INITIATIVE ON
Transforming Agrifood Systems in South Asia

INITIATIVE ON
Asian Mega-Deltas

Can digital climate services help avert agricultural losses and damage?

Insights from a social experiment with women farmers in Bangladesh

Research Note 18

December 2023

ABOUT THIS NOTE

This research note explains the results of social experiment designed with three primary objectives. These include (1) to mitigate the digital divide concerning the accessibility of forecasted weather information and crop advisories for women farmers in Bangladesh and (2) to assess the potential impact of a digital climate advisory tool on the agricultural practices of women farmers. Finally, (3) we sought to assess the potential advantages of climate-smart agriculture facilitated by digital advisory tools for stakeholders in the value chain, such as microfinance institutions offering crop loans in areas facing higher weather-related risks. 'Agvisely' is a farming systems decision support system (DSS) for Bangladesh. It serves as the digital climate advisory tool used in this experiment. The study involved 120 female farmers in Patuakhali district of coastal Bangladesh. We aimed to assess the impact of climate services on the cultivation of mung bean (*Vigna radiata*) and *boro* rice (*Oryza sativa*) during the winter *rabi* season.

KEY STUDY FINDINGS

1) Agvisely weather-forecast based farm management advisories resulted in higher productivity of both *boro* rice and mung bean grown by women.
2) Farmers altered their farm management practices based on weather forecasts and crop management advisories, thereby mitigating losses attributed to weather conditions affecting crop yields.
3) Trained lead farmers conveyed advice generated by the Agvisely DSS to randomly selected female farmers who did not possess smartphones through telephone calls.
4) Sixty-five percent of farmers self-reported an average financial benefit of USD 537 for *boro* rice and USD 207 for mung bean per hectare due in part to utilization of weather information-based advisory services. Switching regression model results suggest a potential (average) yield gain of 1,173 kg per farmer (2,298 kg per hectare) compared to control farmers if they used Agvisely-based advisory for *boro* rice.

CIMMYT
IFPRI International Food Policy Research Institute
IRRI International Rice Research Institute
IWMI International Water Management Institute
CIP International Potato Center

BACKGROUND AND RATIONALE

The southern coastal zone of Bangladesh is a hotspot for climate change related risks, where farmers grapple with weather events that lead to crop stress and often significant financial losses. Digital climate services tools like 'Agvisely' are often proposed as solution to enhance farmers' capacity to make smart farming decisions by providing crop-stage-specific advisories based on high-frequency and downscaled weather forecasts. Given the fact that digital solutions often fail to reach women and marginal farmers, empowering women lead farmers by training them to use digital climate information services can potentially enable them to become catalysts for change and improve inclusivity of climate services.

There are many high-quality digital climate services emerging worldwide, several of which are related to agriculture. These services leverage advanced weather forecasting abilities combined with expertise in crop science to generate localized and crop stage-specific advisories (Simelton and McCampbell, 2021; Ganesan et al., 2020; Das et al., 2018). Together with the Bangladesh Meteorological Department (BMD) and Department of Agricultural Extension (DAE) in Bangladesh, the International Maize and Wheat Improvement Center (CIMMYT) developed climate service decision support system called 'Agvisely'. The tool was developed initially with USAID support through the Cereal Systems Initative for South Asia (CSISA) and was approved for use by the Ministry of Agriculture in December of 2019.

Agvisely generates climate advisory services for multiple crops, including rice, maize, wheat, lentil, mung bean, potato and mustard. The DSS processes gridded short-term weather forecasts (temperature, rainfall, and humidity) from BMD and downscales them for all 465 sub-districts of Bangladesh. Location-specific and customized advisories at various critical stages, from crop establishment to harvesting (Bamis, 2021; BMD, 2021), are generated using the forecasts, in combination with information on the crop-specific biological thresholds (phenological stage-specific) for rainfall and temperature stress embedded in the system.

Farmers in the southern coastal zone of Bangladesh, a hotspot for climate risks, often experience extreme weather (Akter, 2015; Alamgir, 2018; Barua, 2017, 2020; Rahman, 2015). Extreme weather can often result in crop damage and economic losses that not only affect farmers but also other stakeholders in the value chain, including microfinance, banking, input, and output dealers as well as processors (Luzardo et al., 2020).

Digital climate service applications like Agvisely are suggested as potential options to help prevent crop losses due to unfavorable rainfall and temperature extremes by advising on actions such as changing seeding dates, irrigation and/or nutrient management, and the timing of harvesting, among other interventions. Use of these advisories can potentially benefit both farmers and other value chain actors.

STUDY OBJECTIVES

i) To understand how a digital advisory tool that provides short-term forecasts (with a 5-day lead time) with crop-specific advisories (Agvisely) can influence farmers' decision-making throughout a cropping season and minimize the risk of crop losses due to weather-related events.

ii) To investigate whether trained female lead farmers can serve as digital service providers for women farmers who lack access to smartphones, thereby ensuring inclusivity within the digital service.

iii) To explore whether microfinance agencies can function as providers of forecast-based advisories to borrower farmers, aiming to mitigate the credit default risk arising from unpredictable weather events

THE SOCIAL EXPERIMENT

Between February 2023 and June 2023, CIMMYT collaborated with the NGO, *Grameen Jano Unnayan Sangstha* (GJUS), to involve 120 female farm microfinance recipients in testing the Agvisely DSS. Farmers were randomly selected from the list of current or previous loan recipients of GJUS, cultivating *boro* rice and *mung bean* during the winter *rabi* season in four unions of the Patuakhali district in southern Bangladesh (Figure 1).

When a farmer borrower of microfinance experiences crop loss due to weather extremes, it poses a risk to microfinance lending. As there is no crop insurance available for micro-borrowers, forecast-based advisories can potentially help in reducing their risk of default or delays in loan repayment. In response, we collaborated with GJUS to design a preliminary study during the winter *rabi* season of 2022-2023.

As Agvisely is a digitally-based DSS, one of the main challenges in setting up the experiment was farmers' access to smartphones, as the majority utilize feature phones. Given the documented evidence of women farmers having limited access to smartphones and weather-related information in Bangladesh (Rahman and Huq, 2023), the study was tailored for women borrowers of microcredit, focusing on two key crops including winter *boro* rice and mung bean.

We trained GJUS staff on use of the Agvisely DSS so that their staff members could subsequently train lead women farmers, who possess smartphones with internet access. As part of the study, these lead farmers disseminated crop management advisories from Agvisely application for *boro* rice and mung bean to women farmers who lacked access to smartphones and who had low levels of digital literacy to interpret the information. This dissemination occurred through phone calls made twice a week during which crop management advice was verbally transferred to women farmers.

METHODOLOGY

120 farmers were randomly selected from the list of past and present microcredit borrowers of GJUS to be a part of the experiment. 60 *boro* rice and mung bean farmers received regular calls (twice weekly) providing five-day forecast-based advisories for these crops. Calls were delivered by lead farmers trained by GJUS in using the Agvisely app. Training they received enabled them to understand and communicate effectively the management advice automatically generated by the Agvisely algorithm in response to the 5 days weather forecast. Each lead farmer conveyed the forecast and advisories for rice and mungbean to 10 farmer micro-finance borrowers once every three days through telephone calls. The remaining 60 randomly selected farmers constituted the control group, who did not receive any form of weather information or advisory service. CIMMYT collected data from the women farmers (in the treated group) every week on how they utilized the information provided by the women service providers through telephone surveys.

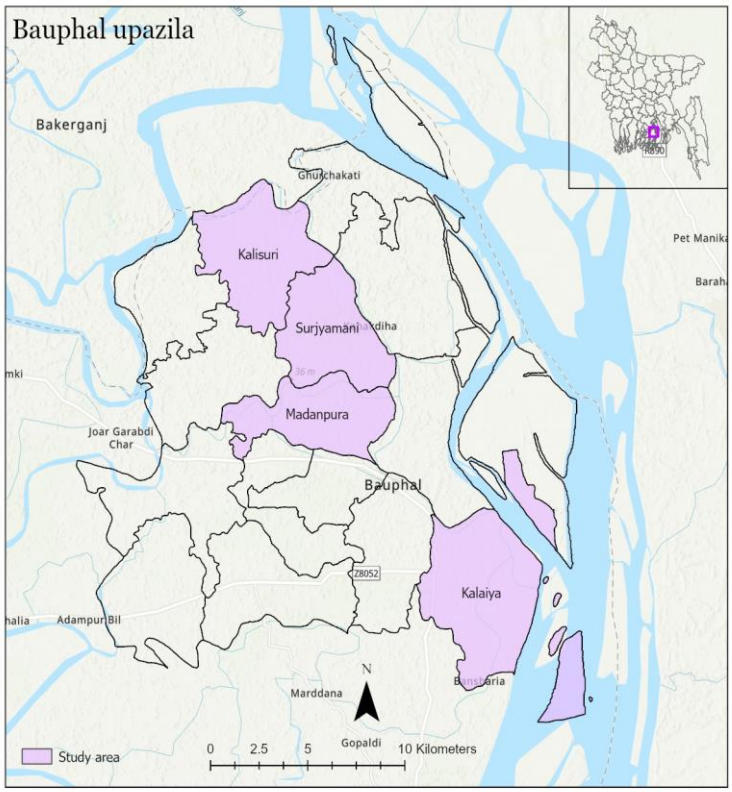

Figure 1. Study area of indicating four unions in the Patuakhali district.

Initial pre-study baseline data collection with selected women farmer beneficiaries was conducted through face-to-face interviews by GJUS's trained enumerators. Additionally, enumerators collected data from participating farmers (both Agvisely advisory users and control group) through weekly telephonic surveys, beginning on the 15th of February 2023. For this high-frequency data on crop management decisions (rice and mungbean) from farmers, CIMMYT prepared a survey questionnaire, which was implemented using Open Data Kit (ODK) software (Figure 2).

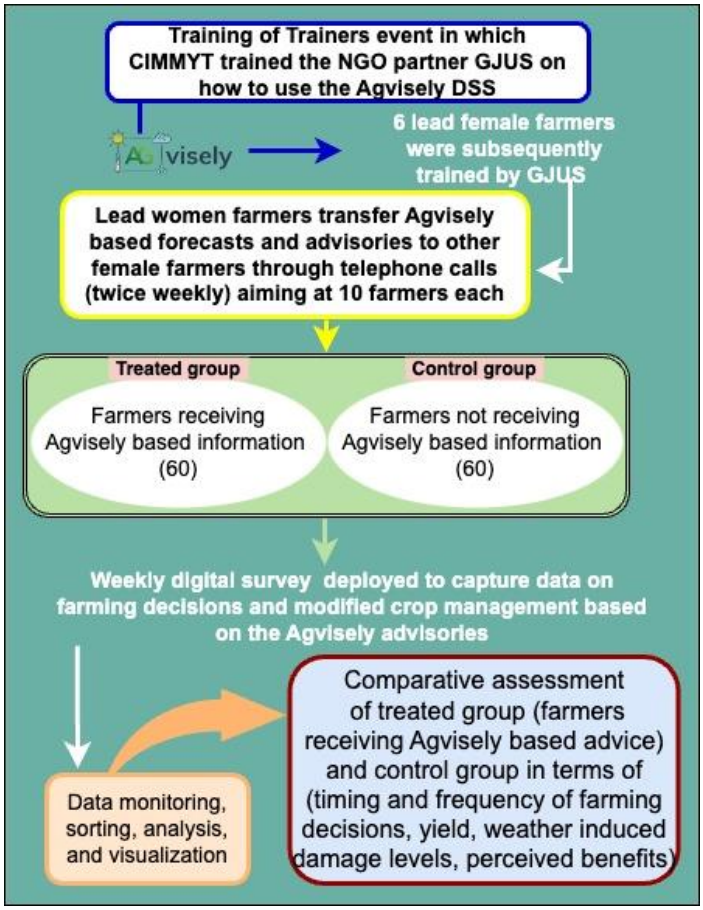

Figure 2. Main steps in the process of the climate services experiment

The weekly surveys were conducted to collect information regarding the farmers' crop-specific weekly management decision-making, including the inputs utilized and actions taken in response to (or rejection of) the climate service information provided through Agvisely trained lead farmers. The survey also gathered exact dates of agricultural operations. Enumerators also gathered information on farmers' perceptions of the effectiveness and accuracy of the climate advice received. At the end of the survey period, data on self-reported crop yield, weather-related crop losses, and crop savings due to advisory services (for farmers who received Agvisely-based information) were also collected. Relevant data were contrasted with control group farmers.

Data analysis and visualization were used to understand the difference between Agvisely and control farmers. A switching regression model (Equations 1-4) was applied to determine key decision variables influencing the yield of both Agvisely and control farmers, and to simulate the yields of the control group farmers if they had also followed the decision-making behavior of Agvisely group of farmers. Equations 1 through 4 are described below:

$$F^i = 1 \text{ if } \beta Z^i + u^i > 0 \quad (1)$$

$$F^i = 0 \text{ if } \beta Z^i + u^i \leq 0 \quad (2)$$

where F^i are the regimes of crop management decisions applied by farmers using information and advice from Agvisely and Z^i are determinant variables.

In assessing potential yield, this leads to two regime equations:

$$\text{Regime 1: } Y^i = \gamma_1 X_1^i + \epsilon_1^i, \text{if } F^i = 1 \quad (3)$$

$$\text{Regime 2: } Y^i = \gamma_2 X_2^i + \epsilon_2^i, \text{if } F^i = 0 \quad (4)$$

PRELIMINARY STUDY FINDINGS

Collected data indicated that farmers who obtained forecasts-based advisories demonstrated a higher level of productivity compared to the control group of farmers who did not get any kind of weather forecast form any sources at all (Figure 3 shows the yield information ordered as highest to lowest for Agvisely and control group).

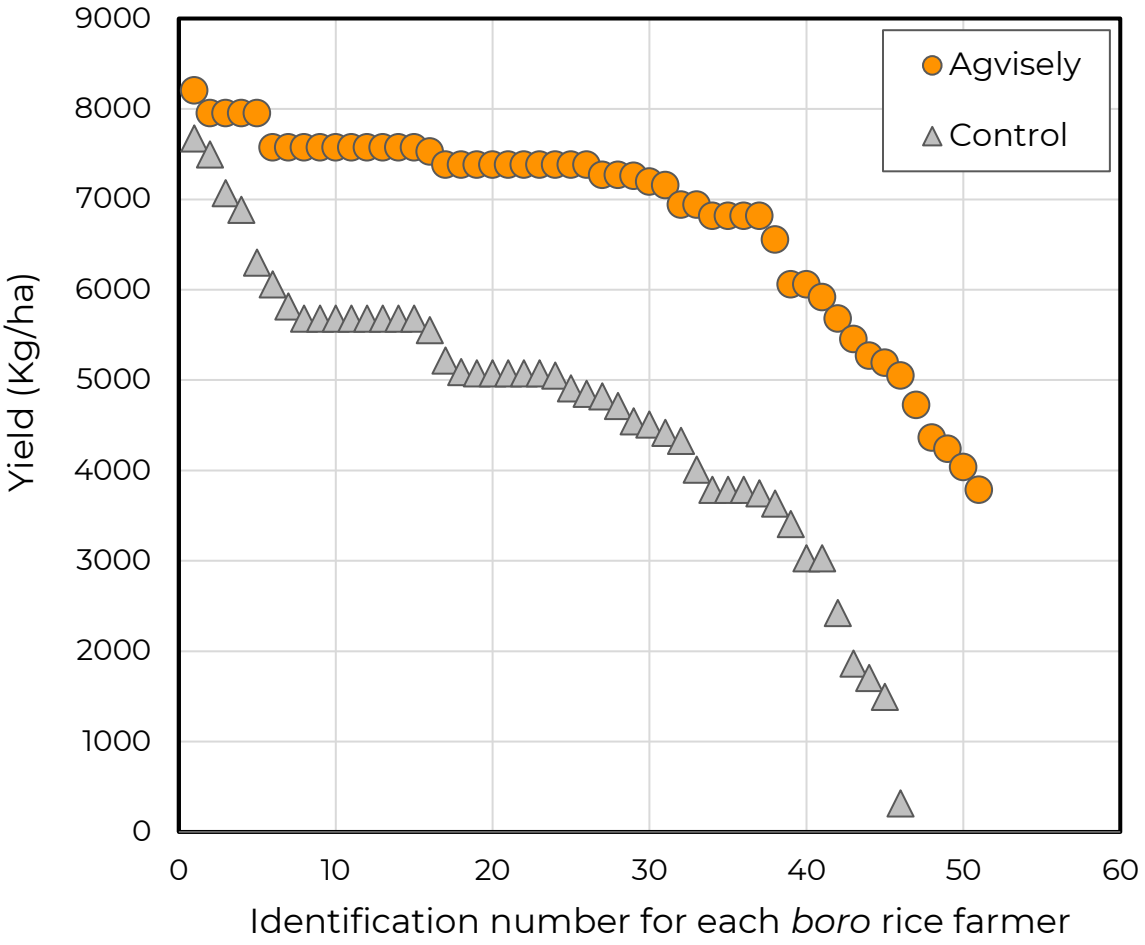

Figure 3: Self-reported yields from farmers accessing Agvisely derived crop management advisories compared to control group farmers for *boro* rice.

Women farmers who received advisories from lead farmers using Agvisely reported productivity of *boro* rice ranging from 3,787 to 8,206 Kg/ha, whereas most of the control farmers' productivity ranged from near complete crop loss at 318 kg/ha to very high yield at 7,676 Kg/ha. Note that these are farmers' self-reported yield levels. 23% of farmers in the control group lost their yield completely where 15% of Agvisely-informed farmers lost the crop.

We also examined the economic implications of yield differences between farmers who had received Agvisely-based information and the control group. Data suggest that losses were lower for farmers who received weather forecast information and associated crop advisories generated by Agvisely (Figure 4). Our analysis suggests that 35% the farmers using Agvisely-based information still faced financial losses in the cultivation of *boro* rice. This suggests the challenges in growing this input intensive crop. Conversely, however, nearly double – 62% – of the control group farmers had estimated production costs higher than returns from the cultivation of *boro* rice.

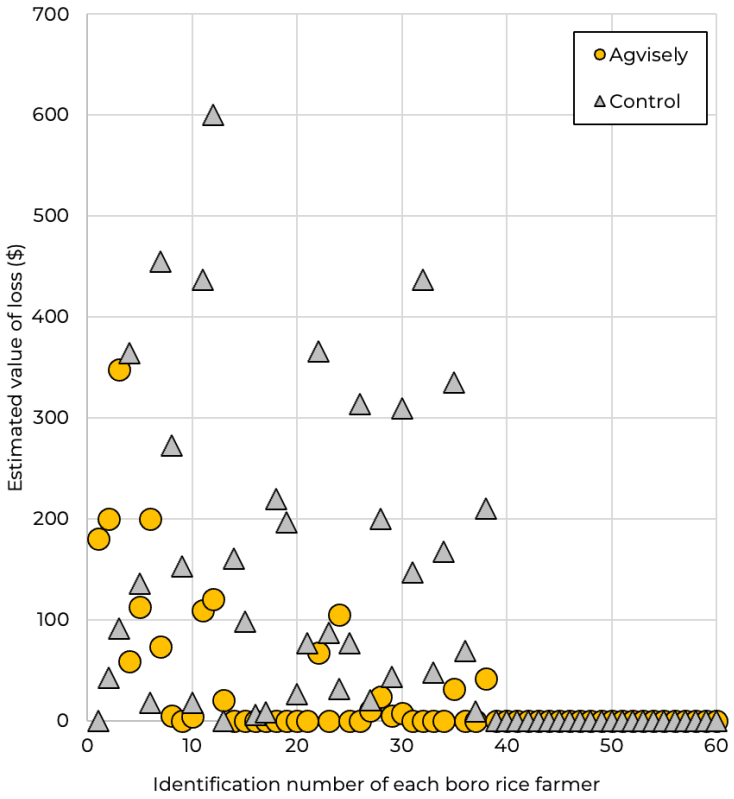

Figure 4. Total financial loss estimation for *boro* rice farmers.

We also asked women farmers who accessed crop management information via telephone call from other lead women farmers what their perceived benefit of regular weather information and advisories for *boro* rice was. 65% that they perceived financial benefit, with an average of USD 537 dollars, the highest being USD 1,547 (Figure 5). Switching regression model results in Table 1 show that the decision variables contributing to the increased yield of farmers using Agvisely appears to be optimized transplanting and improved irrigation decisions during high temperatures during the 2022-2023 *rabi* season.

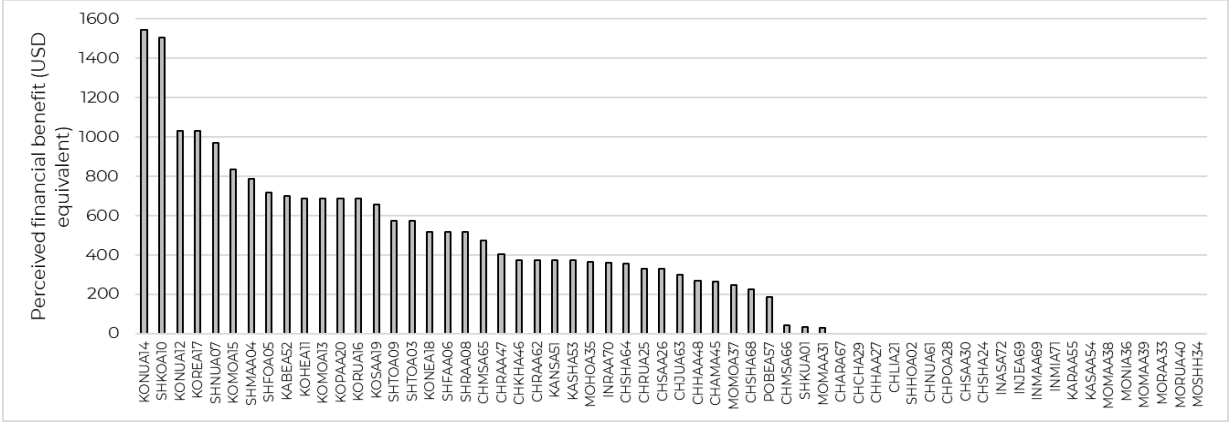

Figure 5. Farmers' perception of the financial benefit accrued from use of Agvisely for *boro* rice production. The *x* axis shows the code number for each farmer considered.

Sixty-five percent of farmers self-reported an average financial benefit of USD 537 for *boro* rice per hectare due in part to utilization of weather information-based advisory services.

Table 1. results the switching regression model for *boro* rice yield (top table section) and the selection equation terms (bottom table section)

Variable	Agvisely farmers				Non-Agvisely (control) farmers		
	Explanation of variables	Coefficient	Std. err.	z	Coefficient	Std. err.	z
area ha	Area of Boro rice cultivation (Ha)	6290.22	443.91	14.16	2950.84	783.46	3.76***
purchasefert	Purchase cost of fertilizer (BDT)	-0.07234	0.03	-2.11	-0.07388	0.09	-0.86
costofirrigationtaka	Cost of irrigation (BDT)	0.00038	0.03	0.01	-0.07176	0.06	-1.2
ir index	Frequency of irrigation application within the forecast span of rainfall	-52.77531	102.54	-0.51	-396.56	167.25	-2.21**
it index	Frequency of irrigation application within the forecast span of high temperature	-47.53326	63.72	-0.75	89.29735	93.50	0.96
fr index	Frequency of fertilizer application within the forecast span of rainfall	4.63905	86.34	0.05	-70.73599	173.88	-0.41
pr index	Frequency of pesticide application within the forecast span of rainfall	-130.00	93.83	-1.39	-118.03	201.62	-0.59
hr index	Frequency of harvesting within the forecast span of rainfall	-8.50997	208.22	-0.04	165.37550	921.48	0.18
Delay in transplanting	Delay in transplanting compared to earliest planting date in sample (days)	-4.90061	8.01	-0.61	-36.37650	18.15	-2.00**
cons		1100.76	749.86	1.46	3460.2	1670.65	2.07

Variable	Variable definition	Coefficient	Std. err.	z
area ha	Area of *boro* rice cultivation (Ha)	-1.19895	0.82	-1.45
purchasefert	Purchase cost of fertilizer (BDT)	0.00000	0.00008	0.01
costofirrigationtaka	Cost of irrigation (BDT)	0.00005	0.00008	0.61
ir index	Frequency of irrigation application within the forecast span rainfall	-0.03719	0.22	-0.17
it index	Frequency of irrigation application within the forecast span of high temperature	0.04178	0.14	0.3
fr index	Frequency of fertilizer application within the forecast span of rainfall	-0.39590	0.2	-1.95
delayintransplanting	Delay in transplanting	0.00085	0.02	0.04
pr index	Frequency of pesticide application within the forecast span of rainfall	0.33991	0.19	1.81
hr index	Frequency of harvesting within the forecast span of rainfall	-0.38733	0.51	-0.75
age	Age of the farmer (years)	0.03638	0.02	1.75
smart phone code	Have smart phone (yes or no)	0.49845	0.45	1.12
loan GJUS taka	Received loan from GJUS (yes or no)	0.00002	0.00001	2.57
cons		-0.92608	1.66	-0.56
/lns1		6.37556	0.17	35.35
/lns2		6.88868	0.11	62.96
/r1		-0.57034	0.72	-0.79
/r2		-0.01862	1.22	-0.02

Regime 1 refers to farmers who received decision support from weather forecast-based crop management advice from Agvisely while Regime 0 represents the control group (Table 1). Switching regression was performed using the 'movestay' command in Stata software. Utilizing the results from the switching regression, the yield levels of control farmers (Regime 2) were estimated assuming they had similar decision behavior to the farmers who received information based on Agvisely (Regime 1). Our preliminary estimates indicate that yields could have been increased by 1,173 kg per farmer (2,298 kg per hectare) compared to control farmers if they had received Agvisely-based information (figure 6).

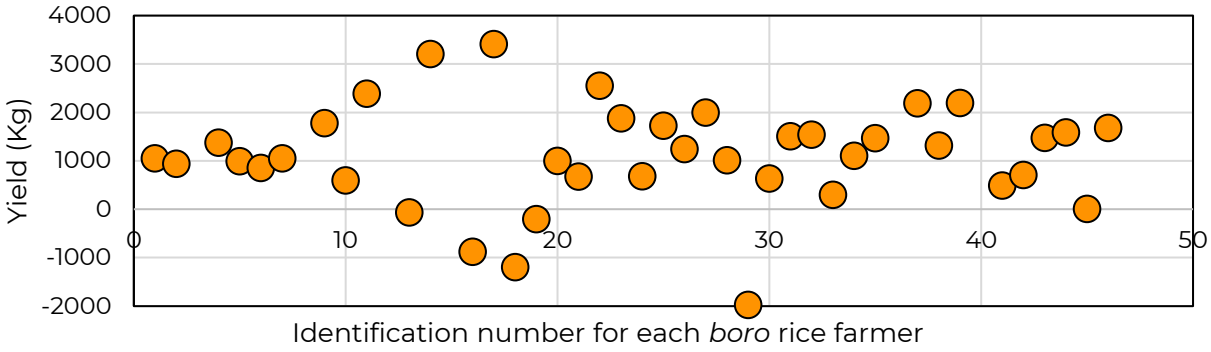

Figure 6. Predicted yield of non-Agvisely advisory using (control) farmers using switching regression results.

Alongside *boro* rice, farmers in this study also cultivated mung bean, considering it a high potential profit cash crop requiring relatively low investment. Despite this, unpredictable rainfall and high temperatures during the harvesting period appeared to have contributed to yield losses among many of the farmers participating in the experiment . Figure 7 illustrates the production levels of mung bean farmers who received forecasts along with advisories five days in advance, compared to those of the control group farmers.

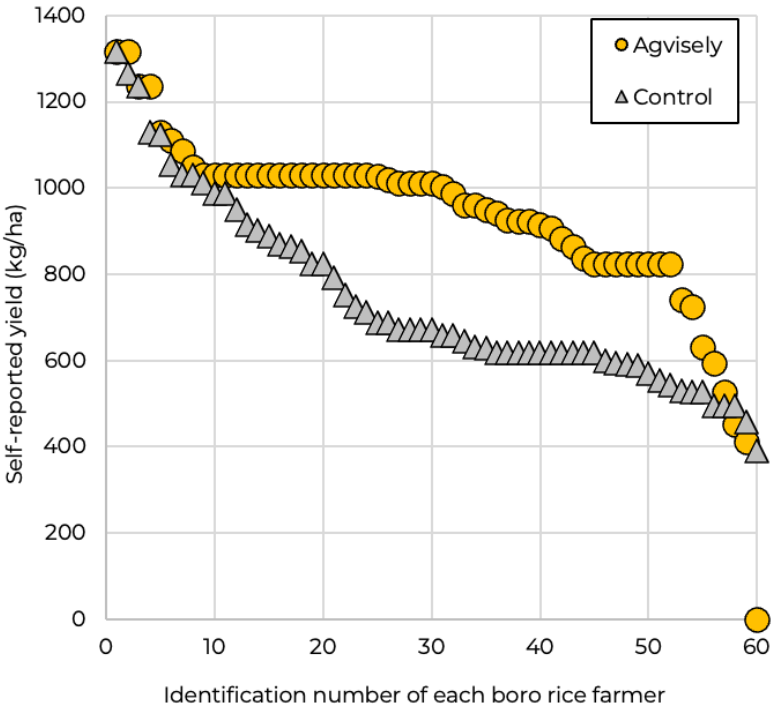

Figure 7. Farmers' self-reported yields for mung bean arranged from highest to lowest including farmers who accessed information from Agvisely on the *y* axis, and control group farmers on the *x* axis.

Data also showed that farmers who used advisories from Agvisely self-reported a lower percentage of yield loss from weather-induced crop damage (16%) for mung bean compared to control farmers (24%) (refer to Figure 8)

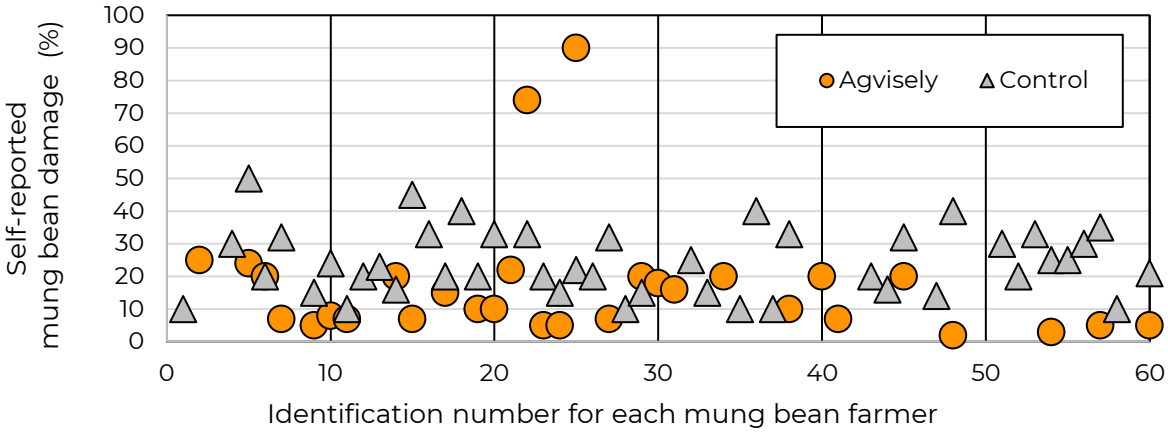

Figure 8: Self-reported crop damage percentage from farmers accessing Agvisely derived crop management advisories compared to control group farmers for mung bean.

According to self-reported damage information, among the 60 farmers who received Agvisely-based forecasted advisories, 34 did not experience any damage due to weather extremes or incidents during the experimental season.

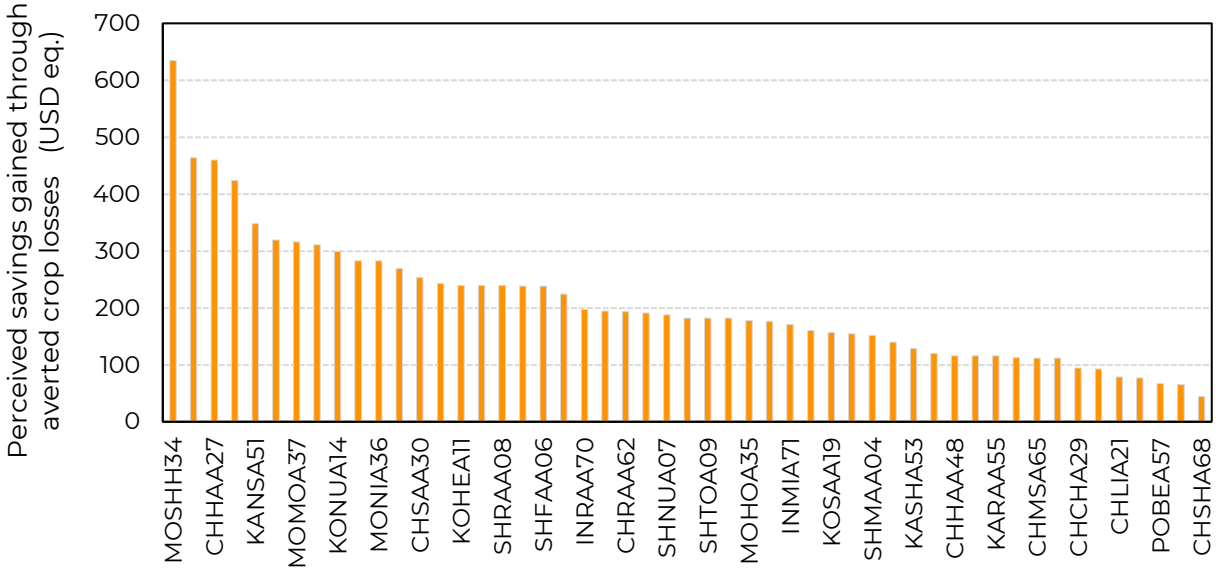

Figure 5. Farmers' perception of the financial benefit accrued from use of Agvisely to avert losses and damage from weather events in mung bean cultivation. The *x* axis shows the code number for each farmer considered.

According to farmers' perceptions, the economic benefit associated with Agvisely use to assist in mung bean management helped contribute to saving of USD 207 per farmer by averting losses and damage from weather extremes. The highest perceived saving reported was USD 635 per farmer (Figure 9).

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Women farmer borrowers associated with the NGO GJUS in southern Bangladesh perceive the 'women to women digital service provider model' of agro-meteorological advisory services as beneficial for both *boro* rice and mung bean cultivation. For both crops, the productivity levels of the Agvisely group of farmers were higher than those of the control farmers. Conversely, the percentage of financial losses resulting from weather induced crop damage was perceived to be lower among farmers that used Agvisely compared to the control group. Yield differences, perceived benefits from climate advisory services by the farmers who received Agvisely based advisory, difference in weather-related crop damage between the groups, and estimated benefits of Agvisely use to control group from the switching regression model provide preliminary backing to these observations.

The results from the switching regression model suggested that access to information from Agvisely helped support improved decision making on irrigation timing and the time of crop establishment (transplanting). Our preliminary study suggests that this may have contributed to higher yields compared to farmers who did not receive any forecasts or management advice. For microfinance institutions, the digital advisory services offered by Agvisely could be helpful in protecting their investments (e.g. loans for inputs for boro rice or mungbean farmers) from a delay or default of repayment due to weather-related stresses. While insurance offsets the cost of weather-related yield losses through compensatory payments, farmers' ability to intervene in crop management with the Agvisely DSS appears to hold promise in preventing loss and damage themselves. So the advisory act as a kind of insurance. Additionally, lead women farmers displayed an interest in being information service providers as it enhances their social recognition and could act as an additional income source (the lead women farmers received honorarium to deliver their services). The experiment also shows that if powered by digital services offering high quality weather forecasts and advisories, women can take the role of information brokers for women and marginalized farmers who are not having access to such information. It can offer recognition and income to lead young women service providers and additional yield and income to women farmer beneficiaries. This requires recognition of microfinance agencies on the benefits of such a service and employment of women as digital climate service providers to protect their loan investment to crop farmer borrowers from weather related yield losses. This women-to-women digital advisory service model, has generated interest among farmers and microfinance providers in coastal Bangladesh. These preliminary results suggest promise, though further validation through multiple rounds of experimentation, and potentially a randomized control trial, are needed, especially given the fact that the value of climate service is dependent upon climate stress level each year.

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ABOUT TAFSSA

TAFSSA (Transforming Agrifood Systems in South Asia) is a CGIAR Regional Integrated Initiative that supports actions improving equitable access to sustainable healthy diets, that boosts farmers' livelihoods and resilience, and that conserves land, air, and water resources in a climate crisis.

ABOUT AMD

The Asian Mega-Deltas (AMD) aims to create resilient, inclusive and productive deltas, which maintain socio-ecological integrity, adapt to climatic and other stressors, and support human prosperity and wellbeing, by removing systemic barriers to the scaling of transformative technologies and practices at community, national and regional levels.

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