International Maize and Wheat Improvement Centre

Final end of project report

Leveraging decision making science to sustain climate- and market-smart mung bean advisories in Patuakhali's polder communities

Project Name:

Leveraging decision making science to sustain climate- and market-smart mung bean advisories in Patuakhali's polder communities

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EXECUTIVE SUMMARY

Mung bean is an increasingly popular crop in the central coast of Bangladesh. Grown by smallholder farmers, mung bean fits easily into the cropping calendar and can be cultivated from February to May after soils drain and temperatures start to warm. The crop requires relatively few external inputs and is not overly cost intensive to cultivate. In addition to the high prices fetched for this crop – and expanding market opportunities including potential for exports – mung bean is increasingly popular among resource-poor farmers who wish to raise a second crop after *aman* rice. Mung bean cultivation in Bangladesh's central coastal areas is however risk-prone.

Heavy rainfall events and storms that occur at the end of the *rabi* winter season and prior to the onset of the monsoon can cause significant damage to mung bean crops during their reproductive and maturation period. If heavy rainfall events occur in coincidence with the maturation period of the crop, large large yield and income losses can occur from pod shattering, waterlogging, and diseases. In addition, unlike many other crops that have male dominated field activities, mung bean is also often harvested by both women and men, and dried and processed predominantly by women. As such, by disseminating gender-targeted weather-forecast information for heavy rainfall events at this critical time of the crop production cycle, climate-smart advisories for when and harvest mung could help farmers – and women in particular – to escape from some of the climate risks associated with mung bean crop production.

This twenty-one month project focused on building the resilience of smallholder mung bean farmers in the southern central coast of Bangladesh to heavy rainfall risks. Research activities developed farmer-friendly and demand-driven climate- and market-smart mung bean advisory dissemination systems using ICT tools in the form of interactive voice response and smartphone app systems. Project consortium partners included the International Maize and Wheat Improvement Center (CIMMYT) as the lead implementing agency, in addition to Wageningen University, the Bangladesh Department of Agricultural Extension (DAE), and the Bangladesh Meteorological Department (BMD), in addition to the company Bangladesh Institute for ICT in Development (BIID)[1].

Three major innovations resulted from the project. These included:

1. **An interactive voice response (IVR) System providing extreme rainfall weather alerts and harvesting advisories:**

   Based on research that highlighted farmers' interest in telephone-based advisory services, the project developed a customized IVR system to provide automated telephone alerts at least five days prior to forecasted heavy rainfall events. The system works by processing weather forecast model outputs from BMD for specific point locations in the central coast of Bangladesh. By analyzing 30 years of precipitation data recorded by BMD in Patuakhali and identifying patterns in rainfall during the mung bean harvesting period, project scientists determined thresholds for rainfall intensity that triggered an automated computer system to deploy IVR messages to farmers. Rainfall forecasts were categorized into light, heavy, or very heavy rainfall events, the latter two implying increased risk of mung bean damage. A series of algorithms were developed to process the three-hourly BMD forecasts into a daily threshold exceedance report. The algorithm next generated customized combinations of pre-recorded voice telephone messages that are sent to farmers alerting them of weather risks and advising them to harvest as soon as possible to avoid crop damage. IVR messages were also custom designed, with farmer gender- and location-specific messages to protect harvested and drying mung bean in particular administrative unions of southern Bangladesh.

[1] Consortium partner details can be found in Annex I.

During the 2019 mungbean growing season, a total of 1,371 farmers received mung bean weather alerts and harvesting advisories by IVR. Analysis of post-season survey data revealed that farmers in project working areas who utilized IVR weather advisories to harvest quickly and protect their mung bean from rainfall perceived that they saved between 48-52% of their crop from damage and losses. This equates to between 238 - 772 kg ha $^{-1}$ equivalent of mung bean yield, or EUR 158 – 511 ha^{-1} after accounting for partial costs. We estimated that farmer respondents to telephone surveys grew mung bean on 51.67, or 31.16 to 164.66 ha in in Betagi Sankipur, Choto Bighai, and Gulishakhali unions. Actions taken by farmers to avoid rainfall-induced damage appears to have saved a total of between 88 and 204 Mt of mung bean. This equates to significant value for money, conservatively estimated at between EUR 58,175 – 136,470, or EUR 107,049 on average. Considering the overall planned investment so far provided by the Blue Gold Innovation fund to CIMMYT (EUR 132,456), activities taken by the project appear to have permitted farmers to avoid damage and losses that are valued 82% on average of the total Blue Gold Innovation Fund amount provided to CIMMYT.

In the 2020 mung bean season, the IVR system was expanded to six new unions. The system also carried crowd-sourced market price information for mungbean, and a suite of options for farmers to listen to pre-recorded messages on improved mung bean agronomic practices simply by pressing different buttons on a mobile phone. The 2020 season was also unusually wet – which meant that the IVR system was of particular use to mung bean farmers. Key monitoring and evaluation (M&E) data analyzed so far for the 2020 season are reported on in the M&E section of this report. Preliminary data are highly promising, indicating that the IVR system was of key use in 2020, with farmers estimating that the weather forecast and harvesting advisory alerts helped them save between 66-71% of their mung bean crop from rainfall induced damages and losses.

2. *Mungdhal Sheba*: A climate- and market-smart app for mung bean

Mungdhal Sheba is a smartphone app to aid farmers and mung bean traders. Using participatory research and iterative development with DAE, the climate and market information services described above have also been packaged in an android app called *Mungdhal Sheba*. The app is embedded in the '*e-Krishok*' app system developed by this project's private sector partner, BIID, and is available on the google play store. The app provides weather forecasts, weather alerts and harvesting advisories as described above, as well as locally crowdsourced market information, and detailed information on improved agronomic practices for mungbean.

3. Customized business models for the climate- and market-smart IVR system

Research conducted by the project also aimed to develop business models that could be used by private sector partners – including BIID – to sustain the IVR system after the close of the project. Surveys conducted among farmers receiving IVR messages indicated a strong demand for continued IVR services. A willingness to pay study conducted by the project suggested that farmers' mean willingness to pay for IVR services was BDT 79.8 per season, with a confidence interval (95%) of BDT 70.1 to BDT 91.2 per season. This provides powerful information and demonstrates demand, though additional investment – likely through corporate social responsibility programs – is likely to be needed to sustain the service if taken over by the private sector, depending on the number of farmer subscribers enrolled. For this reason CIMMYT continues to work to expand the service beyond the current 3,000 farmer beneficiaries.

Workshops conducted in the penultimate month of the project also presented the IVR system to private sector partners and stakeholders. The project team will continue to work on out-scaling opportunities for the IVR system through complementary projects after the close of the Blue Gold Innovation Fund, with the objective of moving the IVR system into a public-private partnership to sustain its use over the next five plus years. Discussions are ongoing with ACI and other private-sector and market-oriented projects working in Bangladesh to pair the IVR system with an appropriate group of investors to sustain its use. Options are also being explored to add advertising and input retailer information to the IVR system from companies that sell *rhizobia* inoculants that enhance mung bean nitrogen fixation and yields. These companies are in particular being targeted as likely investors in the IVR system.

In addition to the above achievements, we are happy to report that this project also facilitated advanced learning and education. A graduate student at Wageningen University completed a MSc degree through collaboration with the project. The student studied how social networks can be used to further spread information on heavy rainfall risks, harvesting advice, and market prices to farmers not receiving IVR messages, or who do not have access to *Mungdhal Sheba* in Patuakhali.

This report provides a summary of the activities that led to these outcomes, presented in light of achievements against the project's three key priority activity objectives. This is followed information the monitoring and evaluation indicators used by the project, and supplemented with Appendices detailing consortium partners, the climatological methods used to identify trigger thresholds for heavy rainfall events during mung bean maturation and harvesting, and a chronology of previous monthly reports submitted to the Blue Gold Innovation Fund.

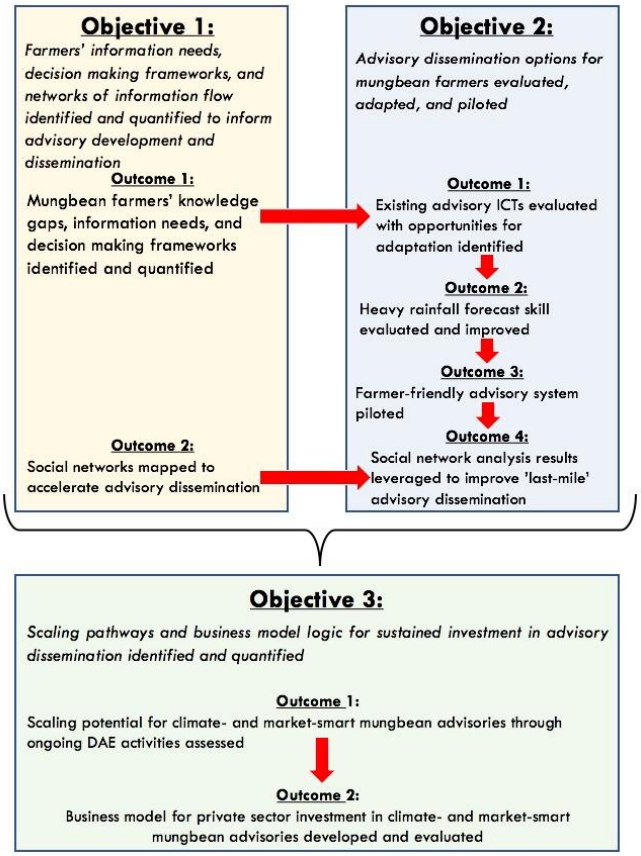
INTRODUCTION

Focusing on highly profitable but weather-risk prone mung bean production, this project developed farmer-friendly and demand-driven climate- and market-smart mung bean advisory dissemination systems. Sown in January-February, after post monsoon season waterlogging subsides, mung bean fits well into the cropping pattern of many of the Bangladesh's coastal Districts' polders. Data of mung bean production costs and benefits in Patuakhali collected by CIMMYT during the project period indicates that farmers can reliably fetch between € 321-982 per hectare. This renders mung bean one the most profitable agricultural options for the dry season in Patuakhali's polders. Markets are also rapidly developing, with large purchasing firms emerging – some even exporting mung bean abroad– in addition to an increasingly active local trader network. Mung bean also contains up to 23% protein. It can therefore address crucial household nutritional needs and contribute to efforts to reduce stunting. Mung bean production has therefore expanded more rapidly than any other crop in Patuakhali, occupying more than one-third of available dry season arable land. Yet despite these encouraging developments, farmers still lack sufficient agronomic and market knowledge on how to best manage mung bean in the face of climactic risks for high yields and profits.

Above: *Mung bean is an increasingly popular and important crop in the central coast of Bangladesh.*

In response, project activities focused on agricultural communities in polders in Patuakhali where the Blue Gold Program operates, although systems developed by the project can after adaptation applied to other crops and locations of relevance in coastal Bangladesh. The problems that lies at the heart the innovations develop by the project are three-fold.

(1) Heavy rainfall events can cause significant damage to mung bean crops during their reproductive and maturation period, causing large yield and income losses for farmers in Blue Gold's polder working areas. Unlike many other crops that have male dominated field activities, mung bean is also often harvested by both women and men, and dried predominantly by women. As such, by integrating and disseminating weather-forecast information, climate-smart advisories for when and harvest mung bean can help farmers could potential help farmers to escape from some of the climate risks associated with crop production – with particular potential benefits to women.



Above: *Flow of activities Objectives 1, 2, and 3 of this project. Objective 1 studies farmer decision making processes and maps social networks to better understand climate- and market-smart advisory demand for mung bean in Patuakhali's polders. Objective 2 develops and pilots a farmer-friendly and demand-driven advisory and information dissemination system. Outcomes from Objectives 1 and 2 are integrated into Objective 3, which develops platforms for scaling and the business case for sustained advisory services.*

(2) Both mung bean farmers and traders can also benefit from real-time market price data. Although farmers often have an impression of what the trading price is for mung bean is, systematic collection and sharing of this information from the region – combined with sharing of the Department of Agricultural Marketing recognized price – can assist farmers when negotiating with farm-gate purchasers.

(3) Last but most importantly, despite increasing use of information and communication technologies (ICT) for agriculture in Bangladesh, the core problem addressed by this project the overall limited application of ICTs by farmers. Many examples of ICTs have been developed, but few have significant or lasting impact in Bangladesh. As such, this project made use of an adaptive management framework to respond to the needs and desires of farmers themselves.

This project was therefore designed based on the hypothesis that the underuse of ICTs results from insufficient attention to understanding farmers' preferences and approaches to crop management decisions when ICTs are designed, engineered, and developed. In other words, farmers' needs and feedback in the development of ICTs and information dissemination systems tends to be undervalued during technology design, thereby resulting in products that are of limited use to farmers as end-users.

Applying these ideas to this project, we for example initially sought to develop only a smartphone app for mung bean climate and market services, though following consultations with farmers after the project initiation, we observed a clear demand for information to be extended to farmers via voice call rather than smartphone app alone. As such, the project adapted and responded by developing a successful interactive voice response system to reach farmers at scale.

The project addressed these issues systematically through three objectives:

Objective I: In this Objective, we studied farmers' information needs, decision making frameworks, and networks of information flow will be identified and quantified to inform climate- and market-smart mung bean advisory development and dissemination.

Objective II: In this Objective, we developed advisory dissemination options for mung bean farmers and then evaluated, adapted, and piloted them.

Objective III: In this Objective, we identified and quantified scaling pathways and business model logic for sustained investment in advisory dissemination. Opportunities for out-scaling use of the climate- and market-smart mung bean advisory innovation in other complementary projects and programs were assessed.

This end of project report provides a review of all activities conducted during the project's 22 month period from September of 2018 through to June of 2020. We report on activities and outcomes in sequential order of the project workplan.

OBJECTIVE I: IDENTIFY KNOWEDGE GAPS, DECISION MAKING AND INFORMATION DISSEMINATION PATHWAYS FOR MUNG BEAN FARMERS AND STAKEHOLDERS

In Objective I, we studied information needs, decision making frameworks, and networks of information flow to inform climate- and market-smart mung bean advisory design, development and dissemination. Mung bean farmers' knowledge gaps, information needs, and decision making approaches regarding mung bean cultivation and market and climate information were identified and quantified in Blue Gold Market Oriented Farmer Field Schools where farmers grew mung bean. Collaborating with Wageningen University, the project also engaged an MSc student to conduct social network research and analysis in mung bean growing communities. Key outputs from this work during the entire project period are summarized below.

Outcome 1: Mung bean farmers' knowledge gaps, information needs, and decision-making frameworks identified and quantified

Project Inception Activities

To kick-start activities, CIMMYT staff debriefed Blue Gold staff working in Patuakhali on the project's objectives and activities on September 11, 2018. This meeting also assisted in developing relationships to help drive the project's first objective forward. The meeting also established a consultative basis for CIMMYT-Blue Gold staff interactions. Following on this meeting, the project collected information from the Blue Gold team with respect to locations where project activities could be implemented. The selection criterial included (a) locations in polders where Blue Gold works actively, (b) where farmers grow mung bean, (c) where Blue Gold has strong relationships with DAE's Sub-Assistant Agricultural officers, and (d) dispersed locations to validate future advisories in a gradient of farming environments.

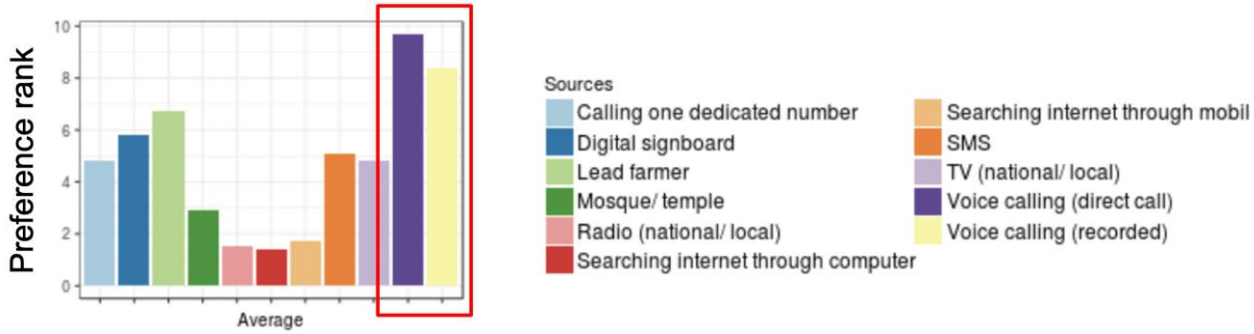
In consultation with Blue Gold, three locations were therefore identified in which project activities and focus group meetings with farmers were undertaken in Objective 1. These included villages from three different unions (Betagi Sankipur and Choto Bighai from Patuakhali, and Gulishakhali from Barguna district) within three different clusters (each within three separate Weather Research and Forecasting Model (WRF) and model grids. The latter is important as the WRF model is used by the Bangladesh Meteorological Department to generate forecasts for Patuakhali.

Above: *Project staff debrief and discuss anticipated activities with DAE at Farmgate in Dhaka in September of 2018.*

CIMMYT also met with the Director of BMD and forecasting staff on September 30, 2018 in Dhaka. The meeting consisted of a presentation on the Blue Gold project, and discussion on ways in which storm and heavy rainfall event prediction could be improved using the WRF model. BMD reiterated their interest in and support for the project. During the month of October 2018, and in consultation with Blue Gold and DAE staff, the CIMMYT team visited 10 water management groups (WMGs) from 4 different regions within Patuakhali to assess their suitability for collaboration and focus group interviews. Slight delays in implementing this work were in part due to coordination difficulties with DAE and Blue Gold staff, who strongly assisted but were not always able to be available for coordination and consultation (given their already very heavy workloads) to visit field locations and criteria for inclusion of a specific WMG. The six focus groups completed were conducted in Betagi Sankipur and Tushkhali. Additionally, the team also communicated with the Upazilla Agriculture Officer and Sub-Assistant Agriculture Officers (SAAOs) and briefed them about the project activities. Briefings were used to encourage full participation of DAE staff (see 'ANNEX 2: October 2018 Progress Report'). In October of 2018, and at the request of Blue Gold, project staff also met with Upazila Agriculture Officers at their offices in Patuakhali to formally describe the project (Figure 14). The Deputy Director (DD), DAE, Patuakhali was present at Dashmina Upazila Agriculture Office during the discussion.

Research to design farmer-friendly climate and market-smart mung bean advisories

Focus groups were held with the collaboration of Blue Gold and Department of Agricultural Extension (DAE) staff from October – November of 2018 across Patuakhali and in Barguna Districts. These focus groups were used to collect additional information on mung bean cultivation and marketing practices, and to assess farmers interest in weather-based advisory and alert systems. Participants from DAE also discussed with a weather app in mobile phone and some farmers seemed interested, but on the whole, SMS or voice calls appeared to be more appropriate route for disseminating information.



Above: *Key results from focus 27 focus groups with mung bean farmers in Patuakhali indicated a clear preference for voice calls to receive climate and market advisories for mung bean over all other ICT options.*

Above: *Farmer focus groups conducted by the project team in 2018 and early 2020 were instrumental in the design of appropriate ICTs for mung bean as well as in the design of social network research.*

From December 2018 through January 2019 and based on the first batch of focus group discussion (FGDs) held under this project, a second batch of FGDs was conducted in three communities. These discussions helped project staff ascertain more information regarding farmers' perceptions and information requests for weather forecasts and warnings of heavy rainfall events to receive weather information during mung bean cultivation period. Focus groups covered four villages under Dashmina and Amtali upazila under Patuakhali and Barguna districts. Specific information on farmers' preferences for advisory alert information to be delivered through voice call or voice SMS was examined during the focus groups. Preferences for emergency alert messages and structure was also assessed (readers are referred to the details provided in the monthly reports in Appendix III).

Outcome 2: Social networks mapped to accelerate advisory dissemination

In February of 2019, Social network mapping (SNA) research led by a Wageningen MSc student (Wolfram Simon) began as anticipated for this project. SNA can be a powerful method to study how information moves through a social network, for example through a farming community or a village. Focusing on the project's original design to develop climate- and market-smart mung bean apps, the purpose of the SNA work in this project's pilot locations was to identify the characteristics of individuals with large social networks, so we can later work with DAE and Blue Gold to target these individuals (or types of individuals) to (a) verbally spread information from smartphone owners outward to other when there is an emergency warning of a potentially crop damaging heavy rainfall event, and (b) to effectively transmit additional information about mung bean agronomic best practices and market prices (readers are referred to the monthly reports submitted to Blue Gold in Appendix III for details).

In the following months, Social Network Analysis (SNA) was deployed by a in project working locations, including Betagi Sankipur/Noumala (Polder: 55/2A), Choto Bighai (43/2A) from Patuakhali district, Gulsakhali (43/2F) from Barguna district. The SNA research was intended to give quantitative insights into speed and pathways of weather and market information flows through the farmer communities including

identification of prominent actors. Key research results can be viewed in an online seminar presented by Wolfram Simon at the completion of his MSc. thesis in Farming Systems Ecology at Wageningen University by clicking here.

OBJECTIVE II: ICT OPTIONS FOR CLIMATE- AND MARKET-SMART MUNG BEAN ADVISORIES DEVELOPED, TESTED, REFINED AND DEPLOYED

In Objective II, advisory dissemination options for mung bean farmers were researched, evaluated, adapted, and piloted. The project initially intended to adapt and improve existing ICTs such as Krishorke Janala, Krishoker Digital Thikana already utilized by DAE's Sub-Assistant Agricultural Officers (SAAOs) and related organizations and projects. These were to be assessed by farmers and SAAOs in a series of focus groups and workshop engagements, although early consultation with DAE resulted in a request from DAE to *not* use old apps. This is because they felt were outdated. As such, they proposed to design new apps and/or make use of IVR services to respond to farmers' preferences as identified in Objective 1.

The project therefore started with this in mind, conducted focus groups with farmers to aid in designing more appropriate advisory systems and services. At the same time, CIMMYT's agricultural climate science team began intensive collaboration with BMD to evaluate and improve the predictive accuracy forecasts of heavy rainfall and storm events in Patuakhali and Barguna. In addition, the outcomes from the social network analysis in Objective 1 were designed to be leveraged in Objective 2 improve 'last-mile' advisory dissemination to farmers located in remote areas, or without access to smartphones. However, as the project pivoted towards use of IVR based on the results of research conducted in Objective I, the social network analysis was relevant only to the dissemination of the app developed by the project as telephone systems were used to reach farmers at scale. Key outputs from this work during the entire project period are summarized below.

Outcome 1: Existing advisory ICTs evaluated with opportunities for adaptation identified

During the last quarter of 2018, CIMMYT and BIID leadership met with DAE staff in Dhaka repetitively. This included frequent meetings with the the Director of the ICT division, Director of Field Services, and staff associated with the Blue Gold project, in addition to focal points for the World Bank funded Agro-Meteorological Services project and the synergistic Climate Services for Resilient Development project. The project initially intended to build in adaptations to existing apps released by DAE that could be used for mung bean climate and market information services. These included Krishorke Janala, Krishoker Digital Thikana. However, after discussions, senior staff at DAE suggested modification in the proposed work plan to not focus on reprogramming old apps developed by DAE. Rather than work with old apps, they suggested a combination of working on new apps that could be accessed by extension agents with internet enabled tablets, or interactive voice response technologies to deliver emergency information to farmers. As such, and in consultation with Blue Gold, the project pivoted and began to focus on new app and IVR development, rather than additions to existing apps that DAE considered to be outdated and of less use.

Outcome 2: Heavy rainfall forecast skill evaluated and improved

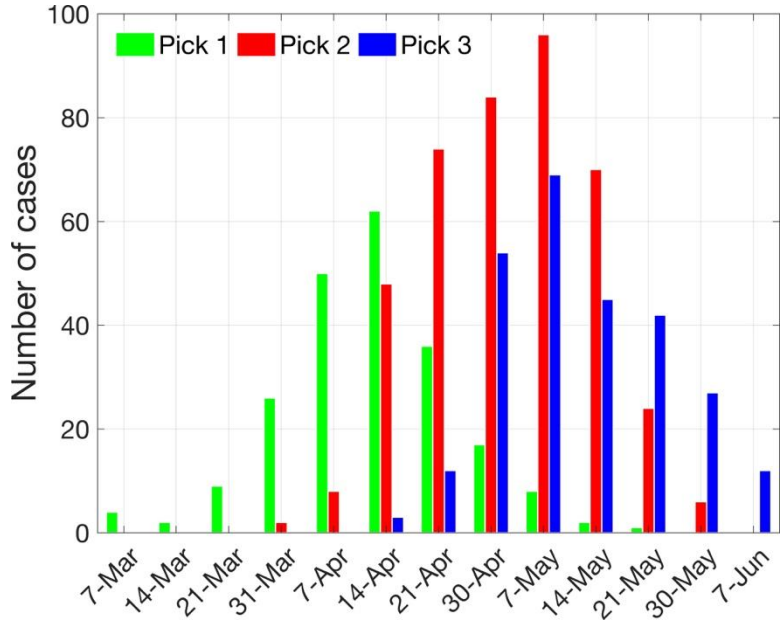
During October of 2019, research to predict mung bean damaging heavy rainfall events began suing historical daily meteorological data provided by BMD. In addition, based on a thorough review of relevant scientific literature, the project decided to apply a mathematical procedure to identify where fitted exponential curve "turns", known as "knee" point could be used to pinpoint thresholds determining heavy precipitation (Please refer to Appendix II for details). This approach was crucial as there is no historical information or record of crop damage events in this part of Bangladesh that correlate with heavy rainfall events. As such, a statistical approach was utilized to develop custom thresholds appropriate for the central coat of Bangladesh. Further research to identify how forecast accuracy might be improved using wind pattern and precipitation products (PERSIANN) available to meteorologists. A case study was assessed to explore the

performance of the WRF forecasting of heavy rainfall events in Patuakhali specifically was initiated. Following endorsement in meetings with BMD, this approach was used to trigger warnings of heavy rainfall events during the mung bean maturation and harvesting period.

Outcome 3: Farmer-friendly advisory system piloted

Research to refine heavy rainfall thresholds and develop the IVR and alert system

This section of the report details the procedure by which the climate- and market-smart advisory systems were further developed. From December 2018 through January of 2019, the project team collect more robust information than available from focus groups on mung bean picking times of the year. A telephone survey was conducted of more than 100 farmers asking very specific information on when they pick mung bean. Using the revised information on mung bean picking periods from the telephone survey, we more adequately defined the period to be considered for the risk of heavy rainfall events, in addition to the value to be considered as a threshold for the forecasting.



Above: *Statistical distribution of Mung bean picking dates (weeks) identified by telephone survey of 100 mung bean farmers in project locations.*

Using daily rainfall data provided by the BMD), the climatology of HRE in Patuakhali was performed for the period between March 1st to May 27th representing the main first and second mung bean pickings. The days with rainfall higher than 1 mm where isolated and ranked to then apply a mathematical procedure to find the location where the fitted exponential curve "turns" ("knee" point), as described above. A daily threshold rainfall amount of 23 mm/day was identified, but for the sake of convenience, a value of 25 mm/day was subsequently used to characterize heavy rainfall events, leading to a total of 181 events for the period March 1st to May 21st 1981-2018. Readers are again referred to Appendix II for detailed information on the methodology used to develop rainfall event thresholds.

Using the this threshold and the refined periods for mung bean picking identified in above, further research exploring how to predict heavy rainfall events was conducted. Research results were used to develop a system by which algorithms can be used to extract Weather Research Forecast (WRF) model outputs, examine them for heavy rainfall event risks, and print them in the form of a text file that could be red by an algorithm to assemble and send interactive voice response messages to farmers at risk of weather-induced mung bean losses. We accomplished this by first segmenting heavy rainfall event threshold into categories as follows:

- No rain: rain < 5 mm for any day in the next five days of forecast (< 5 mm is commonly considered an insignificant amount of rain in forecasts and not worth reporting on)

- Light rain: 5 mm <= rain < 23 mm for any day in the next five days of forecast
- Heavy rain: 23 mm <= rain < 38 mm for any day in the next five days of forecast
- Very heavy rain: rain >= 38 mm for any day in the next five days of forecast (38 mm was chosen on analysis of historical data and an expected level after which mung bean damage and/or waterlogging could occur)

The mechanics of rainfall event threshold triggers

For the three mung bean location considered in the 2019 pilot, two model outputs were selected to extract the rainfall forecast based on the proximity to corresponding to the two most adjacent weather research forecast model (WRF) model grid cells provided by BMD (readers are again referred to Appendix II for details on this method). In this way, for each 24 hour period in which the forecast is generated by BMD, a model output text file containing the daily cumulative anticipated precipitation values for the next five days was generated, stored and transferred to CIMMYT's server located at BMD for processing through an algorithm developed by the project. An algorithm was then developed by project scientists to produce a warning message for farmers in case light, heavy, or very heavy rainfall events were predicted.

An example of how one of these files will be displayed is presented the table below. For this example, occurrence of precipitation is predicted from day 2 (being day 0 the day of the forecast generation), and three HRE are observed for day 5 (site 1) and days 4 and 5 (site 2).

Hypothetical example of text file format containing the daily rainfall forecast for the next 5 days.

Date	Forecast day	Site 1	Site 2
2019 03 09	1	0	0
2019 03 10	2	10	15
2019 03 11	3	10	15
2019 03 12	4	20	25
2019 03 13	5	30	35

In this example, a warning would be generated for both site 1 because >23 mm is expected in the next five days. In site one, however, a limited rain event of 30 mm was expected only on day five. For this reason, the algorithm generated a 'moderate' advisory by voice message roughly as follows:

Assalamualikum! This is an important announcement from the Bangladesh Meteorological Department and Department of Agricultural Extension for mung bean farmers. There is a moderate risk of heavy rainfall expected in your area over the next five days. Heavy rainfall can damage maturing mung bean pods, cause waterlogging in and reduce mung bean yield. You are advised to harvest mature mung bean pods as soon as possible to avoid crop damage. Please share this message with other mung bean farmers in your area. Press 1 to hear this message again"

Conversely, in site two, two days of heavy rainfall events are forecasted. For this reason, the algorithm deployed a more strongly worded advisory as follows:

Assalamualikum! This is an emergency announcement from the Bangladesh Meteorological Department and

Department of Agricultural Extension for mung bean farmers. There is a high risk of heavy rainfall expected in your area over the next five days. Heavy rainfall can damage maturing mung bean pods, cause waterlogging in and reduce mung bean yield. You are advised to harvest mature mung bean pods as soon as possible to avoid crop damage. Please share this message with other mung bean farmers in your area. Press 1 to hear this message again"

Above: *Project team researchers collaborating with BMD to discuss custom rainfall event forecasts for coastal Bangladesh in September of 2018.*

Importantly, this message structure and language was vetted in farmer focus groups and reflects their preferences for getting warnings. Further changes may be made in this wording, although these preliminary examples provide an adequate initial sentence structure and level of detail.

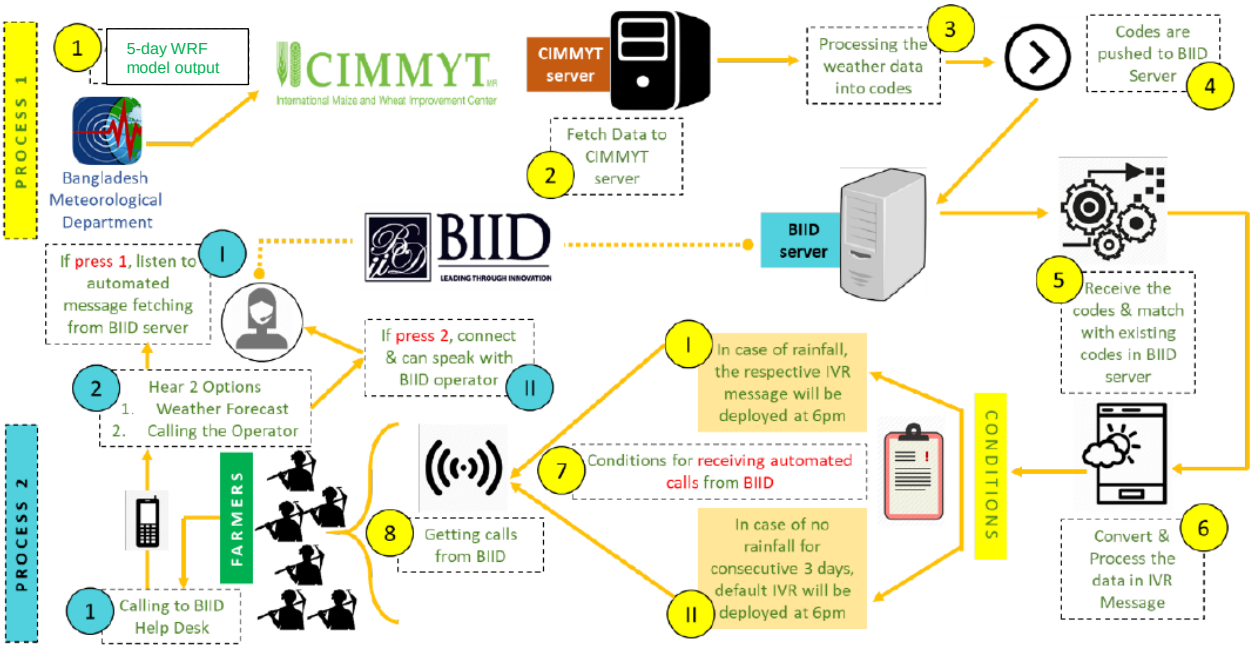
Conversely, the below example provides a hypothetical forecast that would generate an advisory in site one (with a strong emergency method), but not in site two:

Hypothetical example of text file format containing the daily rainfall forecast for the next 5 days.

Date	Forecast day	Site 1	Site 2
2019 03 01	1	0	0
2019 03 02	2	10	15
2019 03 03	3	35	15
2019 03 04	4	20	0
2019 03 05	5	30	5

In this example, if the rainfall forecast in site one or two never surpasses 23 mm/day on any day, no advisory would be given. This iterative procedure will be repeated each day with forecasts and advisories generated as described below for each day of the mung bean harvesting period from April through June.

Making the IVR system operational



Above: *Description of the process by which the project generated interactive voice response messages for mung bean farmers in the central coast of Bangladesh from BMD weather forecasting model outputs.*

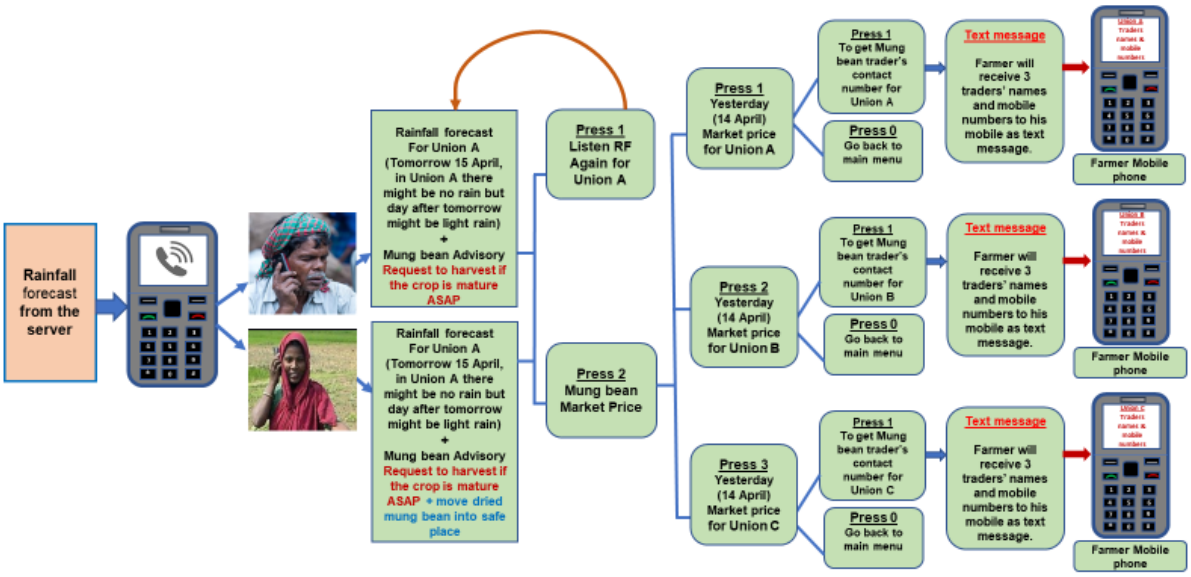
In March of 2019, a sub-grant was provided to the Bangladesh Institute of ICT in Development (BIID) to deploy the IVR system to alert farmers as to light and heavy and very heavy rainfall risks. BIID also worked develop a tailored app designed in such a way that it is responsive to the design demands of farmers and DAE agents in Patuakhali. It is important to note here that the IVR system was developed in response to demand by farmers for voice messages rather than apps or SMS delivery.

The system works by receiving weather 5-day numerical weather model outputs from BMD. The output data are pushed to a server installed by CIMMYT at BMD. Outputs are received on a three-hourly basis and processed automatically by an algorithm to identify if trigger thresholds are surpassed for forecasted rain events as described in the section above. Algorithm products are then pushed to a server at BIID, which processes the outputs and uses an automated algorithm that automatically assembles an IVR message from pre-recorded combinations of partial messages. The algorithm assembles an appropriate full message depending on the forecast location, recipient group (A or B, as described in the monitoring and evaluation section) and their gender, and the severity of the forecasted rain event. Phone calls are then automatically connected to farmers' mobiles in the evenings at preferred call times as identified in focus group research in Objective 1.

In 2019, farmers then had the option of calling into a help desk at BIID for further clarifications, or to press 1 to listen to messages again. In 2020, the help desk was suspended due to costs and incongruence with the business model in terms of costs (see Objective III). Instead, farmers had more options presented to them after listening to the initial message, including options to repeat the message, listen to detailed agronomic information on six topics of relevance to mung bean, or to listen to information on the market prices of mung bean in their local area (readers are referred to the sections below)

In order to pilot the system in 2019, and due to a lack of information from Blue Gold regarding individual farmer beneficiary telephone contact information, this project worked to assemble a list of farmers who will

be receiving the advisories. To make a viable list, we enlisted assistance from DAE, Lead Farmers and *Grameen Euglena*. We also assembled data the list of farmers who're participants of all the nine focus groups conducted as part of Objective 1, and survey participants of the Social Network Analysis. From all the aforesaid sources, a total of 2,032 farmers' contact details were found, still, after verification, the team could finalize the list with 1,371 farmers (1,260 men and 111 women) who had working telephone numbers. The 1,371 farmers were contacted with pre-recorded IVR calls and customized weather forecast and mung bean information during the mung bean harvesting season of 2019. Depending on when a forecasted threshold trigger was surpassed, weather and harvesting advice was deployed as shown below.



Above: *Details of how the IVR system pushes IVR calls to mung bean farmers' mobile phones if there is a rainfall risk threshold passed from 6:00 PM-9:30 PM in three locations (Union: Choto bighai, Betagi Sangkipur and Gulishakhali) in the 2019 pilot.*

Two of the final samples (in English translation) of the IVR call structure are provided below:

1. IVR_ Recording -1- Male: (English version): Assalamualikum! Dear Mung bean farmer (Brother). We have called to inform about weather forecast from the Bangladesh Meteorological Department in Gulsakhali union of Amtoli upzila. In Gulsakhali union, light rainfall may occur tomorrow, day after tomorrow and any day in next three days afterward. Please inform other mung bean farmers (brothers and sister) To hear this message again, press 1 or dial 09612316250.

2. Recording -2- Female: (English version): Assalamualikum! Dear Mung bean farmer (Sister). We have called to inform about weather forecast from the Bangladesh Meteorological Department and Department of Agricultural Extension in Choto Bighai union of Patuakhali Sadar upzila. In Choto Bighai union, light heavy rainfall may occur tomorrow and heavy rainfall may occur the day after tomorrow. Heavy rainfall can damage mung bean. If your crop is mature, you may consider harvesting it without delay. If you are drying harvested mung bean, you may also consider moving it under shelter. Please inform other mung bean farmers (brothers and sister).To hear this message again, press 1 or dial 09612316250.

Polit deployment of the interactive voice response system piloting in the 2019 mung bean season

During May of 2019, the project assembled a database of 1,371 farmers who had telephone numbers in Blue Gold working areas in Patuakhali and Barguna. During the 2019 mung bean harvesting periods for the first and second picking (from May 1 through 27 May), a pilot IVR call was deployed nightly to these farmers if rainfall was forecasted. The farmers who picked up the calls listened to the messages for 44 seconds on average, which indicates that they listened in most cases to the entirety of the message before hanging up.

Because farmers received daily weather forecast updates, the number of IVR dispatched was 18,321 over 14 days between May 1 and 27th, 2019, when rainfall was forecasted. 12,302 of these alerts were received and listened to by farmers (reasons for call failures were due to technical problems including poor networks (n = 4,018), ring time-outs (n = 3,443), or hang-ups (n = 229), in addition to other miscellaneous issues). Importantly, farmers called back 3,208 times to the number provided to the message a second or third time. Those that called back a second time also tended to listen to the messages for a longer period of time; those that called back a third time listened for the longest period (some up to 150 seconds, indicative of using the IVR option to repeat the recorded messages up to three times within one call-back call).

Interactive voice response system expansion and enhancement in the 2020 mung bean season

As interactive voice response (IVR) system developed in the first year of the project was successful, CIMMYT leveraged the Cereal Systems Initiative for South Asia (CSISA) project to co-finance an expansion of the IVR system to another six upazilas in Patuakhali in 2020. Details of the 2020 mung bean season can be found below.

Pre-season and sowing time voice message delivery to mung bean farmers

The project convened a meeting on 13th January 2020 Patuakhali to validate and get feedback on project activities. During this meeting, workshop participants suggested also distributing additional messages via voice message before the season, providing generalized agronomic advice to mung bean farmers. The idea was that information could be provided before and during planting time so they could use the information in their field. Therefore, the project team deployed agronomic voice messages (based on information described in the reports found in Appendix III) on better-bet management options mung bean production.

The voice message on agronomic management of mung bean (translated to English) is as below:

Dear Mung bean Brother and Sister! Assalamualaikum! We have called to inform you about the easy to use methods to improve mung bean production from Bangladesh Department of Agricultural Extension. To get a high yield of the mung bean, you can use diseases and pest free
and high yield variety of seeds like BARI-6, BINA-8. You can get a high yield from sowing the mung bean in lines. Line sowing also makes it easier for weeding, applying crop protection products, and picking matured cobs of the mung bean. During sowing, based on the soil condition, you are advised to use 10-12 kg of DAP and 4-5 kg of MOP fertilizer for 1 bigha or 33 decimals of the land. You must keep the crop weed free next 5 weeks after sowing seeds. During land preparation, please prepare drainage around your field to avoid waterlogging from rain. If would like to know more about mung bean production in detail, please contact the agriculture officers in your Upazila Agricultural office. Sponsored by: the Blue Gold program, CSISA and CIMMYT. If you want to hear the message again, then please press 1! Thank you.

Readers can listen to the Bangla version of this message by clicking on this link. A total of 7,597 voice message calls were deployed from 05 February to 19, 2020 in three unions in Patuakhali and Barguna districts. This is the period when the farmers prepare their land and sow the mung bean seeds. Among 7,597 calls, 7,127 were deployed to mung bean farmers and 24 calls were deployed to mung bean traders in Patuakhali. Voice message calls were received 2,582, 2,507 and 2,062 times in Choto Bighai (Polder 43/2A) from Patuakhali district, Betagi Sankipur/Noumala (Polder 55/2A), and Gulsakhali (Polder 43/2F) from Barguna district, respectively. Only 132, 196 and 118 calls failed in these locations as they were not picked up and listened to by farmers. The main reasons for call failure included mung bean farmers whose phones were switched off, non-pickup (ring out), and/or busy numbers or poor networks.

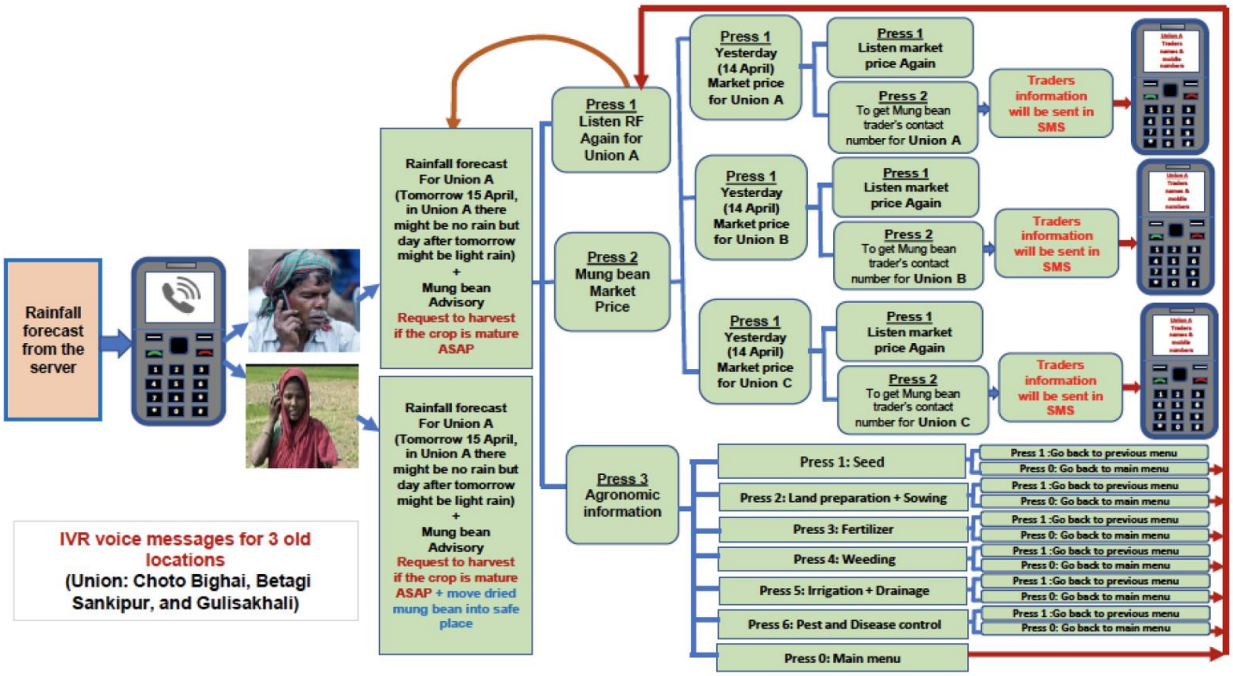
In focus: Gender-sensitive advisory systems

This project developed gender-sensitive mung bean advisory options by involving 261 women in targeted focus groups and workshops to envision and validate how climate- and market-smart mung bean ICT services should be developed and deployed. Project researchers within CIMMYT and BIID collaborated with DAE and reflected on the opinions of the women farmers and expert stakeholders who were involved in these discussions, and used the qualitative data collected in these research settings to design more gender responsive ICT and extension approaches. A key example was the differentiated interactive voice response messages given to male verses female farmers. In the latter case, messages advised not only on harvesting advisories in case of heavy rainfall forecasts, but also on advisories to protect harvested mung bean while it was drying. This intervention was key, as women are most often responsible for the post-harvest drying and processing of crops.

Harvest and post-harvest time climate- and market-smart mung bean IVR calls

In the 2020 mung bean harvesting period, farmers from three previously tested locations from 2019 (Union: Choto bighai, Betagi Sangkipur and Gulishakhali) received both rainfall forecasts with harvesting advisories *and* also mung bean market price information at the union level. Additional DAM (Department of Agriculture Marketing) information were also made available for prices at sub-district level. The following flow diagrams show the IVR call structure – which were gender differentiated and designed to be culturally appropriate and appealing to men and women call respondents – and how they flow from the server to mung bean farmers.

Mung bean farmers from four new unions: Chiknikandi, Madarbunia, Bauphal, and Muradia, also received rainfall forecasts and crop management advisories in 2020. These areas represent an expansion of the project not covered in the original project contract with Blue Gold; expansion was supported by the Cereal Systems Initiative for South Asia as new locations in the efficacy of the IVR system was tested. Like 2019, male and female farmers received customized advisories when there might be light, heavy, or very heavy rainfall. And also like in 2019, all farmers were differentiated in two groups, the first receiving both rainfall forecasts + harvesting advisories and a second group receiving only rainfall forecasts. This 'A' and 'B' group separation assists the project in testing and identifying which IVR script format is most effective.



Above: *Details of how the IVR system pushes IVR calls to mung bean farmers' mobile phones if there is a rainfall risk threshold passed from 6:00 PM-9:30 PM in 2020.*

As with 2019, farmers who received calls in 2020 could also call back into the IVR system and listen to a recording of the advisories upon demand. However, in contrast to 2019, farmers who called back were required to use their own phone credit to pay for the call at the rate of a normal phone call. This decision was taken in consultation with BIID and is part of the business model discussed later in the report.

Between April 22 to April 30 of 2020, and when rainfall was forecasted, the project deployed IVR calls to two 2,850 mung bean farmers (2,568 men and 282 women), in addition to 10 male mung bean traders' in eight unions in the evening time (7:15-8:30 PM). As per request of lead farmers from involved in *Participatory Integrated Climate Services for Agriculture* (PICSA), a Farmer Field School like approach led by DAE, 25 PICSA lead farmers (20 male and 5 female) from Itbaria Union under Patuakhali district were also added in the call list.

The mung bean season was late in 2020, as many farmers established their crops only in the end of February due to cold temperatures that forced them to wait for land preparation and season. When IVR calls began in April, many farmers still had crops in their vegetative stage. However, these voice message alerted the farmers about heavy and very rainfall events so that at least they could open and cut drains around their fields, and also work to manage sluice gates in embankment so that the water couldn't stay in the field. One harvesting started, the IVR calls continued when rainfall was forecasted, although fears of COVID-19 infection in 2020 also meant that farmers were more reluctant to move to their field to harvest than in 2019.

By the end of the mung bean season, the total number of ICVR calls deployed to farmers totaled 22,010 unique calls. Among the calls, 61% (13,349) were successfully received and listened to by farmers and mung bean traders, and 39% (8,576) of the call failed to reach recipients. The reasons of call failures included ring-out without answer or that mobile phones were switched off. The number of calls received is higher in Choto bighai union and Betagi Sankipur in Patuakhali. The length of the whole IVR message – including crop harvest advisories – ranged from 40-65 seconds depending on the recipient's gender, forecasts commination style, and name of the call location. This variation as caused by the ways in which the messages are customized

as per these factors. An analysis of the data from 13,351successful voice calls that were received by mung bean farmers and traders from were listened to for between 20 – 201 seconds, which covers the message from the rainfall forecasts part to the ending message including advisories. This indicates that for most farmers listened to at least the forecasts and advisories, and in many cases listened to the message repetitively.

Twenty-twenty was also a heavy rainfall year. From May 01 -31, BMD's WRF model forecasted heavy and very rainfall events on 8 days, light rainfall events on 13 days, and no rain events for 12 days across the unions included in the IVR calls. After activating the call back system around 200 incoming calls came to the system from May 15 to May 31 during a period of particularly heavy rain. Data indicated that around 95% of incoming calls were listed to mainly to hear the rainfall forecast repeated.

In addition to these heavy rainfall events, the project also deployed a new emergency voice message warning farmers to take protection against cyclone Amphan on May 17 and May 18 of 202. The cyclone made landfall on May 20 in Patuakhali and Barguna district. IVR calls were therefore not deployed on May 19 and 20, as the project wished to avoid the risk of farmers attempting to harvest their crop when national recommendations were to shelter in place. It is important to note that the IVR system was not envisioned for such emergency response, but upon consultation with the Bangladesh Meteorological Department – a core project partner – the customized cyclone warning message was quickly recorded and deployed. These circumstances point to the dynamic and multi-use nature of the IVR system.

Further information on the impact of the 2020 IVR calls can be found in the Monitoring and Evaluation section of this report.

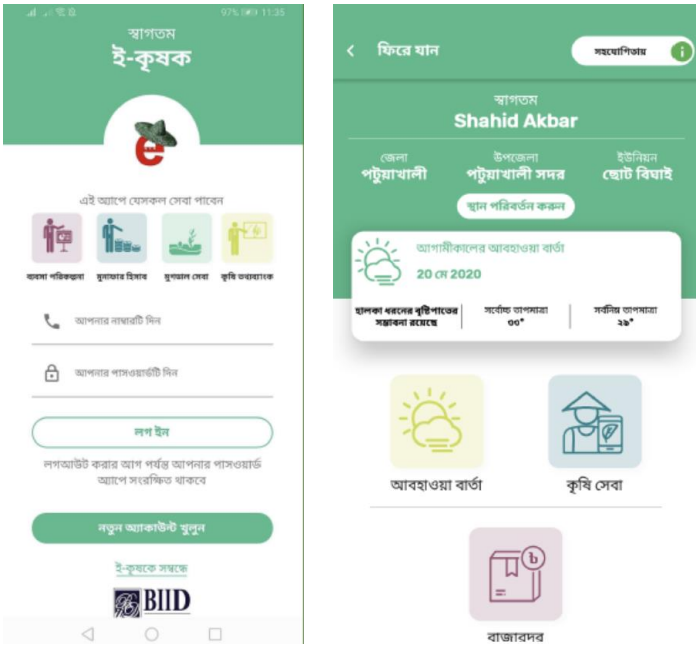
Above: *A farmer research participant displaying his mung bean crop as it nears maturity.*

Mungdhal Sheba: An Android app for climate- and market-smart mung bean advisories

Following consultation with DAE in late 2018 and early 2019, it was decided that a fully new mung bean app will not be built as part of this project. Rather, the decision was taken to build a new set of app modules into an existing app called *E Krishok* that BIID had already operationalized, and that is in use by farmers. Choosing to go with BIID was also strategic: as BIID is a private sector business with a need to sustain revenue from promising innovations, they have a a business interest in the app and assuring its continued use over time.

Throughout 2019, the project worked to develop *Mungdhal Sheba*, an Android app for climate- and market-smart mung bean advisories that can run inside BIID's *E-Krishok* app that is already available and widely used in Bangladesh. *Mungdhal Sheba* app was designed as a complement to the IVR system. The app's functionality works in response to the demand of farmers, DAE, and mung bean traders elucidated during research conducted in Objective I of the project. The key functions of the app are to (a) provide daily weather updates and advisories in similar fashion as to the IVR system, (b) to provide market price information on mung bean by crowd souring information from traders and DAM, and (c) to provide general Information for mung bean farmers on improved agronomy.

On 13th January 2020 a workshop was convened by the project in Patuakhali to validate and get feedback on the beta version of the app. An overview of the app design was also presented by BIID describing the app's content and providing instructions on its use. Feedback was provided on how to improve the app; as a result, the project team refined and improved the app, which was released in April of 2020. The following features are part of the app:



Above: *Examples of the Mungdhal Sheba android app interface*

1) **Weather alert:** This information provides the users weather alert as per the IVR system described in previous reports. Users can also listen to the audio of the IVR which will be linked into the app. This enables users with lower levels of literacy to comprehend the messages.

2) **Market price information** on mung bean is a unique feature of the app. This feature provides the previous day market price of mung bean in Patuakhali district collected from crowdsourcing. Price data captured from the registered traders who share price information daily with BIID by text message; this information then populates a database and is provided through the app. The app also provides price information from the DAM (Department of Agricultural Marketing) website so users can compare the two sources and make decisions with additional available data.

3) In addition, users have the open of accessing additional **general agronomic information on mung bean**: The CIMMYT team has developed guidelines on mung bean crop cultivation and prevention measures from the CIMMYT mung bean guide book. Based on the guidelines, user friendly messages have been developed where the farmers or app users can know more about cultivating mung bean.

4) **The app also has features for customer service**: This feature extend the services for the users to interact with the BIID customer service team and get their queries addressed. The user can reach out to BIID when needed get their queries clarified.

On May 19, 2020, the project team launched *Mugdhal Sheba* remotely using a Zoom meeting (it was not possible to hold an in-person meeting due to the COVID-19 lockdown). At the meeting's peak, 100 participants from various government offices, development programs and universities within Bangladesh and abroad attended the workshop. Dr. Alhaz Uddin Ahmed, Director, Field services Unit, Department of Agricultural

Extension was a chief guest of the workshop. The workshop was presided over by Dr. Timothy J. Krupnik, Country Representative of CIMMYT Bangladesh. Mr. Shahid Uddin Akbar, CEO of BIID and his team member oriented the participants on the app, its development, and how it can be used to assist mung bean farmers and traders. In addition, ASM Shahidul Haque, Group Leader of Strengthened value chain of Blue Gold Program, spoke about the Blue Gold Innovation Fund. Following these presentations, participants voiced their opinions and interest in the app during an interactive session.

The list of participants who attended remotely in the workshop is given *here*. The E-Krishok App where the mung bean service is found has updated in Google Play and the link of the app is found in *this link.*

Outcome 4: Social Network Analysis results leveraged to improve 'last-mile' advisory dissemination

Finalized SNA research results became available in mid-2019, These result suggested that in order to introduce suitable weather and market information into the communities that this project focussed on, a mixed approach targeting influential community members was required at the same time as 'randomly broadcasting' information using IVR systems. Network metrics, such as degree centrality, number of isolated nodes and centralization in social networks within the study areas were assessed suitable to analytically and spatially decide on the suitability of an entry point and the dissemination strategy.

In order to best reach isolated farmers using an app like *Mugdhal Sheba*, study results suggested that using farmers' friendship networks with a very high frequency of information exchange should be utilized. This implicitly leads to the second question on *how* to introduce information into the networks. Broadcasting of information by IVR was advised as the most viable method of reaching farmers when the outdegree of friendship networks exceed that of market or weather information networks.

SNA survey data that 88% of farmers in our study would like to have information / alert through voice calls on a mobile phone with less preference for mobile apps among farmers. Although 72% farmers also use television to get weather and agricultural information, they also stressed a strong interest in direct calls with quality and timely (not general) advice with specific and actionable recommendations. Further details of the SNA results and how they can be used to improve climate and market services dissemination in Patuakhali can be found in a webinar recorded by Wolfram Simon by clicking here.

OBJECTIVE III: IDENTIFY AND QUANTIFY POTENTIAL SCALING PATHWAYS FOR CLIMATE- AND MARKET-SMART MUNG BEAN ADVISORY SYSTEMS

In Objective III of the project, we identified and quantified scaling pathways and business model logic for sustained investment in advisory dissemination. Opportunities for out-scaling use of the climate- and market-smart mung bean advisory innovation in other complementary projects and through the private sector were assessed. In particular, research on farmers' willingness to pay for IVR services was used to develop potential business models for private sector investment in advisory systems – with emphasis on achieving efficiencies in achieving reach among farmers and value for cost. Key outputs from this work during the entire project period are summarized in bullet-point form below.

Outcome 1: Scaling potential for climate- and market-smart mung bean advisories through ongoing extension activities assessed

The success of the IVR system in 2019 and 2020 stimulated increased interest by BIID – which is the project's core private sector ITC development partner – to continue to deploy IVR services after the completion of the project. Combined with the COVID-19 crisis, and in consultation with Blue Gold, the project adapted and

decided to refocus on the private sector as a key means to reach farmers through IVR. The scaling potential for IVR services through existing public-sector pathways was therefore downplayed in favor of private sector assessments. This however pertains primarily to the IVR services.

Conversely, now that the *Mungdhal Sheba* app conversely is now available, and following a Zoom workshop chaired by DAE on June 27th of 2020, the projects anticipates sustained use of the app in DAE's ongoing projects. This is because DAE officials – particularly those in south central Bangladesh – found the app to be of value, as evidenced by comments and suggestions provided during the consultation workshop. As such, CIMMYT will follow up in the 2021 mung bean season through the aligned CSISA project by training DAE staff in south central coastal Bangladesh – where mung bean is widely grown –on how to use the app. As a result, we anticipate that the app will be widely used by public sector extension services in the 2020 season. Additional attention will be placed on working with DAE to train lead farmers – who now have internet enabled tablets supplied by DAE – to make use of the app. Beyond these efforts, ongoing DAE lead PICSA farmer field schools operational in Patuakhali and nearby areas are anticipated to make use of the *Mungdhal Sheba* app as it provides the relevant weather information required for the PICSA process (readers can learn more about the PICSA process by reading pages 5-15 of this document).

Outcome 2: Business models for private sector investment in climate- and market-smart mung bean advisories developed and evaluated

In order to scale-out the IVR advisory system, a viable business model is required and hence viability of a subscription-based business model is considered here. Other business models such as value chain actors supported models government subsidy-based models, corporate social responsibly based models, etc. were considered as an alternative to a subscription-based model. After discussions with experts and stakeholders, however, it was ascertained that a subscription fee-based model is likely to be most viable.

Under the proposed model, a small subscription fee will be collected from farmers for the delivery of advisory services. As such, from April to May of 2020, the project deployed a telephone survey to 150 farmers to assess their willingness to pay for the IRV service. Research questionnaires on willingness to pay for advisory services are available for review here.

This business model has three types of costs. These include a registration fee, ongoing subscription fee, and a push-pull fee for the IVR services. In this model, BIID – which like the app have a clear business interest in sustaining the IVR service – are anticipated share the subscription fee collected with a telecom service provider. Here an individual subscription fee of BDT 50 with a registration fee of BDT 5 and push-pull fee of BDT 2 are assumed per season. The total cost of initial year of subscription therefore would be BDT 57 per farmer.

The project followed up by conducting a willingness to pay experiment, using a contingent valuation (CV) as technique for creating a hypothetical market for the agro-advisory services. The phone numbers of150 farmers were randomly drawn from the IVR call recipient list of Patuakhali Sadar and Amtali subdistricts of Patuakhali and Barguna districts for the assessment of willingness to pay for the IVR services.

The overall positive response for the subscription fee question was 86%. The both positive responses (yes-yes) for initial and follow-up (high) willingness to pay were 51 out of 150 ,while 52 farmers responded positive for first bid and negative any additional higher bid amounts for the hypothetical IVR subscription fee. The number of survey participants who responded negatively to the first bid amount and positively to the second bid in the willingness to pay experiment were 24. Only a few respondents did not want to pay at all (14%). Details on the statistical analysis of these data can be found in the relevant monthly reports included in Appendix III. Project scientists used a multinomial logit regression model that shows the presented subscription fee bid and exposure to harvest losses of mung bean in the previous season were the only significant variables driving farmers' willingness to pay for climate- and market-smart IVR services. Farmers' experience of mung bean damage in the previous season increased the probability their positive willingness to pay response

considerably. Conversely, farmers' willingness to pay does not appear to be affected by factors like age, education, gender, farm size, and so on. The major reasons for farmers not being willing to pay for advisory services were 1) respondents believe that government needs to provide this service for free of costs, 2) they can get the rainfall information through other sources. 3) Cost of the service is high and is not affordable. These results position the IVR well, as most farmers in project working areas have encountered previous mung bean losses due to inclement weather (a result supported by farmer focus groups conducted in 2018 and 2019).

Considering the willingness to pay model results in detail, farmers' estimated mean willingness to pay is BDT 79.8 with a confidence interval (95%) of BDT 70.1 to BDT 91.2. The willingness to pay study show that the planned subscription fee of 57 taka in the business model is within the mean willingness to pay for IVR mung bean advisory services by farmers. That said, a minimum of 500,000 farmers is likely to be needed to sustain profitability for BIID and a telecom provider in this subscription model. This willingness to pay study was useful in in estimating the range of feasible subscription fees and establishing the factors farmers' willingness to pay.

The resulting business model was presented to a range of public and private sector stakeholders during a June 27th, 2020 Zoom workshop held to garner private sector investor interest in the IVR services. At the height of the meeting, close to 50 participants were present. The meeting garnered additional interest in the IVR system by both ACI's ICT division and also the USAID supported Rice and Diversified Crops (RDC) Activity, which works to mobilize the private sector as a leader in agricultural development. The project team is now in discussion with both ACI and RDC on potential investment and partnership options to expand the IVR system in the future. Most likely, CIMMYT will co-support further expansion costs in 2021 through the CSISA project, though we are working to develop a pilot co-investment model with BIID and a private sector partner – either ACI or others in RDC's portfolio. Due to the COVID-19 crisis, it was not possible to advance further on this portion of Objective III before the project closed, though very promising results are available from the willingness to pay surveys that have permitted the project team to negotiate strongly with potential future private sector investors.

MONITORING AND EVALUATION

Detailed information on completion of this project's monitoring and evaluation framework (as defined in the project proposal document) can be found in the table at the end of this section of the report. In addition to this quantitative reporting, we provide detailed updates on the IVR piloting system in 2019 and 2020 below.

Monitoring, evaluation, and learning from the 2019 climate- and market-smart IVR piloting

A telephone survey of 676 farmers whose phone numbers were randomly drawn from the IVR call recipient list for the 2019 mung bean production season was conducted following crop harvest. The total sample size was nonetheless 49.2% of the 1,373 farmers who received IVR calls during the 2019 mung bean season, and can be considered as adequately representative. More than 65% of farmers called reported they received the 2019 advisory messages as they always carry their telephone. Depending on the type of message delivered, 66-82% of the farmers surveyed indicated that they understood the IVR message, with 80-82% of these farmers indicating that they easily understood the precipitation forecasts, which they also suggested were accurate most of the time.

Following questions on receipt of the IVR calls and quality of forecasts, we asked farmers what they did after receiving the calls. Notably, 63-64% of the surveyed farmers started harvesting mung bean after receiving light rainfall forecasts. 69-71% reported taking the same action after receiving the four heavy rainfall alerts deployed in the 14 day period during which IVR alerts were deployed in 2010. A smaller number also reported that they began to arrange labour to harvest their fields. This is not surprising as mung bean farmers in Patuakhali may have several different fields, and could therefore have reported that they started

harvesting in one set of fields while simultaneously arranging labour to harvest in others. A much smaller number of farmers reported making drainage for their fields (ranging from 9-22%).

More detailed analysis can be found in the respective monthly report submitted to Blue Gold and available in Appendix 3, thought the major findings of the monitoring and evaluation work done by the project on the 2019 mung bean season are as follows:

(1) Farmers in project working areas who utilized IVR weather advisories to protect their mung bean from rainfall damage perceived that they saved between 48-52% of their crop from damage and losses.

(2) This equates to between 238 - 772 kg ha $^{-1}$ equivalent of mung bean yield, or EUR 158 – 511 ha^{-1} after accounting for partial costs.

(3) We estimated that farmer respondents to telephone surveys grew mung bean on 51.67, or 31.16 to 164.66 ha in summed total in Betagi Sankipur and Choto Bighai unions in Patuakhali, and Gulishakhali union in Barguna districts.

(4) Actions taken by farmers to avoid rainfall-induced damage appears to have saved a total of between 88 and 204 Mt of mung bean.

(5) This equates to significant value for money, conservatively estimated at between EUR 58,175 – 136,470, or EUR 107,049 on average.

(6) Considering the overall planned investment so far provided by the Blue Gold Innovation fund to CIMMYT (EUR 132,456), activities taken by the project appear to have permitted farmers to avoid damage and losses that are valued at between 42 – 103% of the total Blue Gold Innovation Fund amount contracted to this project (81% on average).

These results suggest that the forecasting system and IVR can be effective in informing farmers of the anticipated weather, and that farmers are quick to take action by harvesting mung bean when rainfall forecasts are provided. Those that did not begin harvesting or that started harvesting some of their fields also reacted by arranging labor to assist in harvesting other fields.

We also queried farmers on the percent of their mung bean crops that they believed they saved from damage by acting on the IVR calls. Survey data strongly indicate that farmers perceive considerable benefits as the calls encouraged them to respond by starting harvesting procedures, thereby resulting in their perception of having saved 45-48% of their mung bean crops from damage. Farmers also indicated very strong demand for the IVR calls, with 99% responding positively to the question 'do you want to get weather forecasts and advisories next year?'. Importantly, these responses are also strongly reflected in the willingness to pay study results described in Objective lll.

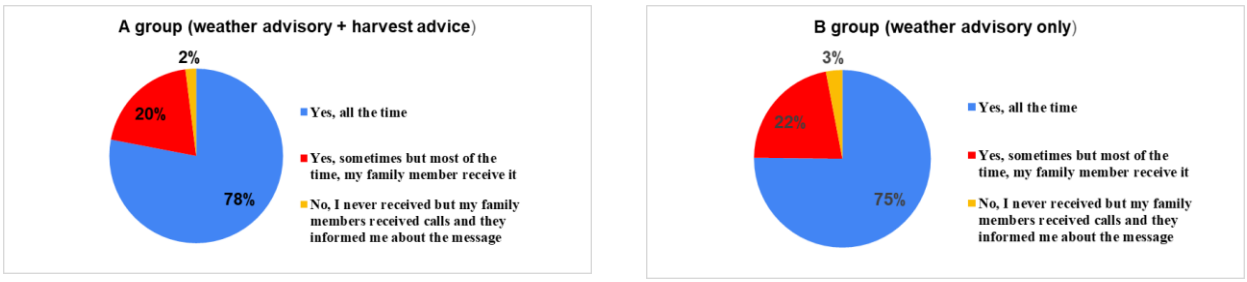
Monitoring, evaluation, and learning from the 2020 climate- and market-smart IVR expansion

Following the 2020 mung bean season, the project deployed an additional follow up telephone survey using roughly the same instrument as in 2019. For comparison sake, and although the IVR system expanded to new areas in 2020, the analysis below focuses only on the same three locations that calls were deployed in during the 2019 season (Choto Bighai, Betagi Sankipur, and Gulisakhali unions). We randomly took 446 farmers' telephone numbers from the IVR call recipient list.

As with 2019 and as noted in previous reports, weather advisories for heavy and very heavy rainfall forecasts were divided into two groups. Group 'A' were given weather forecasts and mung bean

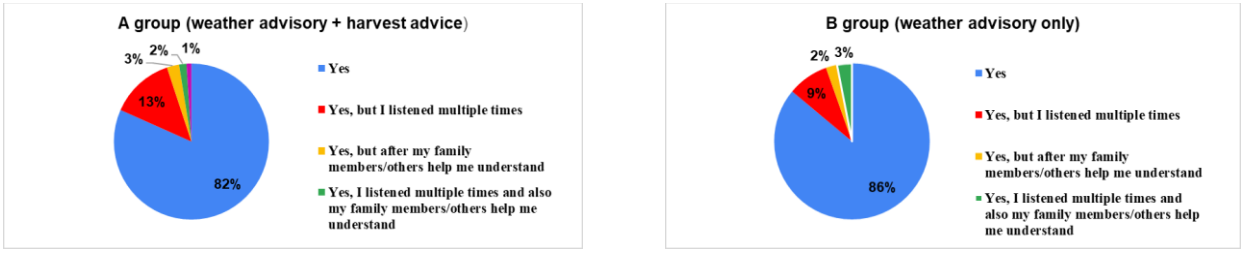
harvesting advisories. Group 'B' were given weather advisories only. The purpose of this exercise was to determine if farmers would respond to weather forecasts alone (the 'B' group) by harvesting mung bean on an accelerated basis, or if additional encouragement was required by advising harvesting (the 'A' group). In our telephone survey, the A group had 200 respondents (189 men and 11 women); the B group had 266 responses (226 men and 40 women).

Key take-away messages from the telephone surveys are detailed in the graphs and passages below. Among the 466 surveyed farmers in 2020, 78% and 75% of the A and B groups reported they received the advisory as they always carry their telephone. 20% and 22% of the A and B groups reported that they received the calls most of the time. If they did not receive the IVR call, they indicated that it was likely that their family members received the calls. The remaining farmers never received the calls, but their family members shared the message with them.



Above: 2020 survey responses to the question 'did you receive weather forecast calls by telephone earlier this year', differentiated by A and B call groups that received weather advisories or weather advisories combined with mung bean management advice, respectively.

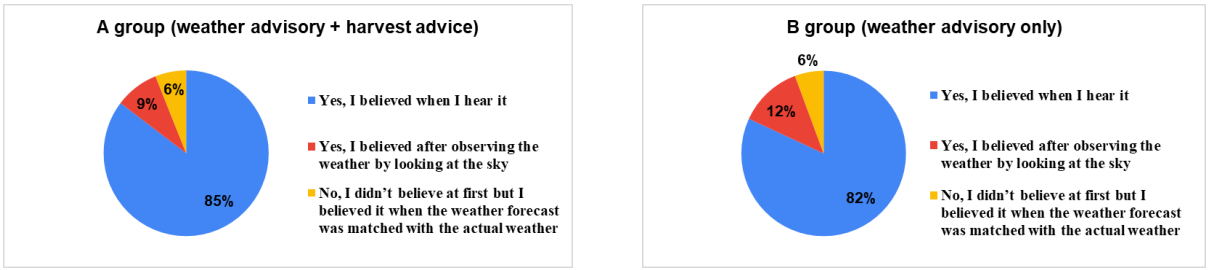
Of the group that responded 'yes' to the question, above, we asked if the IVR telephone message was understood the first time they heard it. 82% and 86% of the A and B groups, respectively clearly stated that they understood the message, though 13% and 9% of the same groups said they understood after listening multiple times. A smaller number of farmers required help from family members and/or multiple listening times to comprehend the messages, while the very limited remainder of the farmers surveyed indicated they did not understand or could not recall the subject of the calls and therefore did not understand them.



Above: Response to the question 'did you understand telephone message when you heard it the first time', differentiated by A and B call groups that received weather advisories or weather advisories combined with mung bean management advice, respectively.

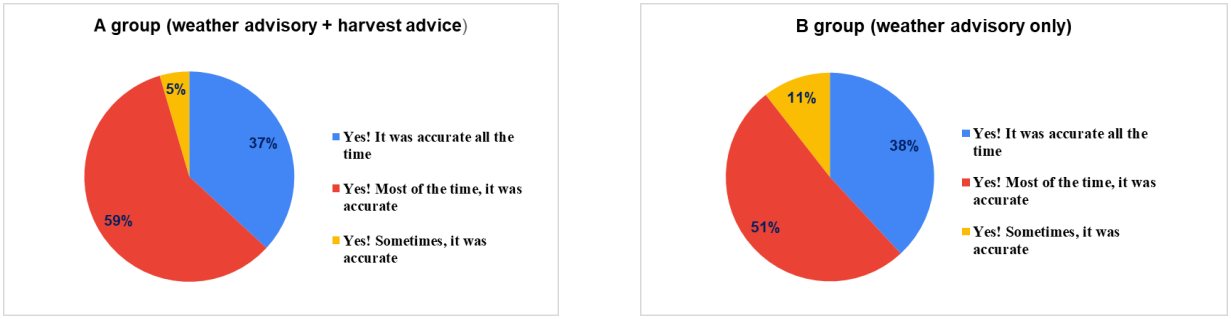
Considering the farmers who understood the IVR calls in the A and B groups, we subsequently asked if they believed in the weather forecasts when they were delivered. In a clear indication that the recordings of forecasts were believed, 85% and 82% of the A and B groups said they understood

the forecast messages. 9% and 12% understood, but also said that they had to visually check the sky and weather conditions before they fully believed the forecasts to be valid. The remaining farmers indicated they believed only after they could confirm the forecasts with observations of the weather, or that they did not believe the forecasts at all. These results are similar to the 2019 surveys.



Above: Response to the question 'did you believe the weather forecast when you heard it the first time', differentiated by A and B call groups that received weather advisories or weather advisories combined with mung bean management advice, respectively.

Farmers were next asked if they thought weather forecasts were accurate this year. In the A group, 37%, 59%, and 5% responded that forecasts were accurate all the time, most of the time, or sometimes. Only one male farmer thought they were not accurate. The B group responses were similar, as shown below. Again, these responses are similar to those observed in 2019, and reinforce the consistency of the results while confirming that farmers appear to have trust in forecasts. Compared to 2019, the percentage of farmers who indicated that forecasts were sometimes accurate declined from 23.1% and 24.5% in the A and B groups, respectively, to 5% and 11% in 2020.



Above: Response to the question 'was the weather forecast accurate', differentiated by A and B call groups that received weather advisories or weather advisories combined with mung bean management advice, respectively.

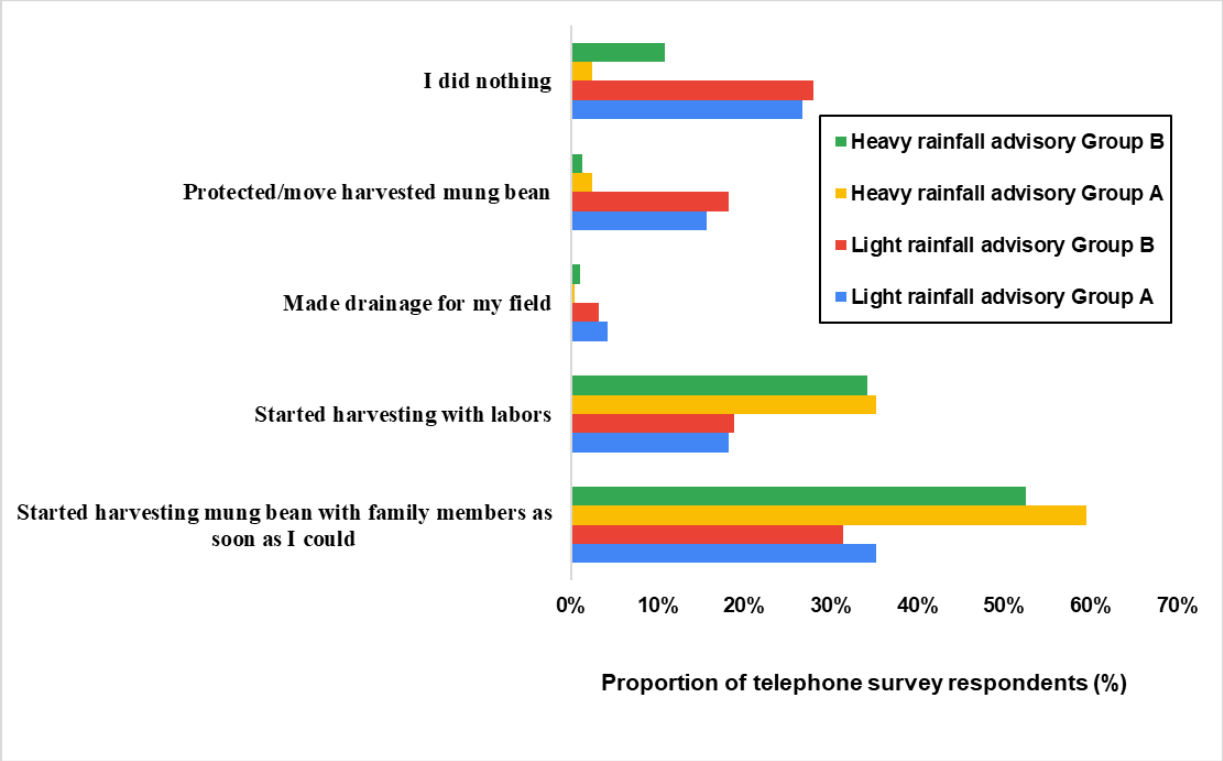
As in 2019, the A and B group forecasts for light rain did not include mung bean management advice as our initial focus group studies indicated that farmers were primarily interested in receiving only heavy rainfall advisories. When heavy or very heavy rainfall was forecasted, the A group also received mung bean harvesting or post-harvest management advice (for men and women, respectively), while the B group did not. We also switched off the IVR system during Cyclone Amphan (which struck Bangladesh on May 20, after most farmers had completed harvest of mung bean). The choice to switch off the IVR system was made so that farmers would not be encouraged by the pre-recorded messages to harvest mung bean at a time during which they should have been seeking shelter.

In the 2020 survey, we also asked farmers what they did after receiving the calls. Most of the farmers participating in the surveys indicated that in the 2020 season, they had sowed mung bean late (largely due to cool temperatures in February). Farmers also indicated that 202 was a rainy season, and that they had encountered a number of rainfall events during the mung bean vegetative state before the crop had fully matured. Therefore, around 30% of farmers who received even the light rainfall forecasts indicated that they had reacted to the information and worked to harvest matured mung bean. This is detailed in the figure below, which indicates that 35% and 31% of the group A and B farmers started harvesting mung bean with the family members after receiving light rainfall forecasts.

In addition, 60% and 53% of the A and B group respondents reported started harvesting starting after receiving the heavy rainfall alerts. Some of the farmers even report that due to water stagnation caused by heavy rainfall, they pulled up entire plants from the field to dry them off-farm. A number of farmers also reported that they began to arrange labor to harvest their fields after getting IVR calls. A smaller number of farmers (1-18%) indicated that they responded to the IVR messages by moving or protecting harvested mung bean from the forecasted rain. A very smaller number of farmers reported making drainage for their fields (ranging from 1-4%).

Depending on the advisory (light or heavy rainfall) or group, 2-28% of the surveyed farmers indicated that they did not do anything when they got the IVR messages, mainly because the crops were not matured, they couldn't go the field for very heavy rainfall, the water entered in the field through broken embarkment, etc. however, far fewer farmers receiving heavy rainfall alerts did nothing in response compared to those who did.

A large proportion of farmers (above 50%) reported that they took action by starting to harvest with the family as soon as possible with heavy rainfall forecasts and over 30% of groups farmers took action by starting to harvest with the family with light rainfall forecasts. Importantly, for some variables, larger differences between A and B groups were observed in 2020. For this reason, data will be subjected to further statistical analyses in the future to attempt to uncover the root causes of the differences, which were most apparent for those farmers who started harvesting as soon as they could when they received heavy rainfall forecasts.



***Above**: Response to the question 'did receiving the voice messages cause you to do something different in how you managed your mung bean this year', differentiated by A and B call groups that received weather advisories or weather advisories combined with mung bean management advice, respectively.*

A key result from this work was that across the A and B groups for farmers who took action to harvest their crop in response to the advisories, estimates were that they saved 71% and 66% of their crops from damage (68.5% on average). Although we have not been able to complete the full economic analysis of the impact of the IVR intervention in 2020 as completed in 2019, data remain under analysis and should become available in August.

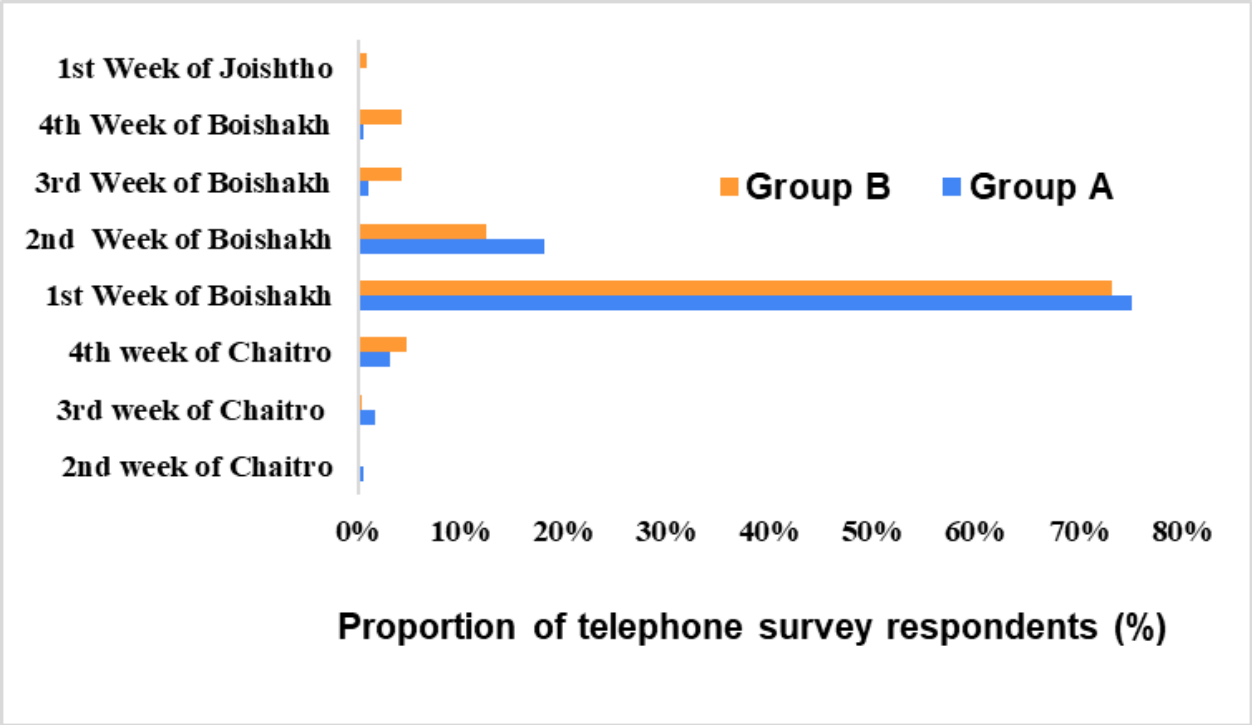
In the telephone survey, we also asked additional questions about IVR calls on mung bean market price for both local and high yield variety and agronomic the usefulness of mung bean agronomic information provided in the IVR calls from May 15th forward, and also the market information deployed from May 28 to June 30 (market price information was deployed regularly even after the harvest period, and when rainfall forecasting had been stopped).

Among the 466 surveyed farmers, 79% and 82% of A and B groups reported that they or their family members received and listened to the mung bean market price information for both local and high yielding improved (BARI) varieties, which were provided at the union and upazila levels. 21% and 18% of the A and B group conversely didn't notice the market price messages after weather messages had played in the call. Some of the farmers who did not listen to the market information indicated they were reluctant to spend additional talk time if they pressed 2 to listen to the market.

Of the group that responded 'yes' to the question, above, we asked what they did after listening to the mung bean market price at the union level and receiving the contact information of their local mung bean traders as a text message that was sent to their phone. As shown below, around 70% of the farmers from group A and B gave the idea of current mung 20% and 25% of group A and B farmers used the information to pro-actively reach out to traders to whom they sold the mung bean directly. A very small number of the farmers

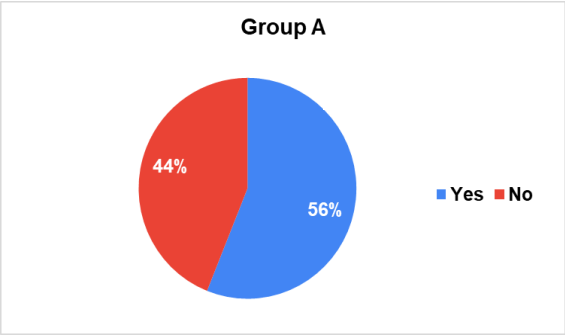
reported (3-8%) that choose not to sell their mung bean in 2020 because they felt other traders were offering them unfair prices based on the additional market information they gained from the IVR calls. These farmers instead opted to keep the mungbean they had grown for home consumption purposes.

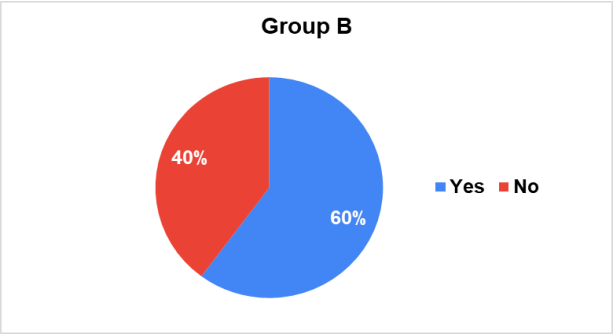
Farmers were also asked if they would like to receive market price information in the future. The majority responded positively, and of those who did, we asked when they would like to receive mung bean market price for both local and high yield varieties. More than 70% of the group A and B farmers requested to deploy the mung bean market price from 1st week of Bangla Month which is mid of April.



***Above**: Response to the question 'Next year, when you would like to receive IVR calls on mung bean market prices at union and Upazila level', differentiated by A and B call groups.*

After getting feedback on mung bean market prices, we asked about the IVR calls on better agronomic information on mung bean. For reference, in 2020, the IVR system provided there were six types of agronomic information (on appropriate seeds, land preparation and sowing practices, fertilizer recommendations, weeding information, advice on irrigation and drainage, and on pest and disease control). 56% and 60% of group A and group B farmers responded that they they or their family members received and listened to the better agronomic mung bean information after listening to the weather forecast and mung bean market price.





***Above**: Response to the question "did you or your family receive and listen to the mung bean agronomic information by telephone alone with weather forecasts and mung bean market price', differentiated by A and B call groups that received weather advisories or weather advisories combined with mung bean management advice, respectively.*

Of the group that responded 'yes' to the question, we asked if they found it useful to receive the agronomic information during the harvest period. As shown below, more than 80% of the group A and B farmers reported that it was not useful to get the agronomic information on mung bean during the harvesting period and that they preferred to get the information at the beginning of the mung bean season. Only 10% and 8% of group A and group B farmers mentioned that it was useful to get the agronomic information as it would help them to practice better agronomy in the 2021 season. These results however present a challenge for the IVR business model described in Objective III, as a near doubling of costs would be required to supply pre-season information to farmers. As such, despite the relatively low positive response rate to this question, it is likely best to continue to deploy the agronomic information as a supplement to the weather and harvesting advisories, as over time, farmers are likely to recall and make use of this information. Additional research planned in 2021 in the CSISA project is likely to address this question to further improve the design of the IVR system.

As the farmers were benefited by receiving IVR calls on weather forecasts last two years and this year they received additional two messages along with weather forecasts, we asked 466 surveyed farmers which IVR calls they would like to get next year during the mung bean harvesting period. The results are clear, indicating that there is a high demand for weather forecasts during the mung bean harvesting period. 61% and 60% of group A and group B farmers suggested they would like to get at least the mung bean market price along with the weather forecast. 24-29% suggested was useful as well. Finally, 11-15% wanted only weather forecasts.

International Maize and Wheat Improvement Centre

Project M&E structure including questions to monitor progress and evaluate outcomes from project activities

	(1) Was this activity successful?	(2) What factors contributed to success or failure?	(3) Is it possible to reproduce this activity to get similar or better results?	(4) Quantitative data collected and data source	(5) Should this activity be scaled up?
Objective 1					
Outcome 1: Mung bean farmers' knowledge gaps, information needs, and decision making frameworks identified	• **Completed in monthly reporting updates:** Output is an email summary/written report section analyzing focus group results and indicating success (or failure) of relevant data collection (submitted in the period following focus groups and with mid-term report):	• **Completed in monthly reporting updates:** Email summary/written report section will consider the degree of farmers' participation and engagement in discussions.	• **Completed in monthly reporting updates:** Email summary/written report section provide recommendations and advice for improvement for other projects wishing to engage farming communities in climate services assessments.	• Number of farmer participants (gender disaggregated from observations): 52 men, 179 women	• Not applicable. This activity and its results provide data to achieve subsequent objectives.
Outcome 2: Social networks mapped to accelerate advisory dissemination	• **Completed in monthly reporting updates:** Output is an email summary/written report section indicating success (or failure) of SNA data collection (submitted with mid-term report)	• **Completed in monthly reporting updates:** Email summary/written report section will consider the degree of farmers' participation and engagement in discussions.	• **Completed in monthly reporting updates:** Email summary/written report section will provide recommendations and advice for other projects considering use of SNA to identify appropriate extension methods and pathways.	• Number of farmer participants (gender disaggregated from observations): 313 farmers participated in research surveys and crop cut yield assessments (312 men; 26 women)	• Not applicable. This activity and its results provide data to achieve subsequent objectives.

	(1) Was this activity successful?	(2) What factors contributed to success or failure?	(3) Is it possible to reproduce this activity to get similar or better results?	(4) Quantitative data collected and data source	(5) Should this activity be scaled up?
Objective 2					
Outcome 1: Existing advisory ICTs evaluated with opportunities for adaptation identified	• **Completed in monthly reporting updates:** Output is an email summary/written report section analyzing focus group results and indicating success (or failure) of relevant data collection (submitted with mid-term report)	• **Completed in monthly reporting updates:** Email summary/written report section will consider the degree of farmers' participation and engagement in discussions.	• **Completed in monthly reporting updates:** Report section will provide recommendations and advice for improvement for other projects using focus groups to assess ICT innovations from the perspective of farmers and extension services.	• Number of farmer, extension agent, or other NGO or development organization participants: 567 men and 194 women were involved in activities aligned with this outcome over the course of the project.	• Not applicable. This activity and its results provide data to achieve subsequent objectives.
Outcome 2: Heavy rainfall forecast skill evaluated and improved	• **Completed in monthly reporting updates:** Output is an email summary/written report section detailing accuracy of current accuracy of heavy rainfall event forecasts and methods used to improve forecast skill (with mid-term and final cumulative reports)	• **Completed in monthly reporting updates:** Email summary/written report section will detail algorithms and corrective measures implemented to improve forecast skill.	• **Completed in monthly reporting updates:** Because algorithms and clarification of models used will be detailed in the report, this activity should be replicable by other projects or researchers.	• Frequency and number of people estimated to receive improved forecast information (gender disaggregated from observations): 4,227(Male: 3834 and Female: 393)	• **Completed in monthly reporting updates:** Only minor improvements in forecast skill were achieved. However, a novel method for prediction of rainfall event thresholds was developed and can be reproduced by other scientists, as the methods are well documented.
Outcome 3: Farmer-friendly advisory system piloted	• **Completed in monthly reporting updates:** Output is an email summary/written report section on innovation dissemination outputs and milestones. This will provide quantitative data in both the mid-term and final cumulative reports)	• **Completed in monthly reporting updates:** Email summary/written report section will include information from focus groups with farmers and extension and development organization staff reporting their impressions of the benefits and constraints of the climate- and market-smart mung bean advisory innovation. These data will be reported qualitatively.	• **Completed in monthly reporting updates:** Email summary/written report section will detail qualitative observations on the potential to reproduce or improve this activity in other similar projects and agricultural contexts	• Number of farmers and extension agents receiving advisories directly (from ICTs) and indirectly (word of mouth) (gender disaggregated from observations): 4227(Male: 3834 and Female: 393) • Number of farmers adapting production by using advisories (directly (from ICTs) and indirectly (word of mouth) (gender disaggregated from observations): Rough estimates based on responsiveness in the 2019 survey applied to both 2019 and 2020 mung bean season data indicate 2,513 men and 194 women (assuming a 65% rate of farmers adapting practices).	• **Completed in monthly reporting updates:** Based on farmer and extension agent focus group assessment estimates following the 2019 and 2020 mung bean seasons, the email/mini-report will assess the potential for scaling-up of the innovation.

				• Land area (ha) upon which advisory information was applied (gender disaggregated from observations): Rough estimates based on responsiveness in the 2019 survey applied to both 2019 and 2020 mung bean season data indicate 904.7 ha farmed by men and 69.3 has farmed by women (assuming a 65% rate of farmers adapting practices and an average field size per farmer of 0.36 ha).	
Outcome 4: Social Network Analysis (SNA)results leveraged to improve 'last-mile' advisory dissemination	• **Completed in monthly reporting updates:** Output is an email summary/written report section on the SNA analysis in both the mid-term and final cumulative reports)	• **Completed in monthly reporting updates:** Email summary/written report section will include information from SNA research, focus groups with farmers and extension and development organization staff. The MSC. student's thesis is another factor contributing to success or failure. The thesis will be included in the final project report as an annex.	• **Completed in monthly reporting updates:** Email summary/written report section will detail qualitative observations on the potential to reproduce or improve SNA work to benefit agricultural extension efforts in other similar projects and contexts	• 313 farmers participated in research surveys and crop cut yield assessments (312 men; 26 women)	• Not directly applicable. This activity and its results provide data to achieve subsequent objectives, although other projects may wish to consider using SNA to inform extension activities, pending the results and lessons learned from this work.

	(1) Was this activity successful?	(2) What factors contributed to success or failure?	(3) Is it possible to reproduce this activity to get similar or better results?	(4) Quantitative data collected and data source	(5) Should this activity be scaled up?
Objective 3 **Outcome 1:** Scaling potential for climate- and market-smart mung bean advisories through ongoing extension activities assessed	• **Completed in monthly reporting updates:** Output will be included as an email summary/as part of the final report detailing results from discussions and negotiations with partners (public and private) to include the climate- and market-smart mung bean advisory information in other climate services and relevant extension projects	• **Completed in monthly reporting updates:** Email summary/written report section will include information from focus groups with extension and private sector partners reporting their impressions of the benefits and constraints of the climate- and market-smart mung bean advisory innovation for use in other projects and activities. These data will be reported qualitatively.	• **Completed in monthly reporting updates:** Based on the findings from the two cells to the left, the mini-report will detail qualitative observations on the potential to reproduce or improve this activity in other similar projects and agricultural contexts.	• Number of participants in focus group discussions and workshops: 118 men and 54 women. • **Completed:** Number of advisory styles reviewed: More than ten advisory styles / formats / ICT types were reviewed in focus groups. • **Completed:** Number of advisory styles selected for out-scaling: Three (2 IVR groups A and B, one app)	• **Completed in monthly reporting updates:** Email summary/written report section will provide commentary from partners regarding the potential and their intentions for including the climate- and market-smart mung bean advisory system as a component in future projects, alongside estimates from extension partners regarding the gender- and categorically disaggregated advisory recipients
Outcome 2: Business models for private sector investment in climate- and market-smart mung bean advisories developed and evaluated	• **Completed in monthly reporting updates:** Output will be included as an email summary/as part of the final report detailing discussions and workshop results with private sector partners interested in investing in the climate- and market-smart mung bean advisory innovation. The report section (which will appear as part of the final report) will include business models constructed using the business model canvass (Osterwalder, and Pigneur 2010)	• **Completed in monthly reporting updates:** We will adapted during our COVID-19 crisis Zoom response calls to include ideas and concerns solicited from private sector partners regarding what factors are likely to contribute to success or failure. This information can be used to qualitatively judge the potential for scaling-up the business model in practice.	• **Completed in monthly reporting updates:** Based on the findings from the two cells to the left, the mini-reports have detail qualitative observations on the potential to reproduce or improve this activity in other similar projects and agricultural contexts.	• Number of participants in focus group discussions and workshops: 118 men and 54 women. • Estimates of level of financial investment (in Euros per organization) in sustaining market information supply and use of the climate- and market-smart mung bean advisory innovation over a five-year period: This can be estimated only after the project is completed during subsequent scaling phases, and will be attempted to be done in the CSISA projects.	• **Completed in monthly reporting updates:** The email summary/ part of the final report will provide commentary from private sector partners regarding their interest in investing in (with cost-benefit and transaction cost reduction analysis) and scaling-out use of the climate- and market-smart mung bean advisory systems, with additional discussion on the scope to expand to other crops.

CHELLENGES, MITIGATION MEASURES, LESSONS LEARNED

Learnings from this project are numerous, but can be neatly summarized in a few simple sentences. First we learned that climate and market information services need to be demand driven, and based on farmer's preferences in order to be successful. Use of focus groups and consumer testing to improve the IVR and app systems helped generate robust products. Secondly, partnerships are key. Our innovations relied on CIMMYT's established relationship with the Department of Agricultural Extension (to assist in designing services and accessing farmers), and BMD (to supply weather data, forecasts, and participate in analysis and develop thresholds to trigger advisories). Without these partnerships, and the integration of BIID to build the IVR and app systems, the project would not have been successful. Lastly, the onset of the COVID-19 crisis hampered Objective 3 activities in the end of the project (rather than the three Outcome 1 and two Outcome 2 workshops planned, one workshop was held in person for Outcome 1 with an additional one moved online after the COVID-19 crisis began. For Outcome 2, only one workshop was held and it was moved to zoom; that said, the workshop was larger than anticipated and very successful[2]. It was not possible to hold as many in-person workshops as had been planned. For this reason, interactions were taken online, with Zoom meetings held instead as described in the report above.

[2] We wish to note that per-diems for attendees of all workshops were paid out as per the project budget.

APPENDICES

'Leveraging decision making science to sustain climate- and market-smart mung bean advisories in Patuakhali's polder communities'

Appendix I, II and III for this project can be found in a drop box by clicking this link.