average of 3.5 tons per hectare from local rice varieties for aman season.

Along with a good harvest, Mr. Roy was also able to free his land early by harvesting rice on November 27, giving him the opportunity to grow a dry-season crop. For the first time this year, he grew sunflower, mungbean, and watermelon. Proactive solutions to retain water, such as removing obstacles to drainage flow and resolving conflicts on drainage, have resulted in a timely harvest of aman rice and a reduced fallow area in Gopipagla. Other CWM areas have turned green with diverse crops of—in addition to rice—sesame, mungbean, watermelon, sunflower, and vegetables.

Mr. Roy is now one of the prominent promoters of CWM knowledge. His WMO arranged two meetings with 60 adjacent WMO farmers to share knowledge. Neighboring WMO farmers have been making visits to Mr. Roy's field to understand the cultivation technique used, and have started replicating the method in their own catchment.

Mr. Roy's social dignity has improved through this successful endeavor, and he feels that a mindset change is now taking place among the WMO farmers toward better internal polder water management to increase crop production and income.

In all, 65 exposure visits were organized in 2016 by the BGP to encourage horizontal learning among members of the community.

Improving varieties to enhance rice productivity in coastal Bangladesh

By Md. Ansar Ali

Resources in the coastal zone of Bangladesh are underutilized, despite many opportunities for increasing its contribution to the national food basket.

Limitations and vulnerabilities of the coastal region are mainly due to its geographical position, and are further aggravated by climate change. The biophysical environment in the coastal zone of Bangladesh is very diverse, and it varies greatly over short distances, particularly in the incidence and severity of water stagnation and salinity. There is also the temporal and spatial dynamics of salinity. Water remains almost fresh in the eastern part of the coastal zone, and salinity increases as we move toward the southwestern part of the coastal zone. Salinity levels are also high in the dry season compared to the wet season.

Cultivation of traditional, photoperiod-sensitive, long-duration varieties is one of the reasons for low productivity in the coastal zone, constraining crop intensification and diversification especially in the low- and medium-salinity areas. Being tall, these traditional varieties are adapted to conditions where water stagnates.

There is good evidence that a community-coordinated approach of operating an irrigation source's sluice gate can help drain water from the fields

to reduce both depth of submergence and duration of water stagnation. However, tolerance for water stagnation and submergence are still highly desired traits when it comes to adoption of new varieties. In the boro season, salinity tolerance greatly improves productivity of rice and is similarly desirable.

In addition, consumer preference of grain type is very diverse in coastal Bangladesh. Giving farmers options with different grain types and quality is therefore as important as improving tolerance for abiotic stresses.

The Bangladesh Rice Research Institute (BRRI) has developed high-yielding varieties (HYV) of rice suitable for cultivation in both wet and dry seasons in the saline ecosystems of the coastal zone. Some of these varieties have little to no photoperiod sensitivity and different growth durations (e.g., from short or medium), and are therefore suited to also improving cropping intensity. Most importantly, potential yield of these varieties is roughly double than that of traditional varieties.

Among the HYVs, these varieties are suitable for cultivation in the wet season in stagnant water conditions: BR10, BR23, BRRI dhan40, BRRI dhan41, BRRI dhan53, BRRI dhan54, BRRI dhan73, and BRRI dhan78. All of these HYVs except for BRRI dhan73 and BRRI dhan78 have an aerobic tillering ability and are suitable for an integrated rice+fish culture in the polder ecosystem—a popular practice in the southwest region of Bangladesh. These HYVs yield 5.0–6.5 tons per hectare—more than 2 tons per hectare higher than traditional rice.

BRRI

Cultivation of BRRI dhan73, an early-maturing HYV, in relatively elevated ecosystems in the wet season allows for timely establishment of dry-season crops. BRRI dhan78, on the other hand, is a dual-stress-tolerant (submergence and salinity) and, thus, climate-resilient HYV suitable for the tidal saline-water inundated ecosystem.

BRRI's recent innovation involves the development of BRRI dhan76 and BRRI dhan77—both wet-season HYVs. These HYVs have the unique characteristics to replace current local cultivars (e.g., Sada Mota, Kalo Mota, Ghungsi Mota, Khoia Mota, and Dudh Kalom) grown in the wet season. Seedlings of BRRI dhan76 and BRRI dhan77 are taller and therefore have a tolerance for tidal inundation that is similar or better than that of traditional rice cultivars. Both HYVs, however, have the ability to produce at least 1.5 tons per hectare more than popular rice traditionally grown in the coastal zone. About 0.8 million hectares lands are available in tidal freshwater ecosystems for wide-scale adoption of the newly released HYVs, which would significantly improve productivity of the tidal non-saline ecosystems of the coastal zone.

In contrast, a few salt-tolerant HYVs (BRRI dhan47, BRRI dhan61, and BRRI dhan67) are suitable for cultivation in the dry season in the coastal zone. These HYVs can tolerate about 8 deciSiemens per meter throughout their life span. However, the grain shattering problem hindered adoption of BRRI dhan47 in the coastal zone. The problem has been eliminated in recently released HYVs (BRRI dhan61 and BRRI dhan67).

BRRI dhan67, released in 2014, is attracting interest of farmers faster than any of the previously released HYVs due to its high yield (6.5 tons per hectare), superior grain quality (slender grain), and higher salt tolerance (8 deciSiemens per meter). It is also considered suitable for cultivation in both low- and medium-saline ecosystems in the coastal zone.

Despite many limitations, enormous opportunities are available to increase the supply that goes into the national food basket through proper planning and integrated management. Development and dissemination of HYV rice are not enough to fully unlock production potentials; multiple interventions are required to harness the potentials of the coastal zone of Bangladesh.

Integration of natural resources management, policy support, smart technological innovations and dissemination, efforts of service providers, capacity building for farmers, and a holistic approach to implementation will undoubtedly unlock the production potentials of the coastal zone and sustain food security in Bangladesh.

BRRI

Newly adopted area (Horizontal expansion) of BRRI dhan67 in the village Moharajpur, Koyra, Khulna

Gender-equitable diversification in rice-based systems: Some considerations

By Ranjitha Puskur

The polder zones of southwestern Bangladesh are prone to flooding, drought, and cyclones at different points during the year, altogether resulting in low productivity and crop loss. Eight million people depend on rice-based systems in these ecosystems— spread over 1 million hectares—for their livelihoods and nutrition. A large majority of these people live below the poverty line.

In these areas, rice is the main crop (traditional varieties are usually grown) and cropping intensity is very low. Sometimes oil seeds (sesame) and pulses (mungbean) are grown, but the land is mostly left fallow during the dry season.

Several initiatives are ongoing in the polder zones to increase the productivity and returns from these systems through the deployment of appropriate technologies for crop diversification and intensification. We wish to emphasize, however, that agricultural technologies and interventions are not neutral: these have different impacts on different social groups.

The important role women play in the abovementioned agricultural systems is well documented. Women contribute significantly to agricultural labor, but are also custodians of household care, nutrition, and health. With increasing outmigration of men, farms are being led by women, whose roles are becoming more crucial.

Several studies have established that women face several constraints, such as restricted access to inputs (e.g., seeds, fertilizer), resources (land and labor), assets (machinery and equipment), and services (extension and advisory, financial products) that hinder their productivity. This is popularly termed as the 'gender gap' in agriculture. Deeply entrenched social and gender norms, attitudes, and beliefs underlie the gender gap.

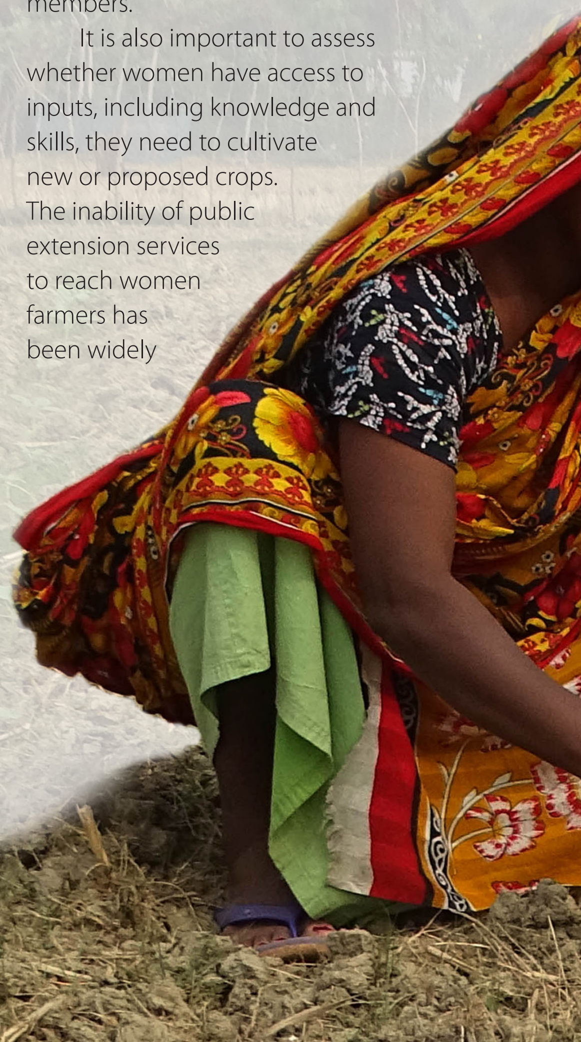
Any effort toward crop diversification and intensification must be informed and underpinned by an understanding of existing gender dynamics in these crop-livelihood-food systems. It also has to have a clear definition of target groups, which would help in identifying strategies and interventions that would benefit both women and men and not put any of the social groups at a disadvantage or make them worse off.

Several considerations came into play as we started designing such initiatives. Fig. 1 presents a simplified and schematic pathway toward better nutrition, livelihoods, and women's empowerment in the rural households through crop diversification and intensification.

Evidence shows us that women and men have different preferences in varieties and in growing crops. This is influenced, in general, by personal preferences as well as household- and specific farm-related roles and responsibilities.

Women, for instance, prefer rice varieties that lend themselves to easy manual threshing, as it is they who are responsible for that job on the farm. They also opt for rice that has good cooking quality, as they are responsible for cooking for and feeding household members. Households that own cattle prefer rice varieties of good quality and that produce a large amount of straw. The choice of crops and varieties results from intra-household negotiation among key family members.

It is also important to assess whether women have access to inputs, including knowledge and skills, they need to cultivate new or proposed crops. The inability of public extension services to reach women farmers has been widely



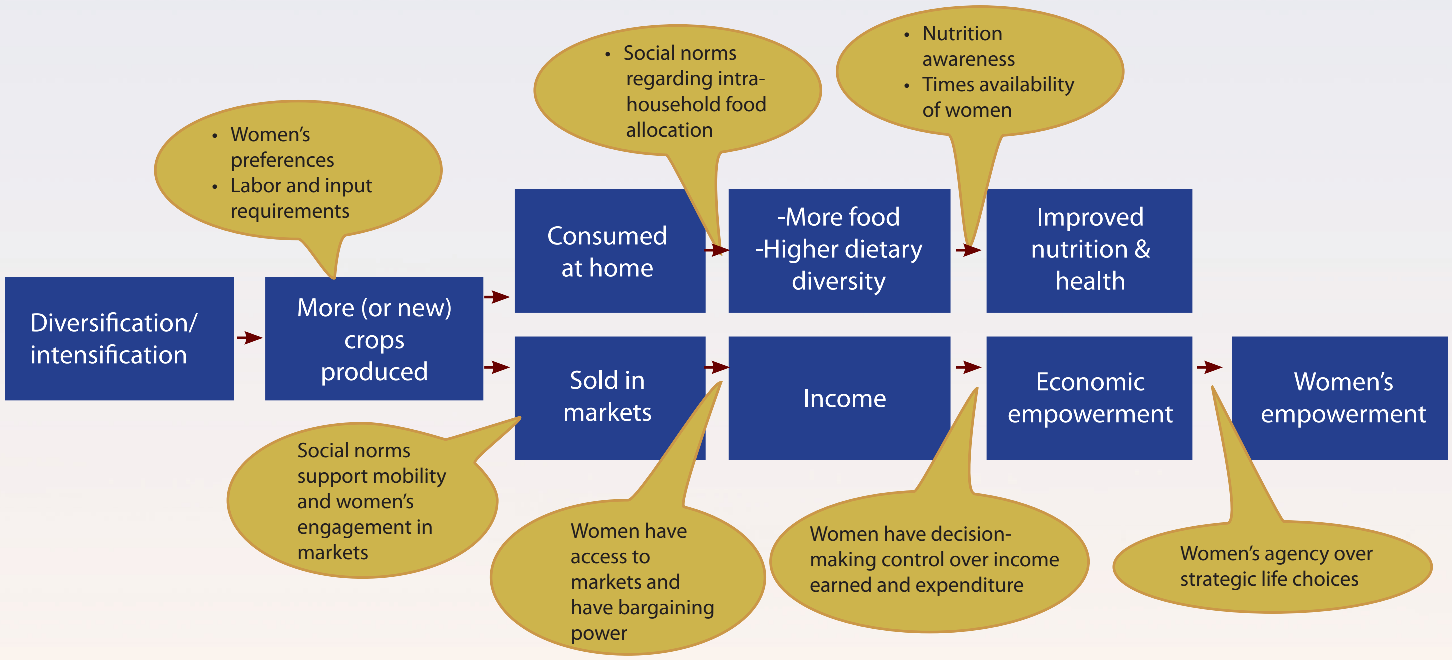
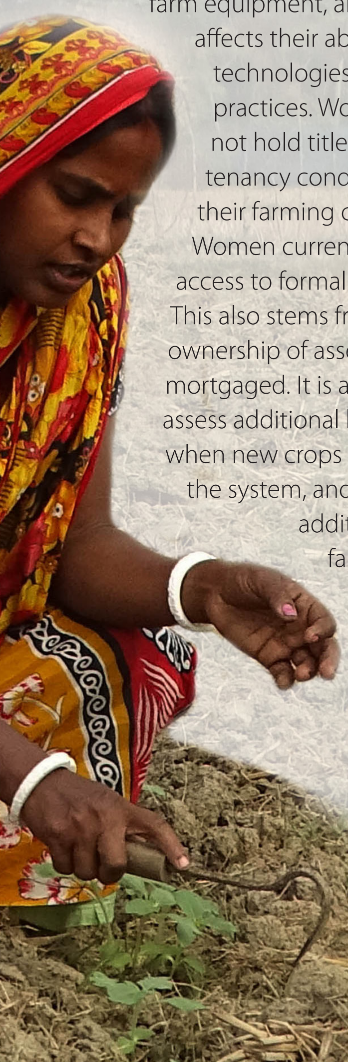


Figure 1. A simplified pathway toward better nutrition, livelihoods, and women's empowerment in rural households.



documented. This is often the result of the women lacking identity as 'farmers.' Measures need to be built into interventions if this is a limitation. Women's access to resources such as land, irrigation, farm equipment, and machinery also affects their ability to adopt new technologies and management practices. Women usually do not hold titles to land, and tenancy conditions determine their farming choices.

Women currently do not have access to formal credit and loans. This also stems from their lack of ownership of assets that can be mortgaged. It is also important to assess additional labor requirements when new crops are added to the system, and on whom this additional work would fall. The added time women spend in their households on unpaid care and domestic work also needs to be taken into consideration. Currently, social norms dictate that this responsibility lies entirely with the women, but their roles and contribution to farming are barely recognized.

Crops are chosen mainly for home consumption or as cash crops for the market. If the latter is the case, more understanding is needed on whether current social norms and expectations allow women mobility and engagement in markets. Otherwise, women could be providing labor or playing a major role in production, and yet do not have a say over the use of income from sales.
Adverse effects on women that could arise from market orientation have been well documented in several contexts. Women engagement in markets can benefit them adequately if they understand the functioning of markets and of market agents. The women also need an appropriate level of financial and business skills. Women engaging collectively with markets has proven to be beneficial in most contexts.

Crop diversification could potentially contribute to a higher household dietary diversity, but is not a sufficient condition. The gender-nutrition nexus and pathways are well-established and articulated. Available evidence points to the inequitable distribution of nutrient-rich food among men, women, boys, and girls in South Asia, due to social norms and preference for the male child. In addition, nutrition awareness among women and availability of their time has a significant influence on household maternal and child nutrition.

The Women's Empowerment in Agriculture Index (WEAI) is a dominant indicator used for major donor-funded initiatives. The indicator names five key domains: women's production-related decision-making, access to productive resources, control over the use of income, community leadership, and time allocation.

Increase in income does not necessarily ensure women's control over income, and economic empowerment does not automatically lead to improvement in all the five domains crucial for women's true empowerment.

Being aware of these dynamics and designing measures to help improve these by influencing behavioral and attitudinal change, as well as working in a multi-sectoral context can go a long way in empowering women through crop diversification and intensification.

Ms. Maloti Sarkar, a poor woman who owns no land, is a member of the Water Management Group in Fultala Village. She hopes to earn enough as custodian of the cocoon storage in her village so she could rent land to grow rice.

Sustaining change: The community seed storage model

By Rokhsana Parvin Ratna, Shilpi Sarker, and Shwapon Vhadra

About the SIIL Polder project

The SIIL-Polder project aims mainly to empower the community to sustainably manage their land and water resources and thus make more productive use of these resources. The project seeks to create strong cooperatives that will interact with public and private organizations that play a role in the agricultural development. Participatory resources management is the entry point and the initial driver of the community organization process. The explicit objective of the project is to reduce poverty among people of coastal areas by enhancing cropping intensity, improving crop productivity, and ultimately increasing incomes.

The low-lying tract of polders along the coastal zone of Bangladesh—home to millions of poor people—is regarded as a low agricultural productivity zone. Farmers here commonly grow a single crop of a traditional rice variety. While many government and international agencies are working to unlock the production potential of the region, adoption of modern high-yielding cultivars has been very slow. Availability of quality seeds is cited as a major reason, among many, for the slow adoption rate.

Most farmers in rural Bangladesh, including those in the polders, store rice seeds in their houses. The common practice among these farmers is to keep and use their own rice seeds. They rarely buy rice seeds, and only do so when they want to grow high-yielding and hybrid rice varieties in the dry season, in limited pockets along the fish ghers.

Traditional storage used for seeds are the *dole*, *berh*, *motka*, *jala*, gunny bag, plastic drum, and plastic bags. Seeds stored in these structures or containers are susceptible to damage from microorganisms, insects, and rodents. Farmers have reported that insect damage in stored rice grains and seeds could be as much as 20–40%.

The SIIL-Polder project is engaged with the farmer community to, among others, increase awareness on hermetic seed storage and provide training on its use. As crop production is seasonal and consumption is continuous, safe storage is important in maintaining seed quality.

In the past, insect infestation was less of a concern among the farmers, as most of them were cultivating traditional rice varieties. But as high-yielding varieties (HYV) of rice, which they now use, cost more and with demand for food increasing, farmers have become more concerned about safe storage of improved rice seeds. Insect-proof storage for grain and seed is essential.

The SIIL Polder project set up a community seed-storage learning hub in Fultala Village. This community-led learning center had the primary goal of providing (A) training on seed storage, (B) a venue for interaction and discussion among members of the community on the importance of quality seeds, and (C) opportunities for income generation for the poorest members of the community.

A seed-storage cocoon with a storage capacity of 1 ton was also placed in Fultala Village. Following a community seed storage model that the project introduced, a landless woman agreed to coordinate and take responsibility for the storage process and maintenance of the cocoon. Members of the community agreed to pay the woman a storage fee of BDT 2 per kilogram of seed, which then becomes her additional income.

Since the usual practice in the community is to keep rice seeds at home, the Water Management Group (WMG) started the community seed bank model. A low storage fee was set to test the viability and social acceptability of the model, and to develop an income generation option for distressed women within the community. In 2017, the community stored 926 kilograms of seed in the cocoon, 70% of which are HYV rice.

One of these women, Ms. Maloti Sarkar, is a member of the WMG and owns no land. She agreed to take responsibility for the cocoon, which she inspects regularly to check for damage by rodents or other causes. She will earn BDT 1,852 from taking care of the cocoon for a season. She plans to use this money to till leased land and grow rice in the 2017 *aman* season.

In the 2016 *aman* season, training on seed storage was provided to 107 farmers (66 male and 41 female). Training events were held in nine locations at the Katakhali sub-polder area. The 107 farmers consisted of 22 who grow HYV rice seeds and 85 from five villages. From the training, they learned about the importance of production of good-quality seed and use of good-quality storage such as the cocoon.

The WMGs have key roles in empowering the community toward achieving the goal of the project, particularly on sustainably managing and using natural resources. They could adopt hermetic storage as a means for income generation to sustainably run the community seed storage hub, and may act as the service provider in quality-seed production and distribution within the community. Further, they could develop the business models and engage the poor women and youth toward improving their livelihoods.


IRRI

Traditional method of seed storage.

IRRI

Making more from a diversified cropping system: A farmer's experience

By Jayanta Bhattacharya and Sudhir Yadav

Mihir Mondal, a 37-year-old farmer, lives with his wife, Archana Roy, their five-year-old daughter/son, Sneha, and Mihir's parents and brother—a 'joint' family household arrangement, not uncommon in Fultala Village where they live.

Both Mihir and Archana have a bachelor of arts degrees to their names. Little Sneha has started going to school. Fultala Village is in Polder 30 of Khulna Division in Bangladesh, and, as many others in their area, Mihir's main source of income is agriculture.

Their family tends 0.75 hectares of agricultural land and a small pond to rear fish. They have four heads of cattle, two of which produce a meager two liters of milk a day. Of these two liters, they sell one for a small added income.

Among many reasons for the low productivity of the livestock, one is the poor quality of feed.

In addition to taking care of livestock, Archana rears 20 chickens and sells about 100 eggs a month, after family consumption. She also earns the family additional income by teaching in a school for the elderly.

Mihir and his brother work together growing traditional aman rice year after year. They also grow sesame and mungbean in the dry season on the same piece of land. Mihir has a two-wheel power tiller that he uses to plow his land as well as rents out to other farmers for added income.

In the last aman season (2016), Mihir decided to participate in a learning hub of the SIIL-Polder project, and agreed to grow a climate-resilient rice variety —BRRI dhan52—in a small portion of land (0.14 hectares). He still grows traditional rice in 80% of his land.

Mihir managed the crop very well, using recommended best management practices. He harvested the rice in the first week of December and cleared the field immediately after harvesting. He harvested 5.4 tons per hectare from BRRI dhan52—a significant increase from his usual harvest of 3 tons per hectare from the traditional variety.

Mihir had been broadcasting sesame or mungbean, or both, in the dry season, but his crops had failed in the last four years. "Rains damaged our sesame and mungbean every year," said Mihir. "I am now considering investing resources in dry-season crops instead."

After obtaining information from the learning hub, Mihir decided to try early seeding of a dry-season crop. As he owns a power tiller, his decision was quickly followed by action, and he was able to plow the land a few weeks after harvesting rice.

Mihir's family used to struggle finding feed for their livestock, especially during the dry season when more than 60% of the land was fallow. After discussing with his family members, Mihir decided to grow maize. The learning hub provided him training and inputs to grow maize in a 400-square-meter area. He successfully protected his maize field from stray animals by coordinating with the community for controlling domestic animals.

Mihir hopes to harvest a good yield from the maize he planted in January. He plans to use maize seeds to feed the chickens and fish and the stalk as fodder for the cattle. Mihir also feels that market demand for maize may increase rapidly, there being no alternative feed options for livestock in the dry season.

The polders of the coastal zone have a high potential to "turn on" the currently "off" season by introducing diverse crops in the dry season. The high risk of crop failure can be reduced through a community approach to managing water, early harvest of rice, and early planting of dry-season crops.

The SIIL-Polder learning hub is routinely working with the farmer community to discuss and introduce various crop options and management practices to minimize their risks, with a hope to have many farmers take up the route that Mihir has taken.

IRRI

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IRRI

Nutrition awareness among women in Polder 30

By Rokhsana Parvin Ratna, Shilpi Sarker, Md Abu Saleque and Md Khairul Bashar

Bangladesh has achieved remarkable progress in poverty alleviation, primary school enrollment, gender parity in primary- and secondary-level education, immunization coverage, and reducing incidence of communicable diseases. However, the prevalence of malnutrition in Bangladesh is among the highest in the world.

Millions of children and women suffer from one or more forms of malnutrition including low birth weight, wasting, stunting, being underweight, Vitamin A deficiency, iodine deficiency disorder, and anemia. The country faces a big challenge attaining nutritional security in majority of the population; the challenge weighs heavier for turning the nutritional tide among those living in the coastal polder zone, where many of these malnutrition indicators are most prevalent.

Globally, nearly half of all child deaths can be attributed to malnutrition. Survivors are left vulnerable to illnesses, stunted growth, and intellectual impairment. In Asia and Africa, insufficient intake of zinc from food results in complex health problems among millions of children, women, and the elderly. Zinc deficiency causes complications during pregnancy, low birth weight, and stunting in small children.

Malnutrition affects not only individuals; its effects are passed on from one generation to the next, when malnourished mothers give birth to infants who struggle to develop and grow. Commonly, in these conditions, girls grow up to become malnourished mothers themselves, thereby multiplying the rate of malnutrition.

Underlying causes of malnutrition include the inability of households to grow or purchase sufficient food for their needs; poor maternal and child-care practices, such as inadequate (A) breastfeeding, (B) supplementary feeding of infants and young children, and (C) food for adolescent girls and pregnant and lactating women. If the mother is malnourished before or during adolescence, prior to and during pregnancy, and immediately after delivery, her children are much more likely to be underweight and potentially remain malnourished throughout their life.

Malnourished children are physically weak, lack resistance to disease, struggle to keep up at school, are less productive as adults, and remain vulnerable for the rest of their lives.

Malnutrition has long been regarded a widespread public health problem, especially in the poorest parts of Bangladesh. With more than 70% of the national diet dominated by carbohydrate-rich cereals combined with a smattering of protein, undernutrition is a serious challenge in the country. In Bangladesh, 37% and 31% of children under the age of five are prone to stunting and being underweight, respectively. The problem is gender-sensitive, is correlated with income level, and varies widely across geographic locations.

The situation is much worse in the polders of coastal Bangladesh, where a large part of the population have limited access to diverse and nutritious food. Nutritional security depends on more than access to food; awareness among members of a farming community of the need for a nutrition-rich farming system and dietary diversity, and educating them about how these can be achieved, are crucial.

HarvestPlus has supported the development and deployment of biofortified high-yielding rice varieties in Bangladesh through an extensive partner network that includes IRRI. Recently released zinc-biofortified high-yielding rice varieties contain 19–24 milligrams of zinc per kilogram of rice, which can thus supply about 60% of the daily zinc requirements of an adolescent.

Under the SIIL-Polder project, zinc-enriched high-yielding rice (BRRI dhan62 and BRRI dhan72), mungbean, and sunflower were introduced in the Katakhali sub-polder area. The goal was to not only increase productivity of the land but to add the micronutrient zinc as well as more protein to the diet.

To create a knowledge hub on nutrition, the SIIL Polder project started an awareness program at the primary school in each village. Past research had found that increasing mothers' knowledge on nutrition contribute significantly to improving the nutritional status of children

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and the whole family. The project thus engaged mothers of primary school children in the awareness campaign and training activities.

Training activities focused on creating awareness among mothers on the importance of micronutrients and high-nutrition rice, and the benefits of zinc-biofortified rice to the health of the mother and children. Three training events were organized in all, involving 19 women teachers and 31 mothers of kindergarten-age children.

The project is also testing a model of engaging and increasing awareness on nutrition among women at the household level—farmer's wife, sister, and mother. Training activities included discussions on consumption of nutritious rice, pulses, and sunflower oil; and the impact these have on the health of children and lactating and pregnant mothers.

In the 2016 *aman* season, the project reached out to 788 women, including 187 direct beneficiaries who received seeds of climate-resilient (flood-tolerant Sub 1) and nutritious (high grain levels of zinc) high-yielding varieties of rice.

In the 2016-17 *rabi* season, the project reached out to 417 beneficiaries—169 of whom are women—from 19 villages in Polder 30. The SIIL team briefly described the concept, importance, and usefulness of *rabi* crops such as pulses and sunflower oil in the daily diet to improve health and nutrition among children and women. As it is the women who play a central role in the family, especially in diversifying food options, they are seen as major partners for carrying out the task of feeding the family more nutritiously and sharing knowledge on nutrition among them.

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Potential for research impact in development: An outsiders perspective

By Aaron M. Shew

My work with SIIL-Polder started about a year earlier, in March 2016, when Drs. Krishna Jagadish and Sudhir Yadav contacted me about research for development (R4D) opportunities in the polders of Bangladesh. As a recent doctoral candidate in Environmental Dynamics at the University of Arkansas, this was the perfect fit for me: applied research on the sustainable intensification of agriculture and agrarian adaptation to climate change, with the potential for direct impact on farming communities.

When I came on board with SIIL in January 2016, I knew little to nothing about polders or coastal areas in general, but through my participation in a field visit during the project inception workshop in March 2016—and numerous conversations on Skype—I came to understand some of the challenges faced by the polder communities in coastal Bangladesh. Based on this newfound knowledge and experience, I worked with the SIIL Polder

project to develop research in the polders that can bridge the gaps among science, agriculture, and agrarian perceptions.

In January 2017, I spent four weeks in Khulna and Polder 30, working with the SIIL Polder project team to begin my field research. One of my key interests is to understand the temporal and spatial variability of salinity in the polders. We set out to collect 50 gridded soil samples across Polder 30 for salinity testing. The collection is ongoing throughout the 2017 dry season between January and June.

Although seasonal salinity is well-understood in river systems, little is known about how soil salinity changes as a function of both time and landscape. For example, scientists do not yet understand whether salinity varies with elevation or distance from irrigation canals or sluice gates—a piece of knowledge that could be critical for crop production. Specifically, soil salinity information generated through this study will be vital to future crop experiments and to agricultural suitability.

Work in coastal Bangladesh is challenging. The polders are difficult to navigate, and these include those like Polder 30 with more developed roads and infrastructure. Each day during soil collection training, we journeyed by motorcycle on small roads through 65 square kilometers of agricultural land, dikes, and canals to villages near the 50 soil collection sites. Most roads were built from bricks or dirt and sand and, upon finding the village, we usually still had to walk long distances through rice fields and aquaculture plots to locate the GPS points. On several days, we spent more than five hours driving and walking from point to point, collecting a mere four to five samples per day.

Though navigation was tough, farmers were very interested in our work and often wanted to converse about their agricultural struggles. They were keen on understanding how we measure soil salinity and how they might use the knowledge in both crop selection and determining planting time. Given the dispersion of the 50 points across Polder 30, we had the opportunity to interview farmers from more than 30 villages, some in rather isolated areas.

Given the dynamic environment in the polders, one of the most prescient challenges facing multiple scientific partnerships is knowing where to suggest and test certain crops or agricultural systems over others. Some areas are predominantly low-lying and may require traditional rice during the monsoon season, while land at relatively higher elevations may be more suitable for high-yielding varieties (HYVs). Most rice in the polder region is grown with gravity-fed irrigation, which poses one of the more interesting and complex issues for sustainable intensification in the polders. Farmers often have to negotiate and petition water management committees to help determine optimal opening and closing of a sluice gate. Following soil salinity testing in the 2017 dry season, we will thus collect water depth measurements in several sites to investigate the spatio-temporal evolution of water depth throughout the monsoon season, i.e., the season of primary rice production.

Understanding water depth under current management scenarios may help improve sluice-gate operations for crop production. Just as improved knowledge of soil salinity can aid dry-season crop selection, water depth information can improve the ability of the SIIL project to recommend site-specific rice varieties and provide best management practices for land and water use within each farming community.

Farmers in the polders are very knowledgeable about their land and the environmental conditions in which they live and work. In interviews, farmers described to us the direction water flows across the landscape, approximate water depth on their plots during different points in time, and the distance from their land to irrigation canals and sluice gates. They also outlined for us the major environmental problems they face.

The main concerns of farmers revolved mostly around water management and insect control, though some also cited weather or cyclone events as key problems. We observed farmers collecting manure for fuel and fertilizer, doing community harvesting, threshing traditional rice, and preparing for aquaculture and dry-season rice production. It was from these daily observations that I realized the importance of indigenous knowledge and linking development projects to this knowledge. Agrarian communities have collected environmental knowledge over the course of generations, and this is invaluable in developing resilient agricultural systems—those that can quickly bounce back from increasing environmental variability in the region.

The problem at hand is the gap among indigenous knowledge, rapidly changing environmental conditions, and adoption of scientific solutions for agricultural development. Environmental changes are occurring at scales not yet apparent to most farmers in the region. For example, sea-level rise, salinization, and flooding events are almost certainly going to affect these farmers, whether they identify them as current problems or not. Thus, it is vital to first understand each of these environmental factors and their respective trajectories in the region, and then to find research-based agricultural solutions that correspond to what communities already know and recognize about their environment.

Institutions external to the local environment, such as the Bangladeshi government, the SIIL Polder project, and other entities that have programs operating in the region may play a pivotal role in creating agrarian resilience to current and projected problems associated with climate change.

By conducting Farmer Field Schools and focus group discussions (FGDs) in each community, the SIIL-Polder project is engaging farmers as partners in improving agricultural production and agrarian livelihoods. This community-based, participatory approach to development highlights a pathway for uniting indigenous knowledge and research-derived agricultural solutions, bringing climate-resilient agriculture closer to reality.

My research in soil salinity, water depth, agricultural suitability, and agrarian perceptions of environmental change will hopefully make a valid contribution to this multi-dimensional development problem through the work of the SIIL Polder project.

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