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Community Water Management and Agricultural Extension Services: Effects, Impacts and Perceptions in the Coastal Zone of Bangladesh

Marie-Charlotte Buisson, Panchali Saikia and Shourav Maitra

R4D Learning Series

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Community Water Management and Agricultural Extension Services: Effects, Impacts and Perceptions in the Coastal Zone of Bangladesh

Marie-Charlotte Buisson, Panchali Saikia and Shourav Maitra

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Project

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Front cover image: A Bangladeshi farmer re-transplanting his field due to flooding (*photo*: From the photo collection of the International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines).

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SUMMARY

The focus of this study was on the coastal region of Bangladesh, which suffers immensely from natural disasters such as cyclones, storm surges, tidal fluctuations, salinity intrusion and land erosion. Combined with anthropogenic factors, these natural disasters significantly impact livelihood opportunities, especially crop production, in the coastal region. Waterlogging due to excessive rain, tidal activity and the lack of proper drainage facilities in crop fields are the main constraints to agricultural production in these areas. Also, increased salinity, internal drainage congestion and external siltation have consequently made large areas of land unsuitable for crop production.

The G9 project (Community water management for improved food security, nutrition and livelihoods in the polders of the coastal zone of Bangladesh) of the CGIAR Research Program on Water, Land and Ecosystems (WLE) (referred to as 'WLE-G9' in this report) aimed to test at a pilot scale the combination of innovative agricultural technologies (cultivation of high-yielding varieties [HYV] of rice and sunflower) with improved water management (construction of field channels and improved operation of the sluice gates).

The aim of this report was to assess the WLE-G9 project intervention by measuring the short-term impacts, identifying potential for long-term impacts and discussing the challenges. The WLE-G9 project was implemented in Fultola, Basurabad and Bhennabunia villages at Katakhali sub-polder in Polder 30 between 2015 and 2016.

A team from the International Water Management Institute (IWMI) was responsible for the socioeconomic analysis. The WLE-G9 intervention was implemented in the field by BRAC and the International Rice Research Institute (IRRI). The assessment was split into three different components and the results are presented in three separate chapters of this report: (i) crop economics data were used to measure changes in terms of input use, yields and profitability as a result of the intervention; (ii) results from the baseline (2015) and follow-up (2016) household surveys were used for a quantitative evaluation of the impact of the WLE-G9 project and Blue Gold program interventions on the water-related issues perceived by farmers, and on waterlogging, drainage and agricultural practices; and (iii) qualitative and quantitative data were combined to analyze how communities perceived the intervention and the sustainability of the practices introduced.

First, results of the analysis highlighted that cultivating HYV rice in the *Aman* season produced higher yields compared to traditional rice varieties, but the associated labor and input costs were higher, and the selling price was lower. Yet, some farmers expressed their interest to continue with cultivating HYV rice. In the dry season, benefitting farmers cultivated mostly sesame in the baseline survey and sunflower in the follow-up survey, but they were not able to make a profit when all the associated costs were taken into consideration. This questions the current practices of cultivation in the dry season, and highlights the need for better water management and early sowing of crops to avoid weather and water stresses.

Second, the quantitative impact evaluation, conducted on a relatively limited time window, presents encouraging results. The water management interventions undertaken by the WLE-G9 project, especially the establishment of field channels and improvements in the operation of the sluice gate, have been able to decrease the likelihood of farmers facing water-related issues, decrease the pressure of waterlogging and ensure that the plots are dry earlier in the season to establish the *Rabi* crop. Similarly, at the polder level, water management interventions undertaken by the Blue Gold program, mostly in the form of repair of existing, and construction of new, sluice gates and canal excavation, had positive effects in limiting the waterlogging faced by farmers and in facilitating drainage.

Third, regarding agricultural extension services and cropping patterns promoted by the WLE-G9 intervention, even if the levels of information available increased in the WLE-G9 intervention sites, beneficiaries perceived the limits already established by the quantitative analysis. This appears to be due to the integration of the technologies in the local context and not to the technologies that were introduced. This local context includes the practices of other farmers and the local market, which has not yet adapted to the introduction of alternative crops. Qualitative analysis also revealed positive perceptions held by both beneficiaries and non-beneficiaries regarding drainage improvement through the construction of field channels.

INTRODUCTION

1. Background: Agricultural Challenges in the Coastal Region of Bangladesh

Located at the interface between land and sea, the coastal zone of Bangladesh has particular natural settings which differentiate it from the rest of the country. The natural processes of erosion and accretion cause continuous and dynamic changes in land formation. These areas suffer immensely from natural disasters such as cyclones, storm surges, tidal fluctuations, salinity intrusion and land erosion. Combined with anthropogenic factors, these natural disasters significantly impact livelihood opportunities, especially crop production, in the coastal zone (Mishu and Zaman 2013).

Waterlogging due to excessive rain, tidal activity and the lack of proper drainage facilities in crop fields are the main constraints to agricultural production in these areas. This is especially true in the low-lying pockets of the polders, which suffer from months of flooding due to drainage congestion.

Riverbed siltation, along with the backwater effect due to sea-level rise and high tides, has also contributed to prolonged waterlogging in southwest Bangladesh during the last two to three decades. Gradual siltation of the riverbed is the main source of the problem, and one which increased following construction of the polders under the Coastal Embankment Project (CEP) during the 1960s. The consequent losses in agricultural production, due to inundation of about 128,000 hectares (ha) of cropland in Jessore, Satkhira and Khulna districts, continue to directly affect the livelihoods of around a million people. The impacts of climate change will place additional pressure on the poorest communities who are already facing a number of social and economic challenges. For example, by increasing and emphasizing their vulnerability due to their dependence on climate-sensitive natural resources and the weak social protection structures (Awal 2014).

Another obstacle to agricultural production in the coastal areas is the seasonally high content of salt in the soil root zone. Salt enters inland through rivers, channels and sluice gates, especially during the latter part of the dry season when the downstream flow of freshwater becomes very low. As an example of the levels of salinity, in the last few decades, coastal polders, which were initially constructed to protect agricultural land from salinity intrusion, have been turned into shrimp farms.

Increased salinity, internal drainage congestion and external siltation have consequently made large areas of land unsuitable for crop production, while other agricultural areas face numerous other risks. As a result, cropping intensity in the coastal region (162%) is lower than the national average (173%). This means that either a lower proportion of the net cultivable area is being cropped or the land cannot be effectively used for multiple crop rotations in a single year. This also implies lower yield per unit of arable land during the year. In fact, a sizeable amount of cultivable land remains fallow in the dry (*Rabi*) season (October to March) and even in the monsoon (*Kharif*) season (July to October), due to soil wetness, water stagnancy, tidal surges, drought and increased salinity (BBS 2010). In addition to these environmental constraints, poor road networks and marketing facilities also contribute to both low cropping intensities and yields.

Traditionally, farmers cultivate a low-yielding variety of rice in the *Aman* season, which occurs during and after the monsoon (July to December). Following this, a large proportion of arable areas remain fallow in the dry (*Rabi*) season and in the pre-monsoon (*Aus*) season due to high soil and water salinity, and lack of good quality irrigation water (Karim et al. 1990). Farmers who decide to cultivate in the *Rabi* season face numerous challenges and often lose some of their harvest.

2. Description of the WLE-G9 Project Interventions

The specificities of this context have been analyzed in detail by the Ganges Basin Development Challenge (GBDC) of the CGIAR Challenge Program on Water and Food (CPWF), which introduced a number of recommendations related to water management, water governance and agricultural practices. Following on from these lessons learned, the G9 project (Community water management for improved food security, nutrition and livelihoods in the polders of the coastal zone of Bangladesh) of the CGIAR Research Program on Water, Land and Ecosystems (WLE) (hereafter referred to as 'WLE-G9' in this report) aimed to test (at pilot scale) some of the most promising recommendations, in order to demonstrate proof of concept, understand the potential impacts and make recommendations for uptake.

Between 2015 and 2016, interventions were implemented by the WLE-G9 project in Fultola, Basurabad and Bhennabunia villages at Katakhali sub-polder in Polder 30. Fultola village consists of two water management units (WMUs). Two further WMUs were selected from the villages of Basurabad and Bhennabunia. On average, polder 30 has a medium to low level of salinity. Also, with the exception of a central zone of the polder, land elevation is relatively high. These characteristics are confirmed by the maps shown in Figures 1 and 2.

The intervention involved the introduction of a high-yielding variety (HYV) of *Aman* rice, in combination with other high-value *Rabi* crops, to improve production levels. Since HYV rice requires comparatively less cultivation time in comparison with traditional rice varieties, the intervention also aimed to reduce the production duration by enabling earlier crop planting in the *Rabi* season. The premise being that if farmers were able to dry and prepare their land earlier for crop cultivation in the *Rabi* season, and if the crop cultivation cycle could be reduced through the use of high-yielding varieties, then farmers should be better placed to harvest the *Rabi* crop successfully before the start of the first rainfall of the *Kharif* season. While sesame was the *Rabi* crop usually cultivated in the selected villages, alternative crops were introduced during the dry season, with a focus on sunflower.

Another important component of the intervention aimed to improve drainage. Therefore, drainage infrastructure improvements through canal re-excavation were carried out in coordination with the Blue Gold program. Additionally, at the plot level, farmers were encouraged to build drainage channels within their fields to improve drainage capacity.

The different units, number of beneficiaries and main activities carried out can be described as follows:

- WMU 1, Fultola: 20 ha, 52 farmers, improved crop and water management.
- WMU 2, Fultola: 64 ha, 105 farmers, traditional cropping with rice and *Rabi* crop.
- WMU 3, Basurabad: 4 ha, 25 farmers, improved crop and water management.
- WMU 4, Bhennabunia: 18 ha, 60 farmers, traditional cropping patterns (*Aman-Rabi*) plus fish in rice fields.

In addition, farmers, local leaders and officials from water management organizations (water management groups [WMGs] and water management associations [WMAs]) of polder 30) were invited to key events (kick-off meeting, crop cutting, trainings) to observe the activities initiated in these locations, with the aim of strengthening the coordination of water management among them.

The diverse interventions implemented generally fit into three categories: (i) agricultural demonstration and extension services, (ii) water infrastructure revitalization, and (iii) information dissemination.

(i) Agricultural demonstration and extension services

- Introduction of short-duration HYV *Aman* rice in WMU 1 and WMU 3.
- Introduction of high-yielding and high-value *Rabi* crops (sunflower, maize, mung bean, sesame) in the dry season in all WMUs.
- Rice-fish integration in WMU 4 in the wet season and *Rabi* crops in the dry season.
- *High-quality, stress-tolerant and nutrient-rich rice and Rabi* crop seeds. Fertilizer and pesticides were provided by the project, and farmers were responsible for land preparation, transplanting/sowing, weeding, harvesting and post-harvesting activities. In the rice-fish culture, improved fish fingerlings were provided by the project and farmers used homemade feed.

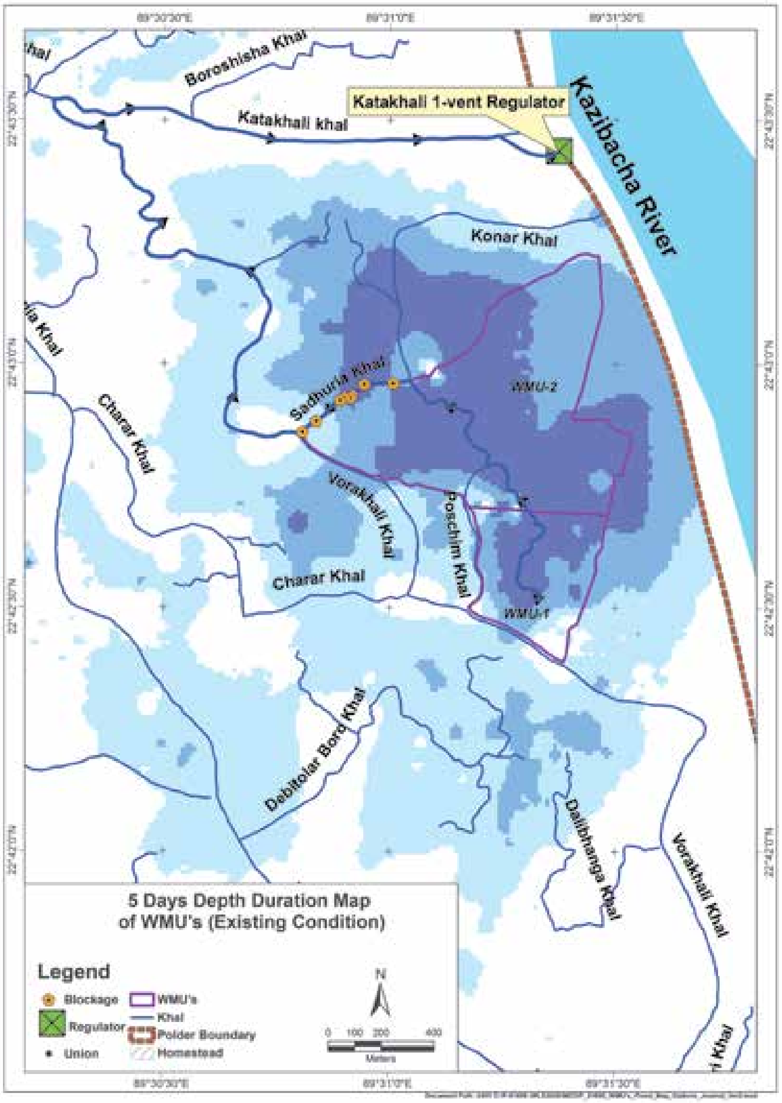
(ii) Water infrastructure revitalization

- Desilting of canals inside Fultola village.
- The main drainage canal that passes through WMU 2, which was silted, was excavated by the Blue Gold program to improve drainage from WMU 1 and WMU 2.
- Field drainage channels were constructed by the farmers, with support from the project, in WMU 1 and WMU 3.

(iii) Information dissemination

- Provision of training on crop production technologies and polder water management to the farmers and officials of WMGs and WMAs from polder 30.

FIGURE 1. THREE-DAY DEPTH DURATION MAP OF WATER MANAGEMENT UNITS IN POLDER 30.



Source: Institute of Water Modelling (IWM).

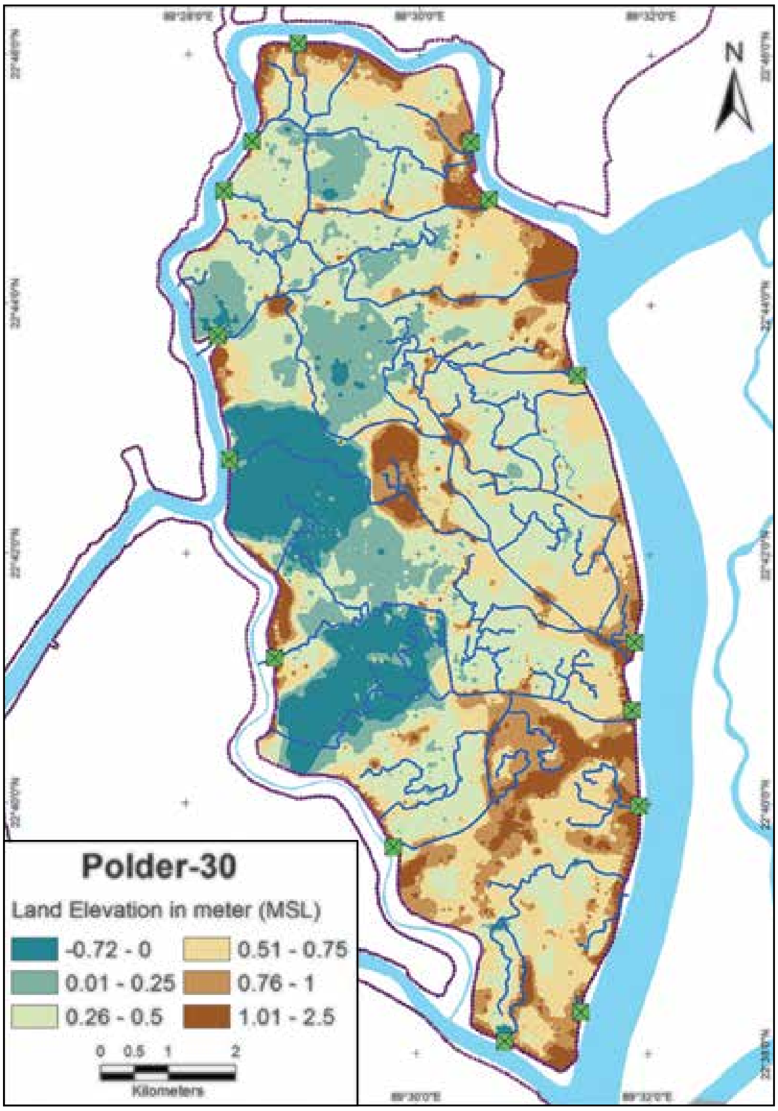
3. Objectives and Structure of the Report

This report is divided into three chapters, each detailing the socioeconomic analysis and impact assessments of the interventions implemented in the field by BRAC and the International Rice Research Institute (IRRI). A team from the International Water Management Institute (IWMI) conducted this analysis and the impact assessments. Recognizing that this analysis and the impact assessments posed a number of challenges, these challenges were detailed in the initial research design document and include the: (i) small scale of the pilot intervention, (ii) difficulty in identifying a counterfactual, and (iii) short duration provided for implementation and evaluation.

Chapter 1 provides an assessment of the changes introduced by the WLE-G9 project intervention, using crop economics data collected from the beneficiary farmers. This consists of a simple comparison between the initial situation (measured in the *Aman* season of 2014 and the *Rabi* season of 2015) and the situation after the WLE-G9 intervention was introduced (measured in the *Aman* season of 2015 and the *Rabi* season of 2016). Changes in the use of inputs, as well as in yields and profitability are considered.

Chapter 2 provides a quantitative evaluation of the impact of the WLE-G9 project and Blue Gold program interventions on the water issues perceived by the farmers, and on waterlogging, drainage and agricultural practices. The evaluation uses data compiled through a baseline household survey conducted in 2015 and a follow-up survey conducted in 2016. Key indicators considered are the short-term outcomes resulting from the intervention. The sample design used in this chapter takes into consideration the situation before and after the intervention, and with and without the intervention. Consequently, the analysis is based on a difference-in-differences estimation, which measures the impact of the treatments.

FIGURE 2. LAND ELEVATION MAP OF POLDER 30.



Source: Institute of Water Modelling (IWM).

Chapter 3 provides an analysis of how the communities involved perceived the interventions introduced by the WLE-G9 project, using a combination of qualitative and quantitative data. The objective is that this chapter (a) qualitatively confirms the quantitative results, (b) reveals a greater understanding of the heterogeneity of the potential impacts, and (c) provides a discussion of the sustainability of practices introduced by the intervention.

The three components detailed in these chapters together confirm that suitable governance arrangements can facilitate farm and polder use of improved water management practices, and that improved water management practices are a necessary condition for intensifying *Aman* season rice production, and also for both early sowing of *Rabi* crops and raising productivity in this season.

CHAPTER 1 – POTENTIAL EFFECTS OF IMPROVED CROPPING PATTERNS AND WATER MANAGEMENT ON INPUT USE, YIELDS AND PROFITABILITY, FOLLOWING THE WLE-G9 PROJECT INTERVENTIONS

1. INTRODUCTION

The multiplicity of cropping patterns is one of the main features of agriculture in Bangladesh. This is attributed to the diverse environments and socioeconomic conditions prevailing in farming communities. The coastal region of Bangladesh has a different crop distribution from other regions, especially in relation to rice cultivation. Local *Aman* rice is the dominant crop in the coastal region, occupying over 30% of the net cultivable area. During the monsoon season, both access to irrigation facilities and salinity levels are comparatively low. HYV *Aman* and *Aus* rice are not widely cultivated in the coastal zone. In other parts of the country, *Boro* rice, which covers less than 14% of the land in the coastal area, is the most important rice cultivated. However, in the coastal region, the cultivation of *Boro* rice is limited by high salinity levels and the scarcity of good quality irrigation water, which in turn limits the total rice yield in this region. In addition, farmers in the coastal region use traditional technologies, which can be both labor intensive and expensive, in crop production.

This provides an opportunity to examine whether modern agricultural technologies, applied through a 'systems approach' rather than a seasonal or crop-specific approach, can be effectively used in these particular soil and micro-climatic conditions.

The WLE-G9 project intervention seeks to understand whether the introduction of HYV rice in the *Aman* season with high-value crops in the *Rabi* season, along with improved drainage facilities and better water governance, could reduce the vulnerabilities faced by farmers in the coastal region. It also seeks to improve food security and farmer incomes in the coastal areas.

This chapter is based on an analysis of the economic efficiency of conventional, traditional farming, on the one hand, and improved HYV crop farming, on the other, in both the *Aman* and *Rabi* seasons.

To assess the economic efficiency of cropping patterns, a cost-benefit analysis was conducted. This was combined with descriptive statistics on land characteristics, cropping patterns, agricultural inputs and labor management. This chapter aims to assess the economic efficiency of different cropping patterns practiced in adjacent years. However, due to a number of methodological caveats, it should not be considered as an assessment of the technologies introduced themselves.

2. METHODOLOGY

2.1 Study Area and Sample Size

Research was conducted in four different WMUs in Polder 30, where the WLE-G9 project intervention took place.

In October 2015, 58 farmers from Fultola village were selected to participate in the farmer-targeted baseline crop economics survey. Information on the *Aman* 2014 and *Rabi* 2015 seasons was collected directly from these farmers. In the follow-up crop economics survey, information on the *Aman* 2015 and *Rabi* 2016 seasons was collected from 52 of the same farmers who had since engaged in HYV rice cultivation in the project area (Table 1).

Detailed questions in the questionnaire focused on a single plot, representing the largest plot cultivated by each farmer, in the WLE-G9 project intervention area.

A questionnaire was used to collect information from farmers in the crop economics survey (Annex 1). The aim of the questionnaire was to collect detailed information on crop production, selling price, price of inputs and the cost of labor used.

One possible limitation in the collection of data directly from farmers is memory bias. This can affect data on yields mainly because the details provided are based on memory and are not an estimation based on crop cuts. However, since the questionnaire was used with farmers

TABLE 1. DESCRIPTION OF THE CROP ECONOMICS SURVEYS.

YEAR OF DATA COLLECTION	CROPPING SEASONS	SAMPLE SIZE	UNITS
2015	*Aman* 2014	58	WMU 1, WMU 2
2015	*Rabi* 2015	58	WMU 1, WMU 2
2016	*Aman* 2015	52	WMU 1, WMU 3
2016	*Rabi* 2016	52	WMU 1, WMU 3, WMU 4

Source: Authors' survey.

after each cropping season in the same way and under similar conditions, it can be assumed that any bias would be similar for each of the crops cultivated, and therefore would not affect comparison between different crops.

2.2 Analytical Techniques

Two analytical techniques are employed in this chapter: (i) descriptive statistics, and (ii) activity budgets (Dillon and Hardaker 1993).

Aside from descriptive statistics, the following algebraic equation (Zaman et al. 2014) was used to assess the profitability of crop farming:

$$\Pi = TR - (VC + FC)$$
$$GM = TR - VC$$
$$GM = \sum (Py_i . Y_i) - \sum (Px_i . X_i)$$

Where:

Π = Profit or net return from the crops concerned (BDT/ha)
GM = Gross margin from the crops concerned (BDT/ha)
TR = Total return from the crops concerned (BDT/ha)
VC = Variable cost of producing the crops concerned (BDT/ha)
FC = Fixed cost of producing the crops concerned (BDT/ha)
Py_i = Per unit price of the i^{th} crop (BDT/kg)
Yi = Quantity of the i^{th} crop (kg/ha)
Px_i = Per unit price of inputs for i^{th} crop (BDT/kg)
X_i = Total quantities of inputs for i^{th} crop (kg/ha)
i = 1, 2, 3, n
n = Number of crops

2.3 Profitability Analysis

Profitability calculations were made from the standpoint of the value to individual farmers. All costs and benefits of selected crops were determined in the domestic currency (Bangladeshi Taka [BDT]) using farm gate prices. Production costs of individual crops include all costs associated with the production of the crop concerned.

Both family and hired labor are included in the analysis. Family labor was found to be widely used in crop cultivation, even if no payment was made by farmers for this type of input. The costs of inputs purchased are calculated on the basis of the average price paid at the farm gate. Home-supplied inputs, such as family labor and some seeds, were assessed by applying the opportunity cost principle. The opportunity cost of a resource is the return the resource can earn, or be worth, when put to a best alternative use (Doll and Orazem 1984).

2.4 Interest on Operating Capital

Not all costs were incurred at the start of the production period. Instead, some costs were spread over the entire production period. Investment in operating capital (OC) was, therefore, computed using the following formula specified by Zaman et al. (2014):

Interest on OC = AI × I × t

Where:

AI = Average Investment (total investment/2)
I = Interest rate per year, set at 10% here, the lending interest rate of Bangladesh in *Krishi* (i.e., agriculture) of the Bank for Agriculture Credit (crop production) in 2014
t = Time required for crop production in months

3. LAND CHARACTERISTICS

3.1 Plot Elevations

In this section, we characterize the type of land used for the cultivation of *Aman* and *Rabi* crops in both the baseline and follow-up crop economics surveys (Figure 3). In the baseline survey, the amount of lowland was 21%, while the amount of medium land and highland used was 77% and 2%, respectively.

The sample used in the follow-up survey consisted of a slightly larger percentage of highland and medium land (Figure 3). One reason for this could be that the WLE-G9 project intervention promoted HYV *Aman* rice, which has to be planted at higher elevations, due to its much lower height compared to traditional varieties of rice, to avoid the risk of submergence. However, it was noted that the availability of highland is relatively rare in this context, which could constrain the extent of HYV *Aman* rice cultivation.

3.2 Salinity Levels

The project area in Polder 30 is located in one of the low salinity areas of the coastal region. Therefore, salinity is not a challenge for most of the plots in the WLE-G9 project areas (Figure 4).

In the baseline survey, there were no issues with salinity in 89% of the plots, according to farmers' perceptions. In the follow-up survey, 38% of the plots had no salinity and 56% of the plots had a low salinity level, according to farmers' perceptions (Figure 4). The increase in salinity levels between the baseline and follow-up surveys could be due to different climatic conditions between the two years.

3.3 Ownership Status of the Plots

In this section, 'owned land' is defined as land for which farmers have legal papers; 'leased land' is defined as plots where farmers lease the land from the landowner and make payments for it on a regular basis; and 'sharecropping' is when farmers cultivate plots owned by a landowner and share a percentage of the harvest with them in return.

In both surveys, the majority of plots were farmers' owned land - 73% and 68% in the baseline and follow-up surveys, respectively (Figure 5). Land under sharecropping was 22% and 24% in the baseline and follow-up surveys, respectively. Ownership status may have had some impact on the intervention, because direct ownership could have more easily facilitated implementation and hence enhanced the effects of it. This will be discussed further in Chapter 3.

It was notable that the amount of leased land was very limited in both the baseline and follow-up surveys.

3.4 Crop Submergence in the *Aman* Season

Figure 6 shows the percentage of plots that are totally submerged in the *Aman* season, according to the baseline and follow-up surveys.

According to the baseline survey, 9% of the plots in the WLE-G9 project intervention areas were totally submerged in the *Aman* season. However, this was not the case in the follow-up survey (Figure 6). This may be linked to an improvement in drainage conditions related to the WLE-G9 project intervention.

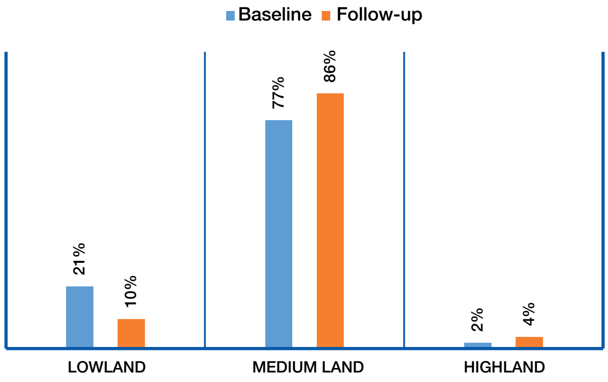
3.5 Cropping Patterns in the *Rabi* Season

While all of the farmers grow rice in the *Aman* season, cropping patterns are more diverse in the *Rabi* season. For example, according to the baseline survey, 79% of the plots were cultivated with sesame, 5% with lentils and pulses, and 16% was left fallow in the 2015 *Rabi* season (Figure 7).

In the project area, sesame was the most common crop cultivated in the *Rabi* season, according to the baseline survey. Farmers have been cultivating sesame for many years. In spite of the climate vulnerability of the crop, its low maintenance requirement, combined with farmers' access to a well-developed market, ultimately made sesame the primary crop selected by farmers in these villages. However, the inability to achieve expected outputs from sesame cultivation, due to unfavorable climatic conditions over several years, has led farmers to look for alternative crops for cultivation during the *Rabi* season.

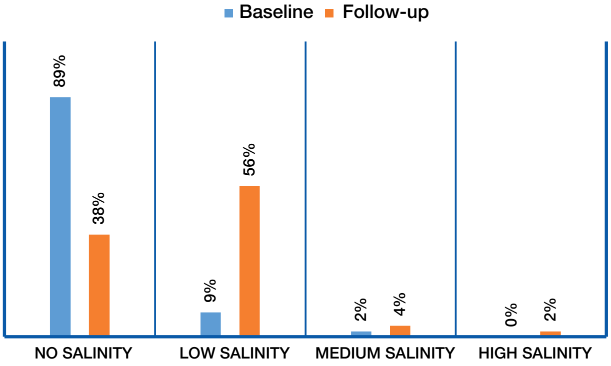
According to the follow-up survey, cropping patterns in the *Rabi* season shifted as a result of the WLE-G9 project intervention, with 90% of the plots cultivated with sunflower and 10% with maize (Figure 7). The fact that none of the plots selected for the intervention were cultivated with sesame can be attributed to two things: (i) the decision by farmers not to cultivate sesame because of unfavorable weather conditions[1], and (ii) support provided by the WLE-G9 project for the cultivation of alternative crops.

FIGURE 3. PLOT ELEVATIONS IN THE BASELINE AND FOLLOW-UP SURVEYS CONDUCTED IN THE WLE-G9 PROJECT AREAS.



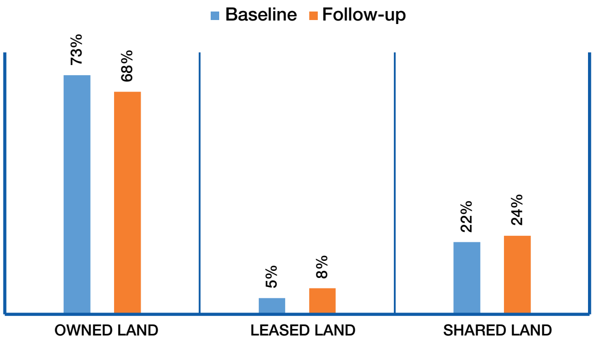
Source: Authors' survey.

FIGURE 4. SALINITY LEVELS IN THE BASELINE AND FOLLOW-UP SURVEYS CONDUCTED IN THE WLE-G9 PROJECT AREAS.



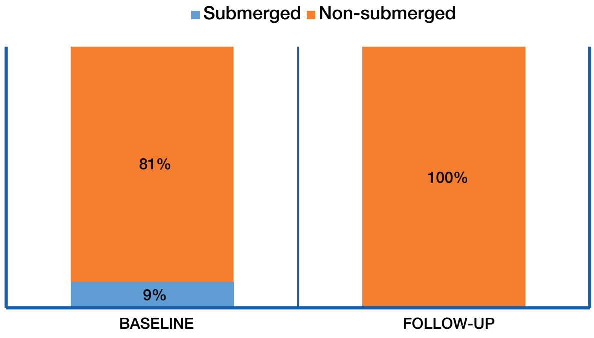
Source: Authors' survey.

FIGURE 5. OWNERSHIP STATUS OF THE PLOTS.



Source: Authors' survey.

FIGURE 6. CROP TOTALLY SUBMERGED IN WATER.



Source: Authors' survey.

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[1] The consequence for the analysis here is that we cannot compare between traditional *Aman* varieties of rice followed by sesame and HYV *Aman* rice followed by sesame. Yet, the introduction of short-duration HYV rice with improved drainage aimed to sow sesame earlier in the season and therefore avoid the rains before harvesting.

FIGURE 7. CROPPING PATTERNS IN THE *RABI* SEASON.

Source: Authors' survey.

4. AGRICULTURAL INPUTS

4.1 Fertilizer Inputs in *Aman* Rice

Figure 8 shows the various fertilizers used for the cultivation of *Aman* rice, according to both the baseline and follow-up crop economics surveys. It can be seen that the use of fertilizer was much higher in the follow-up survey than in the baseline survey. Farmers applied 15 kg/ha and 200 kg/ha of urea in the baseline and follow-up surveys, respectively. A similar pattern was observed in the use of phosphate and potash. Finally, while zinc was not used in the traditional cropping system followed in the baseline survey, 113 kg/ha was used and revealed in the follow-up survey.

In the baseline survey, traditional *Aman* varieties of rice were cultivated on these plots, while HYV rice was cultivated and detailed in the follow-up survey. The quantity of fertilizers required for HYV *Aman* rice is higher than that required for traditional rice varieties. In addition, with the support of the WLE-G9 project intervention, farmers were encouraged to apply the required quantity of fertilizer, which was probably different from the cultivation practices observed in the baseline survey.

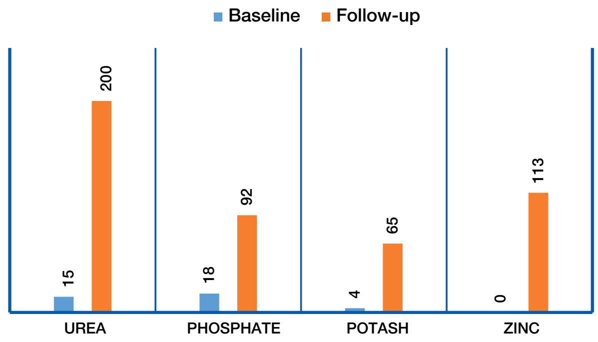
4.2 Fertilizer Inputs in the *Rabi* Crop

As with *Aman* rice, Figure 9 shows details of the use of fertilizers for *Rabi* crops in the baseline and follow-up surveys. It can be seen that the *Rabi* crops cultivated and detailed in the follow-up survey (sunflower and maize) required a higher amount of fertilizer inputs than those cultivated and detailed in the baseline survey (sesame).

The quantity of urea and phosphate applied in the baseline survey was 3 kg/ha and 8 kg/ha, respectively. However, in the follow-up survey, 118 kg/ha and 180 kg/ha of urea and phosphate, respectively, were applied. Also, while potash and zinc were not used in the baseline survey, a notable amount of these fertilizers was applied in the follow-up survey.

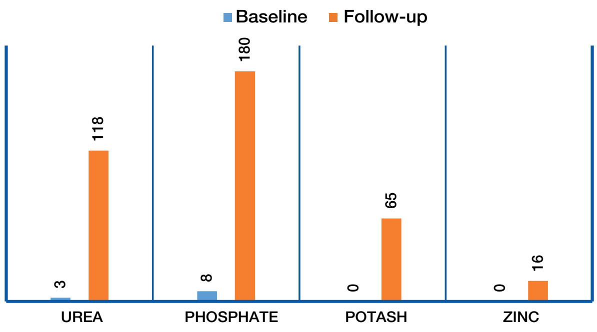
These are important differences. However, the main crops cultivated by farmers were different and relevant to each survey - sesame in the baseline survey and sunflower in the follow-up survey. The fertilizer requirements of these different types of crops are not the same, and the WLE-G9 project intervention also increased the use of the fertilizers.

FIGURE 8. FERTILIZER INPUTS FOR *AMAN* RICE (KG/HA).



Source: Authors' survey.

FIGURE 9. FERTILIZER INPUTS FOR *RABI* CROPS (KG/HA).



Source: Authors' survey.

5. LABOR MANAGEMENT

5.1 Family Labor in the *Aman* Season

Figure 10 shows the number of days (per hectare) spent by family members on the plots in the *Aman* season, presented and desegregated by the type of agricultural activity. The general picture is that, for almost every activity, the time spent by the family members on the plot in the follow-up survey exceeded the time they spent in the baseline survey.

While farmers cultivated only traditional rice varieties in the baseline survey, HYV rice varieties were cultivated in the follow-up survey. Every activity appears to be more labor intensive in the follow-up survey except for harvesting, which actually took a lower number of days of family labor with the HYV *Aman* rice than with the traditional variety.[2] The largest difference observed between the baseline and follow-up surveys was the amount of labor used for threshing and pesticide application.

5.2 Hired Labor in the *Aman* Season

Besides family labor, hired labor was also required in diverse field activities. In the *Aman* season, a comparison of the baseline and follow-up surveys shows that more hired labor was used in the follow-up survey for cultivating HYV rice (Figure 11).

In activities such as tillage, transplanting/sowing and weeding, hired labor was used for 2 days/ha, 4 days/ha and 5 days/ha, respectively, for the cultivation of traditional rice as detailed in the baseline survey. For the cultivation of HYV rice, as detailed in the follow-up survey, hired labor was used for 33 days/ha, 50 days/ha and 41 days/ha for tillage, transplanting/sowing and weeding, respectively. The use of hired labor for harvesting was approximately the same between the baseline and follow-up surveys.

Consistent with global observations, HYV rice is more labor intensive than traditional rice varieties. When desegregated by activity, this remains true for all the activities except harvesting and threshing.

5.3 Family Labor in the *Rabi* Season

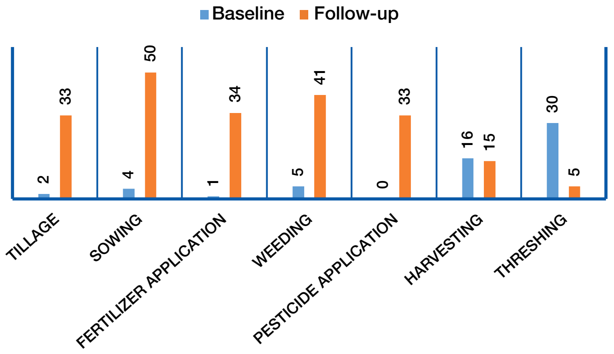
Figure 12 shows the different levels of involvement of the family in agricultural activities, as detailed in both the baseline and follow-up surveys, for cropping in the *Rabi* season.

It was revealed that the time spent by family members for sowing and fertilizer application was higher in the follow-up survey than in the baseline survey. For example, on average, there was an increase from 2 days/ha in the baseline survey to 12 days/ha in the follow-up survey for sowing. In other activities, the differences were not statistically significant.

5.4 Hired Labor in the *Rabi* Season

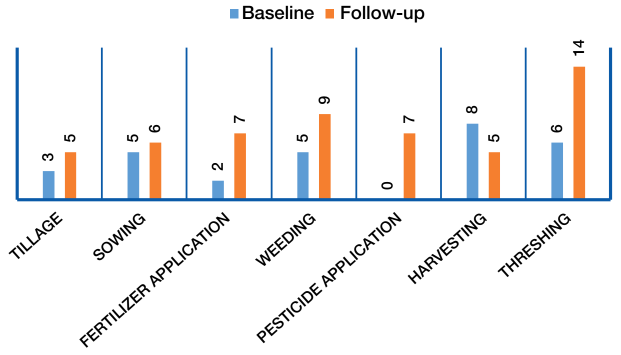
Figure 13 shows the differences between the baseline and follow-up surveys in relation to the use of hired labor in the *Rabi* season. The only noticeable differences between the baseline and follow-up surveys concern sowing and weeding. Sowing required 12 days/ha of hired labor, on average, for the cultivation of sunflower and maize in the follow-up survey, while only 1 day/ha of hired labor was required for the cultivation of sesame in the baseline

FIGURE 11. HIRED LABOR USED IN THE *AMAN* SEASON (DAYS/HA).



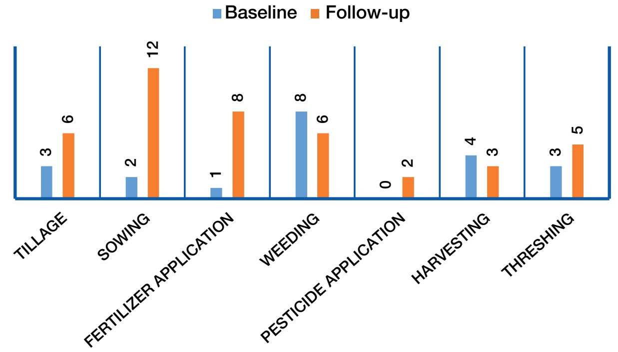
Source: Authors' survey.

FIGURE 10. FAMILY LABOR USED IN THE *AMAN* SEASON (DAYS/HA).



Source: Authors' survey.

FIGURE 12. FAMILY LABOR USED IN THE *RABI* SEASON (DAYS/HA).



Source: Authors' survey.

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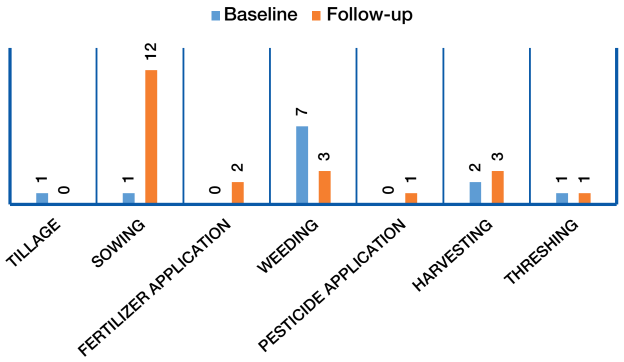
[2] We acknowledge that family labor data in the follow-up survey reflect the activities that the project introduced in the pilot intervention and are probably not replicable in another setting. For example, the project implementation team highlighted the importance of threshing for improved drainage of the plots, explaining the higher number of days spent on threshing. Likewise, during the pilot, harvesting was carried out by a group of beneficiary farmers, resulting in relatively low use of family labor.

FIGURE 13. HIRED LABOR USED IN THE *RABI* SEASON (DAYS/HA).



Source: Authors' survey.

survey. More people had to be hired for weeding when cultivating sesame, according to the baseline survey, in comparison to the labor required for the cultivation of sunflower or maize, as detailed in the follow-up survey.

Combining the number of days of family and hired labor for cultivation during the *Rabi* season, it is noted that the time required for sowing and applying fertilizer increased, while time and costs related to weeding decreased. For other activities, the time requirements remained approximately the same for the cultivation of sunflower and maize in the follow-up survey as for the cultivation of sesame in the baseline survey.

6. PRODUCTION

6.1 Production in the *Aman* Season

In this section, we estimate the production achieved during the *Aman* season in terms of kilograms per hectare (kg/ha) and Bangladeshi Taka per hectare (BDT/ha) using information provided by the farmers.

As expected, with the use of HYV seeds, the quantity produced largely increased from levels detailed in the baseline survey to those detailed in the follow-up survey. In the baseline survey, the yield was on average 3,135 kg/ha with the traditional variety of *Aman* rice, whereas it was 4,049 kg/ha with HYV rice in the follow-up survey (Figure 14). The shift from traditional varieties to HYV rice increased the yields of *Aman* rice by 29.1%. These results match agronomists' expectations in this particular environment.

However, the value generated through the production of HYV rice is lower than that of the traditional variety. This is because the market price for HYV rice is much lower than that of traditional varieties. In that context, the increase in yield in the follow-up survey was not sufficient to compensate for the lower market price of HYV rice. The value of HYV *Aman* rice was also lower than the value of the traditional rice varieties in the baseline year.

6.2 Production in the *Rabi* Season

In the baseline and follow-up surveys, different crops were cultivated in the *Rabi* season. Therefore, in this case, we compare the gross yields for different crops rather than comparing yields between the baseline and follow-up surveys. Interestingly, sesame, which was the preferred crop in the baseline survey, had a lower production value than pulses - a difference of about 50% (Figure 15).

However, sunflower, introduced by the WLE-G9 project intervention and produced in the *Rabi* season of 2016, had a much higher production value. The production value of sunflower is three times that of the sesame crop and 1.6 times that of pulses.[3]

7. PROFITABILITY ANALYSIS

7.1 Profitability Analysis for the *Aman* Season

Tables 2 and 3 show the activity budgets with average per-hectare costs and returns of *Aman* paddy in the baseline and follow-up surveys. Data presented are mean values of the information provided by the sample farmers. Information regarding the production quantity, input quantity, and the price of products and inputs was given by the farmers and collected through an individual questionnaire.

The key results from these tables are summarized in Figure 16, representing inclusion and exclusion of family labor.

These results show that all three indicators – gross return, gross margin and net return – are lower in the follow-up survey with HYV rice than in the baseline survey with traditional rice varieties. This remains the same when either including or excluding the value of family labor.

Finally, we estimate the benefit-cost ratio (BCR) in the *Aman* season. BCR is 1.65 in the follow-up survey and 3.33 in the baseline survey (Figure 17).

7.2 Profitability Analysis for the *Rabi* Season

Tables 4 and 5 present the same activity budget calculations with the cost and return per hectare for the *Rabi* season. We distinguish between the cultivation of sesame and pulses in the baseline survey, and the cultivation of sunflower in the follow-up survey.

Results of the profitability analysis show negative values for the net return and gross margin in the baseline and follow-up surveys (Figure 18). This indicates that environmental and market conditions prevent farmers from making a profit in the *Rabi* season. This is the same with both sesame and pulses in the baseline survey and also with sunflower in the follow-up survey.

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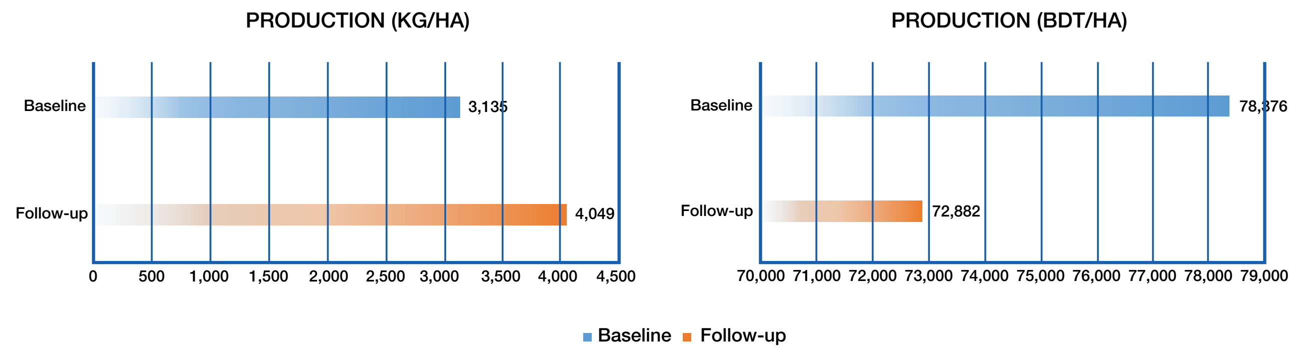
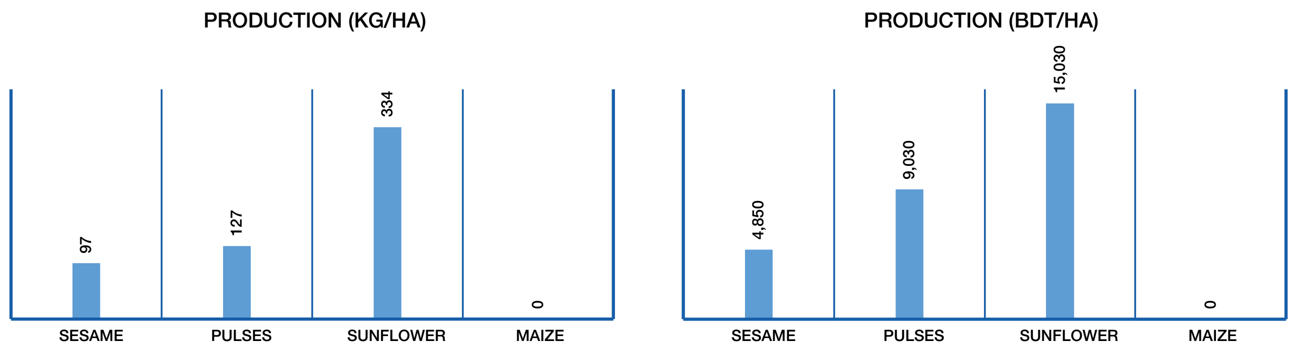
[3] Here, the comparison is between sesame and pulses in 2015, on the one hand, and between sesame and sunflower in 2016, on the other. Unfortunately, data were not collected for sesame and pulses in 2016 to enable a direct comparison under the same climatic conditions. However, the field observations suggest that all crops, except for sunflower and maize, were damaged in the benefitting locations due to rainfall in February and March 2016.

FIGURE 14. PRODUCTION IN THE *AMAN* SEASON.



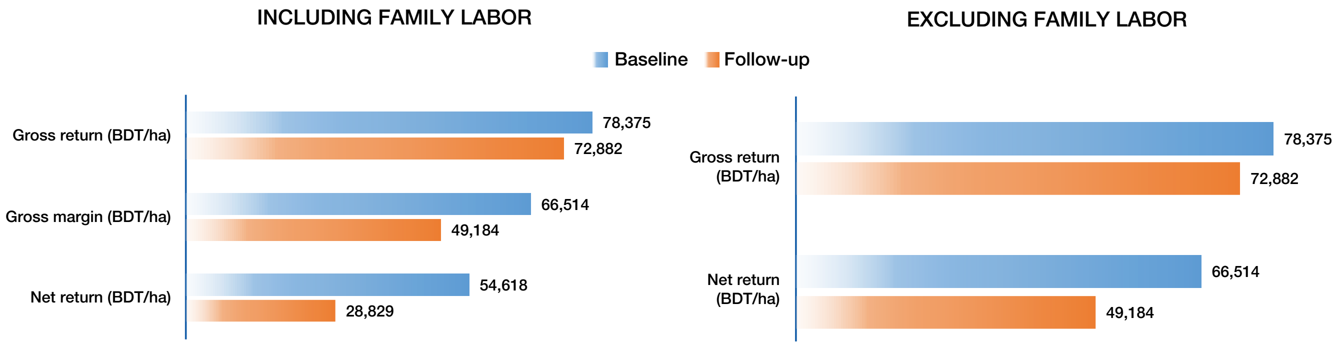
Source: Authors' survey.
Note: The crop value is calculated by multiplying the quantity produced by the price estimated at the farm gate.

FIGURE 15. PRODUCTION TRENDS IN THE *RABI* SEASON.



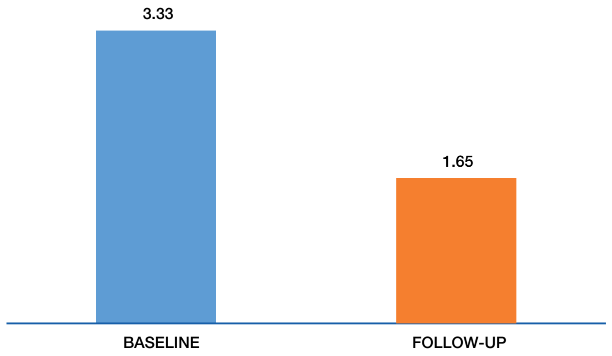
Source: Authors' survey.

FIGURE 16. COST-BENEFIT ANALYSIS FOR THE *AMAN* SEASON.



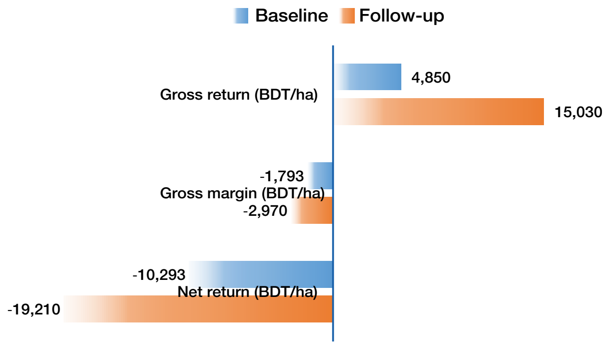
Source: Authors' survey.

FIGURE 17. BENEFIT-COST RATIO FOR THE *AMAN* SEASON.



Source: Authors' survey.

FIGURE 18. PROFITABILITY ANALYSIS FOR THE *RABI* SEASON.



Source: Authors' survey.

TABLE 2. ACTIVITY BUDGETS: PER-HECTARE COSTS AND RETURNS OF *AMAN* RICE IN THE BASELINE SURVEY.

	TOTAL QUANTITY/HA	PER UNIT PRICE (BDT)	RETURNS/COSTS (BDT/HA)	PERCENTAGE OF TOTAL COST (%)
A. Gross returns				
Main product	3,135 kg	25/kg	78,375	-
Total	-	-	78,375	-
B. Variable costs				
Tillage cost			4,771	20.082
Seedlings	49 kg	25/kg	1,225	5.15
Fertilizers:				
Urea	15 kg	19/kg	285	1.19
Phosphate	18 kg	23/kg	414	1.75
Potash	4 kg	15/kg	60	0.25
Diammonium phosphate (DAP)	0.72 kg	32/kg	23	0.097
Other fertilizer			113	0.48
Pesticides + weedicides	NA		73	0.30
Hired labor cost			4,897	20.78
Total variable cost	-	-	11,861	49.50
C. Gross margin (A - B)	**-**	**-**	**66,514**	
D. Fixed costs				
Family labor	29 man-days	400/man-days	11,600	49.25
Interest on operating capital		@10%	296	1.25
Total fixed cost			**11,896**	50.50
E. Total cost (B + D)			**23,757**	100
F. Net return (C - D)	-	-	**54,618**	-
G. Undiscounted BCR	-	-	**3.33**	-

Source: Authors' survey.
Note: BCR: Benefit-cost ratio, NA: Not available

The BCR for different crops in the *Rabi* season is presented in Figure 19. The BCR of pulses is the highest, followed by sunflower.

7.3 Profitability Analysis for One Cropping Season

Figure 20 shows the profitability analysis for the entire year combining the *Aman* and *Rabi* seasons.

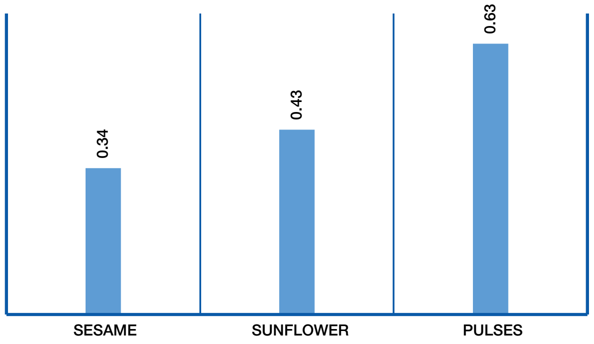
The cost-benefit analysis for the entire cropping year shows a higher gross return for the period 2015-2016 than for the period 2014-2015. However, the net return and gross margin are lower in the period 2015-2016 than in the period 2014-2015. Despite reasonable selling prices in the 2015-2016 cropping year, production costs were much higher than in the period 2014-2015.

TABLE 3. ACTIVITY BUDGETS: PER-HECTARE COSTS AND RETURNS OF *AMAN* RICE IN THE FOLLOW-UP SURVEY.

	TOTAL QUANTITY/HA	PER UNIT PRICE (BDT)	RETURNS/COSTS (BDT/HA)	PERCENTAGE OF TOTAL OF COST (%)
A. Gross returns				
Main product	4,049 kg	18/kg	72,882	-
Total	-	-	**72,882**	**-**
B. Variable costs				
Tillage cost			7,316	16.60
Seedlings	34 kg	48/kg	1,632	3.70
Fertilizers:				
Urea	200 kg	15/kg	3,000	6.80
Phosphate	92 kg	24/kg	2,208	5.012
Potash	65 kg	15/kg	975	2.21
Zinc	113 kg	13/kg	1,469	3.33
Hired labor cost			7,098	16.11
Total variable cost	-	-	**23,698**	53.79
C. Gross margin (A - B)	-	-	**49,184**	
D. Fixed costs				
Family labor	50 man-days	400/man-days	**20,000**	45.39
Interest on operating capital		@ 10%	355	0.80
Total fixed cost			20,355	46.21
E. Total cost (B + D)			44,053	**100**
F. Net return (C - D)	-	-	**28,829**	-
G. Undiscounted BCR	-	-	**1.65**	-

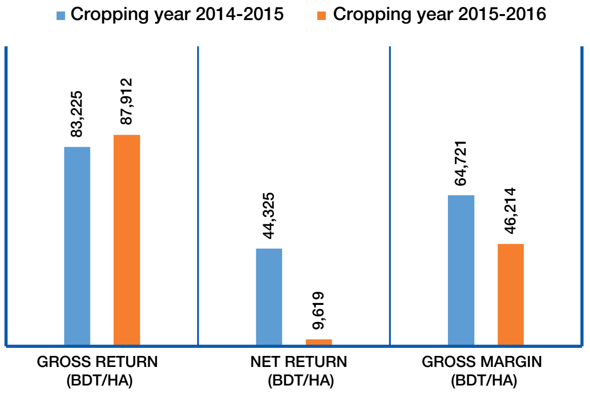
Source: Authors' survey.
Note: BCR: Benefit-cost ratio

FIGURE 19. BENEFIT-COST RATIO FOR DIFFERENT CROPS IN THE *RABI* SEASON.



Source: Authors' survey.

FIGURE 20. PROFITABILITY ANALYSIS FOR ONE CROPPING YEAR.



Source: Authors' survey.

TABLE 4. ACTIVITY BUDGETS: PER-HECTARE COSTS AND RETURNS OF THE *RABI* CROP IN THE BASELINE SURVEY.

	TOTAL QUANTITY/HA		PER UNIT PRICE (BDT)		RETURNS/COSTS (BDT/HA)		PERCENTAGE OF TOTAL COST (%)	
	Sesame	**Pulses**	**Sesame**	**Pulses**	**Sesame**	**Pulses**	**Sesame**	**Pulses**
A. Gross returns								
Main product	97 kg	129 kg	50/kg	70/kg	4,850	9,030	-	-
Total	-		-	4,850	4,850	9,030	-	-
B. Variable costs								
Tillage cost					3,540	7,903	25.13	55.45
Seedlings	12 kg	13 kg	66/kg	78/kg	664	1,014	4.71	7.11
Fertilizers:								
Urea	3 kg	0/kg	19/kg		57		0.40	
Phosphate	8 kg	0/kg	15/kg		120		0.85	
Pesticides + weedicides	NA		12		12	419	0.001	2.94
Hired labor cost					1,223	0	8.68	0.00
Total variable cost	-		-		5,616	9,336	39.87	65.51
C. Gross margin (A - B)	-	-			-766	-306		
D. Fixed costs								
Family labor	21 man-days	12 man-days	400/man-days	400/man-days	8,400	4,800	59.63	33.68
Interest on operating capital				@10%	70	116	0.50	0.81
Total fixed cost					8,470	4,916	60.13	34.49
E. Total cost (B + D)					**14,086**	**14,252**	100.00	100.00
F. Net return (C - D)	-	-			**-9,236**	**-5,222**		
G. Undiscounted BCR	-	-			**0.34**	**0.63**		

Source: Authors' survey.
Note: BCR: Benefit-cost ratio, NA: Not available

8. DISCUSSION AND SENSITIVITY ANALYSIS

To clearly understand the scope of these results, it is important to recognize that the analysis presented here has a number of limitations.

First, this is a simple comparison between two cropping seasons. In the absence of a counterfactual (see Chapter 2), we cannot certify that the differences observed between the two years are only attributable to the technical interventions. Indeed, for example, meteorological conditions were different in the two adjacent years and could partly explain the differences in yields and inputs used.

Second, an important limitation of this analysis is that the crop economics data provided by the farmers likely reflect the instructions given by the facilitators from the WLE-G9 implementing team. The quantity of inputs was advised by researchers based on agronomic experiments with the objective of maximizing yields. Furthermore, some of the inputs were not purchased by the farmers, but provided by the WLE-G9 project intervention. It is likely that, in a context where farmers would purchase the inputs themselves and make their own decisions on application rates, the associated costs may be lower than those identified in the follow-up survey.

Third, the profitability analysis is based on prices identified for the years 2015 and 2016. However, for the newly introduced crops, such as sunflower and HYV rice, these prices are not yet well established and are likely to evolve rapidly with changes in demand and increasing supply.

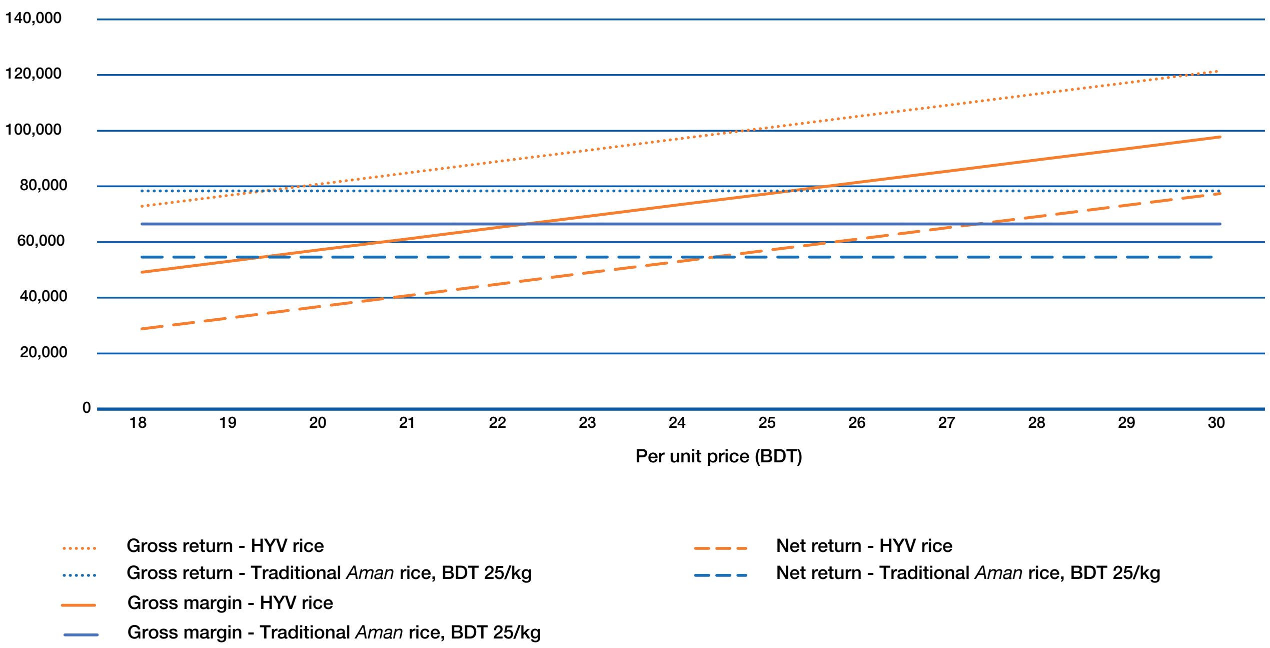
Therefore, a sensitivity analysis was conducted. In spite of the limitations of the estimated values of inputs and labor, especially in the case of HYV rice, it is difficult to propose alternative estimations. The farmers themselves mentioned that producing HYV rice is labor and input intensive. Therefore, in this context, it is impossible to estimate yields when the use of inputs and labor is low, which is probably what is observed under normal conditions. A simple sensitivity analysis, based on the price of HYV rice (Figure 21), was conducted. With an increase of 30% in the selling price, HYV rice cultivation would become more profitable (net return) than the cultivation of traditional rice varieties, given current conditions. In a fluctuating market, this could be achieved within a few years.

TABLE 5. ACTIVITY BUDGETS: PER-HECTARE COSTS AND RETURNS OF THE *RABI* CROP IN THE FOLLOW-UP SURVEY.

	TOTAL QUANTITY/HA	PER UNIT PRICE (BDT)	RETURNS/COSTS (BDT/HA)	PERCENTAGE OF TOTAL COST (%)
	Sunflower	**Sunflower**	**Sunflower**	**Sunflower**
A. Gross returns				
Main product	334 kg	45/kg	15,030	-
Total	-	-	15,030	-
B. Variable costs				
Tillage cost			6,740	19.68
Seedlings	36 kg	40/kg	1,440	4.20
Fertilizers:				
Urea	118 kg	15/kg	1,770	5.16
Phosphate	180 kg	18/kg	3,240	9.46
Potash	65 kg	15/kg	2,826	8.25
Zinc	16 kg	15/kg	240	0.007
Hired labor cost			1,744	5.09
Total variable cost	-	-	18,000	52.48
C. Gross margin (A - B)	-	-	-2,970	
D. Fixed costs				
Family labor	40 man-days	400/man-days	16,000	46.72
Interest on operating capital		@10%	240	0.70
Total fixed cost			16,240	47.42
E. Total cost (B + D)			**34,240**	**100**
F. Net return (C - D)	-	-	**-19,210**	-
G. Undiscounted BCR	-	-	**0.43**	-

Source: Authors' survey.
Note: BCR: Benefit-cost ratio

FIGURE 21. SENSITIVITY ANALYSIS: PROFITABILITY OF *AMAN* RICE.



Source: Authors' survey.

9. CONCLUSION

This chapter provides details of the results of the crop economic analyses conducted to compare the costs with the values of production. The aim of the analysis was to determine the alternative cropping pattern that would provide an acceptable net return.

Although HYV *Aman* rice provides a higher yield compared to the traditional rice variety, the costs of labor and inputs are higher and the sale price is low, resulting in lower profitability. At the time of the analysis, HYV rice had a lower market price because the market for it was not yet established. Almost every farmer cultivates the traditional rice variety and, most importantly, farmers prefer to consume traditional rice. Yet, some farmers who cultivated HYV rice through the WLE-G9 project intervention expressed their interest in continuing to cultivate HYV rice for sale, while keeping a small proportion of their land for the cultivation of traditional rice varieties for their own consumption. In this way, the market for HYV rice could steadily be established. Since November 2016, the price of HYV rice appears to have increased, which suggests potential for increased profitability in the future. This is further confirmed by the sensitivity analysis.

In the case of the *Rabi* season, both in the baseline and follow-up surveys, farmers were not able to make a profit when all the associated costs were taken into consideration. This is mostly due to environmental conditions which hamper the production of the *Rabi* crop. Yet, the profitability of cultivating sunflower is better than that achieved with the cultivation of sesame.

In conclusion, if the market for HYV rice varieties develops in the future, the shift from the cultivation of traditional rice to HYV *Aman* rice may become profitable. However, beyond the *Aman* season, the potential of shifting from a system with traditional rice followed by sesame to a system with HYV short-duration rice followed by sesame is still unknown.

CHAPTER 2 – SHORT-TERM IMPACTS OF THE BLUE GOLD PROGRAM AND WLE-G9 PROJECT INTERVENTIONS ON WATERLOGGING, DRAINAGE AND AGRICULTURAL PRACTICES

1. INTRODUCTION

Improvements in the quality of water management infrastructure, community management of this infrastructure and small-scale innovations are expected to reduce the water issues faced by farmers, reduce their vulnerability to waterlogging and facilitate drainage. These direct effects would enable farmers to change their agricultural practices by increasing cropping intensity or cultivating different crops, for example. Ultimately, the final outcome should be higher income from agriculture and better nutrition.

These pathways would require several growing seasons to be observed and measured. In this chapter, we focus on short-term indicators, such as perceived issues related to water, extent of waterlogging and drainage practices, cropping intensity and crop choice. It is assumed that farmers are able to observe and perceive some changes related to these indicators, after only one year of project implementation, even if the evolution of practices may take longer.

The impacts of two interventions are analyzed: (i) Blue Gold program, and (ii) WLE-G9 project interventions. The Blue Gold program intervention spans the whole of Polder 30, while the WLE-G9 project intervention focuses only on three villages within this polder – Fultola, Basurabad and Bhennabunia. In addition to the individual impacts of these two interventions, we also consider the combined impacts.

Robust quasi-experimental methods are used to establish the impacts of these two interventions on the outcomes of interest.

2. DESCRIPTION OF THE INTERVENTIONS

2.1 Blue Gold Program Intervention in Polder 30

The Blue Gold program started in March 2013 and lasted for 6 years. The program's stated objective was "to reduce poverty for 150,000 households living in 160,000 ha area of selected coastal polders by creating a healthy living environment and a sustainable socio-economic development"[4]. The program was implemented through five different components and Polder 30 was one of the first polders selected for the intervention. The five components implemented in this polder are as follows:

(i) Community mobilization and institutional strengthening: Under this component, 40 water management groups (WMGs) have been created or revitalized and supported with a participatory approach (see Annex 2 for a map of the WMGs in Polder 30). At the polder level, a Water Management Association (WMA) has also been supported.

(ii) Water resources management: Based on an environmental impact assessment, this component consisted of the following activities (see Annex 3 for a map of these interventions):

- Re-sectioning of the embankment where required.
- Repairing all water control structures and culverts, and construction of three new inlets (Deuatola, Dakhin Sholmari and Fultola).
- Temporary protection for the erosion hot spots at Dakkhin Sholmari, Kismat Fultola, Batiaghata Upazila HQ, Hogalbunia Darunmallik and Bigordana.
- Canal re-excavation. A total of eight canals were proposed for re-excavation, covering approximately 46% of the total length of watercourses.

(iii) Food security and agricultural production: This component organized Farmer Field Schools (FFSs) linked to the WMG to educate and assist male and female farmers on increasing productivity in crops, aquaculture and livestock farming.

(iv) Business development and private sector involvement: This component supported the creation of a business development plan for Polder 30 for the production and marketing of selected farm products. It focused on field crops or other agricultural products, for which value chain analyses were carried out and private sector linkages established.

(v) Livelihood improvement and crosscutting issues (governance, gender, climate change, disaster risk reduction and innovation).

2.2 WLE-G9 Project Intervention in Polder 30

Details of the WLE-G9 project intervention – in the three villages of Fultola, Basurabad and Bhennabunia – are provided in the main *Introduction* to this report (see section 2 on page 2).

In addition, the WLE-G9 project implementing team played a role in the WMGs as part of the intervention. This

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[4] http://www.bluegoldbd.org/what-we-do/about-blue-gold/

included the WLE-G9 project team having an advisory role in the operation of the sluice gate under the control of the WMG, which resulted in more timely opening and closing of the gate, especially in the dry season for drainage of excessive early rainfall.

3. METHODS

The main method of analysis used was a Difference-in-Differences (DiD) approach. The DiD method consists of comparing the changes in outcomes over time between the beneficiaries of the project (the treated group) and non-beneficiaries (the non-treated, counterfactual group).

The first difference is akin to the 'before and after' difference, which means that outcomes before the intervention are compared with those after the intervention. However, if only the before and after changes are considered then causality cannot be established, since other factors (climatic shocks, election, new policy or project, etc.) can also influence the outcomes at the same time.

The second difference is then akin to the 'with and without' difference, where the outcomes are compared between a treated and non-treated group. Again, when considered alone, this difference cannot identify any causal impact because of a selection bias. It is indeed very likely that a treated group differs from the non-treated group, which then explains why the intervention took place. Therefore, the two groups cannot be directly compared. However, when considering these two differences together, we are able to control both the other influencing variables (because they influence the two groups) and the selection bias (which remains constant over time).

Following this methodology, we measure three types of impacts:

- The impact of the Blue Gold program intervention. In this case, we measured the impact indicators of a treated group of households located in a polder benefitting from canal revitalization and other Blue Gold interventions (Polder 30), and of a counterfactual group from polders without the Blue Gold intervention (polders 28/1 and 28/2). Here, the villages benefitting from the WLE-G9 project intervention were excluded from the treated group. We, therefore, had a group of 950 households (455 in polder 30 and 495 in polders 28/1 and 28/2). They were surveyed during the periods May-June 2015 and August 2016 before and after the interventions related to canal revitalization, respectively.
- In addition, we also used the same method to assess the impact of the WLE-G9 project intervention alone. In this case, the treated group includes the villages of Fultola, Basurabad and Bhennabunia from Polder 30, with a sample of 75 households. Households from other locations in Polder 30 formed the counterfactual group.
- Finally, we assessed the effect of the combined Blue Gold program and WLE-G9 project interventions by considering the villages of Fultola, Basurabad and Bhennabunia as the treated group, and the other households from Polder 30 and polders 28/1 and 28/2 as the counterfactual group.

The impact evaluation design and the method used for selecting the counterfactual group have been described in detail in the impact evaluation design document and the baseline report (Buisson et al. 2016). Polders 28/1 and 28/2 were selected based on the environmental characteristics and their cropping patterns (collected from secondary and primary data), which were similar to the situation in Polder 30, even if the Blue Gold program was not involved in these polders at the time of analysis.

The results of the three types of impacts stated above are presented in this chapter. However, care should be taken when interpreting the impacts of the WLE-G9 project intervention alone, and the impacts of the combined Blue Gold program and WLE-G9 project interventions. The sample was primarily selected to detect the impacts of the Blue Gold program intervention with a balance of treated and non-treated households (Table 6). The very limited size of the WLE-G9 project intervention prevented the research team from designing a large-scale impact evaluation of this pilot.

The analysis considers variables measured at the household level as well as at the plot level. Households were asked to provide details of the two most significant plots (by size) they cultivate (Annex 1).

4. WATER ISSUES

First, the likelihood of a farmer facing any water-related issue on one of his plots was considered. This indicator relates to the situation faced by farmers in the baseline survey of 2014 and in the follow-up survey in 2015. In the baseline survey, 36% of plots from polders 28/1 and 28/2 had a water-related issue, while 25% of plots from Polder 30 were similarly affected. We also noted that the percentage was higher in villages where the WLE-G9 project intervention took place - almost 41% of the plots were affected by a water-related issue. Overall, the situation improved slightly in the follow-up survey for all groups. Using the difference-in-differences regression, we identified a significant, positive impact of the Blue Gold program intervention on the likelihood of farmers facing a water-related issue, and a significant, negative impact of both the WLE-G9 intervention alone and the combined Blue Gold and WLE-G9 interventions (Table 7). This result is quite remarkable considering that the situation was initially worse in the villages where the WLE-G9 intervention took place. In these villages, the likelihood of farmers facing a water-related issue on one of their plots after the WLE-G9 intervention decreased by 19% when compared to other villages in Polder 30.

TABLE 6. SAMPLE SIZE, AND TREATED AND CONTROL GROUPS FOR THE THREE LEVELS OF ANALYSIS.

	TREATED SAMPLE		CONTROL SAMPLE		TOTAL SAMPLE	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Number of households						
Blue Gold treatment	455	455	495	495	950	950
WLE-G9 treatment	75	75	455	455	530	530
Blue Gold + WLE-G9 treatment	75	75	950	950	1,025	1,025
Number of plots						
Blue Gold treatment	840	816	871	862	1,711	1,678
WLE-G9 treatment	140	139	840	816	980	955
Blue Gold + WLE-G9 treatment	140	139	1,711	1,678	1,851	1,817

Source: Authors' survey.

TABLE 7. DIFFERENCE-IN-DIFFERENCES ANALYSIS OF FARMERS FACING ANY WATER-RELATED ISSUE ON ONE OF THEIR PLOTS.

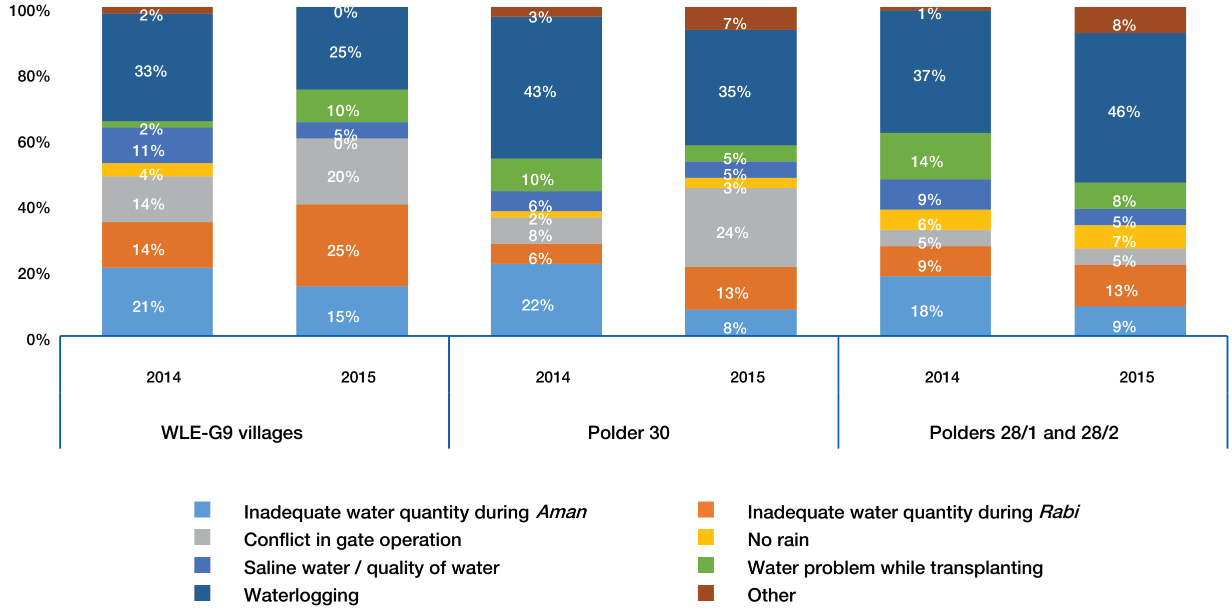
	BASELINE			FOLLOW-UP			DiD	R^2
	Control	Treated	Difference (T-C)	Control	Treated	Difference (T-C)		
Dependent variable: **Water-related issue on the plot**								
Blue Gold treatment	0.363	0.252	-0.11***	0.235	0.199	-0.036*	0.075**	0.02
			(0.021)			(0.021)	(0.03)	
WLE-G9 treatment	0.252	0.407	0.155***	0.199	0.161	-0.038	-0.193***	0.02
			(0.038)			(0.039)	(0.055)	
Blue Gold and WLE-G9 combined	0.309	0.407	0.099**	0.217	0.161	-0.057	-0.155***	0.02
			(0.039)			(0.039)	(0.055)	

Source: Authors' survey.

Note: Figures in parentheses are the standard errors. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

Second, the type of water-related issue was considered. The types of water-related issues mentioned by farmers for the different groups of interventions are presented in Figure 22. Some changes in the distribution of these water-related issues at the plot level can be seen, especially in the case of villages where the WLE-G9 intervention took place and in the case of Polder 30. The general scenario shows a reduction in the share of issues

FIGURE 22. MAIN WATER-RELATED ISSUES AT THE PLOT LEVEL BY TREATMENT AND YEAR.



Source: Authors' survey.

related to waterlogging and inadequate quantity of water during the *Aman* season, an increase in the share of issues related to inadequate quantity of water during the *Rabi* season and an increase in the number of conflicts that arise in gate operation.

A more detailed analysis of the type of water-related issue faced by farmers at the plot level is given in Table 8. Three indicators are considered: the likelihood of a farmer facing a water-related issue (inadequate quantity of water, waterlogging or water issue while transplanting) in the *Aman* and *Rabi* seasons, and the likelihood of farmers facing a conflict in gate operation. These three indicators represent the most important issues at the plot level mentioned by the farmers.

In the *Aman* season, even if the likelihood of a farmer facing a water-related issue decreased between the baseline and follow-up surveys, this cannot be adequately explained by any of the three levels of interventions. Indeed, the same is actually observed in the treated and control locations. The same holds true in the case of the water-related issues faced at the plot level in the *Rabi* season. However, an interesting picture appears in the case of issues related to conflicts in gate operation. The Blue Gold intervention increased the likelihood (by 3%) of a plot facing a water-related issue due to conflict in gate operation. The WLE-G9 intervention, however, decreased the likelihood (by 5.5%) of a plot facing such an issue. In the WLE-G9 and Blue Gold combined intervention, the effect remains significant and negative, and logically lower than in the WLE-G9 intervention alone. This result suggests that it is important to consider (and question) the participatory approach the Blue Gold program used when forming the WMG that led the gate operation. Longer-term analysis will, however, be required to understand whether this resurgence of conflicts due to the intervention was a transitional outcome observed at an intermediary step of the program or whether it persists in the longer term.

TABLE 8. DIFFERENCE-IN-DIFFERENCES ANALYSIS FOR THE MAIN TYPES OF WATER-RELATED ISSUES FACED BY FARMERS ON THE PLOTS.

	BASELINE			**FOLLOW-UP**			**DiD**	**R^2**
	Control	Treated	Difference (T-C)	Control	Treated	Difference (T-C)		
Dependent variable: **Water-related issue in the *Aman* season**								
Blue Gold treatment	0.25	0.19	-0.06***	0.14	0.091	-0.05***	0.01	0.02
			(0.018)			(0.018)	(0.025)	
WLE-G9 treatment	0.19	0.229	0.038	0.091	0.072	-0.019	-0.057	0.02
			(0.032)			(0.032)	(0.045)	
Blue Gold and WLE-G9 combined	0.221	0.229	0.008	0.116	0.072	-0.044	-0.052	0.02
			(0.032)			(0.033)	(0.046)	
Dependent variable: **Water-related issue in the *Rabi* season**								
Blue Gold treatment	0.033	0.014	-0.019**	0.03	0.025	-0.006	0.013	0
			(0.008)			(0.008)	(0.011)	
WLE-G9 treatment	0.014	0.057	0.043***	0.025	0.036	0.011	-0.031	0.01
			(0.014)			(0.014)	(0.019)	
Blue Gold and WLE-G9 combined	0.024	0.057	0.033**	0.027	0.036	0.009	-0.025	0.01
			(0.014)			(0.014)	(0.02)	
Dependent variable: **Water-related issue - conflict in gate operation**								
Blue Gold treatment	0.018	0.019	0.001	0.012	0.045	0.034***	0.033***	0.01
			(0.007)			(0.007)	(0.01)	
WLE-G9 treatment	0.019	0.057	0.038**	0.045	0.029	-0.017	-0.055**	0.01
			(0.016)			(0.017)	(0.023)	
Blue Gold and WLE-G9 combined	0.019	0.057	0.038***	0.028	0.029	0.001	-0.038*	0
			(0.014)			(0.014)	(0.019)	

Source: Authors' survey.
Note: Figures in parentheses are the standard errors. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

5. WATERLOGGING AND DRAINAGE

5.1. Crop Submergence in the *Aman* Season

The results detailed above establish the significance of waterlogging as a challenge for many farmers in the coastal zone of Bangladesh. The Blue Gold and WLE-G9 interventions aimed to reduce this risk.

Relating to this, data on two indicators were collected in the survey and analyzed: (i) the probability of a plot being submerged during the *Aman* season, and (ii) the probability of suffering from an inadequate height of water during this season. While the two indicators deal with the same issue of waterlogging at the plot level, the degree of waterlogging can be different, with submergence representing the more acute scenario.

Considering the entire sample in 2014, on average, 39.4% of plots had a height of water exceeding the requirements and 14.0% were submerged (Table 9). Due to weather conditions prevailing during the monsoon season of 2015, the situation worsened with, on average, 64.4% of plots having an inadequate height of water and 21.9% entirely submerged.

In this context, it is very interesting to note that the plots from Polder 30 performed relatively better than their counterfactual groups from polders 28/1 and 28/2, in spite of an initially worse situation. This means that the Blue Gold intervention has significantly reduced the likelihood of waterlogging at the plot level, and has been able to effectively mitigate the effects of rainfall received in 2015. On average, the Blue Gold intervention reduced the probability of crop submergence by 7.5% and the probability of an inadequate height of water by 13.8%. While both the impacts are significant, it must be noted that the extent of the impact is lower for the indicator describing a more acute situation for the farmers.

5.2. Drainage in the *Aman* Season

The direct consequence of waterlogging in the *Aman* season is that farmers have to drain their plot, both during the growing season and, in some cases, just before the harvest. However, consistent with the impact of the Blue Gold intervention on waterlogging at the plot level, the Blue Gold program has also significantly reduced the requirement for drainage during the *Aman* season (Table 10). Plots benefitting from the Blue Gold intervention had a 17% less chance of requiring drainage. Therefore, even if the effect of the WLE-G9 intervention is not significant per se, the effect of the combined WLE-G9 and Blue Gold intervention remains significant.

More detailed indicators related to drainage in the *Aman* season complement this picture (Table 11). Improvements in the drainage infrastructure and notably the in-field channels built through the WLE-G9 intervention, and improved operation of the sluice gate had a significant impact and decreased the number of days with water above the desired level by almost 3 days (2.7) in the *Aman* season. These 3 days are relatively important, if we

TABLE 9. DIFFERENCE-IN-DIFFERENCES ANALYSIS FOR CROP SUBMERGENCE IN THE *AMAN* SEASON.

	BASELINE			FOLLOW-UP			DiD	R²
	Control	Treated	Difference (T-C)	Control	Treated	Difference (T-C)		
Dependent variable: **Crop submergence**								
Blue Gold treatment	0.128	0.154	0.025	0.248	0.198	-0.05***	-0.075***	0.01
			(0.019)			(0.019)	(0.027)	
WLE-G9 treatment	0.154	0.136	-0.018	0.198	0.176	-0.021	-0.003	0
			(0.034)			(0.035)	(0.049)	
Blue Gold and WLE-G9 combined	0.141	0.136	-0.005	0.223	0.176	-0.046	-0.041	0.01
			(0.034)			(0.034)	(0.048)	
Dependent variable: **Inadequate height of water**								
Blue Gold treatment	0.363	0.413	0.05**	0.689	0.602	-0.087***	-0.138***	0.07
			(0.023)			(0.024)	(0.033)	
WLE-G9 treatment	0.413	0.479	0.065	0.602	0.619	0.017	-0.048	0.03
			(0.045)			(0.045)	(0.064)	
Blue Gold and WLE-G9 combined	0.387	0.479	0.091**	0.647	0.619	-0.028	-0.119**	0.06
			0.043			0.043	0.06	

Source: Authors' survey.
Note: Figures in parentheses are the standard errors. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

TABLE 10. DIFFERENCE-IN-DIFFERENCES ANALYSIS FOR DRAINAGE IN THE *AMAN* SEASON.

	BASELINE			FOLLOW-UP			DiD	R^2
	Control	Treated	Difference (T-C)	Control	Treated	Difference (T-C)		
Dependent variable: **Drainage in the *Aman* season**								
Blue Gold treatment	0.501	0.623	0.122***	0.693	0.645	-0.048**	-0.17***	0.02
			(0.023)			(0.024)	(0.033)	
WLE-G9 treatment	0.623	0.686	0.063	0.645	0.626	-0.019	-0.082	0
			(0.044)			(0.044)	(0.062)	
Blue Gold and WLE-G9 combined	0.56	0.686	0.125***	0.669	0.626	-0.043	-0.169***	0.01
			(0.042)			(0.043)	(0.06)	
Dependent variable: **Drainage required for the harvest**								
Blue Gold treatment	0.16	0.254	0.094***	0.1	0.2	0.1***	0.006	0.02
			(0.018)			(0.019)	(0.026)	
WLE-G9 treatment	0.254	0.143	-0.111***	0.2	0.127	-0.073*	0.038	0.01
			(0.037)			(0.038)	(0.053)	
Blue Gold and WLE-G9 combined	0.206	0.143	-0.064*	0.15	0.127	-0.023	0.041	0.01
			(0.033)			(0.034)	(0.048)	

Source: Authors' survey.
Note: Figures in parentheses are the standard errors. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

consider that the plots experience, on average, 5 days with water above the desired level in the *Aman* season.

An interesting result was observed while considering the number of times farmers drained their plots. While the Blue Gold intervention significantly reduced the number of times drainage was required, the impact of the WLE-G9 intervention is also significant but positive (Table 11). Here, it appears that improvements made to the drainage infrastructure, especially the rehabilitation of canals, by the Blue Gold program have improved the natural flow of water within the polder and this decreased the necessity for farmers to drain their plots. The WLE-G9 intervention follows a different approach, in which farmers were encouraged to drain more through the use of the in-field channels and improved use of the sluice gate. Albeit contradictory, these two results probably translate to an overall improvement in the waterlogging situation through better functioning canals (Polder 30), improved operation of the sluice gates, and farmers better able to control the level of water in their plots (WLE-G9 project intervention sites) through the use of micro-scale channels

5.3. Drainage in the *Rabi* Season

While irrigation is required during the growing stage of the *Rabi* crop, drainage is required at an early stage to avoid late planting of the crop. Indeed, late planting of the *Rabi* crop puts it at risk when the first rainfall starts, which is particularly problematic for sesame, which should not receive any water for 70 days after sowing.

Draining the plots as early as possible is, therefore, key to securing a *Rabi* harvest. Improvements to the canal systems and the sluice gates put in place by the Blue Gold program, and field channels initiated through the WLE-G9 intervention, aimed to improve drainage conditions and thereby reduce the number of days required before *Rabi* tillage, allowing earlier crop planting. According to Table 12, these assumptions are not confirmed by the data collected. On the contrary, the number of days required before *Rabi* tillage (for the plot to be dry enough) significantly increased for the plots under the WLE-G9 intervention, and also in the case of the combined WLE-G9 and Blue Gold intervention. This occurred in the context of a rainy season in 2015, which brought more rainfall than the 2014 rainy season. Under these circumstances, the interventions were not able to significantly decrease the average time required before *Rabi* tillage.

This initial analysis hides some heterogeneity, which appears more clearly in Figures 23 and 24. The two graphs indicate the cumulative percentage of plots which were dry enough to start *Rabi* tillage according to the date. For the Blue Gold intervention, the curves for the control and treated plots in the follow-up survey are slightly higher than the curves in the baseline survey in December and January. This means that a higher number of plots were ready for tillage early in the season in the follow-up survey than in the baseline survey. However, no clear gap appears between the treated and control groups.

The situation is a bit different for the WLE-G9 intervention. The curve for the group of treated plots in the follow-up survey has clearly shifted to the top left when compared to the other groups. This indicates that a higher proportion

TABLE 11. DIFFERENCE-IN-DIFFERENCES ANALYSIS FOR DRAINAGE AND TIME IN THE *AMAN* SEASON.

	BASELINE			**FOLLOW-UP**			**DiD**	**R^2**
	Control	Treated	Difference (T-C)	Control	Treated	Difference (T-C)		
Dependent variable: **Number of days with water above the desired level**								
Blue Gold treatment	5.076	4.796	-0.28	5.326	5.296	-0.03	0.249	0
			0.477			0.49	0.684	
WLE-G9 treatment	4.796	6.377	1.581*	5.296	4.174	-1.122	-2.702**	0.01
			0.911			0.929	1.301	
Blue Gold and WLE-G9 combined	4.94	6.377	1.437*	5.311	4.174	-1.137	-2.573**	0.01
			0.87			0.89	1.244	
Dependent variable: **Number of drainage facilities**								
Blue Gold treatment	3.598	4.325	0.728**	4.851	4.163	-0.688**	-1.416***	0.01
			0.321			0.299	0.438	
WLE-G9 treatment	4.325	2.789	-1.536***	4.163	4.025	-0.138	1.399**	0.01
			0.476			0.501	0.692	
Blue Gold and WLE-G9 combined	3.987	2.789	-1.198**	4.51	4.025	-0.485	0.714	0.01
			0.507			0.535	0.737	
Dependent variable: **Number of days required for drainage**								
Blue Gold treatment	4.554	5.292	0.738**	4.82	5.142	0.322	-0.416	0
			0.333			0.312	0.456	
WLE-G9 treatment	5.292	3.78	-1.512**	5.142	4.317	-0.825	0.687	0.01
			0.569			0.593	0.822	
Blue Gold and WLE-G9 combined	4.951	3.78	-1.171**	4.98	4.317	-0.663	0.508	0
			0.53			0.553	0.766	

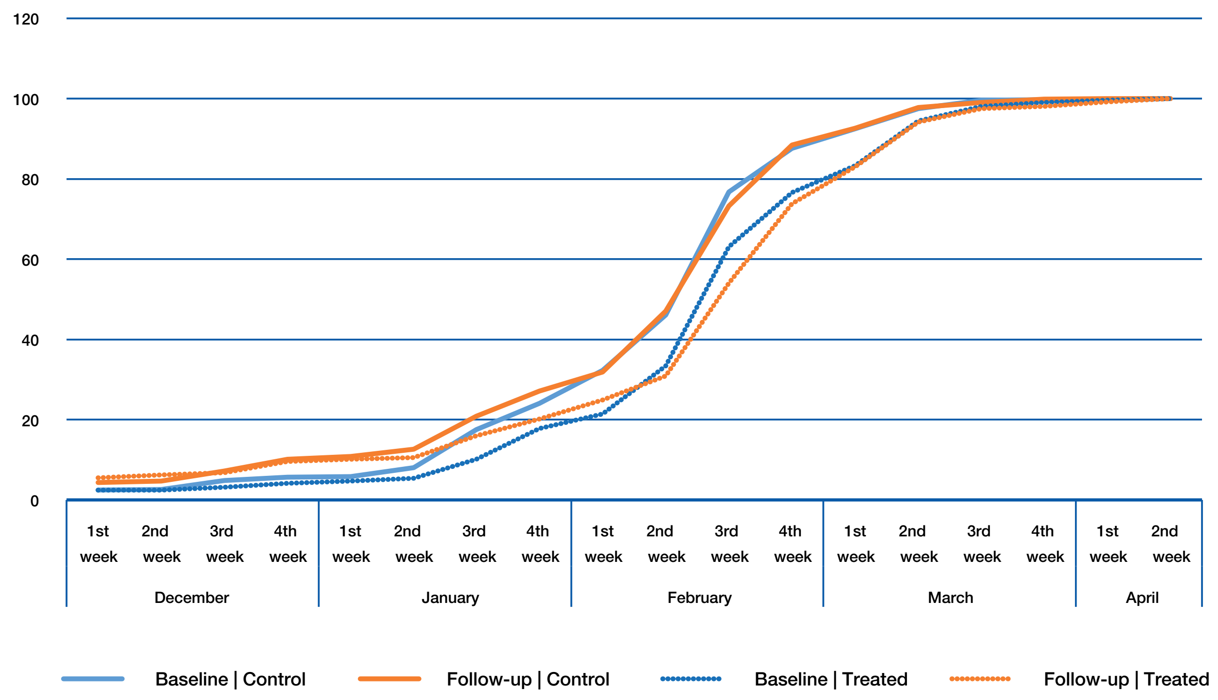
Source: Authors' survey.
Note: Figures in parentheses are the standard errors. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

TABLE 12. DIFFERENCE-IN-DIFFERENCES ANALYSIS FOR DRAINAGE IN THE *RABI* SEASON.

	BASELINE			**FOLLOW-UP**			**DiD**	**R^2**
	Control	Treated	Difference (T-C)	Control	Treated	Difference (T-C)		
Dependent variable: **Number of days required before *Rabi* tillage**								
Blue Gold treatment	38.755	41.429	2.674***	41.206	43.548	2.342**	-0.332	0.01
			(0.94)			(0.995)	(1.368)	
WLE-G9 treatment	41.429	38.239	-3.19*	43.548	44.567	1.019	4.209*	0.01
			(1.716)			(1.842)	(2.517)	
Blue Gold and WLE-G9 combined	40.14	38.239	-1.901	42.379	44.567	2.188	4.089*	0.01
			(1.569)			(1.681)	(2.3)	

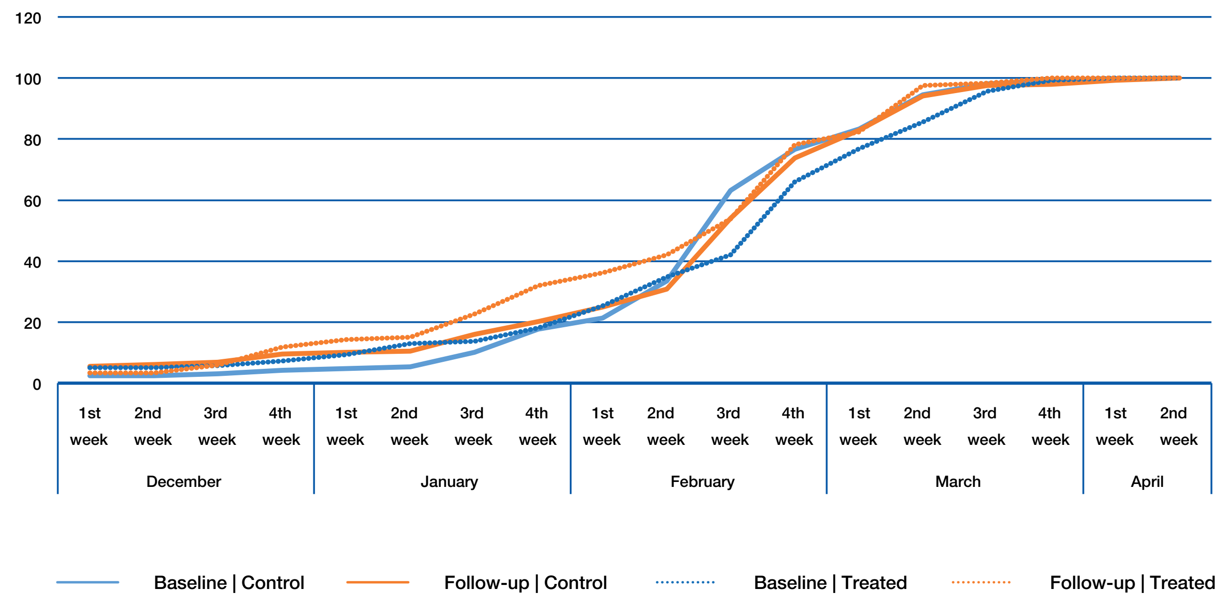
Source: Authors' survey.
Note: Figures in parentheses are the standard errors. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

FIGURE 23. CUMULATIVE PERCENTAGE OF PLOTS THAT WERE DRY ENOUGH FOR *RABI* TILLAGE BY DATE FOR THE BLUE GOLD INTERVENTION.



Source: Authors' survey.

FIGURE 24. CUMULATIVE PERCENTAGE OF PLOTS THAT WERE DRY ENOUGH FOR *RABI* TILLAGE BY DATE FOR THE WLE-G9 INTERVENTION.



Source: Authors' survey.

of the plots benefiting from the WLE-G9 intervention were dry enough to start *Rabi* cultivation between mid-January and mid-February.

6. CROPPING PATTERNS AND TYPE OF CROPS CULTIVATED

The Difference-in-differences (DiD) method was also used for the analysis of cropping patterns. Cropping patterns are a more intermediary outcome, as the decision to grow crops in different seasons and the type of crops to cultivate are likely to be influenced by the observation of short-term outcomes by farmers (Figure 25).

For example, it is likely that a farmer will decide whether to switch from one crop to another only after observing a change in waterlogging or drainage conditions, and after verifying market conditions. For this reason, even if we expect, in the medium term, these interventions to strengthen the likelihood of a plot being cultivated in the *Boro* season, we did not expect to see these changes after only one year. This is broadly confirmed by the results in Table 13. However, an interesting point to highlight is the significant and negative impact of the Blue Gold intervention on the probability of a plot being cultivated in the *Rabi* season. The likelihood of a plot being cultivated in the *Rabi* season actually declined by 9.1% in Polder 30 when compared to Polders 28/1 and 28/2, between the baseline and follow-up surveys. This result may not translate the direct impact of the Blue Gold intervention, as the decision may have been taken before the start of the rehabilitation work. It does show, however, that the prevailing situation in terms of water management and the risks associated led some farmers to stop cultivating in the *Rabi* season.

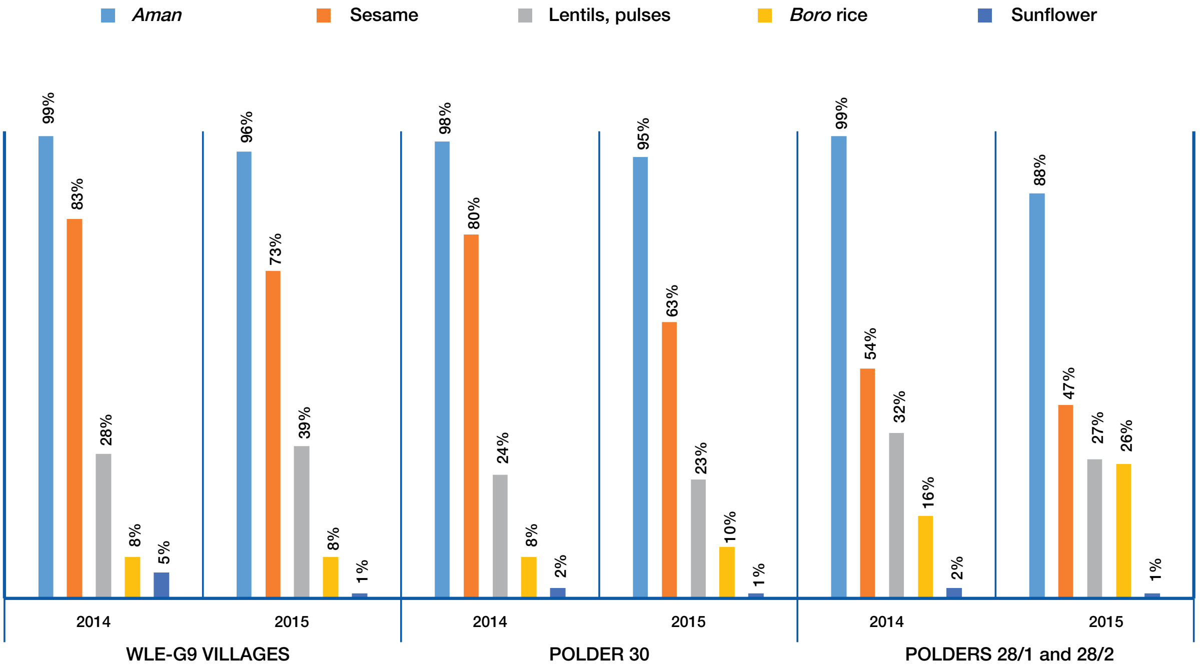
The type of crops cultivated by farmers surveyed in each location and its evolution over time were then noted using descriptive statistics (Figure 25). No drastic changes are observed in the cropping patterns, on average. For the WLE-G9 intervention, this is logical because the intervention started to work on sunflower crops during the 2016 *Rabi* season and the follow-up survey considered the 2015 *Rabi* season. The only clear change is the decline in the number of farmers deciding to grow sesame in all three interventions between 2014 and 2015. It appears that lentils and pulses, in the villages under the WLE-G9 intervention and in Polders 28/1 and 28/2, were grown in the *Boro* season instead.

7. DISCUSSION AND CONCLUSION

This chapter provides an analysis (using quantitative data) of the short-term impacts of the WLE-G9 intervention, the Blue Gold intervention in Polder 30, and the impacts of these two combined interventions on short-term indicators. The indicators considered were selected based on their potential to evolve quickly, i.e., showing changes after only one year of implementation. Data collected from the baseline and follow-up household surveys, in treated and control locations, were used to apply a difference-in-differences (DiD) methodology.

The analysis has established that the WLE-G9 intervention reduced the likelihood of farmers facing a water-related issue. This result is quite remarkable considering that the situation was initially worse in villages where the WLE-G9 intervention took place. When the type of issue was considered, overall, there was a decrease in the proportion of issues related to waterlogging during the *Aman* season, while the proportion of water issues increased in the *Rabi* season.

FIGURE 25. CROPPING CHOICES AT THE FARM LEVEL BY INTERVENTION AND YEAR.



Source: Authors' survey.

TABLE 13. DIFFERENCE-IN-DIFFERENCES ANALYSIS FOR CROPPING PATTERNS.

	BASELINE			FOLLOW-UP			DiD	R^2
	Control	Treated	Difference (T-C)	Control	Treated	Difference (T-C)		
Dependent variable: **Number of seasons the plot is cultivated**								
Blue Gold treatment	1.716	1.789	0.074***	1.629	1.672	0.042*	-0.031	0.02
			(0.023)			(0.023)	(0.032)	
WLE-G9 treatment	1.789	1.886	0.096**	1.672	1.734	0.062	-0.034	0.02
			(0.041)			(0.041)	(0.058)	
Blue Gold and WLE-G9 combined	1.752	1.886	0.134***	1.65	1.734	0.084**	-0.05	0.02
			(0.041)			(0.041)	(0.058)	
Dependent variable: **Plots cultivated in the *Aman* season**								
Blue Gold treatment	0.986	0.994	0.008	0.901	0.969	0.068***	0.061***	0.04
			(0.009)			(0.009)	(0.013)	
WLE-G9 treatment	0.994	1	0.006	0.969	0.957	-0.012	-0.018	0.01
			(0.012)			(0.012)	(0.017)	
Blue Gold and WLE-G9 combined	0.99	1	0.01	0.934	0.957	0.023	0.013	0.02
			(0.016)			(0.016)	(0.023)	
Dependent variable: **Plots cultivated in the *Rabi* season**								
Blue Gold treatment	0.73	0.795	0.065***	0.728	0.702	-0.026	-0.091***	0.01
			(0.021)			(0.021)	(0.03)	
WLE-G9 treatment	0.795	0.886	0.09**	0.702	0.777	0.075*	-0.015	0.02
			(0.039)			(0.039)	(0.055)	
Blue Gold and WLE-G9 combined	0.762	0.886	0.123***	0.715	0.777	0.062	-0.061	0.01
			(0.038)			(0.038)	(0.054)	

Source: Authors' survey.
Note: Figures in parentheses are the standard errors. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

For crop submergence and inadequate height of water in the *Aman* season, the Blue Gold intervention decreased the likelihood of waterlogging at the plot level and this result is statistically significant. This means that the interventions related to infrastructure revitalization have been able to effectively mitigate the impacts of the main rainfall received in 2015. Then, measured in terms of the number of days with water above the desired level in the *Aman* season, it is clear that the WLE-G9 intervention had a significant impact on waterlogging and reduced the indicators by almost 3 days.

Consistent with the impact of the Blue Gold intervention on waterlogging at the plot level, the Blue Gold program also limited the requirement for drainage during the *Aman* season. We also note that a higher proportion of the plots benefiting from the WLE-G9 intervention were dry enough to start cultivation in the *Rabi* season between mid-January and mid-February.

Finally, there were no impacts of the interventions on cropping patterns, but such changes may take more time. However, a trend toward less cultivation in the *Rabi* season, and a shift from the cultivation of sesame to lentils and pulses was noticed in the treated as well as control locations.

In summary, although measured during a relatively limited time window, these results are encouraging. It is clear that the water management interventions undertaken by the WLE-G9 project, especially the establishment of field channels and improvements in the operation of the sluice gate, have been able to decrease the likelihood of farmers facing water-related issues, decrease the pressure of waterlogging and ensure that the plots are dry earlier in the season to establish the *Rabi* crop.

Similarly, at the polder level, water management interventions undertaken by the Blue Gold program, mostly in the form of repair of existing, and construction of new, sluice gates and canal excavation, had positive effects in limiting the waterlogging faced by farmers, and in facilitating drainage.

A limitation of this analysis is the small scale of the WLE-G9 intervention. As the WLE-G9 project was implemented only in a few locations, the sampling strategy had to be adapted, resulting in an unbalanced sample between the treated and control groups. The consequence is that estimations produced may underrepresent the exact situation, and some of the impacts may not have been detected.

In addition, with implementation at a pilot scale for the WLE-G9 project, the heterogeneity in the impacts cannot be analyzed. It is likely that implementation at a larger scale, in more diverse locations, could impact different farmers in a variety of different ways (based on landownership status, socioeconomic background, environmental specificities, etc.). This is certainly an area for future research.

CHAPTER 3 - CHANGE IN PERCEPTIONS, KNOWLEDGE AND PRACTICES DRIVEN BY THE WLE-G9 PROJECT INTERVENTIONS

1. INTRODUCTION

The anticipated development outcomes of the WLE-G9 project intervention were the promotion and improvement of the management of irrigation water and cropping systems in the polders, further facilitating livelihood opportunities to generate household income. To assess the impacts, and to observe results of the interventions, field visits were conducted, and qualitative and quantitative data were collected through baseline and follow-up surveys. Chapters 1 and 2 detailed the use of quantitative data collected to examine results and impacts on short and intermediary outcomes. This chapter provides a qualitative, longer-term perspective of the impacts.

The research project was designed for a two-year period, so there was limited time to consider the impacts. This chapter provides an overview of the changes driven and induced through the project intervention, by examining the change in perceptions and knowledge pertaining to different agricultural and water management practices. We examine the perceived benefits and opportunities of the interventions, and the constraints and challenges faced in participating in these interventions.

Opinions of the beneficiaries and non-beneficiaries, both in the treated and non-treated villages, are also examined. This provides a greater understanding of the potential impacts and sustainability of the intervention, across and within the communities.

The results contribute to the evidence base needed by donors and policy makers to determine the feasibility of replicating such interventions.

2. METHODOLOGY AND RESEARCH DESIGN

The findings presented here are primarily based on qualitative data collected through Focus Group Discussions (FGDs). It is also supported by quantitative data on household perceptions, through a comparative analysis of household data collected via surveys in 2015 and 2016.

2.1. Qualitative Research: Focus Group Discussions

The objective of data collected through FGDs was to understand how communities perceived the past and newly introduced water management and cropping systems. The FGDs were conducted in June 2016.

2.1.1. Sample Design and Composition of the Groups

In all, eight FGDs were conducted with 8 to 11 participants in each group (Table 14). In the treated villages, FGDs were conducted with two farmer groups – (i) farmers who were participants (direct beneficiaries) in the project, and (ii) non-beneficiaries. Farmers in the beneficiary group were randomly selected from the list of project participants; farmers in the non-beneficiary group were selected using a snowball sampling method (information was collected on people who cultivated land and were aware of the WLE-G9 project intervention, but did not participate in it). Participants in the non-treated villages were also non-beneficiaries of the project; they were selected at random. Sixty-eight farmers participated in the FGDs across these villages; 54.4% of the participants were female. In the beneficiary

TABLE 14. SAMPLE DESIGN AND COMPOSITION.

UNITS	NAME OF THE VILLAGE	TREATMENT STATUS	NUMBER OF PARTICIPANTS	
			MALE	FEMALE
Unit 1	Fultola	Beneficiary	6	2
Unit 2	Fultola	Non-beneficiary	1	6
Unit 3	Basurabad	Beneficiary	7	1
Unit 4	Basurabad	Non-beneficiary	2	9
Unit 4	Bhennabunia	Beneficiary	3	3
Unit 5	Bhennabunia	Non-beneficiary	4	5
Non-treated	Hetalbunia	Neighboring village	4	6
Non-treated	Kismat Fultola	Neighboring village	4	5

Source: Authors' survey.

groups, the majority of participants were male (72.7%); in the non-beneficiary groups in the treated villages, 74% of participants were female, while participation among males and females in the non-treated villages was balanced. The age of participants ranged from 30 to 45 years.

2.1.2. Topics Included in the FGDs

The following topics were covered in the FGDs:

- Agricultural patterns: To understand the prevalent agricultural patterns in the selected sites, whether any changes in these patterns were induced by the WLE-G9 intervention, and whether farmers perceived any improvement in productivity due to better management of irrigation water.
- Perceptions related to the WLE-G9 intervention and water management: To understand how communities perceived the benefits and opportunities resulting from the intervention, the constraints they faced in participating in this intervention, and whether they thought the intervention would continue to be adopted.
- Water challenges: To understand persistent irrigation water challenges, and the perceived impact the WLE-G9 intervention may have had in improving water management in the communities.
- Water governance, operation and maintenance of water infrastructure, Water Management Organizations (WMOs)[5]: To understand the state of water infrastructure (gates, canals and embankments), water management and governance in the villages, and the key challenges faced by communities in ensuring maintenance of the infrastructure. Perceptions about rehabilitation activities implemented in these sites were also elicited.

Guidelines were used for conducting the FGDs (Annex 1).

2.2. Quantitative Household Survey on Perceptions

In addition to the qualitative data, the analysis relies on the perceptions elicited in the baseline and follow-up surveys conducted across 1,025 households.

Respondents were asked about their perceptions on opportunities for, and ease or difficulty of, cultivating new crops; using HYV rice and *Rabi* crops; building field channels to drain plots faster; and changing the timing of cultivating *Rabi* crops (sesame). A Likert scale was used with a rating from 1 to 10 (Figure 26).

3. WLE-G9 AGRICULTURAL DEVELOPMENT THROUGH CHANGING AGRICULTURAL PRACTICES ALONG WITH IMPROVED WATER MANAGEMENT

The major agricultural development challenges in Polder 30 are waterlogging, lack of access to irrigation water during the dry season, increased salinity and inefficient water governance. More than one-third of the plots surveyed suffered from excess water; and due to the lack of proper drainage, farmers were not able to drain the plots during the cultivation of *Aman* rice. This resulted in excess soil moisture leading to delays in planting the *Rabi* crops. The majority of farmers in Polder 30 are dependent on the cultivation of *Aman* rice, and on the cultivation of crops such as a flood-tolerant rice variety developed by the International Rice Research Institute (IRRI), known locally as 'IRRI rice', sesame, lentils and vegetables in the *Rabi* season.

The following section discusses the impacts related to agricultural and water management practices induced by the WLE-G9 intervention: improving the drainage system through field channels, introducing short-duration, HYV *Aman* rice, and diversifying the *Rabi* crops with sunflower, maize and mung beans.

3.1 Introducing Short-duration, HYV *Aman* Rice and its Impact

The *Aman* season usually commences in July (late *Ashar*) or August (early *Sraban*) and the harvest takes place at the end of December or in early January (*Poush*). However, this calendar can vary from one village to another. For example, in Basurabad, they are able to plant at the end of June (early *Ashar*) and harvest in mid-December (*End-Agrahayon*). In this context, the introduction of short-duration, HYV seeds for paddy during the *Aman* season in Unit 1 (Fultola village) and Unit 3 (Basurabad) was seen as a positive intervention by the farmers in these sites. Farmers had a lot of expectations for improving rice productivity with this intervention, as the HYV crops are thought to be of good quality compared to the traditional variety. Farmers also noted that HYV seeds were flood and salinity resistant, and required shorter cultivation periods, which helped them to harvest early; this further enabled farmers to plant *Rabi* crops at the right time and thereby reduce the probability of damage caused by an early monsoon.

FIGURE 26. SCALE OF RATING (1-10) ON PERCEPTIONS.

0 = Very strongly disagree	1 = Strongly disagree	2 = Disagree	3 = Mostly disagree	4 = Somewhat disagree	5 = Neither agree or disagree	6 = Somewhat agree	7 = Mostly agree	8 = Agree	9 = Strongly agree	10 = Very strongly agree

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[5] WMGs and WMAs are different tiers of Water Management Organizations.

However, farmers pointed out some of the constraints and challenges they faced over the use of HYV seeds, primarily the HYV *Aman* rice. According to farmers, cultivating HYV crops required a large investment in comparison to the traditional variety. The main concern was that it was labor intensive and thus required hiring a larger number of laborers. This is echoed in results from the quantitative data detailed in Chapter 1. Nearly 33.4% of households rated 'agree' to the statement that cultivating HYV paddy crops is labor intensive and 18% rated 'strongly agree' (Figure 27).

In addition, a common problem noted in the villages where HYV *Aman* rice was introduced was the challenge faced in selling HYV in markets. Farmers were not able to earn sufficient profit due to the lack of access to markets for HYV. As seen in the quantitative data, most of the farmers wanted to sell the majority of produce from HYV paddy cultivation (Figure 27). In the FGDs across both the beneficiary groups in Fultola and Basurabad, farmers hoped that the selling price for HYV would be higher than that of the traditional variety, but they did not get the price they expected and had to sell HYV rice at a price lower than that of the traditional variety. A few farmers stated that this might be because there are very few farmers cultivating HYV rice, and its supply in the local market is limited compared to the traditional variety. Nonetheless, they hoped that, with an increasing number of farmers producing HYV rice, demand would grow, leading to the establishment of an improved market for HYV rice and thereby enabling farmers to sell HYV at a better price.

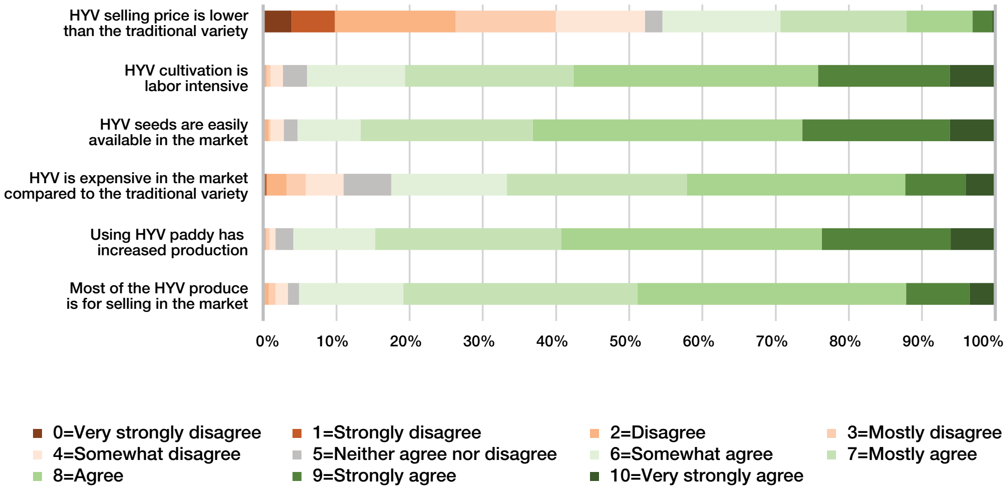
As well as concerns about the selling price of the harvest, concerns were also raised during discussions about the price of HYV seeds compared to traditional variety seeds.

During the FGDs, farmers in the beneficiary villages identified that a major shortcoming of the intervention was the lack of knowledge of, and access to, technical inputs for cultivating HYV rice. Farmers in the study area perceived that lowland was not suitable for HYV rice, since the crops are of low height and easily submersible. Farmers also noted the poor productivity of rice cultivated in lowland areas when compared to those who cultivated the HYV BR-52 and BR-51 paddy in the highlands. Indeed, as detailed in the quantitative survey, the highland area is limited (just 4%) in Polder 30 when compared to lowland (10%) and medium land (86%). The beneficiary farmers felt that this could be a threat to the sustainability of cultivating HYV crops in this location, as the majority of the land there is either medium land or lowland. This issue was also raised in discussions among non-beneficiaries from the intervention sites. Some of the farmers stated that they prefer not to cultivate HYV rice or any other HYV crops in the *Aman* season, because most of their lands are at a low elevation and this is not appropriate for the cultivation of such crops due to the low height of the HYV crops. This point likely requires further analysis by agronomists, but reveals a constraint perceived by farmers, which could prevent expansion of the cultivation of HYV *Aman* rice in this location.

The low height of the HYV rice plants also affected the traditional variety of rice cultivated in the neighboring plots as noted by a few farmers in Basurabad. HYV *Aman* rice yield is good, if the water level is below 1 meter (Haque and Jahan 2013) due to the low height of the crops. As a consequence, farmers cultivating HYV varieties drained out the excess water to keep the water level at a minimum in their fields. This led to conflicts with farmers in neighboring plots who were growing the traditional rice variety which requires more water.

Similarly, some farmers in the treated villages further noted that the short duration and early harvest of HYV rice had been a disadvantage for them. On the contrary, the intention was that this should have been an advantage for

FIGURE 27. PERCEPTIONS ON THE CULTIVATION OF HYV PADDY (FOLLOW-UP HOUSEHOLD SURVEY).



Source: Authors' survey.

them, leaving them sufficient time to drain and dry their plots to cultivate *Rabi* crops earlier. A concern raised by the farmers was that, when HYV rice was ready for harvesting, the fields were still inundated and this made it difficult to harvest the rice.

These two points suggest that there is a need for increased coordination among farmers with different cropping choices. Improved cooperation is clearly essential to ensuring the sustainability of such technical interventions.

3.2. Diversifying High-yielding and High-value *Rabi* Crops

Water management issues have been a major challenge in the cultivation of *Rabi* crops in the polders. This is in addition to the unfavorable weather conditions and heavy rainfall that can damage the *Rabi* crop harvest. Due to these factors, a sizeable portion of cultivable land remained fallow. Farmers growing crops such as sesame during this season faced regular losses of their entire harvest due to the damage caused by rainfall. Sesame is usually grown from January to June, and it is the most common and preferred *Rabi* crop in the area, mainly because of its low maintenance requirements, modest cultivation costs and ease of sale.

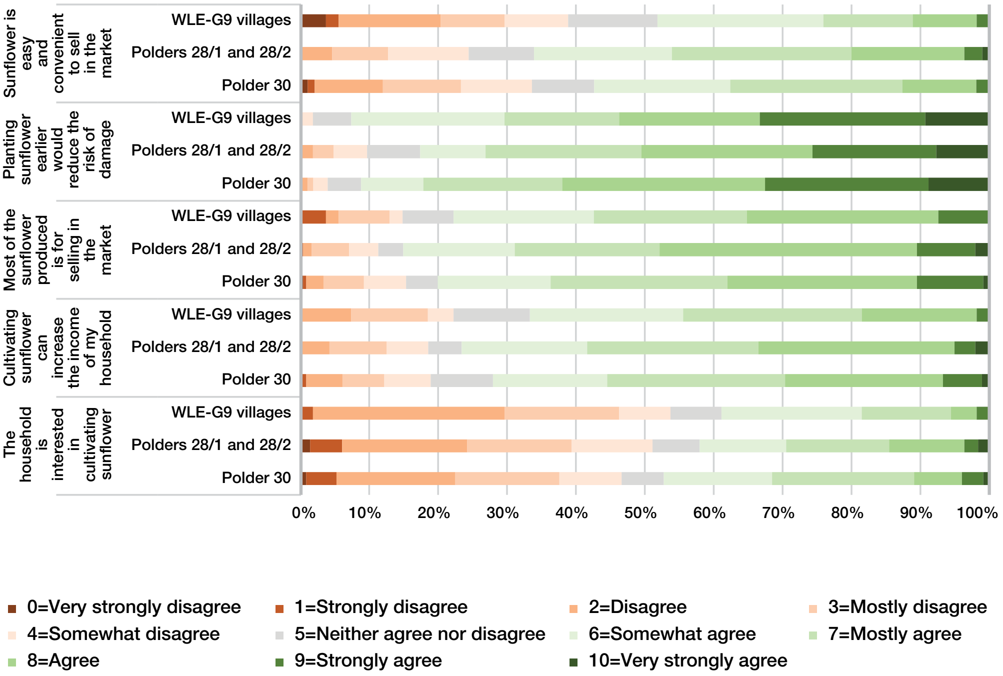
Some interventions under the WLE-G9 project (such as the creation of hydrologically defined water management units through separation of land of different elevations, introducing short-duration HYV *Aman* rice, improving drainage through field channels, etc.) were aimed at facilitating the early planting and harvesting of *Rabi* crops. Beneficiaries in intervention units 1 and 3 were also encouraged to diversify by introducing high-value *Rabi* crops such as sunflower, maize, mung bean and sesame in the dry season.

Baseline survey results show that a large number of farmers agreed that planting the crops early could prevent the risk of crop damage from early monsoon rains and cyclones. Sunflower was the most preferred crop in the *Rabi* season. Farmers' main objective was to sell the produce for cash. In comparison, other *Rabi* crops such as maize and wheat would mostly be used for household consumption. The follow-up survey confirms a growing interest in sunflower cultivation. In the intervention sites, 90% of farmers in treated villages cultivated sunflower and 10% grew maize in the 2015 dry season.

Quantitative data on farmers' perceptions on planting and selling sunflower in the WLE-G9 project beneficiary villages show that the majority of farmers believed that planting sunflower early would reduce the risk of crop damage from early rainfall (Figure 28). It was also highlighted that they would prefer to sell the produce in the market, if they cultivate sunflower. Over 27% of households in WLE-G9 project intervention villages, 28.% of those in other villages in Polder 30, and 37% in the villages surveyed in polders 28/1 and 28/2 gave a rating of 'agree' (Figure 28).

However, 54% of households in the WLE-G9 intervention villages were not willing to cultivate sunflower (from 'very strongly disagree' to 'somewhat disagree'), which is higher than the same rating given by farmers in Polder 30 (47%) and in polders 28/1 and 28/2 (51%) (Figure 28). As the survey was conducted post-*Rabi* crop harvest, it is apparent that some farmers from the treatment locations

FIGURE 28. PERCEPTIONS ON THE CULTIVATION OF SUNFLOWER AND SALE OF PRODUCE (FOLLOW-UP HOUSEHOLD SURVEY).



Source: Authors' survey.
Note: From a sample of 1,025 households.

may have faced difficulties with sunflower cultivation and could be disappointed by the profits generated.

The constraints in the cultivation of sunflower noted by farmers in both the baseline and follow-up surveys include: the limited market demand for the produce, lack of access to machinery to process the seeds into oil, high costs of inputs and labor, and the difficulty in selling the produce profitably. For example, in the WLE-G9 project intervention villages, 24% of households seemed to be unsure and provided a rating of ‘somewhat agree’ to the ease and convenience of marketing. In total, in the follow-up survey, 39% of households from these villages disagree (from ‘strongly disagree’ to ‘somewhat disagree’) with the easiness and convenience of selling their sunflower harvest (Figure 28). Interestingly, this perception is again different in the non-treated locations: in Polder 30, 34% of households, and only 24% in polders 28/1 and 28/2, share the same feeling. The difference noted between the intervention sites and the control villages translates to a lack of knowledge in the control site. Farmers in the intervention sites have practical experience of cultivating sunflower and have experienced the difficulties in selling their harvest, while farmers in the control villages don’t have this experience and base their perceptions on expectations. Similarly, when a comparison is made between the baseline and follow-up surveys in the WLE-G9 treated villages, disagreement on the ease and convenience of selling the harvest slightly increased, which suggests that answers given in 2016 were more informed and based on firsthand experience rather than just on belief.

During the FGDs, farmers in the intervention sites also discussed their lack of knowledge on cultivating sunflower. This may explain why they preferred cultivating the traditional *Rabi* crops such as sesame and mung beans, or why some of them did not take the risk of cultivating sunflower in 2016. The group of non-beneficiary farmers from Basurabad also stressed this issue, stating that without the knowledge of appropriate techniques there is more risk involved in cultivating *Rabi* crops such as sunflower, maize and wheat than sesame. Since this point was raised by both groups of beneficiaries and non-beneficiaries, it highlights the need for further information dissemination and training for farmers. This could take the form of farmer field schools to address initial fears and help farmers to innovate in their agricultural practices.

The non-beneficiary group in Bhennabunia also highlighted that they did not like to experiment with new crops during the *Rabi* season and preferred to continue to cultivate *okra* (ladies’ fingers), which requires less investment and the produce can be easily sold in the market. Another point raised by the same group was that the cultivation of *Rabi* crops is not relevant to farmers involved in rice-fish cultivation, since their land remains fallow during this season. Indeed, in the plots under rice-fish cultivation, draining out the water from the field takes time and the soil remains wet for a long period of time. This makes it difficult to plant any *Rabi* crops. This concern was also highlighted by the beneficiary group in the same village, and only a limited number of farmers cultivated sunflower and mung beans in this location.

3.3. Improving Drainage through Field Channels

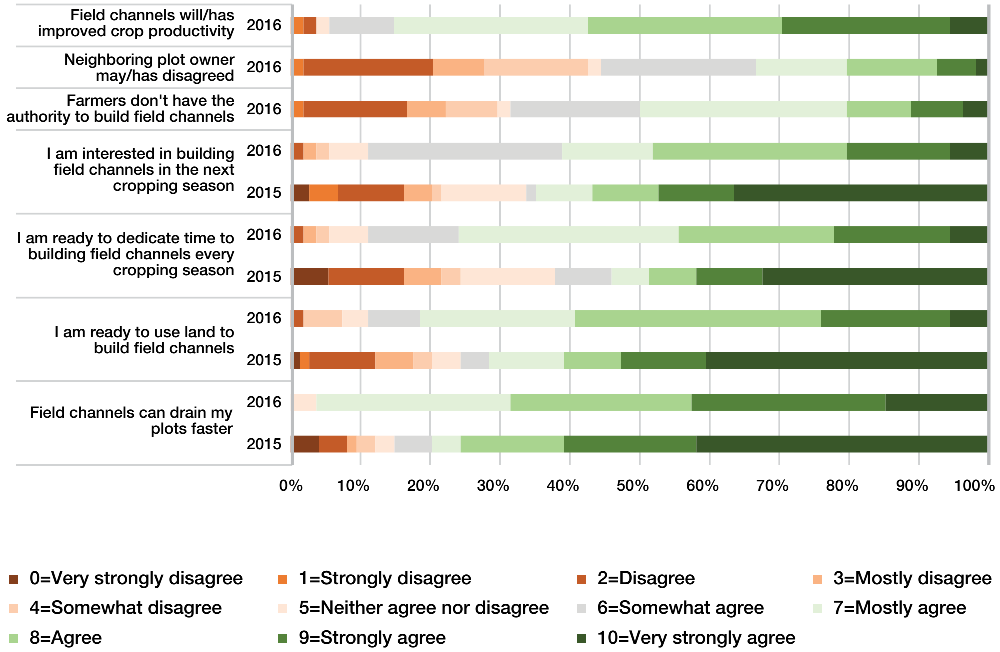
Improving drainage is crucial for crop intensification and increasing agricultural productivity in the coastal regions of Bangladesh. To improve the drainage system and drain out water faster from the farm plots to the *khals* (canals), rather than relying only on the slow seeping of water through soil, farmers were encouraged to build field channels in the WLE-G9 intervention. The aim was to improve on-farm water management prior to the *Aman* season of 2015, enabling early plantation of *Rabi* crops after water had drained faster from the farm plots through the field channels.

Farmers across intervention sites – units 1 and 2 – indicated that the building of field channels had been the most promising water management intervention, since it not only helped them to flush out water faster before planting but also provided easy flow of water through these channels for irrigating the *Rabi* crops. This further encouraged farmers to grow a wider variety of *Rabi* crops, which is likely to contribute to improved household incomes and food security in the future.

The 2015 baseline survey data showed that the majority of farmers believed that field channels could improve the drainage system, and that they would be willing to use land from their plots to build these field channels. In villages involved in WLE-G9 interventions, 85% agreed (from ‘strongly agree’ to ‘somewhat agree’) that field channels can drain their plots faster (Figure 29). A similar perception is also noted in the post-intervention period, where the percentage of farmers agreeing with this statement increased. The same trends are observed for statements on the allocation of land to field channels, the will to dedicate time to build these channels, and on the will to build these channels for the next cropping season. Comparing responses to these four statements between 2015 and 2016, an increase in positive responses following the first experience is noted, with the percentage of households disagreeing being close to zero. Yet, it is also interesting to note that, in spite of overall agreement on the practice, households provide more diverse responses in the agreement spectrum in 2016. For example, the percentage of ‘very strongly agree’ responses decreased. This indicates that farmers’ responses also become more nuanced after firsthand experience.

Despite the benefits of building field channels, and very positive perceptions about it, farmers across the intervention sites faced challenges in implementation. In Basurabad (Unit 3), farmers raised their concerns about elite capture of the water infrastructure and land, which constrained building of field channels. According to participants in the FGDs, control over these resources, and over the WMO in the village by certain people with social and economic power, affected tenant and

FIGURE 29. PERCEPTIONS ON FIELD CHANNELS (BASELINE AND FOLLOW-UP SURVEYS).



Source: Authors' survey.
Note: From a sample of 54 households.

marginal farmers and their ability to benefit from this water management innovation. Almost 70% of surveyed households in the WLE-G9 intervention site believe that the authority to build field channels is not in the hands of the cultivating farmers. Indeed, in certain cases, farmers who cultivate land on lease or as sharecroppers are not able to cut field channels as authorization to do this was denied by the landowners. For example, as highlighted in the beneficiary group in Fultola, where most of the farmers were cultivating leased land, their landowners did not agree to cutting their plots to build field channels. A few participants also noted that, even if the landowner agreed, they could not build the channels because they could not afford the time and money required to do it. Other participants argued that building field channels is much easier and cheaper than excavating canals, and has hence been an effective option for them to drain water out.

The major hindrance farmers face with this practice appears to be the conflicts with other farmers in neighboring plots over the building of field channels. This point is confirmed both by responses to the quantitative survey on perceptions and by the FGDs. Although the benefits of building the field channels could in theory serve the farmers in the neighboring plots as well, a lack of motivation and an unwillingness among farmers to discuss and coordinate the construction blocked mutual benefits and created conflicts in some cases. The group in Bhennabunia proposed resolving this by only implementing field channel construction through community efforts and not through individual initiatives.

4. WATER MANAGEMENT AND WATER GOVERNANCE CHALLENGES

4.1 Long-lasting Inconsistencies between Lowland and Highland Water Management

In spite of the potential of the improvements detailed in this report, challenges over the release of water from the highlands, which causes floods in the lowland areas, still exist. Beneficiaries in Fultola expressed their concern about the damage to their harvests from sluice gate mismanagement and control over the water flow by highland farmers. Even though interventions by the WLE-G9 and Blue Gold projects (such as building field channels) and efforts by farmers, such as harvesting and storing rainwater in ponds, have been beneficial and have resolved many issues, it has not completely solved the challenges of waterlogging and flooding. Solving these issues effectively may also require better management and monitoring of sluice gates, and an effective WMO. Some farmers participating in the FGDs even recommended that villages could be divided based on land elevation to form sub-polders, which would enable more aligned and effective management of highland and lowland areas, and their respective water needs and demands.

The beneficiary group in Basurabad also complained about the irrigation water challenges they face due to mismanagement, and dysfunction, of sluice gates. They indicated that they could not irrigate crops cultivated during the *Rabi* season, because the canals were silted, and furthermore they faced severe problems in draining out water during the *Aman* rice cultivation season. Also, in Bhennabunia, beneficiaries mentioned similar concerns relating to canals being silted and filled with duckweed. The problem in this village appears to be severe because the area is located between the highland and lowland areas. Consequently, it is impacted from both sides when the water is drained out or flow is stopped by the highland areas, and also when lowland farmers drain water through another gate to avoid excess water. A participant suggested building a culvert in the canal, which could be used to control water flow and be operated according to their needs. Farmers from this village have already taken the initiative to build a culvert and have requested support from the WMO and chairman of the local government.

4.2 Water Governance: Weaknesses in Operation and Maintenance of Water Infrastructure and in Participation in WMOs

With the formation of Water Management Groups (WMGs), initiated by the Blue Gold program in the WLE-G9 villages, farmers have benefited from diverse interventions related to agriculture and water management. For example, training was provided on cattle farming, sesame and sunflower cultivation, and on modern agricultural methods. Machinery such as power tillers and power pumps were also provided to the WMGs for use by villagers.

The role of WMGs has been crucial to the WLE-G9 project intervention, and this underlined the need to better understand the current functioning, management and perceptions of the beneficiaries about WMGs. Through this research, it became clear that an effective and well-functioning WMG in these sites is essential to the longer-term sustainability of the WLE-G9 interventions, for example, in extending coordination and mobilizing farmers to work as a community to manage and resolve their irrigation water issues, in monitoring water flows flushing in and out, and in planning their cultivation practices.

Concerns over mismanagement in the operation of sluice gates, lack of maintenance and monitoring, and old and damaged sluice gates were echoed by farmers across all the groups involved in the FGDs. In Fultola, beneficiaries mentioned that rehabilitation work done so far by the Blue Gold program has not helped to resolve the siltation problem and the newly constructed sluice gates were inactive. Farmers felt that the WMGs have not yet been successful in effectively addressing these issues and needs, and this has mainly been due to the lack of monitoring. The non-beneficiary group in this village also mentioned the lack of monitoring of sluice gate operation by government authorities and WMGs, which has caused a lot of problems for farmers in accessing irrigation water on time. Some participants in the group stated that, since the officials do not monitor siltation and water flow regularly, the timing of the opening of the gate is often mismanaged. Also, in many instances, when the gate is opened, water cannot flow through the narrow passage because the canals are silted up. With the time required to clear the silt, most crops were damaged by the time it was possible to irrigate.

According to beneficiaries in Basurabad, the problem also stems from the approach of the Water Development Board in building the sluice gates. Villagers were not involved in any consultation meetings of the development or rehabilitation projects. Participation was limited to WMO members. This limits the possibility of such projects being able to effectively address the main concerns of users. Some participants of the FGDs noted that, despite being a member of the WMG, they never get the opportunity to actively participate in such meetings and when they do their opinions are ignored. They complained that discussions and decisions about operation of the sluice gates are often dominated by influential people from the village. The issue of decision making over the operation of sluice gates being dominated by farmers near the gate was also raised by the non-beneficiary group in Basurabad and the beneficiary group in Bhennabunia. Some participants in this latter group suggested that, in order to improve management of the sluice gates and for equitable decision making, the position of president of the WMG should be changed on a rotation basis with effective monitoring of the gate operation. They also suggested that a person should be given the responsibility for each sluice gate, which would include the responsibility for carrying out consultations with all the users of that location.

5. CONCLUSION

These results clearly demonstrate the positive perceptions of beneficiaries and non-beneficiaries on the impacts of the project intervention in relation to drainage improvement through the construction of field channels in the study area. Although some farmers faced challenges in implementation, and the fact that it may not entirely solve waterlogging issues in the polders, there is a significant possibility that it may be adopted and up-scaled because of its low cost and the benefits provided. Field channels appear to be most effectively implemented through community efforts, since many of the direct beneficiaries faced opposition to cutting channels in farming plots from non-beneficiaries (such as their landowners and neighboring plot owners). This will require mobilizing farmers through a participatory process, with support from the WMOs to disseminate information on the benefits of building field channels.

Among the other innovations suggested by the WLE-G9 intervention, the promotion of the cultivation of HYV rice in the *Aman* season and cultivation of sunflower in the *Rabi* season achieved limited results as perceived by the households, according to both the quantitative and qualitative data. It is clear that levels of information available to farmers increased in the WLE-G9 intervention sites, but improvements in knowledge have, in some instances, resulted in more negative perceptions than before and when compared to other locations. This is not due to the technologies introduced themselves, but is more to do with the integration of the technologies in the local context. This local context includes, for example, the practices of other farmers and there is a clear need for better coordination at the local level in relation to cropping practices and the local market, which is as yet not well adapted to the introduction of alternative crops (HYV rice or sunflower).

CONCLUSION

The aim of this report was to assess the WLE-G9 project intervention, which was implemented at a pilot scale in the coastal region of Bangladesh, by measuring the short-term impacts, identifying potential for long-term impacts and discussing the challenges.

The WLE-G9 project was implemented in three villages from Polder 30 – Fultola, Basurabad and Bhennabunia – in 2015 and 2016, and focused on a combination of agricultural extension services, such as the introduction of HYV *Aman* rice and the cultivation of alternative *Rabi* crops (mostly sunflower), improved water management through the construction of field channels, and improved operation of sluice gates. At the same time, the selected locations benefitted from the Blue Gold program, which revitalized some water infrastructure, de-silted some of the canals and reestablished WMOs.

The first chapter of this report dealt with the potential impacts of improved cropping patterns introduced by the WLE-G9 project on input use, yields and profitability. Using a small survey on crop economics conducted with beneficiary farmers, the changes introduced by the WLE-G9 intervention were measured. This analysis compared the situation of the *Aman* 2015 season before the intervention with the situation of the *Aman* 2016 season, on the one hand, and between the *Rabi* 2015 and 2016 seasons, on the other, in treated locations.

Through this analysis, it has been established that, even if the introduction of HYV *Aman* rice produced high yields when compared to the traditional rice varieties usually cultivated by farmers, the high associated labor and input costs, and the relatively low selling price, resulted in lower overall profitability for farmers in the *Aman* season. Nonetheless, some farmers expressed their interest in continuing the cultivation of HYV *Aman* rice on smaller plots with the expectation that a higher supply may lead to the progressive establishment of a market for HYV rice with ultimately better prices. This assumption has been confirmed, as it has been noted that the price of HYV rice has increased since the survey detailed in this report was conducted.

In the case of the *Rabi* season, with the cultivation of mostly sesame in the baseline survey and sunflower in the follow-up survey, farmers were not able to make a profit when all the associated costs were taken into consideration. This clearly questions the viability of cultivation in the *Rabi* season in its current format, and underlines the need for managing water better, and starting the sowing earlier to avoid weather and water stresses. However, the research team noted that sunflower crops performed better than sesame in this regard, which is encouraging, especially if market conditions evolve positively in the future.

In the second chapter of this report, the baseline and follow-up household surveys conducted in 2015 and 2016 were used in a quantitative evaluation of the impacts of the WLE-G9 and Blue Gold project interventions. Short-term indicators related to waterlogging, drainage and agricultural choices were considered. This mostly indicates the impact of the water management component of the project (field channels and improved operation of the sluice gate in the case of the WLE-G9 project).

The analysis has established that the WLE-G9 intervention reduced the likelihood of farmers facing a water-related issue. This result is quite remarkable considering that the situation was initially worse in villages where the WLE-G9 intervention took place. Overall, the proportion of issues related to waterlogging during the *Aman* season decreased. Measured in terms of the number of days with water above the desired level in the *Aman* season, the WLE-G9 intervention had a significant impact on waterlogging and reduced the indicators by almost 3 days. It was noted that a higher proportion of the plots benefiting from the WLE-G9 intervention were dry enough to start cultivation in the *Rabi* season, between mid-January and mid-February. Finally, the interventions had no effect on cropping patterns, but those changes may take longer to be identified.

In summary, though measured on a relatively limited time window, these results are encouraging and establish that the water management interventions undertaken by the WLE-G9 project, especially the establishment of field channels and improved operation of the sluice gate by the WMG, have been able to decrease the likelihood of farmers facing water-related issues. The interventions have also resulted in a decrease in the pressure of waterlogging, and in dry plots being available earlier in the season to cultivate *Rabi* crops.

The third chapter of this report combined qualitative and quantitative data on farmer perceptions in order to analyze how the interventions introduced by the WLE-G9 project were viewed. This chapter aimed to confirm, qualitatively, the quantitative results and to discuss the sustainability of the practices introduced by the intervention.

Regarding agricultural extension services and cropping patterns promoted by the WLE-G9 intervention, beneficiaries perceived the limits already established by the quantitative analysis. Even if the levels of information available increased in the WLE-G9 intervention sites, the improvement in knowledge has, in some instances, resulted in more negative perceptions than before and when compared with other locations. This appears to be due to the integration of the technologies in the local context and not to the technologies that were introduced. This local context includes the practices of other farmers, and there is a clear need for better coordination at the local level in relation to cropping practices and the local market, which have not yet adapted to the introduction of alternative crops (HYV rice or sunflower).

Qualitative analysis revealed positive perceptions held by both beneficiaries and non-beneficiaries regarding the impact of the project intervention in relation to drainage improvement through the construction of field channels. Although some farmers faced challenges in implementation, and the fact that it may not entirely solve waterlogging issues in the polders, there is a significant possibility that it may be adopted and up-scaled because of its low cost and the benefits provided.

Based on suggestions from the communities themselves, field channels appear to have the greatest chance of being effectively implemented if this is done through community efforts, fostering collective ownership of the initiative and thereby also helping to avoid opposition to them or lack of coordination. This will require mobilizing the farmers through participatory methodologies and with support from the WMOs to disseminate information on the benefits of building field channels.

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ANNEX 1. QUESTIONNAIRES AND GUIDELINES USED IN THIS STUDY.

This annex provides details of the questionnaires and guidelines used in this study.

Crop Economics Survey

A questionnaire was used to collect information from farmers in the crop economics survey. The aim of the questionnaire was to collect detailed information on crop production, selling price, price of inputs and the cost of labor used.

The **questionnaire** used for the Crop Economics Survey is available at:
http://www.iwmi.cgiar.org/Publications/wle/r4d/wle_research_for_development-learning_series-8_annex-1.pdf

Household Survey

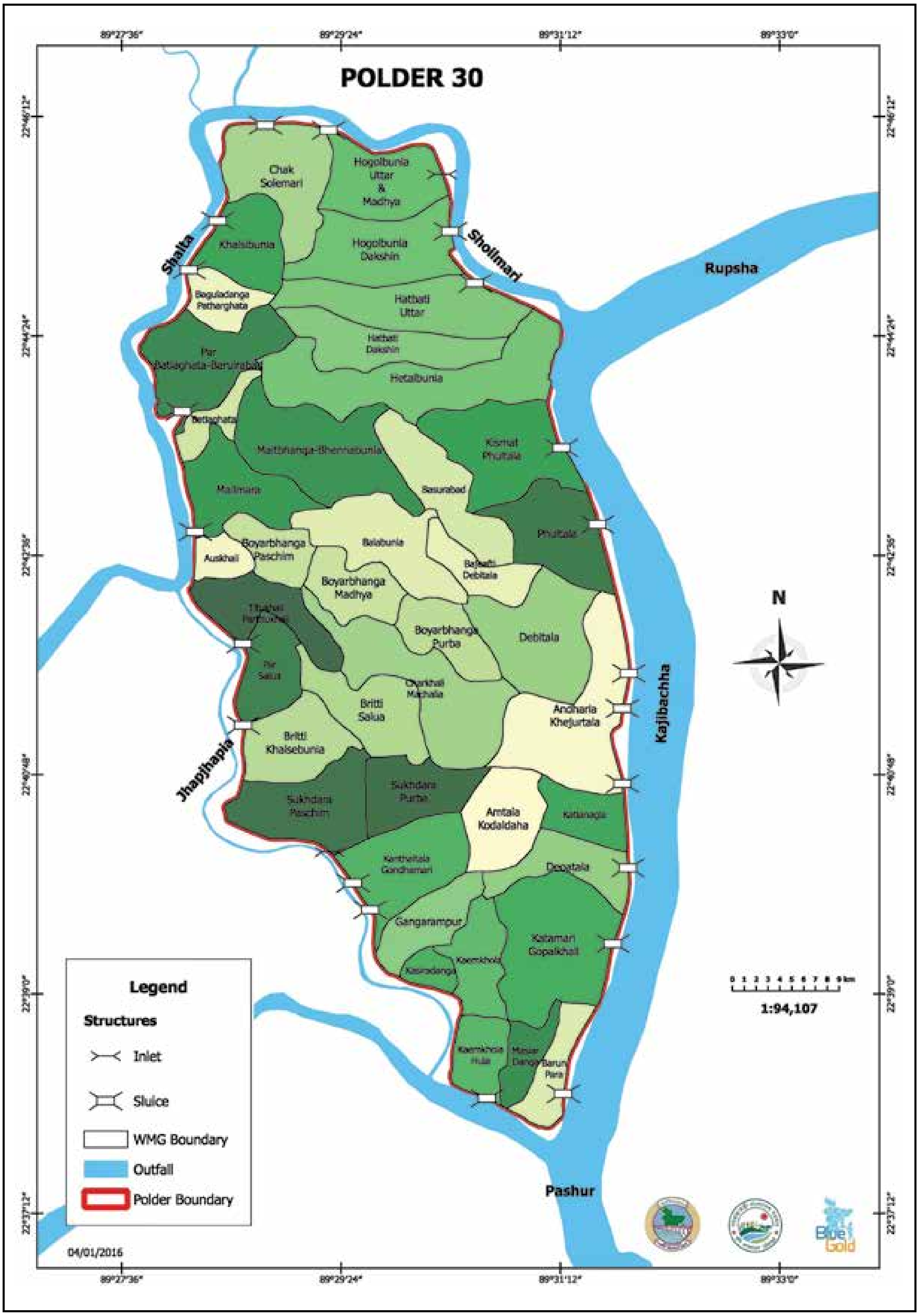
Household and plot-level data were collected using a household questionnaire. Households were asked to provide details of the two most significant plots (by size) they cultivate (see section 2 of the household questionnaire).

The **questionnaire** used for the Household Survey is available at:
http://www.iwmi.cgiar.org/Publications/wle/r4d/wle_research_for_development-learning_series-8_annex-1.pdf

Focus Group Discussion

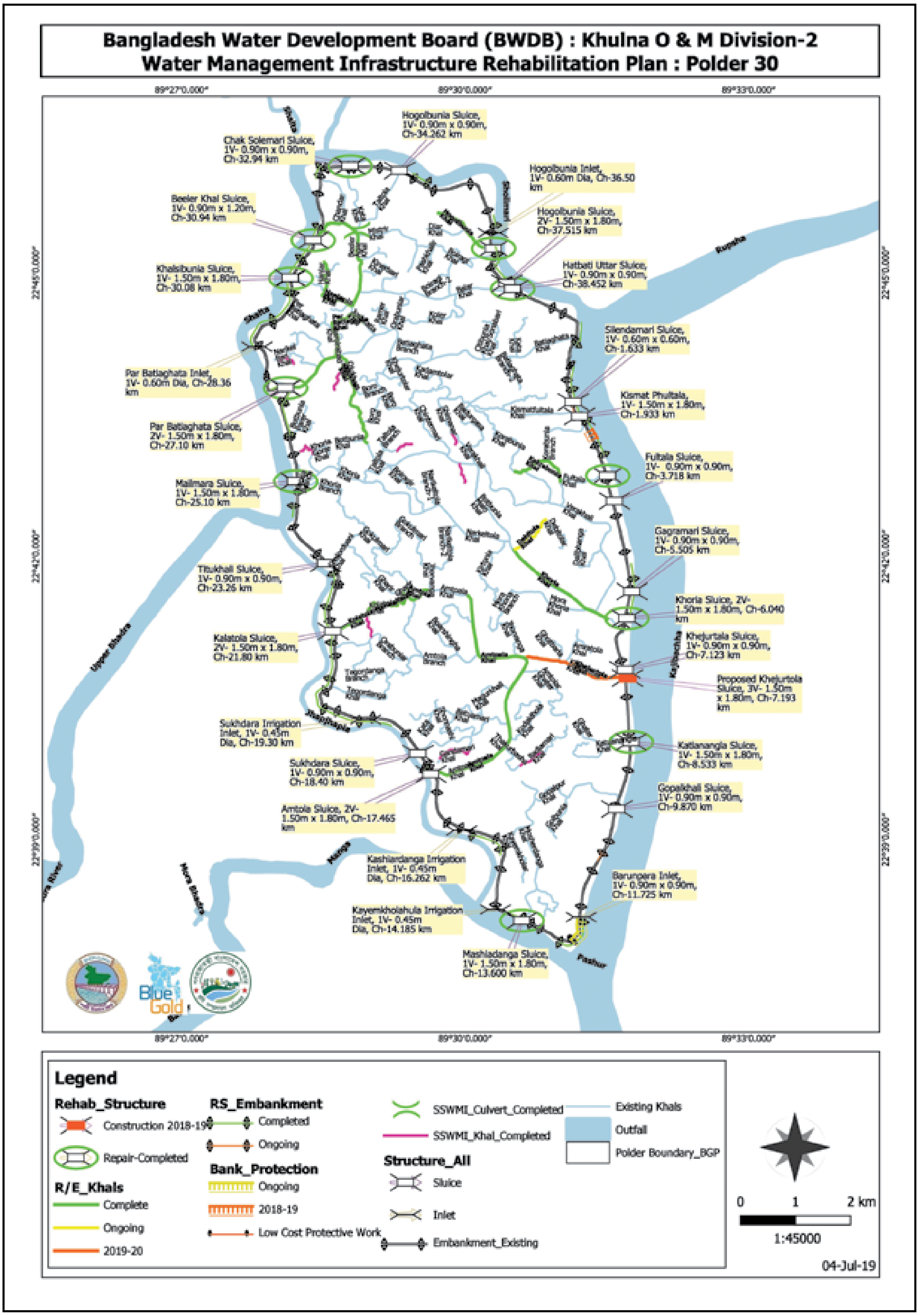
The **guidelines** used for conducting the Focus Group Discussion are available at:
http://www.iwmi.cgiar.org/Publications/wle/r4d/wle_research_for_development-learning_series-8_annex-1.pdf

ANNEX 2. WATER MANAGEMENT GROUPS SUPPORTED BY THE BLUE GOLD PROGRAM IN POLDER 30.



Source: Blue Gold website (http://www.bluegoldbd.org/wordpress/wp-content/uploads/2017/09/Polder-30-4000p.jpg - accessed on September 30, 2019).

ANNEX 3. WATER INFRASTRUCTURE REHABILITATION BY THE BLUE GOLD PROGRAM IN POLDER 30.



Source: Blue Gold website (http://www.bluegoldbd.org/wordpress/wp-content/uploads/2019/09/Polder-30_Rehab.jpeg - accessed on September 30, 2019).

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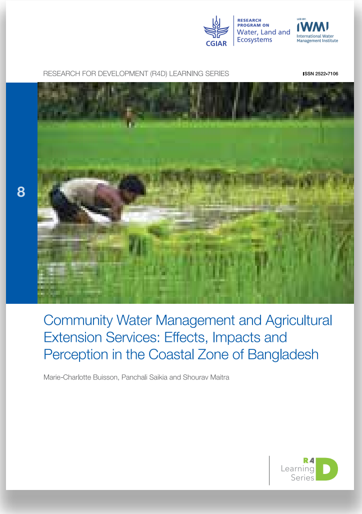
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Marie-Charlotte Buisson, Panchali Saikia and Shourav Maitra

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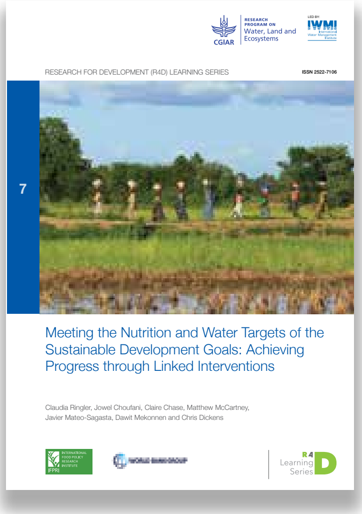
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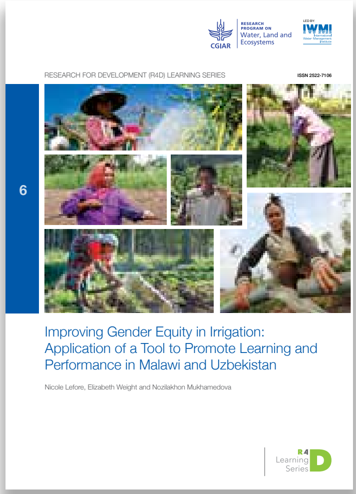
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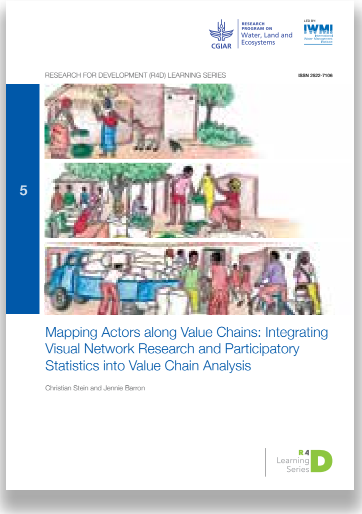
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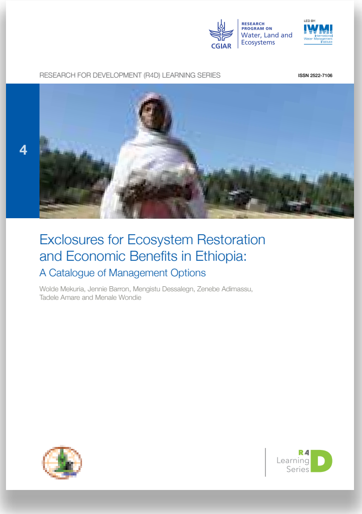
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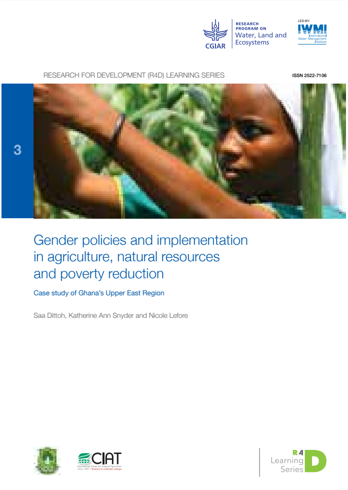
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Saa Dittoh, Katherine Ann Snyder and Nicole Lefore

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