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Review article

Agrometeorological advisory services in Bangladesh for sustainable agriculture development: An overview

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ABSTRACT

Agromet Advisory Services (AAS) is a program run by the Agrometeorological Information Systems Development Project (AMISDP) under Department of Agricultural Extension (DAE), Ministry of Agriculture, Bangladesh to address the issues related to climate change and variability impact on food security and sustainable agricultural output and other issues. By maximizing the benefits of favorable weather and reducing the negative effects of unfavorable weather, AASs provide farmers with a unique type of input in the form of advisories that can significantly improve agricultural productivity. This might significantly alter Bangladesh's situation with regard to food security and the reduction of poverty. AMISDP, DAE, provides agro-meteorological services that are a step toward supporting weather-based crop and livestock management plans and operations aimed at improving crop production in a sustainable way. The current article provides an overview of the project and discusses the various actions and initiatives that fall under these services, as well as the ways in which farmers and the environment may benefit from the use of weather and climate information.

***Keywords*:** Agromet advisory services, Climate variability and change, Weather and climate information, Food security.

The weather is currently the most significant factor affecting agricultural productivity. The weather has an impact on the crop's development and output at every stage. The two most significant weather variables are temperature and rainfall. Agricultural production is highly vulnerable to climate change. Transformational change to farming systems is required to cope with this changing climate to maintain food security, and ensure farming to remain economically viable (Sarkar *et al.,* 2023). The timing and quality of agricultural output are eventually impacted by variations in the rainfall pattern during plant growth, such as delayed monsoon arrival, extended rainfall, and excessive crop growth. Aside from natural disasters like floods, droughts, and cyclones, other significant meteorological parameters include relative humidity, air temperatures, wind speeds, and cloud cover. It may have an impact on crop growth and yield while also influencing farmers' decisions about crop selection, appropriate and consistent input use, and crop supervision. By helping farmers choose the best crop management techniques based on the weather forecast, agro-met advisory services' weather forecasting helps them increase their financial gains (Surya *et. al.,* 2020).

Farmers can increase agricultural production by following the right crop management practices and choosing the agromet advisory to minimize yield losses. Weather-based agro-meteorological services can lower cultivation costs by 2-5% in crop management practices in India, according to the impact assessment (Rathore and Parvinder, 2008). Weather forecasts are often released in three different categories: short, medium, and long-range. The medium-range forecast is the most advantageous of the three forecast types in terms of agricultural productivity and output. The long-range weather forecast offers recommendations for choosing appropriate crop varieties that are location-specific. Since the amount

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of rainfall in the upcoming season is known, crops can be chosen appropriately. Farmers will find short and medium-range weather forecasts useful in making decisions about day-to-day agricultural operations such as planting seeds, pulling weeds, cultivating several crops, applying pesticides, adjusting fertilizer dosages, and so forth (Narasimha *et. al,.* 2023; Hansen 2002). Thus, the adverse effects of more varied weather can increase production by reducing the yield losses by agromet advisory on a real-time basis in the modern era. The ability of agromet advisory services to deliver accurate and fast weather forecasts has the potential to reduce the unpredictable nature of weather patterns. Chattopadhyay (2023) has demonstrated how the extended range weather forecast i.e., sub-seasonal forecast can be translated into agromet advisories for the farming communities to increase crop production in India and how the present state of accuracy could be used for generating advisory under contingent crop planning conditions and other advisories by citing different case studies and ultimately helping the farming communities to improve their economic conditions. Sarkar *et al.,* (2023) suggested adaption of new technologies to address the emerging crises in food security and economic prosperity. New digital technologies, including remote sensing (Nigam *et al.*, 2023), should become part of the Agro-met arsenal to deliver valuable information directly to the farmers at the field scale. Singh *et al.,* (2023) emphasized the Information and Communication Technology (ICT) based Agromet Decision Support System for automation of the services provided under Agromet advisory services in India. This includes a dynamic framework to link the information of weather forecast, real time weather observation, crop-weather calendar etc. to translate weather forecast into actionable farm advisories for efficient farm level decision making in India.

The majority of farmers in Bangladesh are smallholder farmers, frequently with restricted access to resources and technologies, making them more susceptible to variations in the weather and climate. In many high-risk areas, increased frequency, severity, and intensity of weather-related extremes have led to food shortages and the inability to stop widespread famine. Indigenous knowledge and traditional coping mechanisms are being overwhelmed by the rapidly changing climate, despite the fact that farming communities around the world have survived by learning to adapt to drastically different weather and climatic conditions. There is a growing global focus on climate services. Climate-sensitive livelihoods like rain-fed agriculture and livestock rearing may also be negatively impacted by an increase in extreme weather events like droughts and floods brought on by climate change. To help small farmers understand the products and climate, the National Meteorological Services (NMS) can play a significant role (Chattopadhyay and Chandras, 2018). It is often the case that NMS require realignment, increased resources, and training to fulfill their dual roles as service providers and participants in the development process. Enough information on climate change ought to reach the last mile. There is an urgent need to translate climate data into information that farmers can use. Connecting the climate information to modern technology and advised farming practices is essential. Customized, crop-specific, and actionable information is necessary for small farmers as well as farming community.

AGROMETEOROLOGICAL ADVISORY SERVICES IN BANGLADESH

Agrometeorological services may be defined as any information pertaining to agrometeorology and agroclimatology that may be directly employed to try to enhance and/or safeguard farmers' livelihoods in agricultural output. This enhancement/ protection preserves the agricultural resource base from deterioration and benefits yield quantity, quality, and revenue (Stigter, 2007). By maximizing the benefits of favorable weather and reducing the negative effects of unfavorable weather, the Agromet Advisory Services (AASs) provide farmers a unique type of inputs in the form of advisories that can significantly improve agricultural productivity. This could fundamentally alter the face of any nation in terms of reducing poverty and ensuring food security.

Agrometeorological Advisory Services (AASs) in Bangladesh involves a comprehensive process that integrates data collection, analysis, and dissemination to provide actionable weather and climate information to farmers. Bangladesh has taken this initiative for the first time in 2018 by Department of Agricultural extension (DAE), Bangladesh. Real-time meteorological data is collected from the Bangladesh Meteorological Department (BMD), and forecast data is also collected at the same organization. BMD medium-range forecast data is provided to the Agro-Meteorological Information Systems Development Project (AMISDP) (Component C: Bangladesh Weather and Climate Services Regional Project (BWCSRP)) under the DAE, Ministry of Agriculture, Bangladesh. Flood forecast information is collected from the Flood Forecasting and Warning Center (FFWC) of the Bangladesh Water Development Board (BWDB). This information is combined with agronomic data, including crop calendars, soil conditions, and pest-disease models, to develop tailored agromet advisories. These advisories are disseminated through the BAMIS portal (https://www.bamis.gov.bd/) and various channels and community-based approaches, ensuring timely and effective communication with farmers. Continuous capacity-building programs for farmers and extension officers enhance the effective use of these advisories, thereby supporting sustainable agricultural development in Bangladesh.

The Agrometeorological Information Systems Development Project (AMISD), under the Department of Agricultural Extension (DAE), Ministry of Agriculture, Bangladesh, provides agrometeorological services as a first step toward supporting agromet advisory-based crop and livestock management strategies and operations aimed at improving crop production and food security in Bangladesh. AMISDP of DAE aims to support the country's farmers in producing food in a sustainable manner. The primary tasks being performed as part of this effort are to reduce the threat to Bangladesh's agricultural system. An outline of AASs in Bangladesh is shown in Fig. 1.

GENERATION OF AGROMET PRODUCTS

Information on the weather and how it deviates from normal at various temporal and spatial scales is helpful in creating Agromet advisories. Because of this, DAE generates the following agricultural products as contours for maximum temperature, minimum temperature, diurnal temperature, cloud cover, wind speed, and relative humidity on a daily, weekly, fortnightly, and

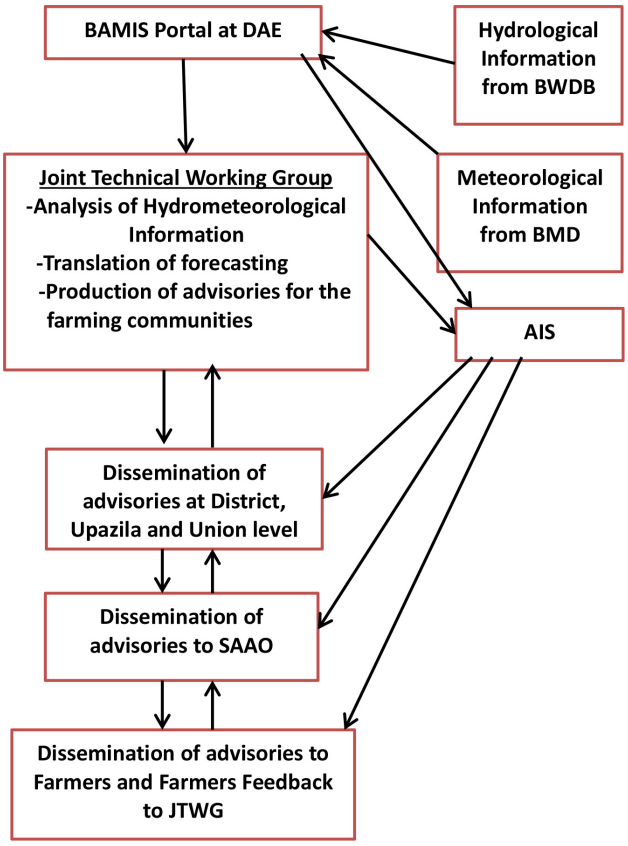

Fig. 1: Overview of agromet advisory services in Bangladesh

monthly basis: Additionally, BMD used a python program to create daily gridded rainfall data, which integrated satellite rainfall data and observed rain gauge station data over Bangladesh at a grid resolution of 0.05° x 0.05°. Furthermore, maps of the Standard Precipitation Index (SPI) and the Normalized Difference Vegetation Index (NDVI), Vegetation Condition Index (VCI), Temperature Condition Index (TCI), Vegetation Health Index (VHI) at the national level, as well as progress over the course of the week, are generated. Crop weather calendars for major crops include detailed information on important dates for sowing, the start and duration of major cultural operations, key life cycle stages, and most of the weather requirements for each crop. Pest weather calendars provide detailed information on important insects for each crop, and disease weather calendars provide detailed information on important diseases for each crop. The various agromet products utilized in Agromet advisory bulletins are shown in Fig. 2.

GENERATION OF AGROMET ADVISORY

Every Sunday and Wednesday, 64 districts receive Agromet Advisory services (AASs) bulletins, which are created based on the medium-range weather forecast. Every Wednesday, there are also concurrent national AASs bulletins released. The Bangladesh Meteorological Department (BMD) has made efforts to create an accurate medium-range weather forecast. Additionally, BMD produces sub-seasonal to seasonal climate forecasts in association with the Agro-Meteorological Information Systems Development Project (AMISDP), DAE, to assist farmers in managing climate risks and making efficient use of these forecasts, as well as helping farmers make crucial decisions related to crop selection, planting dates, and harvesting schedules by using seasonal forecasts. Beginning in 2023, BMD produces sub-seasonal to seasonal climate forecasts that meet the demands of many stakeholders, such as planners, policymakers, and farmers.

Bangladesh is a small nation that experiences extreme weather events such as cyclones, floods, flash floods, droughts, and hailstorms every year. However, one can greatly reduce the effects of weather by adopting the necessary safety measures and sharing information about AASs through AMISDP of DAE. DAE offers agricultural services by utilizing state-of-the-art tools and technology to monitor hazard situations and deliver advance agromet advisory. To assist farmers in minimizing crop damage, these advisories are sent out in the event of a storm, flood, cyclone, and drought. In order to track and evaluate the weather, BMD also maintains a variety of weather station networks, including satellite observation stations, automatic weather stations (AWS), buoy/ship observations, conventional observational networks, and Doppler weather radars. Extreme weather occurrences and climate change and variability are two more significant topics being addressed. In order to save crops and lives, BMD installed five Doppler weather radars throughout Bangladesh, some of which are operational.

Additionally, different kinds of satellite data are used to provide information about extreme weather events, such as heavy rainfall and cyclones, and to provide farmers with contingency planning for choosing appropriate crops based on expected climatic variability during the monsoon season and high resolution numerical

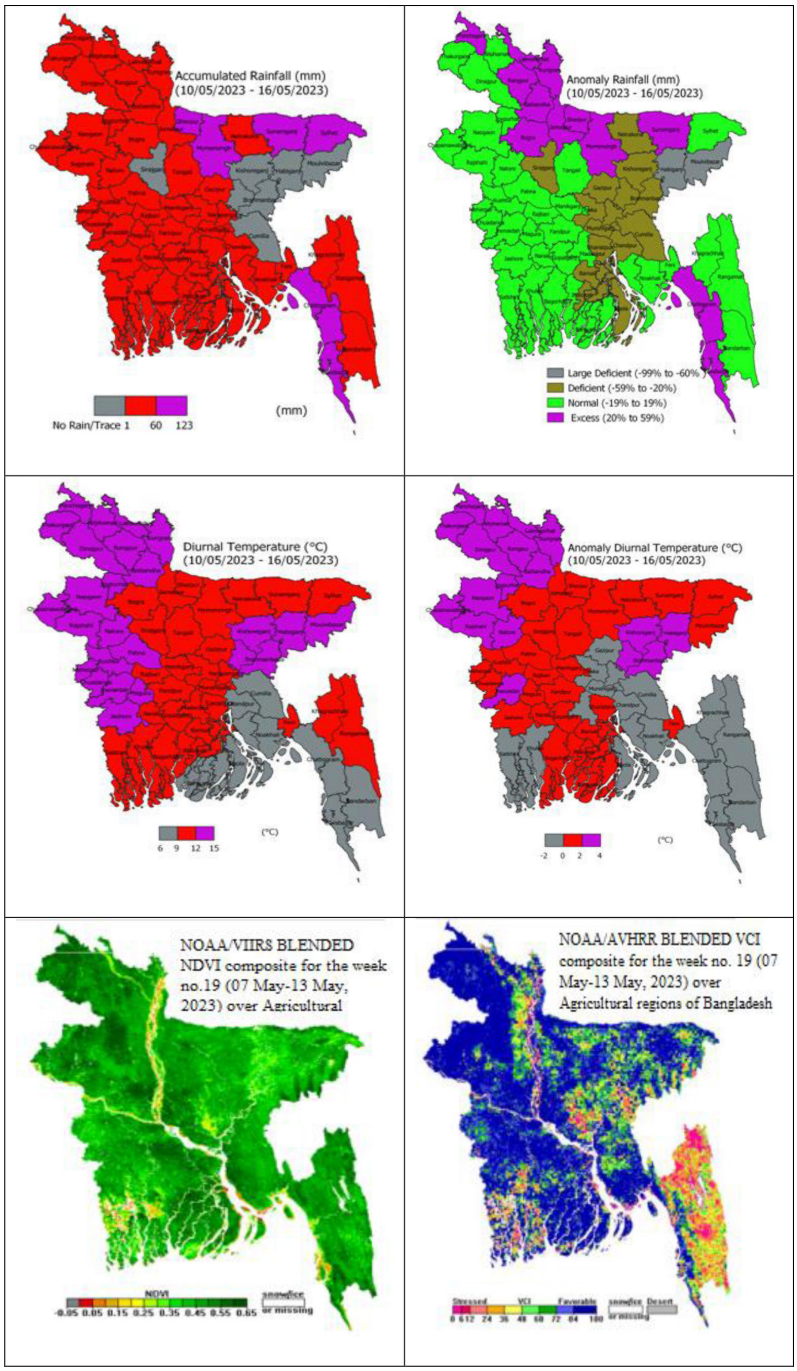

Fig. 2: Different agromet products for agromet advisory services in Bangladesh.

weather prediction model are used to forecast temperature, precipitation, clouds, thunderstorms, cyclonic storms, heavy precipitation alerts, squall warnings, heat waves, cold waves, and other weather phenomena. Along with a wealth of other observed data, digital and image information from Doppler weather radar acquired at 10-minute intervals is a valuable tool for thunderstorm activity prediction. A major part of disaster management in agriculture is also played by specialized products derived from satellites, such as soil moisture, drought index, satellite-based rainfall, NDVI, TCI, VHI and VCI. Such produced agricultural products can help lower the risk of disaster management for the farming community if they are provided to the end users in a timely manner. With this knowledge, farmers can prepare for various extreme weather events and lessen the effects of bad weather in the long run. Additionally, by leveraging realized data recorded at surface observatories within Network of BMD, efforts have been undertaken using automated advisory tools to build a method for development of agromet advisories along with crop and its stages.

DISSEMINATION OF WEATHER FORECAST AND AGROMET ADVISORIES

The distribution of agromet advisories to farmers is being

done on a larger scale via various multi-channel platforms such as YouTube, Facebook Group, Community Radio, Digital Display Board, Leaflet, booklet, brochure, poster etc. distribution, Mass media (Radio, TV, Newspapers etc.), Farmers training, National, district and special bulletin, Union weather display board, Kiosk, Voice message, SMS, BAMIS mobile apps and BAMIS portal. Details are given below:

YouTube: YouTube is an online video sharing and social media platform with a global audience. A video hosting service's online video platform allows people to upload, store and play video content over the Internet. Through virtual communities and networks, social media are interactive technologies that enable the creation and sharing of information, ideas and other kinds of expression. It is a very popular medium for people of all ages. When any hazard-disaster related information is uploaded to the internet, it quickly goes viral. As a result, people may take necessary measures on time.

Facebook Group: Facebook Groups are areas on the social media network where friends, acquaintances, or individuals with similar interests can talk or share information on a wide range of topics. It is a widely used media among people of all ages. When a special agromet advisory is posted on Facebook, it is rapidly shared with other friends and even those who are connected with this group and distributed one by one to other individuals, allowing people to take action in a timely manner.

Community Radio: It is a powerful communication tool which reaches the farmers in the absence of regular and stable electric supply that can run with a battery. As it is also a portable medium which a farmer can carry with him/her to the place where they work and listen to the station while doing their work. It plays an important role in raising farmers' awareness and understanding of better farming practices, improved seeds, timely planting, agroforestry, better harvesting methods, soil conservation, marketing, post-harvest handling, and diversification.

Digital Display Board: A digital display board improves awareness and helps in mitigation planning which can lead to achieving a better lifestyle of farmers in different districts of Bangladesh. It helps to achieve "Faster, more inclusive and sustainable agricultural growth" which are committed by rendering valuable input regarding climate services on agriculture. Digital display boards are a very popular media to act and take preventive measures for agriculture as well as livestock by the farmer's/farmers community. Farmers can watch all the related information on digital display boards at zila/upazila popular places. Hence, farmers benefit from the digital display board to reduce the loss of agriculture from any type of disaster.

Leaflet, booklet, brochure, poster etc. distribution: It will help in the dissemination of Agrometeorological information to success design and implement project campaign activities such as leaflet, booklet, brochure, poster, and so on will increase visibility and the project's activities will be fruitful and providing the agricultural sector with a decision support information system to mitigate climate-related agricultural production risks as well as development.

Mass media (Radio, TV, Newspapers etc.): The term "mass media" refers to technology that is designed to reach a large number of people. It is the principal mode of communication for the great majority of the general public. Newspapers, magazines, radio, television, and the Internet are the most common kinds of mass media. Before every extreme occurrence, a special agromet bulletin is disseminated through mass media because many progressive farmers watch TV and read newspapers so they can quickly know information and communicate it to their other member's farmers so they can take the necessary action to reduce agricultural loss.

Agromet brochure: For the benefit of the farmers, AMISDP of DAE has released an English brochure called Agromet Brochure that highlights many operations, especially those related to integrated agromet advisory services. The project background, project objectives, development of BAMIS infrastructure, creation of an agromet database at the upazila level, analysis of agromet data and future scenario development at the upazila level, creation of agromet advisories, risk mapping of climate-vulnerable areas, DAE agromet Technical Committee, installation of kiosks, and benefits of the project disseminated for broader publicity are all included in the agromet brochures.

National, district and special bulletin: National bulletin is prepared and disseminated once in a week for national level. District bulletin is prepared and disseminated twice in a week for all 64 districts. Special bulletin is produced and disseminated before and after natural hazards. All kinds of bulletins are prepared based on information received from Bangladesh Meteorological Department (BMD) and Bangladesh Water Development Board (BWDB) and research organizations (BARI, BARRI, BJRI, BSRI). It generates information and products to be used by the farming communities.

Union weather display board: Weather display board was installed in 4051 at union parishad level (i.e. village level) which is called agrometeorological display board. This display board provides agrometeorological forecast and advisory services for the farmers twice in a week. DAE officials especially Sub Assistant Agriculture Officer's (SAAOs) have been trained to manage the information according to the district agrometeorological bulletin. These boards help the farmers with a decision support system for regular agricultural practices.

Kiosk: A kiosk free standing physical structure that displays information or provides a service. Kiosk means a one-stop service, where you can get many items at a single place. Touch screen kiosks with android and window version, printers and routers have been installed in the Upazila Agriculture Offices of 487 upazilas. These allow users to navigate necessary information.

Voice message: Voice messaging is an instant communication tool that sends messages via voice media. Voice messaging can be used instead of phone calls or text messages. It saves voice messages in a voice mailbox that may be accessed via a smart device such as a cell phone. Voice messages are provided to the lead farmers before the extreme event, and they disseminate the information to their member farmers. Voice messages are very useful for farmers, and every farmer has a cell phone to receive it and can take the appropriate action to reduce loss of agriculture.

SMS: SMS stands for Short Message Service and is commonly

known as texting. It's a way to send text-only messages of up to 160 characters between phones. Special agrometeorological information is sent to the lead farmers before disaster. SMS plays an important role in developing adequate agricultural production strategies before hazards as well as after disasters.

BAMIS mobile apps: A mobile app (or mobile application) is a software application designed for use on tiny, wireless computing devices such as Android smartphones and tablets rather than desktop PCs. It is user-friendly and can access to BAMIS portal from anywhere and navigate BAMIS portal information such as district bulletins, national bulletins, special bulletins and crop management, and so on.

BAMIS portal: The portal named www.bamis.gov.bd has been established and it is becoming very popular in the country and abroad day by day. Users can navigate necessary information on a number of aspects including current weather data, river & flood situation, agrometeorological advisories, crop weather calendar, pest-disease weather calendar, crop management time table etc.

EXTENSION ACTIVITIES

Training sessions and workshops are conducted to educate farmers and extension officers on interpreting weather forecasts and implementing agromet advisories. These activities promote best agricultural practices and resilience strategies. AMISDP, under DAE, creates the BAMIS portal (http://bamis.gov.bd/) to provide weather forecasts and Agromet advisories to the farming community in both Bangla and English. The services assisted farmers not just in raising crop yields but also in decreasing losses brought on by bad weather and other issues. Farmers can access the mobile apps from the Play Store and the web portal without restriction in order to utilize this service. Farmers can display every item that is required for the crops. Besides, the dissemination strategies of AMISDP have significantly improved farmers' preparedness for extreme weather events, reduced crop losses, and increased the adoption of best practices. The use of diverse communication channels ensures comprehensive outreach, while extension activities enhance understanding and application of agromet advisories.

Training programmes

Awareness campaigns for both farmers and farming communities can help improve AASs. With better planning and management decisions, awareness programs help farmers become more self-reliant in addressing weather and climate issues that impact agricultural production. A participatory, cross-disciplinary approach is being used to deliver climate and weather information and raise the awareness of information user groups. These programs were collaboratively organized in Bangladesh by the Bangladesh Water Development Board (BWDB), the Department of Agricultural Extension (DAE), the Bangladesh Meteorological Department (BMD), and other stakeholders in the country. District-specific crop techniques, package information, and a weather-based farming agromet advisory are sent to farmers. District Agromet bulletin is available in Bangla and English. Community-based approaches, such as farmer cooperatives and community forums, will be created in order to strengthen the connections and create a network in the near future. These methods are crucial for the dissemination of information to farmers. Extension officials make sure that agromet advisories are clear and useful by giving out printed materials and offering one-on-one consultations. Outreach programs such as farmer's clubs, project officials' field visits, farmers' field schools, etc. can be used to prepare the ground for the project's second phase. AMISDP under DAE have organized 1254 batch farmers' awareness training programs at the district/upazila level, with Sub-Assistant Agriculture officers 368 batch and Extension Officers 36 batch in the country. An overview of the country's Farmer Awareness Training Program from 2017–2024 is provided in Table 1.

ECONOMIC IMPACT: A CASE STUDY OF CYCLONE "MOCHA"

The AMISDP offers farmers agromet advsory to help them save their crops prior to a cyclone. AMISDP officials create an agromet advisory for farmers based on weather forecasts from the Bangladesh Meteorological Department and flood forecasts from the Flood Forecast and Warning Center of the Bangladesh Water Development Board. The creation of this agromet advisory occurs every Sunday and Tuesday. The next five days are covered by this agromet advisory. This provides the weather forecast parameters, which include rainfall, air humidity, wind direction and speed, maximum and minimum temperatures, and cloud cover conditions. The study's conclusion was based on input gathered from farmers through an interview schedule that evaluated the impact and use of Agromet Advisory Services (AAS). Farmers received this agricultural weather-based advisory via SMS, IVR, BAMIS portal, and agricultural extension officials. Farmers can readily implement crop management techniques, such as appropriate irrigation, fertilizer dosages, and pesticide spraying for disease and pest control, based on agro-advisories.

To reduce the risk associated with Cyclone 'Mocha', Agro-Meteorological Information System Development Project (AMISDP) under Department of Agricultural Extension (DAE) issued Special Agromet Advisory on 11 May 2023 first and suggested the farmers to harvest crops quickly. Moreover, DAE directed the farmers to harvest mature crops like mango and other crops to avoid possible damages during the impending cyclone Mocha. Therefore, the farmers harvested 80% of crops to avoid possible damages as response. According to the local officials, crops were saved. Daily national and local newspapers, national and international organizations also recognized the initiatives of DAE.

A survey was conducted during Cyclone "Mocha" in May 2023 in the Teknaf upazila of Cox's Bazar District as part of AMISDP, which was created in 2017 by the Department of Agriculture with funding from the World Bank. One Teknaf upazila served as the site of the current investigation. The district of Cox's Cox's bazar is located in Bangladesh's southeast coastal zone, which has black and sandy loam soil. Analysis reveals that the maximum crop coverage during landfall of cyclone Mocha was cereals and then vegetables. Drugs and Narcotics were the lowest. Due to special agro-advisory bulletin AMISDP under DAE it has been found to save spices (i.e., onion, chili, mint) 81.4% area, other food (potato and sweet potato) of 80.1% area and vegetables of 74.4% area, but the drugs and narcotics (betel leaf) was only 47.4% (Fig.

Table 1: Awareness Training Programme conducted from 2017 to 2024 in Bangladesh.

Year	Farmers training	Agriculture officer training	Extension officers training
2017-2018	----------	---------	20
2018-2019	280	28	3
2019-2020	300	100	10
2020-2021	420	100	10
2021-2022	254	140	6
2022-2023	---------	---------	---------
2023-2024	---------	---------	7
Total batch	1254	368	36

Note: one batch consists of 30 persons

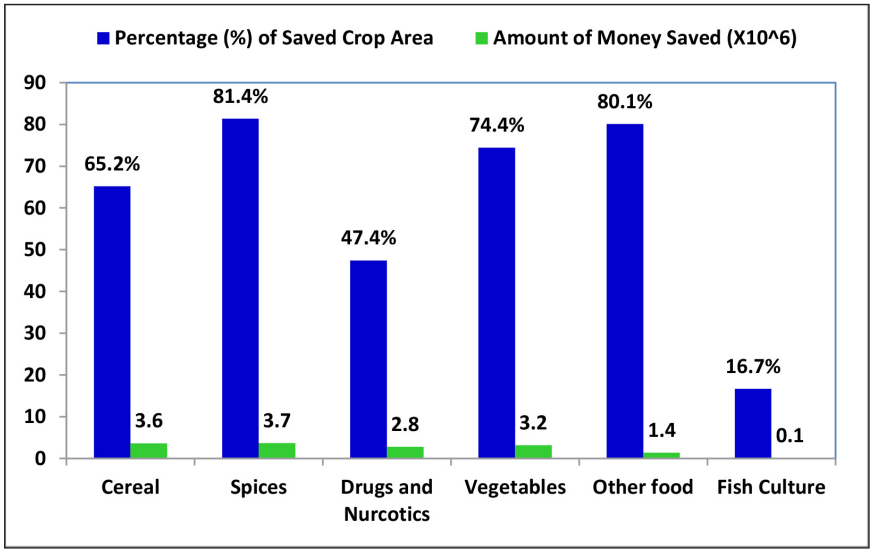

Fig. 3: Savings of money (BDT x10^6) and percentage of saved crop area in Teknaf upazila due to special advisory service of DAE.

3). As a whole, farmers were able to save 62.8% crop area. Analysis also indicated that the maximum amount of money saved for spices and condiments (onion, chili, and mint) with the amount of BDT 3.7 $x10^6$ then cereals (rice, wheat and maize) with the amount of BDT 3.6 $x10^6$ (Fig. 3). The total amount of saved money for all crops together was BDT 14.9 $x10^6$.

CONCLUSION

Sustainable development requires understanding the interactions between crops, livestock, and weather and climate. Improved methods require longer development time and consideration of agroclimatic factors. Accurate climate and weather information is crucial for improved agricultural productivity and community resilience. The Global Framework for Climate Services (GFCS) is improving countries' capacity to provide these services. The Department of Agricultural Extension launched the Agrometeorological Information Systems Development Project (AMISDP) to provide farmers with weather-based, crop-focused agrometeorological advisories. DAE's AMISDP services significantly saved crops from cyclone 'Mocha' risk, particularly in Teknaf Upazila near Myanmar. Farmers saved BDT 14.9 $x10^6$ (one crore forty-nine lac seventeen thousand two hundred and eleven taka), a significant cost savings compared to analyzing just one upazila. DAE and BMD plan to enhance service by increasing manpower, R&D, network distribution, real-time information flow, observation, and weather forecasting. They aim to expand district-level delivery to sub-district/upazila levels and establish 64 District Agrometeorological Units for sustainable agricultural growth.

To enhance the impact of Agro-meteorological Advisory Services (AAS) in Bangladesh, future efforts should focus on strengthening institutional capacity and expanding local-level dissemination. Technological infrastructure, including real-time weather monitoring and digital platforms, must be upgraded for better accuracy and outreach. Localizing advisories and using regional languages will improve accessibility for smallholder farmers. Ensuring gender and disability inclusion in advisory services is essential for equitable outcomes. Collaboration with private sector partners can help scale innovations and improve delivery systems. Continuous training of extension officers and farmers will build long-term capacity. Integrating AAS into national agricultural and climate policies will promote sustainability. Regular monitoring and feedback mechanisms should be established for adaptive improvements. Awareness campaigns and community-based outreach will increase adoption. These actions collectively will support a more resilient and climate-smart agricultural in future.

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