DAE Cadre Officials ToT Manual on Agricultural Climate Services

Government of The People's Republic of Bangladesh
Agro Meteorological Information Systems Development Project
(Component-C of BWCSRP)
Department Agricultural Extension
Khamarbari, Farmgate, Dhaka-1215

THE WORLD BANK

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Preface

Population growth, rapid urbanization, and climate change are placing tremendous challenges to farming system in Bangladesh. These challenges are intensified by the modulation effects of agro-climatic services on raising crops, livestock and fisheries. This added variability makes changes in the agricultural conditions practiced and requires site-specific strategies to mitigate the challenges. As agricultural activity is highly sensitive to climate variability, both inter- and intra-seasonal variation in weather/climate impose notable impacts on timing as well as the efficiency of regular agronomic practices, pest & disease management, harvesting and postharvest operations of crops etc. In this context, weather forecasts and climate information can assist farmers to take appropriate remedial measures to avoid or reduce economic losses against stresses as well as take advantage of favorable conditions. Forecasts of weather and climate, monitoring and early warning products on rainfall, drought, floods or other calamities when translated into agro-meteorological advisory services, that ultimately could increase the preparedness of farming community. At the same time, agricultural production systems need to undergo a profound transformation. Such a transformation will involve a variety of stakeholders along the agricultural supply chains and at policy levels. Food producers will have to adapt their farming techniques in the context of new climate conditions. The promotion of climate-smart agricultural activities and outcomes requires integrating a wide range of concepts, information and practices from different disciplines and stakeholders. As such, greater professional knowledge of agricultural climate services is needed amongst farmers, officials, and the research communities in Bangladesh. The number and quality of technical and professional personnel in agricultural meteorology are crucial factors since the effectiveness of extension services and their ability to meet farmers' needs and expectations is determined by the competence and qualifications of its staff. Therefore, this training manual is specifically designed for the DAE cadre officers /Researchers, who are at the front line of agricultural system changes, to provide with a broad range of information and strategies to achieve climate resilience. This manual seeks to increase awareness and understanding of agro-meteorological services and their relevance to build climate-smart approaches to support sustainable productivity in Bangladesh. The module provides a summary of the lectures, demonstrations and exercises for cadre officers/researchers in utilizing weather & climate information and forecasts in their daily operations to increase agricultural production, optimize the use of limited resources, and maximize economic benefits for farmers from agro-meteorological advisories. In this regard, an MoA entitled "Developing Agricultural Climate Services Training Module" was signed with Sher-e-Bangla Agricultural University under the Component-C: "Agro-Meteorological Information Systems Development Project" of Bangladesh Weather and Climate Services Regional Project, implemented by Department of Agricultural Extension (DAE), Government of the People's Republic of Bangladesh, funded by the World Bank. The module was developed by the Department of Agronomy, Sher-e-Bangla Agricultural University with implementation support from Practical Action Consulting Bangladesh Ltd. and technical support from Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES).

Acknowledgement

DAE Cadre Officials training manual on Agricultural Climate Services was developed by the Department of Agronomy, Sher-e-Bangla Agricultural University with implementation support from - Practical Action Consulting Bangladesh Ltd. and technical support from the International and Intergovernmental organization Regional Integrated Multi-Hazard Early Warning System (RIMES), who have proven expertise and currently working in this field. The manual is one of the outputs of the DAE project "Agro meteorological Information Systems Development Project (AMISDP)' component-C of Bangladesh Weather and Climate Services Regional Project funded by the World Bank. It is greatly indebted to many people who contributed to this manual. However, special recognition to Professor Dr. Kamal Uddin Ahamed, the Honourable Vice-Chancellor of Sher-e-Bangla Agricultural University for the administrative approval and expert advice for preparing the manual. Some portion of the manual is based on Forecast Application for Risk Management in Agriculture (FARM) School curriculum developed by the Center for Ecology and Research (CER), Tamil Nadu in collaboration with RIMES. We would like to thank CER team including Dr. V. Palaniappan, Dr. P. Venkatesan and Mr. P. Kalaivanan who were involved in the initial development of the FARM School curriculum for Agriculture extension officers in Tamil Nadu, India. A number of academic experts of Sher-e-Bangla Agricultural University provided valuable contributions including Prof. Dr. M. Salahuddin Mahmud Chowdhury, Department of Plant Pathology; Prof. Dr. S. M. Mizanur Rahman, Department of Entomology; Prof. Dr. Mohammad Humayun Kabir, Department of Horticulture and Assistant Professor Md. Tofail Hossain, Department of Agricultural Botany towards designing of this manual. The development of this module has been technically coordinated by Professor Dr. H.M.M. Tariq Hossain, Department of Agronomy, Sher-e-Bangla Agricultural University. The Department of Agronomy would also like to acknowledge the contributions of the Editorial Committee members including Professor Dr. H.M.M. Tariq Hossain, Dr. M. Sahab Uddin, Additional Director, Planning, Project Implementation and ICT Wing, DAE; Professor. Dr. Md. Shahidul Islam, Professor Dr. S. M. Mizanur Rahman and Professor Dr. Mohammad Humayun Kabir for rigorous editing of the manual. We were deeply encouraged with suggestions and supports made by Dr. Mazharul Aziz, Project Director, AMISDP, DAE, Khamarbari, Dhaka; Professor Moin Us Salam; Dr. G Srinivasan, Mitesh Sawant, Raihanul Haque Khan from RIMES and Syed Mahmud Hasan from PAC and Dr. Nabansu Chattopadhyay, Consultant, DAE for their efforts and commitment to materialize this business. Finally, we can't name here them all those who in one way or another have shared their time and effort in making this activity a success but we wish to thank those most deeply involved.

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Schedule

Day	Time	Topic
Day 1	8.30-9.00	Registration
	9.00-9.30	Inauguration
	9.30-10.30	Fundamental of Weather Forecast- Terminology and Weather vs Climate
	10.30-11.00	Tea Break
	11.00-13.00	Global Observation System, Introduction to instruments used in Agromet Stations
	13.00-14.30	Lunch and Prayer Break
	14.30-15.30	Fundamental of Forecast Generations- Terminologies, Types of Forecast, Accuracy and Skill of weather forecast, Overview of Modelling, Uncertainties
	15.30-16.30	Group work, Exercise
	16.30-17.00	Open Discussion
Day 2	9.00-9.30	Review of previous day
	9.30-10.30	Seasonal, Sub-seasonal, Climate Forecast: Terminology, Example, Available BMD Products for Agriculture
	10.30-11.00	Tea Break
	11.00-12.00	Sensitivity of Crops to Weather/Climate: Understanding Crop weather relation ship, Different diseases and their relationship to Different Climatic Conditions
	12.00-13.00	Influence of Weather on Pest development and Outbreak
	13.00-14.30	Lunch and Prayer Break
	14.30-16.30	Climate Smart Agriculture: Terminology, Concept
	16.30-17.00	Open Discussion
Day 3	9.00-9.30	Review of Previous day
	9.30-10.30	Application of Weather Forecast: Weather and Cropping Strategy, Economic Value of Weather/Climate Information
	10.30-11.00	Tea Break
	11.00-13.00	Water and Hydrologic Cycle in Agriculture: Different Concepts and Definitions
	13.00-14.30	Lunch and Prayer Break
	14.30-15.00	Drought in Bangladesh
	15.00-16.00	Irrigation Scheduling, Floods in Bangladesh
	16.00-16.30	Group Activity and Exercise
	16.30-17.00	Open Discussion
Day 4	9.00-9.30	Review of previous lectures
	9.30-10.30	Introduction to BAMIS Portal
	10.30-11.00	Tea Break
	11.00-13.00	Cutting-Edge Technology in Agromet: Remote Sensing, Agromet Indi ces/Indicators
	13.00-14.30	Lunch and Prayer Break
	14.30-16.00	Making Use of Operational Satellite Products: Modelling and Agromet Advisory Generation
	16.00-16.30	Case Study
	16.30-17.00	Open Discussion
Day 5	9.00-13.00	Field Visit: BMD
	14.00-16.30	Field Visit: FFWC of BWDB
	16.30-17.00	Workplan, Evaluation and Closing Ceremony

Guidelines for Using the Manual

For effectively and creatively using this module in Agrometeorological Climate Services training, the following guidance should be considered for the best use of this module.

- As a trainer, use this module to achieve specific goals of the training by supervising the sessions with a participatory approach
- Get familiar with the objectives of the sessions carefully before the training. Evaluate after each session whether the objectives are achieved or not by gathering feedback.
- Before starting a session, read the module and related technical supplements carefully. The Pre -Training Evaluation form is available at Annex.3. The facilitator should request all the participants to fill and submit the form before the start of the training.
- Follow the instructions of the module to supervise the sessions. You can adapt to other methods if the circumstances demand so. In that case, keep track of the schedule.
- If you supervise the sessions with the module in your hand, the participants might put less trust in you. It might also interrupt the sessions frequently.
- Follow the training sequence according to the module. If you do not follow it, you might lose the coherence of the discussion.
- While following the sequence from the module, do not rush or slow down.
- Before starting the sessions, keep the required books or materials organized and ready. Get the posters prepared (if any) before the sessions start.
- You may keep the required technical module's photocopy with you while conducting the session.
- The introducing session should attractive and participatory so that it can be the ice-breaking among the all participants.

Please read carefully

There might be some questions or issues raised during the discussions by the participants which are not included in this module. In such cases, use your own experience and intellect to answer the questions.

Module 1

Fundamentals of Weather and Climate

Session

- Introduction to the terminology
- Interactive session: Weather vs. Climate
- Lecture: Global Observation System
- Meteorology and Agrometeorology
- Introduction to the Instruments used in Agromet Station
- To impart the theoretical knowledge of instruments / equipment used for measurement of agrometeorological variables

Learning Objectives

Get to know basic terminologies related to weather and climate elements, enhance the capacity of participants to clearly differentiate between weather and climate terminologies and introduce participants to various weather measuring instruments and their functions

Duration

[4 hours]

- Introduction to terminology: 10 minutes
- Exercise: 60 minutes
- Lecture/Presentation : 2 hours 20 minutes
- Discussion: 30 minutes

MODULE 1: FUNDAMENTALS OF WEATHER AND CLIMATE

Objective:
The participants may have some knowledge about the terminologies mentioned below. The objective is to check their understanding and introduce the scientific definition of various terms they come across in their daily lives.

Session Time:
This session takes around 30 minutes

Instructions:
The session will start with facilitator introducing few basic terminologies of weather, climate and various related phenomenon to the participants. The facilitator should firstly encourage the participants to define the following terms as per their own understanding, discuss within themselves and then explain the scientific definitions to the participants

Session I: Introduction to the Terminology

1. Weather: Weather is the specific condition of the atmosphere at a particular place and time. It is measured in terms of wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. (source: Weather Channel Interactive, year)

2. Climate: The average of weather over extended period like 30 years or more. Note that the climate taken over different periods of time (30 years, 1,000 years) may be different. The old saying is climate is what we expect, and the weather is what we get.

3. Climatology: Climatology is a science of climate, which study the physical state of the atmosphere:

Over specific region
During a specific period
On the basis of climatic data

4. Climate Change: The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". (source: ISDR)

5. Monsoon: "MONSOON" has originated from the Arabic word "MAUSIM" which means season. It is most often applied to the seasonal reversals of the wind direction along the shores of the Indian Ocean, especially in the Arabian Sea, that blow from the southwest during one half of the year and from the northeast during the other

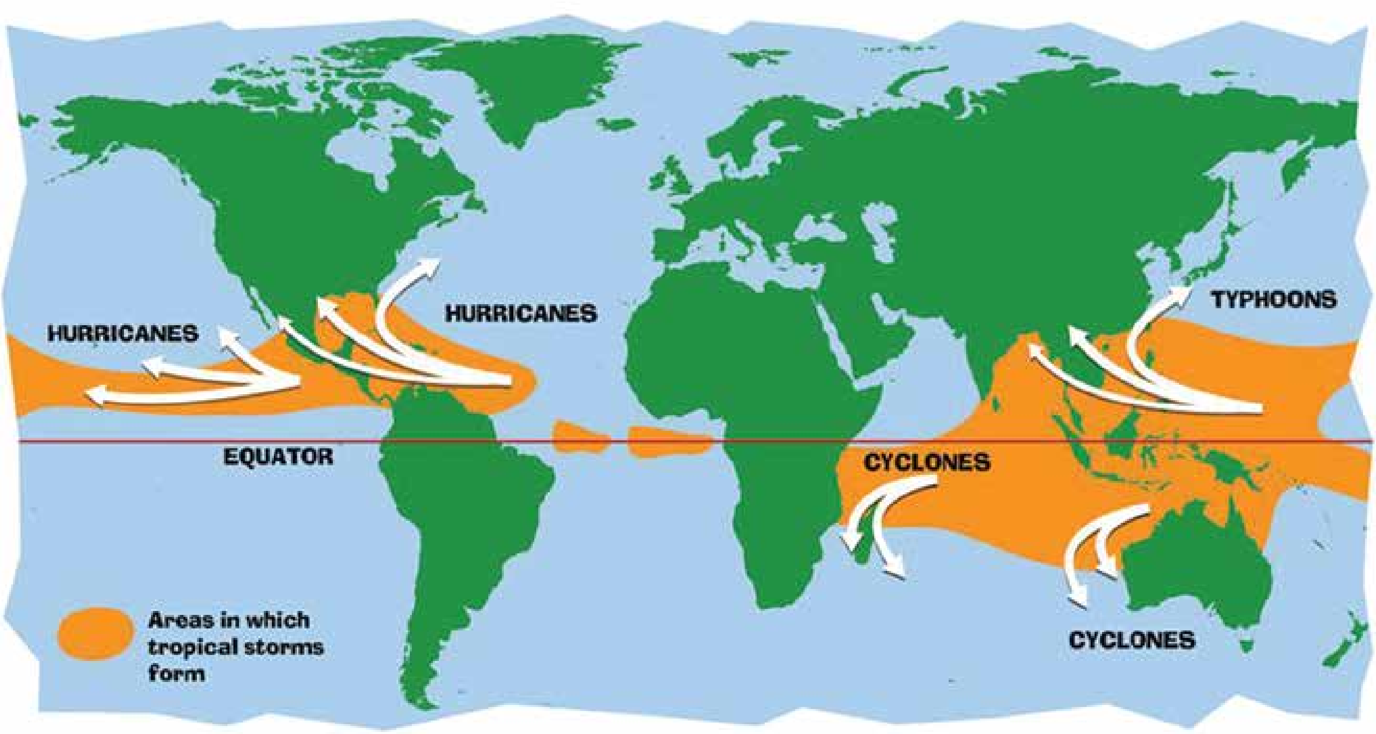
6. Forecast: In general, forecasting is the process of estimation of unknown situations. Weather Forecasting is the application of science and technology to predict the state of the atmosphere (rainfall, temperature, wind, humidity etc.) for a future time and given location. One of the primary functions of the National Hydrological & Meteorological Services is forecasting the weather parameters such as rainfall, temperature, wind, humidity etc. over a region averaged over a particular period. For example, forecasting of daily rainfall.

7. Hurricanes / Cyclone / Typhoons: Basically, they all are the same things, but are given different names depending on where they appear along with the wind speed.

7.1 Hurricanes are tropical storms that form over the North Atlantic Ocean and Northeast Pacific.

7.2 Cyclones are formed over the South Pacific and the Indian Ocean.

7.3 Typhoons are formed over the Northwest Pacific Ocean.



(Source: sciencelearn.org.nz)

Figure 1. Difference between Hurricanes, Cyclones and Typhoons

Session II: Interactive Session: Weather vs Climate

Outcomes:

At the end of the session, participants should be able to:
- Distinguish the difference between weather and climate;
- Identify the different weather and climate elements.

Session Time: This session takes about 60 minutes.

Materials Needed:
- Flip charts
- Pieces of paper containing words related to weather/climate elements
- Pieces of paper containing short statements describing weather or climate
- Marker pens

Step 1. Identify weather and climate elements

The facilitator will introduce a game where participants will choose a piece of paper that contains weather /climate elements and non-weather/climate elements. Each of them will be asked to identify whether the term written on their paper is a weather/climate element or not, by attaching the said piece of paper in either column as seen in Table 1. Clarification for this will be carried out with the participants and the facilitator will give opinions to enhance participants' capacity to distinguish weather/climate elements from those that are not.

Table 1. Distinguish between weather/climate and non-weather/climate element

Weather/Climate Elements	Non-Weather/Climate Elements
Temperature	Flood
Rainfall/Precipitation	Sky
Humidity	Water
Wind	Map
Atmospheric pressure	Soil

Step 2. Exercise: Differentiate weather and climate

The game will be continued to build understanding about the differences between weather and climate by choosing a piece of paper containing short statements/words that describe either weather or climate. Participants will then be divided into sub-groups for discussion, with at most six (6) people per group. The facilitator will ask each group to discuss the statement/words in the piece of paper and attach this to either the weather or climate column until all statements/words are categorized in a similar way as the Table 2 below.

Table 2. Distinguish between weather and climate element

Weather	Climate
It is stormy today	Average atmospheric condition
Day-to-day temperature has changed	The temperature is expected to increase in the next 10 years
Forecast for next three days is rainy	Scenarios and projections
Short-term variability	Long-term change

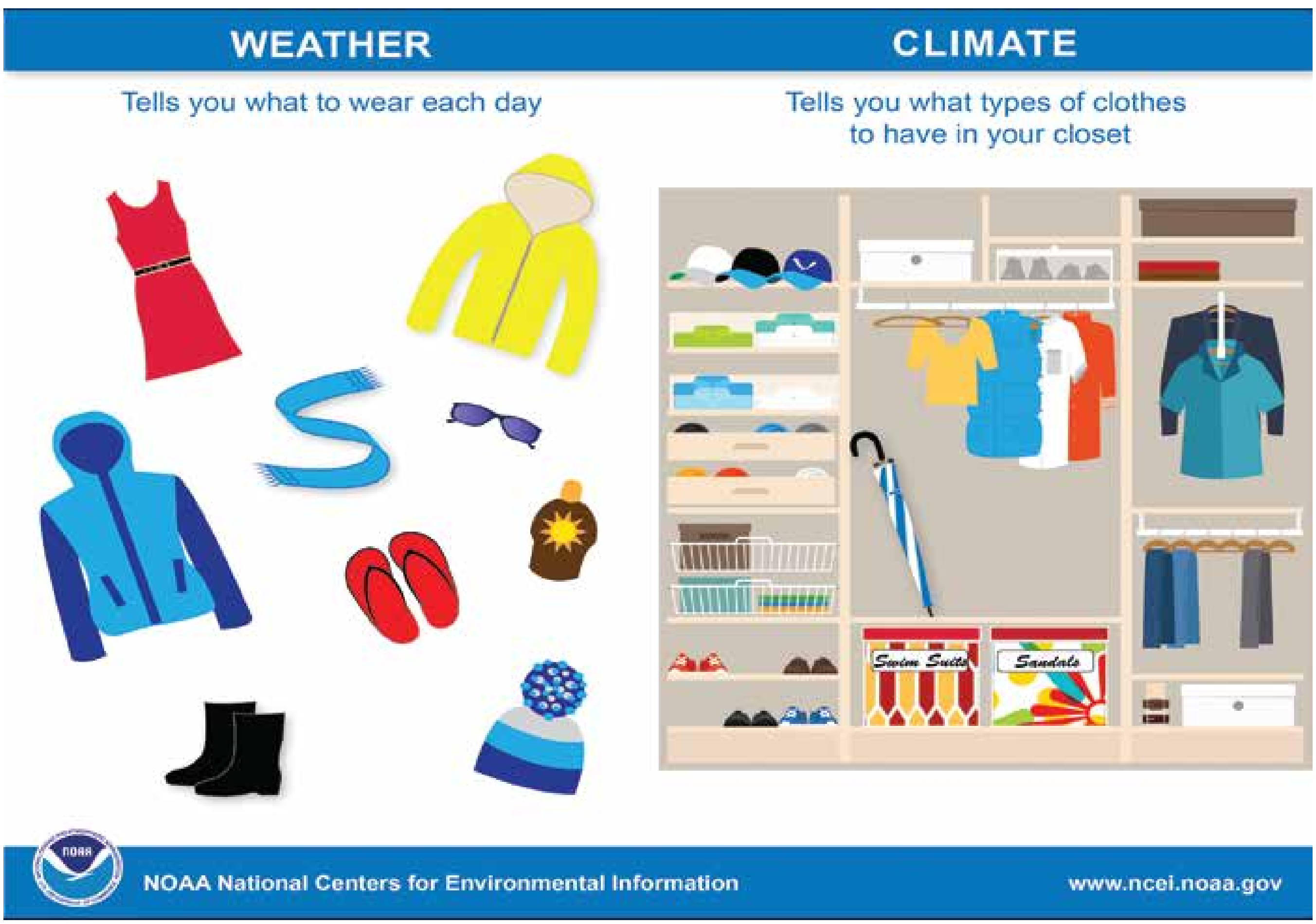
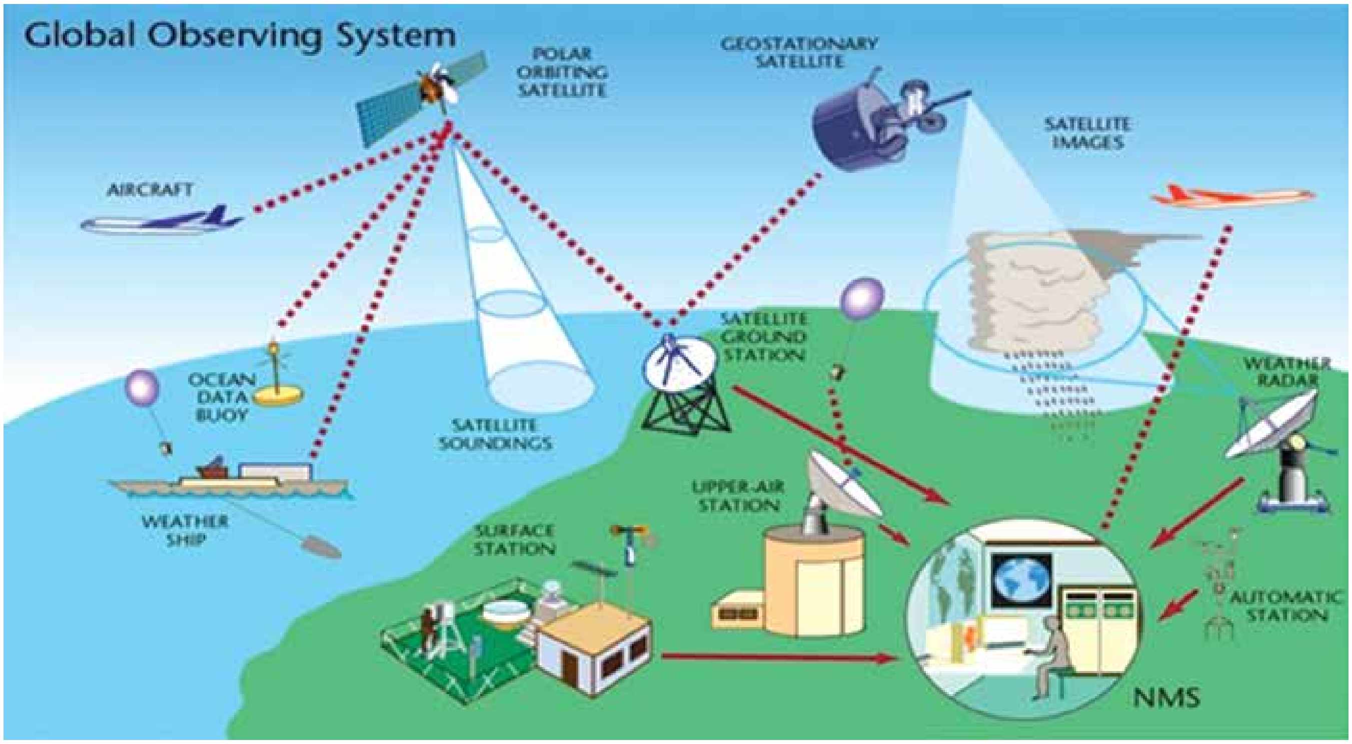


Figure 2. Weather vs. Climate

Once completed, the facilitator goes through each statement and identifies whether the categorization is correct or not. He/she distinguishes the differences between both terms.

Session III: Lecture on Global Observation System:

The Facilitator should organize a lecture on Global Observation System for the participants. One meteorologist from the Bangladesh Meteorological Department (BMD) could also be invited to give the speech on the abovementioned topic. It might include but not limited to surface and upper-air observation, ocean and seismic monitoring, remote sensing etc.



(Source:public.wmo.int)

Figure 3. The example of Global Observation System

At the end of the session, participants should be able to know:

- How the observations are recorded on a global scale;
- How the global observations help to prepare local weather parameters.

Session IV: Meteorology and Agrometeorology

Meteorology: Meteorology is a branch of the atmospheric sciences which includes atmospheric chemistry and atmospheric physics, with a major focus on weather forecasting. It deals with Earth's atmosphere: temperature, air pressure, water vapour, mass flow, and the variations and interactions of those variables, and how they change over time. Different spatial scales are used to describe and predict weather on local, regional, and global levels.

Agrometeorology: Agrometeorology is the study of weather and use of weather and climate information to enhance or expand agricultural crops and/or to increase crop production.

Agro-meteorology mainly involves the interaction of meteorological and hydrological factors on one hand and agriculture, which encompasses Crop Production, animal husbandry, and forestry on others. Agrometeorology can be considered in temporal and spatial contexts. In a temporal context, strategic applications are defined as those aiding in issues and decisions that are assessed on a seasonal or yearly basis or only once, such as in a planning process. These applications aid in the planning process whether the decision is choosing a specific crop variety to plant if an area should be exploited for forage products and livestock, how to design and plan where or if greenhouses or animal shelters should be built, or how to assist governments in setting agricultural pricing policies. Such decisions can be based on climatological analyses, agro-climatic information, and the use of complex soil-plant–atmospheric models. Tactical applications are considered to be short-term operational decisions relating to a period ranging from a few hours to a few days .[1]

The main differences between Meteorology and Agrometeorology[2] are as follows :

Table 3. Difference Between Meteorology and Agrometeorology

Meteorology	Agro-meteorology
1. Meteorology is a branch of atmospheric physics .	1. Agrometeorology is an inter disciplinary science.
2. It is actually science dealing with processes that take place in the atmosphere	2. It includes both agriculture and meteorology.
3. It is physical science.	3. It is a biophysical science.
4. It focuses on weather forecasting and other weather-related services.	4. It focuses on the agro-advisory service to the farmers by translating weather and climate information.

1. Application of meteorology to Agriculture, Chapter 9, World AgroMeteorological Information Service
2. https://en.wikibooks.org/wiki/Introductory_Agrometeorology/Introduction

Session V: Introduction to the Instruments of at Agromet Stations

Outcome:

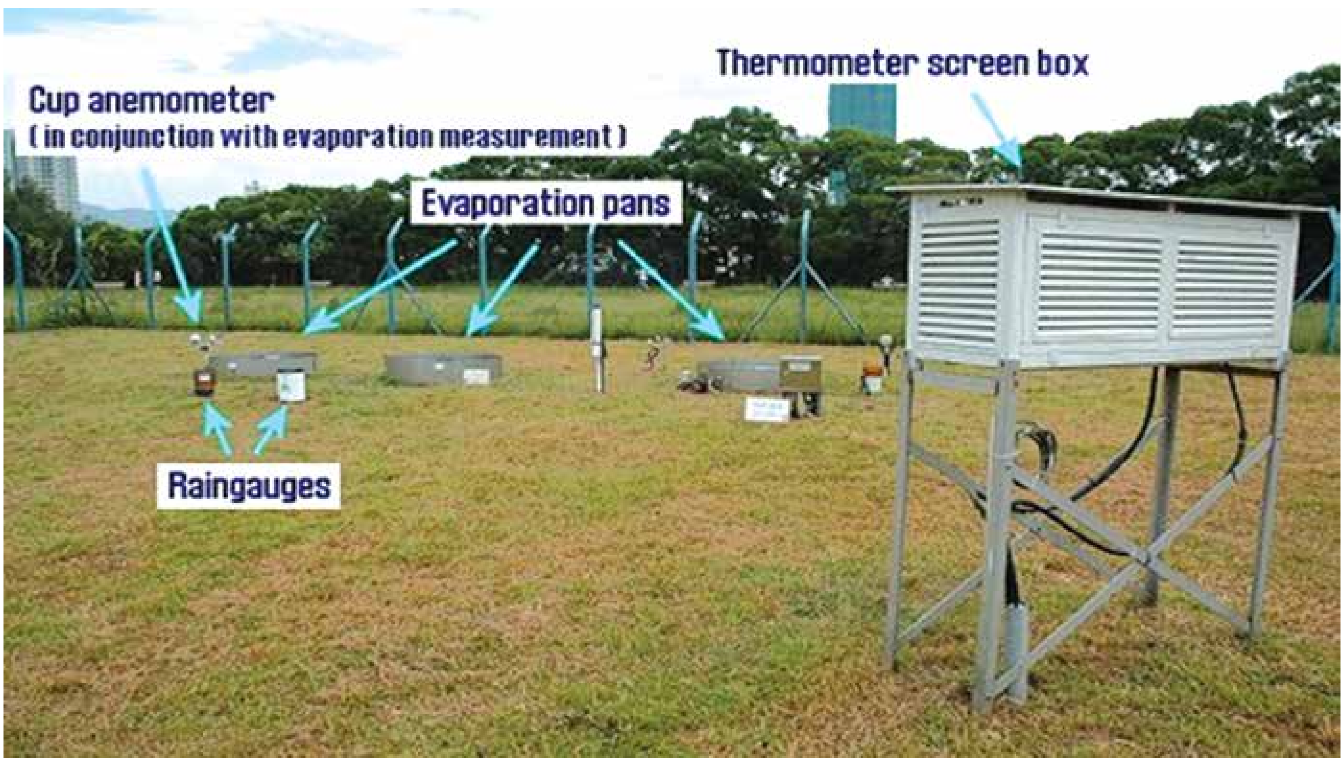
At the end of the session, participants should be able to:

- Know a typical set up of Agromet stations
- Know about the various weather measuring instruments and their functions

Session Time: This session takes about 90 minutes.

Step 1. Typical set up of agromet station

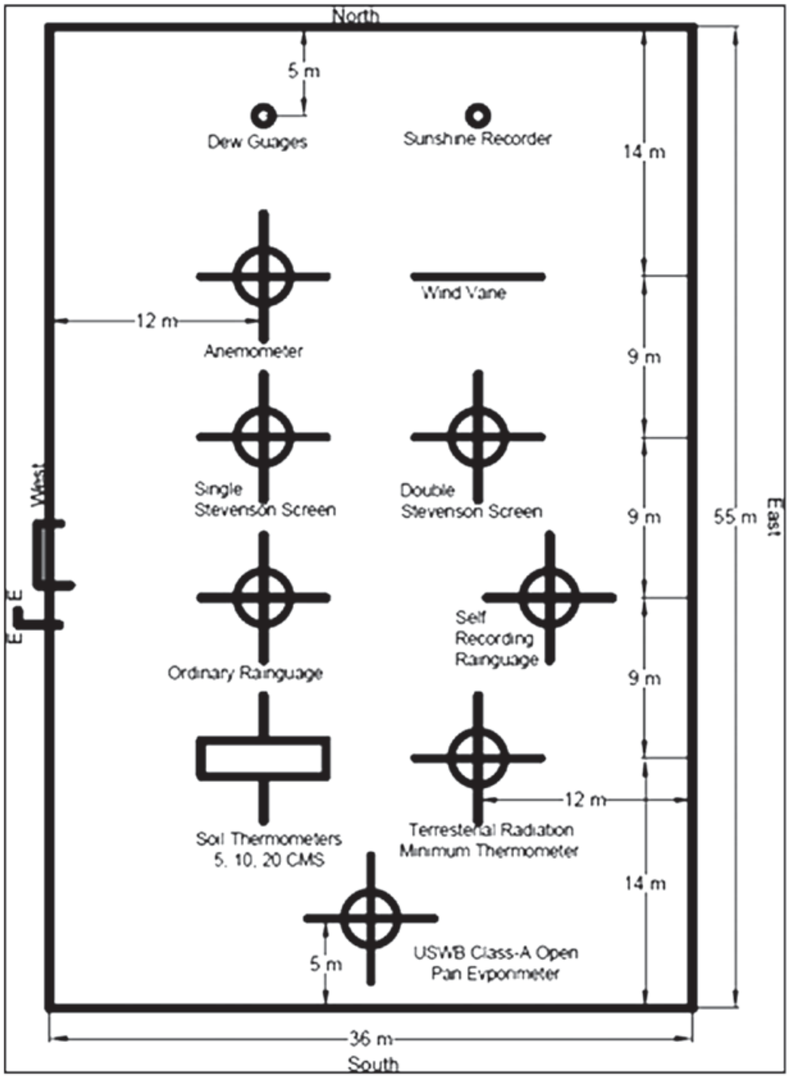
It is important for the participants to know about the global standard for a typical set up of the Agro-met station. The facilitator should explain in detail the set-up of (Figure 4.) agro- met station and the purpose behind the set-up. He should also encourage the participants to ask questions.



(source: https://www.hko.gov.hk)[3]

Figure 4. Typical setup of the Agromet Station

3. Ahmad, Drlatief & Kanth, Raihana & Parvaze, Sabah & Mahdi, Syed. (2017). Measurement of Atmospheric Pressure. 10.1007/978-3-319-69185-5_11.



(Source: Measurement of atmospheric pressure)

Figure 5. Top view of the typical set up of Agromet observatory Station

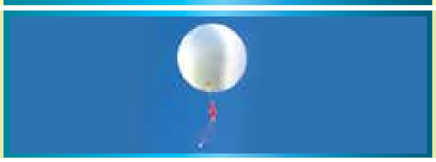
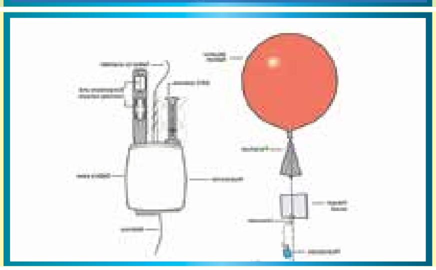
Step 2. Weather measuring instruments and their functions:

Next, the participants will be given a presentation on various weather measuring instruments with their functions and their pictures. This session is more of an interactive kind. At the end of the presentation, the facilitator should stick the picture of the different instruments (without the name). The sticky notes will be given to the participants with the names and functions of the instruments written on each note. Each participant will then ask to come on stage and stick the name and function of the instrument against the picture of the instrument. The other participants should decide whether the matching of instrument name/function is correct or not? The facilitator should also arrange actual Agromet station visit for the participants.

Table 4. Various weather measuring instruments and their functions

SL. NO	Name of Instrument	Picture of the Instruments	Functions of the instrument
01	Stevenson's Screen/ Thermometer screen		It is a wooden shelter box painted white with double louvered sides and mounted on a stand 122 cm (4 ft.) above the ground. The meteorological instrument inside, record humidity and temperature. It is having dry- and wet-bulb thermometers and measures maximum and minimum temperature
02	Sunshine Recorder		It measures sunshine into one side of a glass ball and leaves through the opposite side in a concentrated ray. This ray of light burns a mark onto a thick piece of card. The extensiveness of the burn mark indicates how many hours the sun shone during that day
03	Cup Anemometer		It measures wind speed. The cups get the wind, turning a dial attached to the instrument. The dial shows the wind speed.
04	Wind Vane		It is a device that measures the direction of the wind. Wind direction is the direction from which the wind is blowing.
05	Open Pan Evaporimeter		It measures the rate of evaporation of water into the atmosphere It enables farmers to understand how much water their crops will need

SL.NO	Name of Instrument	Picture of the Instruments	Functions of the instrument
06	Self-recording Raingauge		It measures the amount of rainfall automatically on the paper chart It helps to track daily, weekly and monthly rainfall history on a chart mounted on a drum which rotates round a vertical axis once per day
07	Wind Sock		It is a conical textile tube, which resembles a giant sock. Designed to indicate wind direction and relative wind speed.
08	Manual Raingauge		It measures the amount of rainfall. It measures precipitation in millimetres, or to the nearest 100th of an inch. It consists of a long, narrow cylinder capable of measuring rainfall up to 8 inches.
09	Soil Thermometer		It measured the temperature of the soil at various depths. Two forms of the mercury-in-glass thermometer are used for this purpose. To obtain a measurement, the instrument is lowered into a steel tube that has been driven into the soil to the desired depth.
10	Barograph		It records the changes in the atmospheric pressure on paper chart It tells whether the pressure is rising or falling.

SL.NO	Name of Instrument	Picture of the Instruments	Functions of the instrument
11	Doppler Weather Radar		Accurate, real-time detection and tracking of the hazardous weather Determine the precise location of areas of turbulence and wind shear Determining the height, amount of precipitation and speed of movement of rain-bearing clouds
12	Automatic Weather Station		It is an automated version of the traditional weather station It consists of a weather-proof enclosure containing the data logger, rechargeable battery, telemetry (optional) and the meteorological sensors with an attached solar panel or wind turbine
13	Weather Balloon		Measure wind direction & wind speed at different levels in the atmosphere.
14	Radio Sonde		A convenient way to gather atmospheric data at high altitudes is to use weather balloons It sends information about atmospheric pressure, temperature, humidity and wind speed.
15	Hygrometer		A hygrometer is a weather instrument used to measure relative humidity (How much water vapor is present in the air) It is measured as a percentage (%)
16	Weather Satellite		A Weather Satellite is able to photograph, track and measure the conditions of large-scale air movements, precipitation depth etc. It collects real time weather data and transmit the data immediately. Meteorologists compile and analyze the data with the help of computers.

Module 2

Fundamentals of Forecast Generation

Session

- Introduction to the basic terminology in forecast System
- Types of forecast
- Preparation of weather forecast
- Lecture on accuracy and skills of the weather forecast
- Overview of the weather forecast modelling
- Uncertainties associated with weather forecasting

Learning Objectives

Get to know about basic knowledge of weather forecast generations. How the forecast is being prepared, an overview of models used, the accuracy of the forecast and uncertainty associated with forecasting.

Duration

[4 hours]

- Introduction to terminology: 10 minutes
- Exercise: 60 minutes
- Lecture/Presentations: 2 hours and 20 minutes
- Discussion: 30 minutes

MODULE 2: FUNDAMENTALS OF FORECAST GENERATION

Session I: Introduction

1. The Forecasting Science: Weather forecasts are prepared by gathering as much data as possible about the current state of the atmosphere (particularly the temperature, humidity and wind) and using the understanding of atmospheric processes (through meteorology) to determine how the atmosphere evolves in the future.

However, the chaotic nature of the atmosphere and incomplete understanding of the processes mean that forecasts become less accurate as the range of the forecast increases.

2. Type of Forecast:

Sl. No.	Type of Forecast	Description
01	Nowcasting	Forecast having a lead time/validity of 3 to 6 hours
02	Short-range forecast	Forecasts having a lead time/validity period of 24 to 72 hours
03	Medium range forecast	Forecasts having a lead time /validity period of 3-10 days
04	Extended range forecast	Forecasts having a lead time /validity period of more than 10 days to monthly scale.
05	Long-range forecast/ Extended range forecast	Forecasts having a lead-time /validity period beyond 10 days (However, considered beyond 7 days in tropics). Usually, this is being issued for a season.
06	Local Forecast	In the local forecast, whenever any weather phenomenon is expected, its intensity, frequency and time of occurrence are indicated. In the absence of a weather phenomenon, the local forecast describes anticipated sky conditions. The other parameters for which the local forecast issued include maximum temperature and/or minimum temperature, rainfall, wind and special phenomenon. It is valid for a radius of 50 km around the station and is updated 4 times in a day.

3. Numerical Weather Prediction (NWP): The Numerical weather prediction (NWP) uses mathematical models of the atmosphere and oceans to predict the weather based on current weather conditions.Several global and regional forecast models are run in different countries worldwide, using current weather observations relayed from radiosondes, weather satellites and other observing systems as inputs.

Factors affecting the accuracy of numerical predictions include the density and quality of observations used as input to the forecasts, along with limitations in the numerical models themselves.

Exercise: Differentiating types of weather forecast

The facilitator will recap participants on type of weather forecast in meteorology i.e. now casting, , short-range, medium-range,extended range and long-range forecast. To check the understanding of the participants, the group will be provided with examples of forecast related to the Bangladesh context. The participants need to classify the weather forecasts provided in the appropriate category.

Session II: Preparation of the Weather Forecast

The weather forecaster from Bangladesh Meteorology Department (BMD) could be invited for the lecture on the preparation of the weather forecast. He/ She could explain participants on general activities undertaken in BMD to produce short, medium,extended and long-term weather forecast using the following points. At the end of the lecture, participants are encouraged to ask a question on the process of preparation of the weather forecast in BMD.

The resource person from BMD could use the following points to explain the process of preparation of the weather forecast to the participants.

The preparation of any kind of weather forecast generally involves three steps:

1. Observation and Analysis
2. Extrapolation to find the future state of the atmosphere
3. Prediction of particular variables

1. Observation and Analysis: Meteorological observations are taken around the world including reports from surface stations, radiosondes, ships at sea, aircraft, radar, and meteorological satellites. Although data-access policies vary among countries, many ofthese reports are transmitted on the Global Telecommunications System (GTS) of the World Meteorological Organization (WMO) to regional and global centers. There the data are collated, re-distributed back across the GTS, and used in various numerical forecast models.

2. Extrapolation: Whenever possible, meteorologists rely on numerical models to extrapolate the state of the atmosphere into the future, since these models are based othe actual equations that describe the behavior of the atmosphere.

3. Prediction: When a forecaster sets out to predict a specific variable - for example, the minimum temperature on a given night in the city where he or she is located - a great deal of observed and model-generated data are available. None of the data, how ever, provide a definitive prediction. The forecaster must apply a knowledge of average climatic conditions, local microclimate variations, and typical model behavior in the current situation.

Session III:Accuracy and skills of weather forecast

Outcome:

After the session, participants should be able to know:

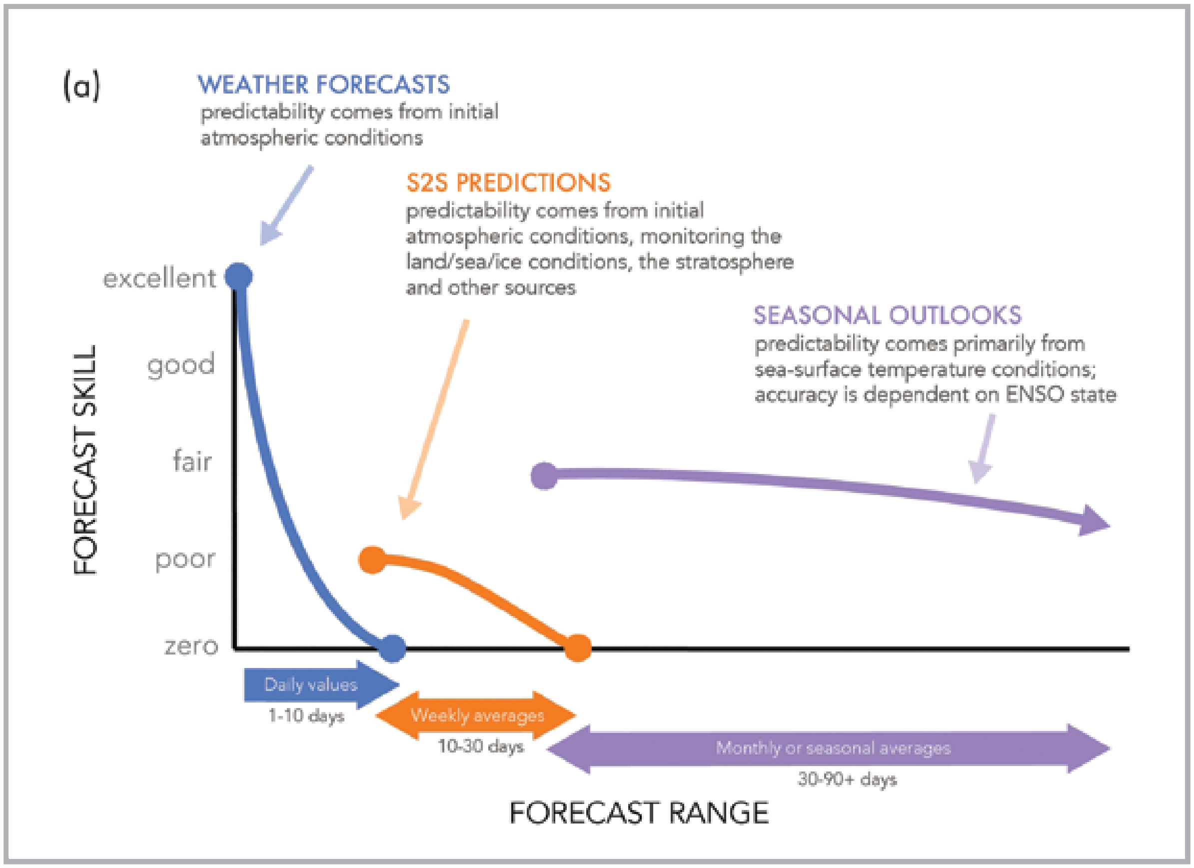
- The relationship between forecast range and forecast skills;
- Accuracy of the different kind of forecasts generated by Hydro-met service providers.

Materials:

Projector, Dashboard, Flipchart, Marker pen

Session:

The session will take approximately 70 minutes.



(Source: IRI)

Figure 6. The Relations between forecast skill and forecast range

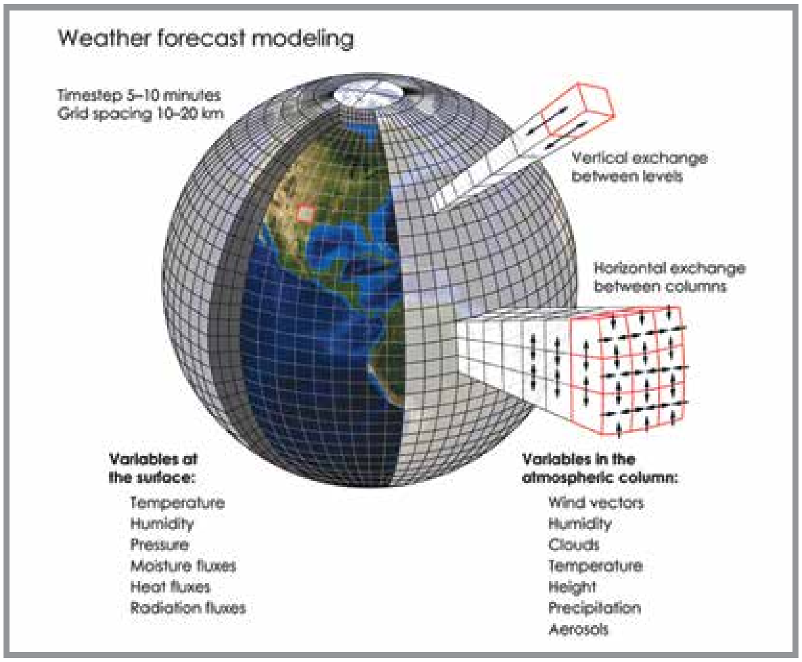
Process followed:

The facilitator will display the figure 6. on the projector for all the participants. Before starting the lecture, the facilitator should ask the participants to observe the graph and ask them to give their opinion by just looking at the figure.

Next, Facilitator should explain in detail to the participants. The terms like the weather forecast, season to sub season prediction and seasonal prediction should be explained clearly to the participants. It is clear from the figure that short-range forecast such as weather forecast is more reliable than the long-range forecast. As the range for forecast (days after the forecast) increases the forecast skill decreases. In the end, the facilitator should encourage the participants to discuss these findings.

Session IV: Overview of the Weather Forecast Modeling

The two best-known NWP models are the National Weather Service's Global Forecast System, or GFS, and the European Center for Medium-Range Weather Forecast, known as the ECMWF model. They are also known as the American and European models, respectively. The European model has produced the most accurate global weather forecasts. The facilitator could explain in brief about these two models and encourage them to ask the questions.



(Source: EWB- MADISON)

Figure 7. Weather Forecast Modelling

Session V: Uncertainties associated with weather forecasting

We should know about the certain limitations of the weather forecast models e.g. the Numerical Weather Prediction (NWP) models. The facilitator should explain the limitation and encourage participants to discuss in the group regarding, reasons for uncertainties, how to overcome these uncertainties and limitations in the actual field operations.

- Models represent a "simplified" atmosphere - not every real process in the atmosphere can be resolved in the models
- The model equations compute quantities at grid points. Currently, grid spacing ranges from 30-50 km apart. Any phenomena smaller in size that grid spacing will not be resolved in models (e.g., thunderstorm)
- Models cannot address boundary layer very well
- The initial atmospheric state is not well-known - want a dense, global network of observations
- Have many data-parse regions, particularly over the oceans.
- The data may also have errors in it. Local impacts-not represent in the model
- Small-scale terrain features will not be handled properly
- Small differences in the model initial conditions can produce radically different results later in time; each model can produce different predictions.

Module 3

Weather Sub-Seasonal and Seasonal Climate Forecast for Agriculture

Session

- Introduction to the terminology
- Understanding weather and seasonal climate forecast for agriculture
- Understanding seasonal forecasting by example
- The Bangladesh Meteorological Department (BMD): activities and Services for Agriculture

Learning Objectives

Get to know the importance of weather and seasonal scale forecast for agriculture, understand the probability concept and interpretation of seasonal forecast.

Duration

[3 hours 30 minutes]

- Introduction to the terminology: 15 minutes
- Interactive Games: 1 hour 30 minutes (3 Games- 30 min. each)
- Exercise: 1 hour 30 min (3 exercise- 30 min. each)
- Discussion: 15 min.

MODULE 3: WEATHER, SUB-SEASONAL AND SEASONAL CLIMATE FORECAST FOR AGRICULTURE

Session I: Introduction to Terminology

1. Forecast: A weather forecast, or prediction, is an estimation based on specialized knowledge of the future state of the atmosphere concerning temperature, precipitation, and wind.

2. Climate Monitoring: An approximate numerical/mathematical representation of the Earth's climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties.

3. Seasonal Forecast: Seasonal forecasts predict weather anomalies at monthly intervals out to 7 months. It is scientifically impossible to provide accurate daily forecasts one, two, or seven months in advance. Instead, seasonal forecasts offer guidance on large-scale weather patterns and whether a given location or region will more likely see above-normal or below-normal temperatures or precipitation over a month (source: business.weather.com)

4. Sub Seasonal Forecast: Sub seasonal forecasts are generated at weekly intervals out to 5 weeks. Accuracy levels are similar to seasonal forecasts since there is a balance between predicting less far into the future (higher accuracy) and predicting at weekly rather than monthly intervals (lower accuracy).

5. Climate Models: In general, a climate model can be defined as a mathematical representation of the climate system based on physical, biological and chemical principles. Climate models use quantitative methods to simulate the interactions of the important drivers of climate, including atmosphere, oceans, land surface and ice.

6. Probabilistic Forecast: Probabilistic forecasting is a technique for weather forecasting that relies on different methods to establish an event occurrence/magnitude probability(source: http://tornado.sfsu.edu)

7. Deterministic Forecast: Deterministic forecasting is a technique for weather forecasting that gives precise information on the occurrence/magnitude (or not) of the event.A perfect deterministic (or categorical) forecast can only be as good as

(a) The meteorologist's skills in interpreting;

(b) The degree to which we understand the forecast models and how good these models are at estimating things

(c) The degree to which the original observations are accurate.

Session II: Understanding weather and seasonal climate forecast for agriculture

Background Information:
Weather and climate forecasts are very important for farmers to prepare immediate remedies to address unexpected change in weather in a short term and/or adjust their seasonal crop plan in the long term. The weather and climate forecast information include short-range, medium-range, long-range and seasonal weather forecasts.

On the other hand, seasonal forecasts in the form of probabilities of rainfall falling in any of the following three categories: above normal, near normal and below normal will help farmers to develop their cropping pattern and calendar in a given cropping season. In general, Rainfall is regarded as NORMAL if the condition ranges between 96% and 104% of its average value (50 years' average). It is regarded ABOVE NORMAL if the condition of the climate is between 104% and 110% of the average value, and BELOW NORMAL if it is between 90% and 96% of the average value. If it is below 90% of the average value, it is a DEFICIT and above 110% is considered as EXCESS. It is important that farmers appreciate the usefulness of weather and climate forecasts in their farming operations and in crop planning and water budgeting.

Objectives:
The main objectives of this session are:

1. Understand weather and climate forecasts and their importance to farming activities.
2. Understand the meaning of above normal (AN) rainfall, Normal (N) rainfall and below normal (BN) rainfall.
3. Learn the meaning of probability within the context of forecast accuracy and its rela tion to decision making.

Materials:
Cardboard, Board marker, Pieces of paper containing words describing weather and climate forecasts and potential benefits from forecast, Monthly climatological rainfall data for pilot locations, Cardboard to display the definition of ABOVE NORMAL (AN), NORMAL (N), BELOW NORMAL (BN), DEFICIT (DF) and EXCESS (EX).

Session: The session will require 120 minutes

Process followed:
After knowing weather and climate elements and information that could be utilized in farming operations, equally, important forecasts of different timescales will be presented and how these could be utilized. A game intended for identifying benefits from a specific forecast will be introduced. The nature of deterministic and probabilistic forecasts will also be discussed. The importance of understanding forecasts and how information could be integrated into various farm decisions will be presented and participants will be engaged in the analysis of forecasts through historical data and subsequent application. The whole process will be explained to the participants through three games:

Game 1. Understanding weather and climate forecasts and its potential benefits
Game 2. Determination of Above Normal (AN), Near Normal (N) and Below Normal (BN) Rainfall
Game 3. Describe the probability concept through the game of marbles.

The detailed process to play the games for clear understanding of forecasts is as below:

Game1: Weather and Climate forecasts and it's potential benefits

1. Start the game: Each group member will be asked to take a piece of paper from a box containing descriptions of weather and climate forecasts and then a member from another group will take out a note with a write-up on potential benefits that can be derived if that forecast is utilized. He has to check and stick the note in front of the appropriate weather/climate forecast. Continue the game until all the pieces of paper from the box until the entire column in left and right will be filled up.

2. Discuss with the members of the group and members of the other groups whether the groupings are correct or not.

3. Make the following observation table onboard/ projector for all participants to watch and discuss among themselves.

Weather and Climate Forecasts	Potential Benefits from the Forecasts

Game 2: Determination of Above Normal (AN), Near Normal (N) and Below Normal (BN) Rainfall

Background information:

The facilitator has explained the uncertainty associated with forecasts and emphasized that the prediction or forecast is not always correct. The forecast has certain level of probability. If the probability of rain is high, it means that we can expect the rainfall may occur or the chance to have rain is high. On the other hand, if it is said that the probability of rain to occur is low, it means that we may not expect that the rain will come. The facilitator has also provided basic science of forecasting and explained simple methods of forecasting based on statistical techniques and numerical models. For example, rainfall occurrence can either be predicted based on history or in terms of other parameters that have a high correlation with rainfall such as temperature, humidity, wind speed and pressure.

Numerical prediction technique is based on the evolution of the surface boundary conditions and its interaction with the atmospheric properties. Outputs from numerical or statistical models provide forecast in the form of probabilities of rainfall as: ABOVE NORMAL (AN), NORMAL (N), BELOW NORMAL (BN), DEFICIT (DF) and EXCESS (EX). The meaning of terms ABOVE NORMAL (AN), NORMAL (N), and BELOW NORMAL (BN)" was then discussed and also the procedure to use the meteorological agency's weather forecasts to predict the condition of rain in the farmer's location was explained.

The terms ABOVE NORMAL, NORMAL and BELOW NORMAL was then defined in the context of a specific location of participants' region to define statements like "The rain in my place is normal ranging between v and w mm, whereas below normal is x and y mm, and above normal is above z mm, etc. The participants will again be divided into sub-groups for discussion, at the most 6 persons per sub-group and assigned a task. Distribute the working sheet of a game model to all sub-groups. When finished, each sub-group will present the results of their discussion. The facilitator will clarify and conclude what ABOVE NORMAL, NORMAL, and BELOW NORMAL rainfall are.

Steps:

1) Prepare two pieces of papers, each of which contains average monthly rainfall data (over 30 years); one for January and the other one for June.

2) Prepare two tables as shown below, one for determining AN, N, and BN rainfall con cerning rainfall for January and the other to stick the answer sheet (cardboard pieces) prepared by participant according to rainfall depth given to them.

Table 5. Rainfall classification categories with rainfall range

Sl. No.	Classification of Rainfall	Rainfall Range (% of LPA)
1	Below Normal	90-96
2	Normal	96-104
3	Above Normal	104-110
4	Excess	>110
5	Deficit	<90

3) Divide the participants into two groups: A and B Group, A asked to determine AN, N and BN rainfall with reference to rainfall depth for January and Group B asked to determine AN, N, BN rainfall with reference to rainfall data forJune.

4) Start the game by taking a piece of paper containing data of rainfall depths. Then attach it on the column of ABOVE NORMAL (AN) if it has AN value, or on the column of N if it has N value, or on the column BELOW NORMAL if it has BN value.

5) Discuss with members of the group and the other group, whether the groupings are correct or not and whether the meaning of normal between group A and group B is the same.

6) Try to write down a figure on a piece of blank paper, attach it on the right column, and ask other members of the group whether you have attached it on the proper column.

Continue the game to interpret the results of the meteorological agency's forecasts to estimate the forecast of rainfall depths in the dry season. The facilitator will prepare the results of meteorological agency's forecasts, map of forecast areas, and show the picture of monthly Rainfall Histogram, if available

Above Normal (AN)	Normal (N)	Below Normal (BN)

Game 3: Marble Game (Describe probability Concept)

1. For example, suppose the forecaster's ability to forecast is 80%, and white marbles are used to indicate that the forecast really comes true, and green if the forecast is incorrect.
2. Draw the following table on a piece of paper on put on cardboard/show on the projector.

Steps of Collecting	White Marbles	Green Marbles
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

3. Start the game of playing marbles as follows: one of the members of a sub-group to take one marble from the container containing 40 white marbles and 10 green marbles. Then, see whether it is a white or green marble. If it is a white one, write figure '1' on the 'white marbles' column, and zero on the 'green marbles', column. On the other hand, if it is a green marble, write '1' on the 'green marbles' column and '0' on the 'white marbles' column. After that, return it to the container. The container is then shaken and another participant takes another marble from the container, and so on.

4. Add the numbers in column 2 and column 3. The number of marbles in column 2 shows correct predictions, whereas the number of marbles in column 3 shows incorrect/false predictions.

5. If it is known that the forecaster's skill of forecast is 80%, and then it is told that in the next dry season the rainfall will be below normal, what do you think? Do you decide to believe the prediction or not? If yes explain why and if not also explain why.

6. Try to play with past years rainfall data from a particular station and compare them with previous meteorological forecasts whether the meteorological forecasts are correct or incorrect.

Session III: Understanding seasonal forecasting by example

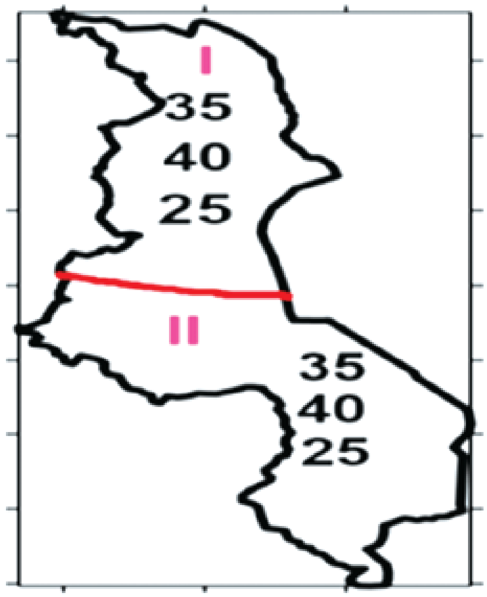
Objectives:
The seasonal forecast is produced by the National Meteorological Agency will be provided to the participants. The product is generally prepared shortly before the season begins. The objective of the exercise is that participants should understand the seasonal forecast and its applicability for the upcoming seasons. The participants will be encouraged to prepare plans or change in regular plans as per the seasonal forecasting. The results will be discussed and presented from each group.

The main objectives of this session are:

- Understand the seasonal forecast and how it is prepared
- Understand terciles and how they are used in the seasonal forecast and from this, how this information may be used
- Understand the advantages and the limitations of the seasonal forecast (what it does tell us and what it does not tell us).

Tools:
Print out copies of the seasonal forecast, Marker, Cardboard etc.

Time Required:
The session requires 90 minutes



(Source: PICSA Field Manual University of Reading, 2015)

Figure 8: Seasonal Forecast

Step 1:

Start by showing the group this example of the seasonal forecast, which provides the seasonal forecast for Malawi. Explain that you will use the figures from the north and south of Malawi to support our explanation of the seasonal forecast . Explain that for the south of Malawi, the forecast was of a 35% chance of an “above normal” season, with 40% chance of a “normal” season and 25% of a “below normal” season.

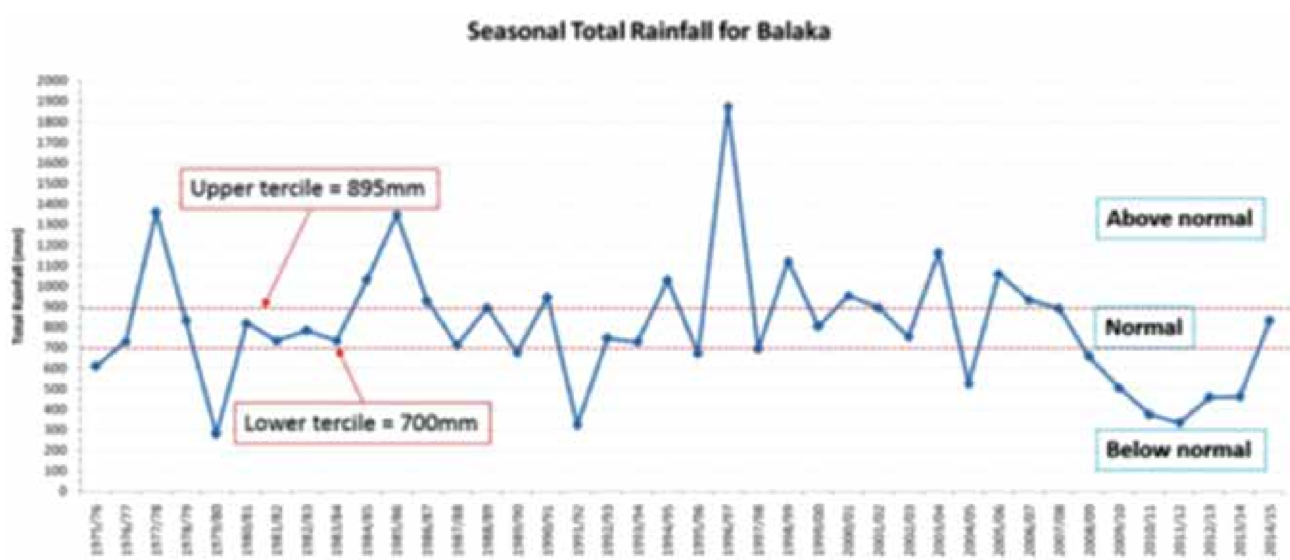


Figure 9: Graphical view of seasonal total Rainfall in Malawi

Step 2:

Next, show them the graph with the terciles (same as the one above but for the Met. Station for your area) and explain that this shows what is meant by the three categories, “above normal”, “normal” and “below normal” season, for one station.

These categories are sometimes called "terciles" because they divide the data into three equal groups (the group may have heard of "quartiles" before, which divides a data set into 4 groups). You can see in the graph that 1/3 of the years in the graph had a rainfall total of more than 895 mm, which is "above normal" and 1/3 of the years had total rainfall of less than 700 mm, which is below normal. The total rainfall of the remaining 1/3 of the years falls in between 700 mm and 895mm, which is normal.

Step 3:
To ensure that this is clearly understood ask the participants to count the occurrences in each tercile.

Step 4:
Once the participants understand what the seasonal forecast. To test their understanding seasonal forecast of 2019 summer monsoon season for Bangladesh will be provided to participants and will be requested to explain in the group about their understanding.

Session IV: The Bangladesh Meteorological Department (BMD): Activities and Services for Agriculture

The Bangladesh Meteorological Department (BMD) is the agency mandated to observe, monitor and provide meteorological Informations and services in Bangladesh. This session encapsulates the key services, mandates and products of BMD.

Objectives

The main objectives of this session are:

- Know and understand the products and services of BMD
- Discuss the potential uses of weather and climate information products in agricultural production

Session Time:
This session takes 60 minutes.

Materials Needed:
Flip charts
Marker pens

Step 1. Discuss with participants their current use of BMD forecasts

The facilitator will ask participants to talk about their knowledge of BMD activities and services, the channels in which they access these forecasts and how they use BMD forecast products in planning or decision-making. The facilitator will list the participants' answers in the flip chart and notes whether participants are fully aware of BMD products, services and their relevance.

Step 2. Present the various weather and climate information products of BMD

The facilitator will present the weather and climate information products released by BMD through multiple channels as follows.

Table 6. BMD activities and services

Service	Release Day/Time	Dissemination Channel	Parameters	Use
Daily		Newspaper, TV, radio		Day-to-day operations
7-day		Newspaper, TV, radio		Logistics planning
Monthly		Website		Crop management
Seasonal		Website		Crop planning

Step 3. Discuss ways to increase access and use of BMD forecasts by end-user farmers

After presenting BMD's information activities and services, the facilitator discusses with participants how BMD and BAMIS portal could raise awareness and capacity to use multi-timescale forecast information in farm-level planning and decision-making.

Module 4

The Sensitivity of Crops to Weather and Climate

Session

- Understanding the influence of weather elements on crop growth, impact of climatic variability and extremes on crop production, climatic normal for crop production
- Major crop diseases affecting crop productivity in Bangla desh and their relationship with weather and/or climate
- Influence of weather and/or climate on pest development and outbreaks
- Growing Degrees of Days

Learning Objectives

Get to know relationship between weather/climate and cultivation of crop. Also, to know the effect of climatic factors on outbreak of pest, insects and diseases.

Duration

[4 hour 30 minutes]

- Presentation - 30 minutes
- Lecture - 60 minutes
- Field Exercise – 3 hours

MODULE 4: THE SENSITIVITY OF CROPS TO WEATHER AND CLIMATE

Session I: Understanding crop weather relationship

Background Information:

All the crops have their own specific requirement of meteorological parameters at each of their growth stages. Hence, they have selective response to these parameters. excess or deficiency of these parameters during crop growth stages have effect on them.. The crops are sometimes influenced by one or two factors, which play crucial role at some critical crop growth stages

Factors that determine crop yields at village and farm levels are mainly environmental conditions and management. Climate, including weather form the most important factors that contribute to variability in crop yields. Farm production can be affected by weather and climate, either directly or indirectly (pests and diseases). On the other hand, favourable climate conditions can enhance production. It is therefore very important to gain some basic understanding of the sensitivity of crops to weather and climate.

The biochemical process within plants is controlled by sunlight, temperature, water availability and nutrient availability. Thus, plant physiology that ultimately determines crop yields is influenced by all these controls mentioned.

All plants have maximum, optimum and minimum temperature limits. The limits are cardinal temperature points. Optimum temperature range is very important. Similarly, optimal water availability, availability of solar radiation (Photosynthetically Active Radiation – PAR) and length of bright sunshine hours are also critical factors in the growth and development of crop plants.

Cardinal Temperature:

Three temperature of vital activity have been recognized which are often termed as Cardinal Points.

- A minimum temperature below which no growth occurs.
- An optimum temperature at which maximum plant growth occurs.
- A maximum temperature above which the plant growth stops.

Growing Degree Days:

Growing Degree Days (GDD), also called heat units, effective heat units or growth units, are simple means of relating plant growth development and maturity to air temperature.

The GDD concept assumes that there is a direct and linear relationship between growth and temperature.

It starts with the assumption that the growth of plants is dependent on the total amount of heat to which it is subjected during its life time.

GDD is the departure from the mean daily temperature above minimum threshold value The minimum threshold value is the temperature below which growth of plant stops.

Growing Degree Days are calculated as: $GDD = \frac{T_{max} + T_{min}}{2} - T_{base.}$ If the average temperature for a day is lower than the base temperature, then no Growing Degree Days are counted.

Experiments on different dates of sowing can provide useful indication of the climatic requirements as they are accompanied by daily meteorological observations, phenological observations and biometric data on crop. In the present scenario, towards better agrometeorological advisory services, some tips on agroclimatology of important crops, based on crop weather relationship study, is essentially required for better crop fitting in suitable zone.

The BAMIS portal lists some of the key crops and their general climatological requirements. Three field crops – Paddy, Maize and Wheat are provided. The crop weather calendar for selected crops is also available on the BAMIS portal. The crop weather calendar also includes information such as favorable weather conditions, congenial weather conditions for pests and diseases and weather warnings.

At the end of this session, the participants are expected to:

1. Understand and learn the concept of the pest/disease triangle;
2. Identify and observe climate factors that contribute to the development of pests and diseases and learn the relationship between climate condition (i.e. particularly air tem perature and humidity) and the development of pest and diseases; and
3. Influence of weather and climate on pest development and outbreaks (Field visit)

Crop Weather Calendar:

The pictorial representation of detailed information for a crop concerning its sowing period and the duration of important phenological stages during its entire life cycle, the optimum climatic requirement during different stages of the crop and the actual and normal weather for the location/region is called the crop weather calendar.

- These CWC provide information on crop growth stages, normal weather for crop growth, warnings to be issued based on prevailing weather conditions, water require ment of crops during their various phytophases, meteorological conditions favourable for development of crop pests and diseases.
- These calendars are useful for crop planning, irrigation scheduling and plant protection measures, which are of vital importance for effective crop planning and for maximizing and stabilizing food production in the country.
- In a broader perspective over a period of say five years, the concise information con tained in these calendars give broad indications of the direction of development which may prove useful to the planners, agricultural administrators, plant breeders and the farmers in formulating policy matters regarding plant breeding, crop adaptation, drought proofing, supplemental irrigation, maximizing the yield etc.

A sample crop weather calendar is provided for a better understanding of crop weather relationship from BAMIS portal.

Crop Weather Calendar of Boro Rice: Dhaka Region (Districts: Dhaka, Tangail, Gazipur, Narsingdi, Narayanganj, Munshiganj, Manikgonj) **Bangladesh**

Region: Dhaka	**Boro Rice**																			**Duration: 150-155 days**			
Months	**October**		**November**				**December**				**January**				**February**				**March**				
Std.Week/Normal	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Rainfall (mm)	26.0	12.5	10.0	6.0	1.5	4.5	1.5	4.5	1.0	3.5	1.0	0.0	0.0	0.5	3.5	3.5	2.5	12.0	3.5	4.0	9.5	13.5	20.5
Max. Temp. (°C)	31.5	30.9	30.6	29.8	29.0	28.3	27.6	26.2	25.5	24.8	24.0	23.9	24.5	25.0	26.2	27.2	28.3	28.9	30.0	31.5	32.3	33.4	33.2
Min. Temp. (°C)	22.3	21.5	20.5	18.7	17.7	16.1	15.5	14.7	13.5	12.9	12.4	12.0	12.0	12.1	13.6	14.3	15.5	16.5	17.5	18.6	19.8	19.8	21.8
Mean Temp. (°C)	26.9	26.2	25.5	24.3	23.3	22.2	21.5	20.5	19.5	18.8	18.2	17.9	18.3	18.6	19.9	20.7	21.9	22.7	23.7	25.0	26.1	26.1	27.5
RHmax (%)	94.8	94.5	95.0	94.7	94.6	94.3	94.8	95.3	95.1	95.0	94.6	94.3	93.8	93.4	92.4	92.1	91.7	91.1	90.0	89.9	89.2	89.6	90.3
RHMin (%)	55.5	54.6	51.5	49.3	47.5	46.3	47.6	49.4	49.8	49.1	50.3	48.8	46.2	43.3	42.3	39.4	39.7	38.9	36.0	35.5	35.9	38.9	44.5
RHmean (%)	75.2	74.6	73.2	72.0	71.0	70.3	71.2	72.3	72.5	72.1	72.4	71.6	70.0	68.3	67.3	65.7	65.7	65.0	63.0	62.7	62.5	64.3	67.4
SShr (hrs)	54.0	49.5	51.5	51.5	52.0	51.5	48.5	46.5	44.5	44.5	42.5	42.5	45.0	49.0	49.5	51.5	53.0	54.5	56.0	55.0	58.0	55.5	52.5
WD (deg)	190	190	189	199	212	211	219	224	225	233	238	238	232	242	241	236	234	228	234	230	223	206	188
WS(Km/hr)	3.8	3.7	3.7	3.7	3.7	3.6	3.7	3.7	3.7	3.7	4.1	4.0	4.1	4.3	4.3	4.5	5.0	5.3	5.0	5.4	5.7	6.2	6.5
																							
	Seedbed					Transplanting				Tillering						Heading		Flow erin g	Grain filling		Maturity to Harvesting		

Favorable Weather Conditions						
Temperature	At least 10° C for germination				22-25°C	23-27°C
Light Intensity			≤200% of normal			
Relative Humidity			High			
Soil Temperature			Above 16°C			
Normal phase wise water requirement (mm)	76	120		190	145	100

Congenial Weather Condition for Pests & Diseases					
Bacterial Leaf Blight	Temperature 28-30° C, Relative Humidity 80-90%, Cloudiness, Rainfall >30mm				
Sheath Blight			Temperature 28-32° C, high Relative Humidity, Cloudy weather		
Blast	Night temperature 16-20°C, for 8.30 hours day temperature 25-30°C, for 8.30 hours day night temperature >10°C Relative Humidity >90%, Cloudy				

Weather Warning					
Rain		>50 mm/day	>100 mm/day	>50 mm/day	
Duration of wet spell		>25 mm for 3 days	>50 mm for 4 days	20 mm for 4 days	
Cloudy weather			Cloudy weather	Cloudy weather	
High wind		>50 km/hr	>40 km/hr	>30 km/hr	
Temperature		Minimum Temperature <10° C	Minimum Temperature <10° C	Minimum Temperature <10° C	

Figure 10. Sample of crop weather calendar available at BAMIS portal (bamis.gov.bd/ calendar/)

Session II: Major crop diseases affecting crop productivity in Bangladesh and their relationship with weather and climate

It is estimated that 4-14% of rice yield in Bangladesh is lost every year by different insect pests. Bacterial leaf blight (BLB) and nematode (ufra) are now the serious diseases in rice. But the technologies resistant to pests and diseases are still very limited. Minor pests that could be easily controlled in the past became strong plant attackers now that are proving difficult to keep under check. Rice, wheat, corn, potato, mango, papaya, coconut, tomato, brinjal, tea and other major crops are increasingly coming under attack from the invasive alien pests and plant diseases. The pest is also attacking brinjal, tomato, chilli and many other vegetable crops besides causing large-scale damage in tea plantations.

Background information:

The application of agro-climatic information to control and manage pests & diseases of crops plants involves a complete understanding of the complex life cycles of the pathogen and its host, as well as the environmental conditions that influence its growth and development. Plant pathologists have developed a disease triangle with a host (a susceptible crop), environment (environmental conditions suitable for disease or pest establishment and development), and disease (the presence of the disease or pest) at the apexes of the triangle.

The concept helps to describe the situation for virtually all known pests and diseases. As a rule, all three sides of the triangle must exist for the pest/disease to develop. If one of the sides is missing, then pest/disease will not occur. In this process, climate factors are important as they affect the growth and development of host plant and animal species and for pests and diseases.

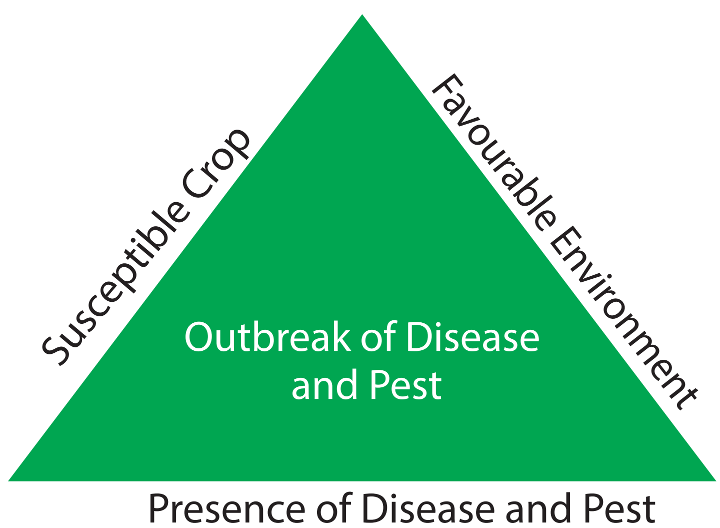


Figure 11: A Disease Triangle

The observation of temperature, humidity, rainfall and soil moisture is therefore essential in applying theconcept. For disease outbreak, conditions described by the triangle have to exist for sufficiently long period of time to result in an epidemic.

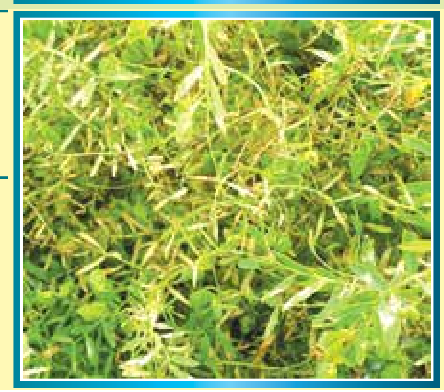
Diseases and Pest Outbreak due to Climatic Conditions: Rice and Wheat

Rice is the staple food of the Bangladesh. The paddy field occupies around 88% of cultivable land. In Bangladesh, the blast disease first outbroke in the early 70s and 80s. The economic loss due to blast is enormous. Blast disease of rice was recorded in ten agro-ecological zones (AEZs) of Bangladesh during Boro (November to May; irrigated ecosystem) and Transplanted Aman (July to December; rainfed ecosystem) seasons. Disease incidence and severity was higher in the irrigated ecosystem (Boro season) (21.19%) than in rainfed ecosystem (Transplanted Aman season) (11.98%) regardless of locations (AEZs). Blast disease of rice caused by Pyricularia grisea. The most favorable condition for Blight is night temperature 16-20ºC for 10 hours, day temperature 25-30ºC for 10 hours or day-night temperature differences above 10ºC, relative humidity above 90% and cloudy environment.

Wheat is the second most important staple food crop in Bangladesh after rice. Its importance as a food and nutrition security has increased since independence. The wheat blast occurred in Bangladesh for the first time in 2016. It is caused by a fungal pathogen, Magnaporthe oryzae Triticum (MoT) pathotype. The favorable conditions for wheat blight are continuous rains and average temperatures between 18-20ºC during the flowering stage of the crop followed by sunny weather and humid days. Highest blast intensity at 30ºC which increased with the duration of the wetting period, lowest at 25ºC with a wetting period of less than 10hr. However, with the increasing wetting period of 40 hr at 25ºC blast intensity of 85% has been observed.

The flowing tables provide favorable climatic parameters for some diseases and pests commonly encountered in Bangladesh.

Table 7. Crop diseases and their favorable climatic parameters

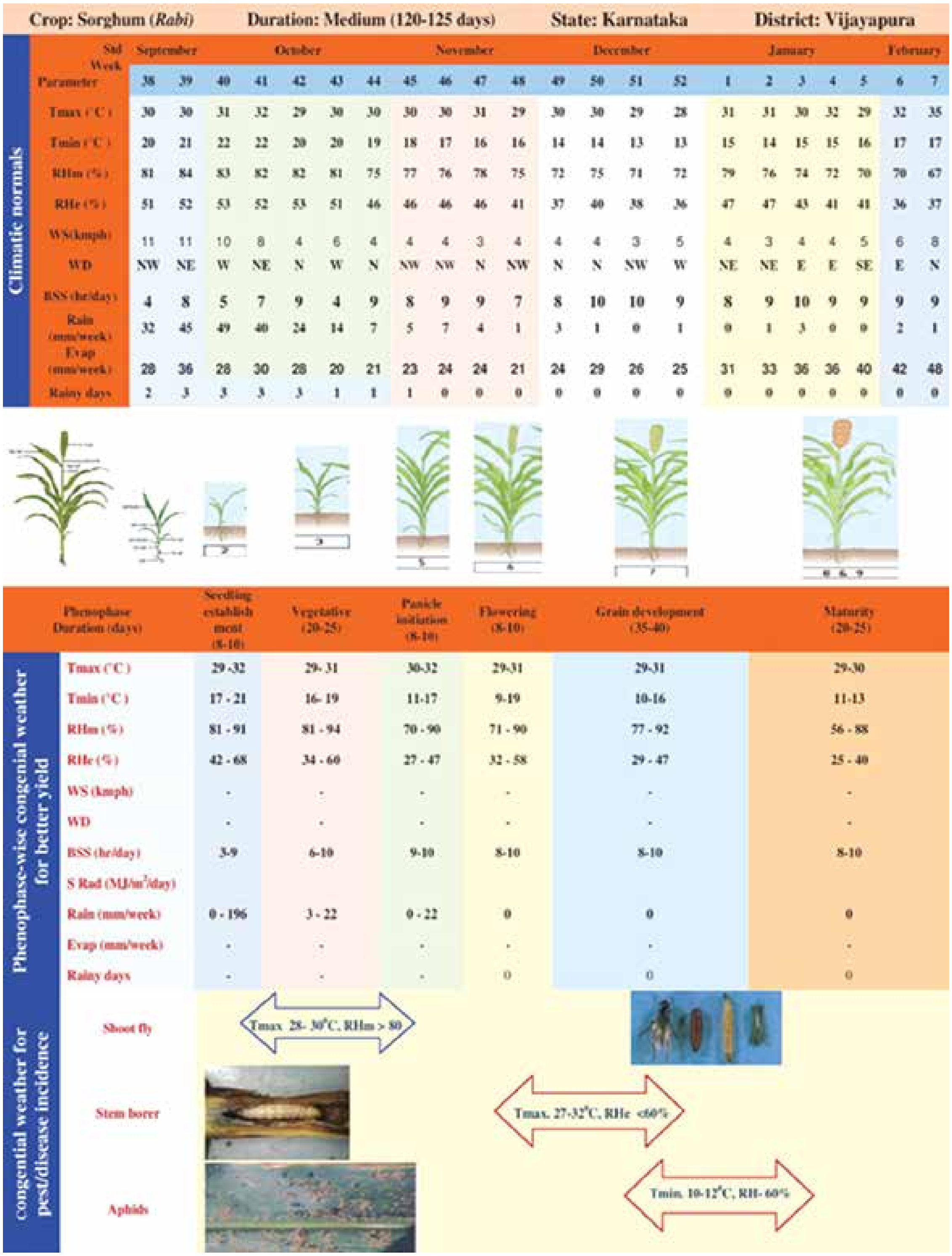
Name of Crop	Name of Disease	Favorable Climatic Conditions	Sample Photo
Potato	Late Blight	Humidity above 90%	
		Day temperature range 14-19°C and night temperature 9-14°C	
		Drizzling rain, fog and dew on the leaf surface	
Pea (Lentil)	Stemphylium blight	Night temperature less than 8°C and day temperature above 21°C	
		Drizzling rain, foggy environment	
Mustard	Sclerotinia stem rot	Temperature 15-18°C and humidity 80-90%	
Maize	Common Rust	High humidity and temperature 17-18°C	

*(*Source: Krishi Projukti Hatboi 2019 (8th Edition))*

Table 8. Crop pests and their favorable climatic parameters

Name of Crop	Name of Pest	Climatic Threshold	Sample Photo
Maize	Fall army Worm	Optimum Temperature 20-30°C	
Rice	Yellow Stem Borer	Optimum Temperature 24-29°C Morning above humidity 84% and Afternoon humidity 38.7% Dry Weather	
	Gall Midge	Max. Temperature above 33°C Afternoon relative humidity less than 71% Sunshine hour above 7.4 hour	
	Leaf Roller	Max. Temperature greater than 31.9°C and Min. Temperature less than 21.6°C Relative Humidity 90% Cloudy Weather	
Wheat	Stem Borer	Maximum, minimum and average temperature ranged from 31.9-33.9°C, 22.2-26.3°C and 26.9-29.5°C, respectively Average relative humidity of 80% Rainfall	
	Aphid	Mean temperature 18.7°C and relative humidity 71.0% Mean weekly temperature 29.1°C and relative humidity 55%	

Further, diseases are listed in the BAMIS portal on important crops to be explained by a plant pathology expert using illustrative images along with information about favorable climate conditions required for the spread of diseases. The following disease calendar from the All India Coordinated Research Project on Agrometeorology (AICRPAM) can be shown to the participants in illustration and encourage them to make one in the exercise session.



Crop: Sorghum (*Rabi*) Duration: Medium (120-125 days) State: Karnataka District: Vijayapura

Climatic normals

Std Week / Parameter	September		October					November				December				January					February	
	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7
Tmax (°C)	30	30	31	32	29	30	30	30	30	31	29	30	30	29	28	31	31	30	32	29	32	35
Tmin (°C)	20	21	22	22	20	20	19	18	17	16	16	14	14	13	13	15	14	15	15	16	17	17
RHm (%)	81	84	83	82	82	81	75	77	76	78	75	72	75	71	72	79	76	74	72	70	70	67
RHe (%)	51	52	53	52	53	51	46	46	46	46	41	37	40	38	36	47	47	43	41	41	36	37
WS(kmph)	11	11	10	8	4	6	4	4	4	3	4	4	4	3	5	4	3	4	4	5	6	8
WD	NW	NE	W	NE	N	W	N	NW	NW	N	NW	N	N	NW	W	NE	NE	E	E	SE	E	N
BSS (hr/day)	4	8	5	7	9	4	9	8	9	9	7	8	10	10	9	8	9	10	9	9	9	9
Rain (mm/week)	32	45	49	40	24	14	7	5	7	4	1	3	1	0	1	0	1	3	0	0	2	1
Evap (mm/week)	28	36	28	30	28	20	21	23	24	24	21	24	29	26	25	31	33	36	36	40	42	48
Rainy days	2	3	3	3	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Phenophase-wise congenial weather for better yield

Phenophase Duration (days)	Seedling establishment (8-10)	Vegetative (20-25)	Panicle initiation (8-10)	Flowering (8-10)	Grain development (35-40)	Maturity (20-25)
Tmax (°C)	29-32	29- 31	30-32	29-31	29-31	29-30
Tmin (°C)	17 - 21	16- 19	11-17	9-19	10-16	11-13
RHm (%)	81 - 91	81 - 94	70 - 90	71 - 90	77 - 92	56 - 88
RHe (%)	42 - 68	34 - 60	27 - 47	32 - 58	29 - 47	25 - 40
WS (kmph)	-	-	-	-	-	-
WD	-	-	-	-	-	-
BSS (hr/day)	3-9	6-10	9-10	8-10	8-10	8-10
S Rad (MJ/m²/day)						
Rain (mm/week)	0 - 196	3 - 22	0 - 22	0	0	0
Evap (mm/week)	-	-	-	-	-	-
Rainy days	-	-	-	0	0	0

Congenial weather for pest/disease incidence

Pest	Congenial weather
Shoot fly	Tmax 28- 30°C, RHm > 80
Stem borer	Tmax. 27-32°C, RHe <60%
Aphids	Tmin. 10-12°C, RH- 60%

(Source: District level crop weather Calendars of Major Crops in India, AICRPAM Bulletin)

Figure 12: Sample Pest Calendar

Session III: Influence of weather and climate on pest development and outbreaks

Background information:

The concept of the disease triangle is also applicable for pests. Presence of a vulnerable host, pest that attacks and favorable environmental conditions are necessary. Such conditions should be there for a sufficiently long time for the pest outbreak to reach damaging levels. The BAMIS portal lists several common pests that attack crop plants. Discussion may be done to explain important features of pests that attack crop plants and the climate conditions that are known to support the outbreak of each pest.

Growing Degrees of Days:

Growing degree days (GDD) is a weather-based indicator for assessing crop development. It is a calculation used by crop producers that is a measure of heat accumulation used to predict plant and pest development rates such as the date that a crop reaches maturity. In the absence of extreme conditions such as drought or disease, plants grow in a cumulative stepwise manner which is strongly influenced by the ambient temperature. The Growing Degree Days calculation allows producers to predict the plants' pace toward maturity. Daily growing degree day values are added together from the beginning of the season, indicating the energy available for plant growth. Growing degree day totals are used for comparing the progress of a growing season to the long-term average and are useful for estimating crop development stages and maturity dates.

Growing degrees (GDs) is defined as the mean daily temperature (average of daily maximum and minimum temperatures) above a specific threshold base temperature accumulated on a daily basis over a period of time. Negative values are treated as zeros and ignored. The base temperature varies among crops and the value is derived from the growth habits of each specific crop. The base temperature is that temperature below which plant growth is zero. For example, cereal and forage crops show little growth or development when average temperatures are below 5°C.

Unless stressed by other environmental factors like moisture, the development rate from emergence to maturity for many plants depends upon the daily air temperature. Because many developmental events of plants and insects depend on the accumulation of specific quantities of heat, it is possible to predict when these events should occur during a growing season regardless of differences in temperatures from year to year.

GDD units can be used to: assess the suitability of a region for production of a particular crop; estimate the growth-stages of crops, weeds or even life stages of insects; predict maturity and cutting dates of forage crops; predict best timing of fertilizer or pesticide application; estimate the heat stress on crops; plan spacing of planting dates to produce separate harvest dates [5]

[5] *https://farmwest.com/node/936*

GDD is calculated by taking the average of the daily maximum and minimum temperatures compared to a base temperature, Tbase, (usually 10 °C for grapes; 5 °C for cereals and many grasses.). The GDD calculation is not usually used for corn, as researchers have developed a more accurate temperature index that considers day and night temperature separately. The GDD equation can be written as follows[6]:

$$GDD = \frac{T_{max} + T_{min}}{2} - T_{base}$$

Where, GDD = Growing Degrees of Days
TMAX = Maximum Temperature
TMIN = Minimum Temperature
TBASE = Base Temperature

Exercise: Development and use of pest and disease weather calendar and its use in prophylactive measures

Exercise
Material and venue required - A field site at a nearby location, a scale for measuring water level, net to catch pests, plastic bags.

Process followed
The participants will be taken to a field located nearby. Pest/disease triangle is introduced to participants to determine possible ways to control and prevent pests/diseases. The participants then will be asked to make observations and measurements in groups, of typically 4-5 persons.

Instructors will take all participant groups into the field and will observe the field conditions, the strength of roots, pests on the crops, diseases affecting the crop and other crop features, like leaf colour. Participants are also instructed to measure the planting conditions, the distance between hills, plant population etc.

Once the observations are completed, each group will be assigned a task to draw the plant as observed in the field and indicate the environment around it along with the presence of pests and diseases. They will also be instructed to undertake observation of several weather elements and relate them to the occurrence of pests/diseases and to measure soil moisture and observe plant growth and development. In actual FARM School, this will be done before starting each FARM School meeting. For the purpose of training of trainers, this has to be done for existing field condition.

[6] *Advanced Silage Corn Management book – on www.farmwest.com*

Module 5

Climate Smart Agriculture

Session

- Introduction to the terminology
- Understanding the concept of climate smart agriculture

Learning Objectives

Get to know the concept to climate smart agriculture, the difference between local agriculture practices and climate smart practices and discussion on the various adaptation and mitigation options available for your area

Duration

[1 hour 15 minutes]

- Terminology - 15 minutes
- Exercise – 60 minutes

MODULE 5: CLIMATE SMART AGRICULTURE

Session I: Introduction to the terminology

Climate Change: The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". (source: ISDR)

Adaptation: The notion of limiting or controlling emissions of greenhouse gases so that the total accumulation is limited. (Source: IPCC Glossary)

Mitigation: The notion of limiting or controlling emissions of greenhouse gases so that the total accumulation is limited. (Source: IPCC Glossary)

Climate Resilience: Climate resilience is the ability of a community or ecosystem to recover quickly from a climate hazard and return to normal functioning. Understanding climate vulnerability requires understanding future climate events (exposure) and their impact on specific local activities (sensitivity). (Source: Conservation International, 2013)

Climate-Smart Agriculture: Climate Smart Agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support the development and ensure food security in a changing climate(source: FAO)

Session II: Understanding the Concept of Climate-Smart Agriculture (CSA)

Background Information:

In general, climate-smart agriculture is adopted as a strategy to increase crop productivity and reduce the GHG emission. It is also an approach for developing agricultural strategies to secure sustainable food security under climate change. The principal goal of CSA is identified as food security and development, while productivity, adaptation, and mitigation are identified as the three interlinked pillars necessary for achieving this goal. This does not mean that every agricultural practice should fulfil all three objectives. Instead, climate-smart agriculture seeks to re-orient agriculture by considering these objectives and informing farmers' decisions. It is an interdisciplinary approach that is not limited to a single set of practices. Climate is site-specific rather than a universal approach. What can be defined as 'climate-smart' in one location may not be smart in another context.

The Facilitator is expected to explain the concept of the Climate Smart Agriculture (CSA) by comparing the general agriculture practices with Climate-smart agriculture practices illustrated in the table below.

Table 9. Comparing the current agriculture practices with CSA practices

Sr. No.	Elements	Current Agriculture Practices	Climate Smart- Agriculture Practices
1	Land	Expand agricultural area through deforestation and converting grasslands to cropland	Intensify use of existing areas rather than expanding to new areas. Expand the area cultivated by restoring degraded land rather than deforesting new areas.
2	Natural resources	Make the most use out of natural resources - the land, water, forests, and soils used in production - without paying much attention to their sustainability over the long term.	Restore, conserve and use natural resources sustainably.
3	Different variety and species	Rely on a few crops or few high yielding varieties and breeds.	Use a mix of traditional and modern, locally adapted varieties and breeds to maintain output, increase yields and ensure their stability in the face of climate change.
4	Inputs	Increase the use of fertilizer, pesticides and herbicides.	-Improve the efficiency of agrochemical use. -Control pests and weeds using integrated management approaches. -Apply compost, manure and green manure. -Rotate crops with legumes to fixnitrogen and reduce the use of artificial fertilizers.
5	Energy use	Use farm machinery that usually relies on fossil fuels – such as tractors and diesel pumps.	Use energy-efficient methods, such as solar power and biofuels
6	Production and marketing	Specialize production and marketing to achieve greater efficiency	Diversify production and marketing to add stability and reduce risk.

(Source: FAO. 2018. Climate-smart agriculture training manual)

Outcome:

At the end of the session, participants should be able to answer the following questions:

- What is climate-smart agriculture, adaptation and mitigation?
- Identify the current agriculture practices and how each practice might be improved to make it more climate smart.

Session Time: This session takes 60 minutes.

Materials Needed: Cardboard sheet, Marker pens, scale.

Step1:
It is expected that before the start of the exercise, the facilitator explains in detail about the concept of climate-smart agriculture, adaptation and mitigation. The participants have already seen the Table in the introductory part.

Step2:
The task will be given to the group, prepared before the exercise. Each group will be asked to prepare a similar kind of table in the context of Bangladesh, i.e. current agriculture practices in Bangladesh and climate-smart agriculture practices (already followed and suggestion for future). The members of the groups discuss with each other and prepare a similar table on the cardboard sheet. Ask the participants to think of examples from their own experience. Ask the participants to identify several major types of farming that are common in the region, such as extensive livestock grazing, intensive dairying, slash-and-burn cultivation, cultivation of cash crops using machinery, cultivation using hand hoes, and others. Ask them to identify how it affects the environment and natural resources, such as the soil and water. Does it cause erosion, deforestation, pollution, water table deterioration. How? Finally, ask them how the farming practice could be improved.

Step3:
Each group will give a presentation on their findings to the plenary. The facilitator should encourage the group members to provide valuable inputs and suggestion.

Final Discussion:
At the end of the session, the facilitator should choose 1-2 of the climate-smart practices described by the entire group. Initiate the discussion by asking the following discussion

- Can this practice be used in their area?
- How should it be adapted to make it applicable while still keeping it climate-smart? If it is not used, why not?
- Identify what barriers may prevent the adoption of climate-smart practices .

Module 6

Application of Weather / Climate Forecast in Agriculture

Session

- Weather and cropping strategies, Consumptive use efficiency
- Weather Signals in Bangladesh
- Economic value of weather/Climate Information

Learning Objectives

Get to know importance of weather/climate knowledge in the preparation of the cropping strategies and understand economic value of weather/ climate information

Duration

[3 hour 30 minutes]

- Exercise 1 : 2 hours
- Exercise 2 : 1 hour 30 minutes

MODULE 6: APPLICATION OF WEATHER / CLIMATE FORECAST IN AGRICULTURE

Session I: Weather and Cropping Strategies

Background Information:

Weather forecasts and climate outlooks are essential in the preparation of crop plans and cropping strategies. Experienced farmers traditionally start land preparation at the onset of the rainy season to maximize rainfall utilization but do not prepare a crop plan that will serve as a blueprint from which they could systematically schedule their farming activities the whole year. Besides, farmers occasionally fail to recognize that the climate condition sometimes deviates from the normal so that the cropping pattern and calendar commonly practiced may not be appropriate at times.

Recent advances in science and technology helped improve the method and skill of forecasting so that seasons can be forecasted in advance quite well. For this reason, climate outlooks can be considered when designing crop plans and strategies to avoid or reduce crop loss or damage.

Farmers can perform a simple analysis of climate information and seasonal outlook. A cropping plan and calendar that would maximize rainfall utilization and minimize irrigation application can be prepared using the information on normal rainfall (i.e. average rainfall amount over the 30-year period) and the forecasted rainfall amount for a given season vis-à-vis the crops' water requirement and growing period.

Objectives:

The main objectives of this session are:

- Recognize the importance of the crop plan to maximize rainfall utilization and mini mize irrigation application.
- Preparing a cropping pattern and calendar using a cropping parallelogram.

Session Time: This session takes about 2 hours.

Materials Needed:

10-day rainfall data
Table showing the crop water requirements and crop growing period
Graphing paper
A transparent plastic sheet with vertical and horizontal lines similar to the graphing paper
Permanent marker

Step 1. Develop a cropping pattern and crop calendar

Using information on normal rainfall (i.e. average rainfall amount over the 30-year period) and forecasted rainfall, the facilitator demonstrates to farmers the process for developing a cropping pattern and crop calendar. Participants should be divided into sub-groups with a maximum of 6 people per group. They areasked to accomplish the following (please refer to Figure 13. for the 10-day histogram,

Table 10. for sample water requirement of selected crops and Figure 14 for a sample parallelogram).

i. Prepare a rainfall data chart (histogram) for 1-year period normal
ii. Draw a horizontal line in a transparent plastic sheet with a length equivalent to the growing period of the selected crops at a similar scale as the rainfall chart.
iii. Draw a vertical line with a height equal to the average crop water requirement in a season at a scale similar to the rainfall chart.
iv. Complete the parallelogram by drawing the remaining two sides.
v. Follow the same procedure in constructing the cropping parallelograms for the second and third cropping.

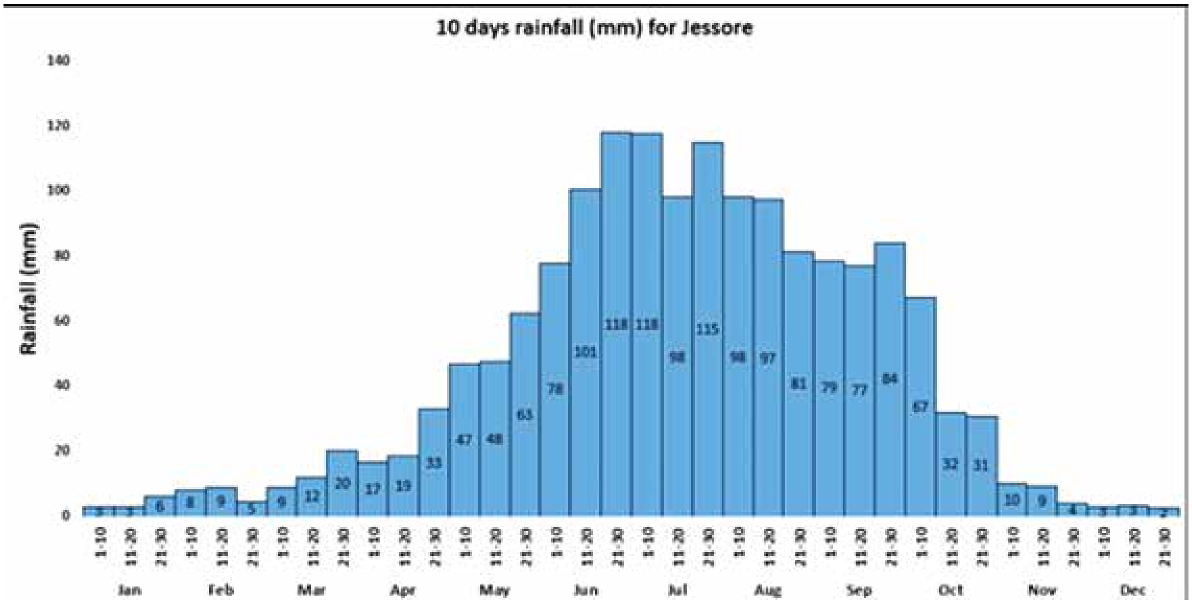


Figure 13. Histogram of annual 10-day rainfall

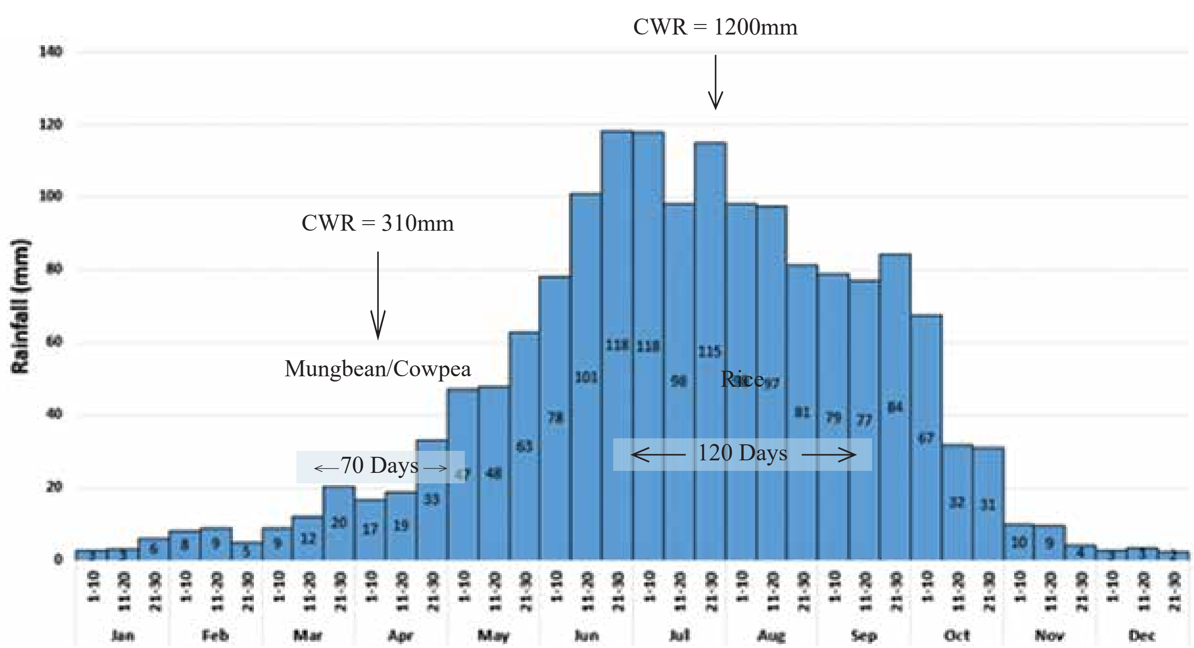


Figure 14. Sample parallelogram

Table 10. Data from this table is based on information from the Philippines and Tamil Nadu, India

Sl. No.	Crop	Growing Period (days)	Average Daily Water Requirement (mm)	Total Crop Water Requirement (mm)
Sample from the Philippines				
1	Pepper	70	3.3	231
2	Radish	60	3.3	180
3	Squash	90	5.1	460
4	Tomato	110	4.2	460
5	Cabbage	60	6.0	360
6	Bitter Gourd	100	4.0	400
7	Okra	100	4.7	470
8	Onion	100	4.8	480
9	Potato	110	4.5	495
10	imyb	120	2.2	268
11	Garlic	150	4.8	720
12	Corn/Maize	110	5.5	650
13	Rice	120	10.0	1200
14	Mung bean	70	4.4	310
15	Soyabean	110	4.8	530
Sample from Tamil Nadu, India				
1	Rice	110	11.3	1250
2	Sugarcane	360	6.11	2200
3	Groundnut	105	4.86	510
4	Sorghum	105	4.76	500
5	Maize	100	5.00	500
6	Ragi	95	3.26	310
7	Cotton	165	3.64	600
8	Black gram	65	4.31	280
9	Soyabean	85	3.76	320

[7]Data from this table is based on information from the Philippines and Tamil Nadu Agriculture University (TNAU) (http://agritech.tnau.ac.in/agriculture/agri_irrigationmgt_waterrequirements.html).

Step 2. Discuss the relevance of crop planning

The facilitator asks participants to brainstorm on the following.

i. What are the most appropriate cropping pattern and calendar under normal conditions?

ii. What other factors influence the cropping pattern and calendar?

iii. Is there potential for flooding during the rainy season when water is "too much"? What strategies do you use to address the problem?

iv. Is there a possibility of water shortage during the dry season? What strategies do you use to address the problem?

v. Do you have alternative cropping plans or planting strategies to maximize rainfall utilization and minimize irrigation?

Session II: Warning Signal in Bangladesh

Classification of Cyclones
The following is the classification of the cyclone according to the intensity and velocity of wind.
(a) Depression: Wind speed 31 miles/hr or 50 km/hr.
(b) Deep depression: Wind speed 32-38 miles/hr or 51-61 km/hr.
(c) Cyclone: Wind speed 39-54 miles/hr or 62-88 km/hr.
(d) Severe Cyclone: Wind speed 55-73 miles/hr or 89-117 km/hr.
(e) Cyclone with hurricane: Wind speed 74 miles/hr or 118 km/hr or more.

Table 11. Signals and their meaning

Signals for Maritime Ports

Signals	Meanings
Distant Cautionary Signal No. I	I) There is a region of squally weather (wind speed of 61 km/hour) in the distant sea where a storm may form.
Distant Warning Signal No. II	II) A storm (wind speed of 62-88 km/hour) has formed in the distant deep sea. Ships may fall into danger if they leave harbour,
Local Cautionary Signal No.III	III) The port is threatened by squally weather (wind speed of 40-50 km/hour).
Local Warning Signal No.IV	IV) The port is threatened by a storm (wind speed of 51-61 km/hour) but it doesn't appear that the danger is as yet sufficiently great to justify extreme precautionary
Danger Signal No. V	V) The port will experience severe weather from a storm of slight or moderate intensity (wind speed of 62-88 km/hour) that is expected to cross the coast to the south of Chittagong port or Cox's Bazar port and to the east of Mongla port.
Danger Signal No. VI	VI) The port will experience severe weather from a storm of slight or moderate intensity (wind speed of 62-88 km/hour) that is expected to cross the coast tothe north of the port of Chittagong or Cox's Bazar and to the west of the port of Mongla.

Danger Signal No. VII	VII) The port will experience severe weather from a storm of light or moderate intensity (wind speed of 62-88 km/hour) that is expected to cross over or near the port.
Great Danger Signal No. VIII	VIII) The port will experience severe weather from a storm of great intensity (wind speed of 89 km/hour or more) that is expected to cross the coast to the south of the port of Chittagong or Cox's Bazar and to the east of the port of Mongal.
Great Danger Signal No. IX	IX) The port will experience severe weather from a storm of great intensity (wind speed of 89 km/hour or more) that is expected to cross the coast to the north of the port of Chittagong or Cox's Bazar and to the west of the port of Mongla.
Great Danger Signal No. X	X) The port will experience severe weather from a storm of great intensity (wind speed of 89 km/hour or more) that is expected to cross over or near the port
Failure of Communication No. XI	XI) Communications with the Storm Warning Centre have broken down and local officers consider that a devastating cyclone is following.

Signals for River Ports

Signals	Meanings
Cautionary Signal No. I	I) The area is threatened by squally winds (wind speed of 60 km/hour) of transient nature. This signal is also hoisted during nor'westers.
Warning Signal No. II	II) A storm (wind speed of 61 km/hour) or a nor'wester (wind speed 61 km/hour or more) is likely to strike the area (Vessels of 65 feet and under in length are to seek shelter immediately.
Danger Signal No. III	III) A storm (wind speed of 62-88 km/hour or more) is likely to strike the area soon (all vessels will seek shelter immediately).
Great Danger Signal No. IV	IV) A violent storm (wind speed of 89 km/hour or more) will strike the area soon (all Vessels will take shelter immediately).

(Source: Bangladesh Meteorological Department)

Session III: Economic Value of Weather/Climate Information

Background Information:

Farmers would appreciate the benefits of climate forecast information if they could assess the economic value of such information in their farming operations. Seasonal climate forecasts can be used to design planting strategies so that the damage of plants due to drought or flood can be prevented. A forecast of "El Niño" could serve as a basis to introduce alternative crops that require less water or for farmers to store and conserve rainwater for use when water becomes scarce.

The problem is that a forecast or prediction can sometimes go wrong. Farmers are frequently disappointed when they use forecasts that do not come true. This discourages them from using forecasts again in the future. The most important thing in any forecast is its accuracy, this is limited by various factors including the data, and techniques available, the skill of the models used, advancements in science and technology, among others. In this case, farmers should be guided in selecting alternatives to maximize the benefits of using forecast information. This is possible through simple assessment methods that enable them to make the best decision with respect to the forecast information provided.

The session will allow participants to appreciate the economic importance of forecasts and at the same time, improve their capability to calculate the financial benefit of using forecasts in formulating planting strategies in a given season.

Outcome:

At the end of the session, participants should be able to:

- Use simple methods of assessing the economic value of using forecast information.
- Make climate-informed decisions when choosing among alternative planting strategies and/or livelihoods.

Session Time: This session takes 1 hour 30 minutes.

Materials:

Flip chart
Cardboard
Marker pens
Cost and income data of some crops

Alternative economic activities as identified in discussion with the participants:

Step 1.

Discuss the economic impacts of droughts/floods and identify alternative income-generating activities.

Probabilistic forecasts (e.g., 80% probability that it will occur, and 20% that it will not happen) are generally provided by national meteorological and hydrological. Based on the forecasts, concerned agencies (e.g., Department of Agriculture) provide advisories on the possible implications and mitigating measures, and farmers have the liberty to decide on their actions based on their past experiences.

Participants will be asked to discuss the financial loss that farmers typically incur when their crops get affected by drought during the dry season or flood during the rainy season. The facilitator will guide the participants in identifying alternative livelihood activities apart from farming. This could include working as a labourer in a dominant/potential industry in the participants' area (e.g. labourer in salt mining/production) or planting crops other than rice (e.g. maize which requires less water or takes a shorter time to grow). The facilitator will list on the flipchart as many alternatives as the participants can give. These alternatives are then ranked according to the most economically viable.

Example. The facilitator will ask the participants to consider the situate where farmers' crops are flooded during the rainy season and damaged due to drought during the dry season. The loss experienced by paddy farmers is as much as their total cultivation cost (i.e., inputs like seeds, fertilizers, pesticides; labour and equipment for land preparation and management). The facilitator must ask the participants to calculate the approximate value) i) the total estimated cultivation cost in their area for rice production, and ii) potential net income/profit if he/she will engage in another job or profession. All alternative strategies and figures will come from participants based on their experience and information from their respective areas.

Step 2.
Conduction of an exercise on response strategies:

The facilitator will present a forecast of Below Normal rainfall and discusses with participants the possible responses of paddy farmers, all of which can generally be classified into four: i) do not plant or let the land lie fallow, ii) do not plant, and temporarily shift to another job or profession, iii) plant other crops, and iv) do not listen to or follow the forecast, and therefore keep planting (refer to the section on sample exercises for more information and guidance).

The facilitator will then asks participants to form four sub-groups based on the abovementioned four response categories. The facilitator will explain the paddy farmers' profit and loss in the following scenarios using the figures (in terms of cost) discussed in step 1.

Step 3.

Compare incomes, profit and loss of the four groups

The facilitator will discuss with each group the about total income and loss resulting from the decisions taken by each group, and together the groups compare and identify which profited and lost the most based on the following scenarios.

Scenario 1. The forecast is correct.

Group 1. Let the land lie fallow. This group saved the cultivation cost.

Group 2. Do not plant and temporarily shift to another job or profession. This group saved the cultivation cost and earned from their shift in the profession.

Group 3. Plant other crops. This group saved the cultivation cost and earned from planting other crops.

Group 4. Keep planting. This group incurred the cultivation cost.

Note: The cultivation cost saved is considered profit. Such amount of money would have been gone, had the farmers not followed the prediction.

Scenario 2. The forecast is not correct.

Group 1. Let the land lie fallow. This group missed the opportunity to earn anything.

Group 2. Do not plant and temporarily shift to another job or profession. Depending on the potential income from planting versus engaging in another livelihood, this group may be profitable or not.

Group 3. Plant other crops. Depending on the potential income from planting other crops, this group may be profitable or not.

Group 4. Keep planting. This group earned from planting.

Step 4. Discuss the challenges of realising the profit and loss indicated in the exercise scenarios

The facilitator must point out that the profit and loss scenarios generally depend on the local context so that it is critical for farmers to identify other income-earning opportunities available to help them mitigate the socio-economic impacts of extreme events on their families.

Sample Exercises

Exercise1.

Forecast of Deficit Rainfall: Paddy farmers are preparing for the upcoming season. They received a forecast of Below Normal rainfall and have been advised not to plant paddy. In this exercise, participants are asked to form four groups based on four categories of responses shown in the following table.

Sample Forecast: Forecast of below normal seasonal rainfall forecast at 60% probability

Participants	Advisory/Response	Remarks
Forecast from BMD	-The rainfall forecast for the given period (i.e., June-September) is Below Normal.	-Normal range is within ±20% of the climatological average for the last 30 years
Advisory from Agricultural Department	-Due to poor water storage in the Dam, water was not let out and irrigation is very limited	-Farmers are advised to plant drought-tolerant crops
Farmer Response Strategies		
Group 1	-Follows the advisory by not planting and allowing the land to lie fallow -Saves the cultivation cost	-IF total cultivation cost is USD 216, then this group saves USD 216 -Total money they have at the end of the season is USD 216
Group 2	-Follows the advisory by not planting, and temporarily shifting to another job or profession -Saves the cultivation cost and earns from their temporary job	-IF the group grew birds, invested USD 360 (.9/bird) and earned USD 646 (1.6/bird), then they earned USD 286 in addition to their savings of USD 216 -Total money they have at the end of the season is USD502
Group 3	-Follows the advisory by planting drought-tolerant crops -Saves the cultivation cost and earns from other crops	-IF the group grew gingili, invested USD 79/ha and earned USD 287/ha, then they earned USD 208 in addition to their savings of USD 216 -Total money they have at the end of the season is USD 424
Group 4	-Does not follow the advisory and keeps on planting drought-vulnerable plants (e.g. paddy)	-IF total cultivation cost is USD 216, then this group lost USD 216 -Total money they have at the end of the season is -USD 216

Exercise 2.

Forecast of Above Normal Medium-Range Rainfall Forecast at Different Crop Stages:

Paddy farmers are currently at different stages of growing their rice crop. They are asked to correlate the 7-day forecast with their respective crop stage and identify their response options. In this exercise, participants are asked to form four groups based on four different growth stages of paddy.

Sample Forecast: Forecast of Above Normal 7-day rainfall at 80% probability

Participants	Advisory/Response	Remarks
Forecast from BDM/SESAME	-The rainfall forecast for the given period (i.e., 9-15 September 2019) is above normal.	-Normal range is within ±20% of the climatological average for the last 30 years
Farmer Response Strategies		
Group 1. Sowing /nursery stage	-It is critical that sown seeds are not affected by rain up to 48hrs to prevent from drifting/draining of seeds	-IF total sowing cost is estimated at USD 11 per ha, then they saved USD 11/ha if they delayed the sowing to avoid the rain
Group 2. Vegetative phase	-During this phase, fertilizers are crucial, but the application should be "timed" to avoid potential erosion and nutrient loss due to heavy rainfall	-IF total fertilizer cost is estimated at USD 9 per ha, then they saved USD 9/ha if they delayed fertilizer application to avoid the rain
Group 3. Reproductive phase	-Top dressing of urea fertilizer is important at this stage but may need to be postponed due to the forecasted heavy rainfall -It is crucial to have good solar radiation 25 days before flowering for development of floral parts and spikelet -Heavy rainfall increases the water in the field and decreases the temperature leading to potential unavailability of micronutrients like Z and Cu. -Water should be drained immediately to increase soil temperature and availability of micronutrients, and ultimately the harvest index	- IF total fertilizer cost is estimated at USD 9 per ha, then they saved USD 9/ha if they delayed fertilizer application to avoid the rain - A slight increase in harvest index may be difficult to estimate
Group 4. Ripening and harvesting stage	- Expected heavy rain may lead to waterlogging, where machines are unable to function efficiently - Harvest could be done in advance to avoid manual labor costs of harvesting	- IF manual labor cost of harvesting is USD 135/ha and loss from the early harvest is USD 58, then the group saved USD 77 (135-58)

Exercise 3.
Forecast of Above Normal Rainfall:

Paddy fields are current fallow, and farmers are asked to correlate the 7-day forecast with their respective situation and identify their response options. In this exercise, participants are asked to form four groups based on four different scenarios.

Sample Forecast: Forecast of Above Normal 7-day rainfall at 80% probability

Participants	Advisory/Response	Remarks
Forecast from DOM/SESA-ME	-The rainfall forecast for the given period (i.e., 9-15 September 2019) is Above Normal.	-Normal range is within ±20% of the climatological average for the last 30 years
Farmer Response Strategies		
Group 1. Fallow with 1 or 2 dry ploughing	-Fields are ready to take up direct sowing of paddy, but it may be unproductive to till the soil due to upcoming heavy rainfall	-IF total sowing cost is estimated at USD 11 per ha, then they saved USD 11/ha if they delayed the sowing to avoid the rain
Group 2. Fallow fields without any ploughing	-As the soil is heavy clay, ploughing is difficult given the forecasted heavy rains	-IF total ploughing cost is USD 14/ha and the group decide to only plough once followed by direct seeding after the rain, they are able to save USD 14/ha
Group 3. Fields recently are sown direct	-Heavy rainfall may cause sown seeds to go deep into the soil or drift/drain to the lower end of the field, reducing their population and causing uniformity in stand	-IF cost of second sowing is USD 4/ha, cost of draining is USD 2/ha, and the group decides to drain instead of 2nd sow, then they can save USD 2/ha
Group 4. Week-old directly sown	-Rain may cause waterlogging and damage the young seedlings thereby reducing their population and potential yield	-Income loss can be assessed only on harvest

It should be noted that throughout the exercise, the participants should play the role of farmers and they have to think alike farmers while carrying out this exercise. The facilitator will encourage the group participants to present their learning at the end of the session. The discussion should be initiated to make sure that all the participants understand the objectives of the exercise.

Module 7

Water and Hydrological Cycle in Agriculture

Session

- The concept of field capacity, water holding capacity, soil moisture, Evapotranspiration and its calculation, bulk density
- Water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and their use; irrigation scheduling based on climatological approaches

Learning Objectives

Get to know the role of water and hydrological cycle in agriculture operations. How climate knowledge could be used in a better way to improve the water use efficiency in the field

Duration

[01 Hour]

- Introduction to the terminology: 10 min
- Exercise/ Demo: 30 minutes
- Discussion: 20 minutes

MODULE 7: WATER AND THE HYDROLOGICAL CYCLE IN AGRICULTURE

Session I: Background Information

All soils contain mineral particles, organic matter, water and air. The combinations of these determine the soil's properties – its texture, structure, porosity, chemistry and colour. Soil is made up of different-sized particles. Sand particles tend to be the biggest. Clay particles are very small – less than 0.002 mm. Soil can be categorised into sand, clay, silt, peat, chalk and loam types of soil based on the dominating size of the particles within a soil.

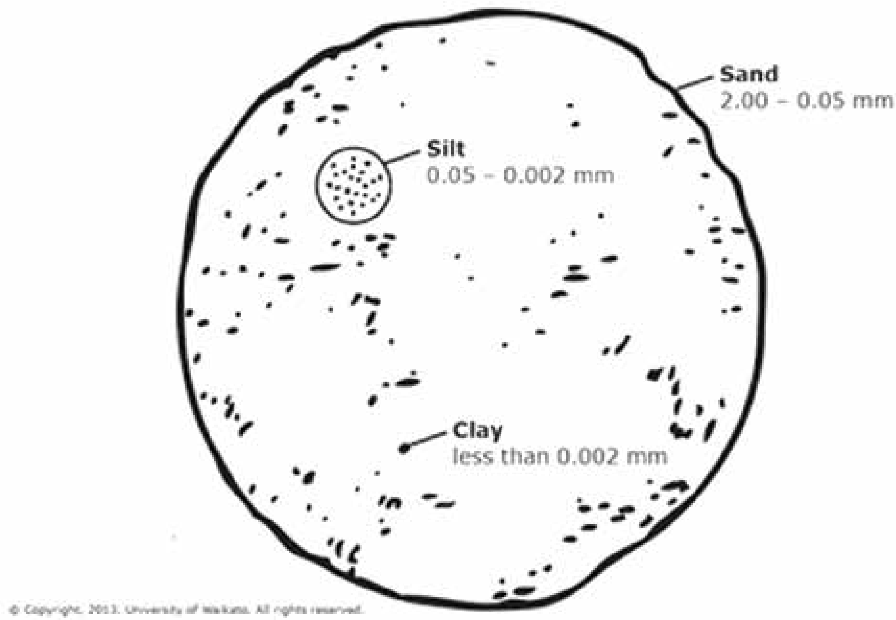


Figure 15: Size of soil particles

Sandy soil:

Sandy Soil is light, warm, dry and tends to be acidic and low in nutrients. Sandy soils are often known as light soils due to their high proportion of sand and little clay (clay weighs more than sand). These soils have quick water drainage and are easy to work with. They are quicker to warm up in spring than clay soils but tend to dry out in summer and suffer from low nutrients that are washed away by rain. The addition of organic matter can help by giving plants an additional boost of nutrients by improving the nutrient and the water holding capacity of the soil.

Clay Soil:

Clay Soil is a heavy soil type that benefits from high nutrients. Clay soils remain wet and cold in winter and dry out in summer. These soils are made of over 25 percent clay, and because of the spaces found between clay particles, clay soils hold a high amount of water. These soils drain slowly and take longer to warm up in summer, combined with drying out and cracking in summer.

Silt Soil:

Silt Soil is light and moisture-retentive soil type with a high fertility rating. As silt soils compromise of medium-sized particles, they are well-drained and hold moisture well. As the particles are fine, they can be easily compacted and are prone to washing away with rain. By adding organic matter, the silt particles can be bound into more stable clumps.

Peat Soil:
Peat soil is high in organic matter and retains a large amount of moisture.

Chalk Soil:
Chalk soil can be either light or heavy but always highly alkaline due to the calcium carbonate or lime within its structure. As these soils are alkaline they do not support the growth of ericaceous plants that require acidic soils to grow.

Loam Soil:
Loam soil is a mixture of sand, silt and clay that are combined to avoid the adverse effects of each type. These soils are fertile, easy to work with and provide good drainage. Depending on their predominant composition, they can be either sandy or clay loam.As the soils are a perfect balance of soil particles, they are considered to be a gardener's best friend, but still benefit from topping up with the additional organic matter.

Objectives:

The main objectives of this session are:

1. Understand different types of soil dominant in Bangladesh;
2. Estimate the characteristics of different soil types;
3. Assess the requirement of nutrients and water as per soil types.

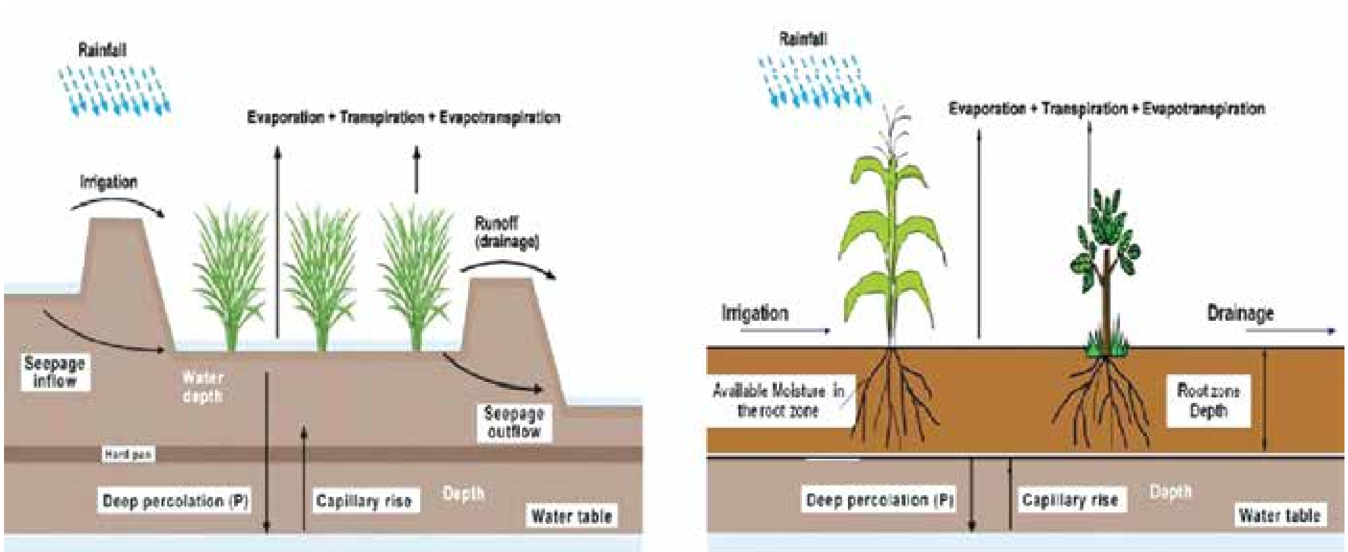
Session Time: This session takes 30 minutes

Discussion:
The facilitator will explain about different soil types and their properties, suitability for cultivation etc. Also, participants will share the common soil types find their area and usual practices being followed. The next exercise will use these soil samples to explain the concept of field water balance.

Session II: The concept of field capacity, water holding capacity, soil moisture, evapotranspiration and bulk density

Background Information:

Rainfall is the natural source of water for crops. The plants can not use most of the rainwater because some of it will be evaporated back to the atmosphere and some other will flow to rivers through the drainage system and will eventually flow to the sea through the surface flow. If the drainage system is not good, when there is an excess of rainfall, water will accumulate, and will eventually result in flooding. On the other hand, during the dry season when rainfall is rare, the water evaporated will originate from the soil so that the land will eventually become dry. If there is no irrigation, the plants will suffer from drought. The field water balance is the balance between the amount of water supplied to the land (from the rain and irrigation) and the amount of water used for filling soil water, loss either through evaporation or runoff and the amount used by crops and transpired into the atmosphere. Field water balance analysis is simply a process of accounting the volume of water within a system that account the potential inflows (Rainfall or irrigation), outflows (Evapotranspiration, losses through surface runoff, seepage and percolation) and the change in storage with the system. It is represented through the following diagrams:



A. Water balance in paddy Field

B. Water balance in upland

Figure 16. Field water balance concept

Soil Moisture:

Soil moisture is the water stored in the soil and is affected by precipitation, temperature, soil characteristics, and more. These same factors help determine the type of biome present and the suitability of land for growing crops. To calculate the soil moisture, Antecedent Precipitation Index (API) is more convenient than SPI. A weighted summation of daily precipitation amounts used as an index of soil moisture.

Evapotranspiration:

Evaporation is the process whereby liquid water is converted to water vapour (vaporization) and removed from the evaporating surface (vapour removal). Transpiration consists of the vaporization of liquid water contained in plant tissues and the vapour removal to the atmosphere. Crops predominately lose their water through stomata. These are small openings on the plant leaf through which gases and water vapour pass.

Evaporation and transpiration co-occur and there is no easy way of distinguishing between the two processes. Apart from the water availability in the topsoil, the evaporation from a cropped soil is mainly determined by the fraction of the solar radiation reaching the soil surface. This fraction decreases over the growing period as the crop develops and the crop canopy shades more and more of the ground area. When the plant is small, water is predominately lost by soil evaporation, but once the plant is well developed and completely covers the soil, transpiration becomes the main process

Evapotranspiration(ET) Calculation:

There are several established methods to calculate the ET of a crop. FAO modified the Penman-Monteith method considering the aerodynamics and surface resistance and this modified FAO Penman-Monteith equation is mostly used by the researchers all around the world for reference.

$$ET_0 = \frac{0.408\Delta(R_n - G) + \lambda\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where,

ET_o = reference evapotranspiration [mm day-1]
R_n = net radiation at the crop surface [MJ m-2 day-1]
G = soil heat flux density [MJ m-2 day-1]
T = mean daily air temperature at 2 m height [°C]
u_2 = wind speed at 2 m height [m s-1]
e_s = saturation vapour pressure [kPa]
e_a = actual vapour pressure [kPa]
$e_s - e_a$ = saturation vapour pressure deficit [kPa]
Δ = slope vapour pressure curve [kPa °C-1]
λ = psychrometric constant [kPa °C-1]

ET Variation:

The value of ET is dependent on many factors such as solar radiation, daily temperature, water conductivity etc. Due to these factors, the value of reference ET is different in different climatic condition. Such as in summer, the value of ET would be high as the daily mean temperature is high as well as the solar radiance. On the other hand, the value of ET would be lower in winter as the daily mean temperature is lower as well as the solar radiance.

For crop, crop coefficient is also different for each crop due to their height, soil condition, climatic condition and phenology. So, while determining the crop water requirements, all these should be taken into consideration.

Outcomes:

At the end of the session, participants should be able to:

1. Understand what is meant by water balance and its components.
2. Estimate the irrigation requirement from a simple water balance concept.
3. Use the water balance to assess the possibility of floods.
4. Use ET for irrigation requirement.

Session Time:

This session takes 60 minutes.

Materials:

Eight plastic bottles

Soil samples sufficient to fill 1/3 of the plastic bottle: 1) dry clayey soils (e.g. clay loam) representing dry land, 2) wet clayey soils with compacted layer representing paddy field, 3) dry sandy soils (e.g. sandy loam), 4) wet sandy soils

Graduated cylinder

Time watch

Concept:

The general overview of the concept of water balance and its components will be explained here:

Under the upland condition, the available moisture within the root zone is an added consideration in place of standing water that should be maintained. The water balance can be simply expressed as:

Rainfall (Rf) + Irrigation (Ir) = Evapo-transpiration (Et) + Seepage and Percolation (S&P) + Drainage (D) + Change in Water Status (S).

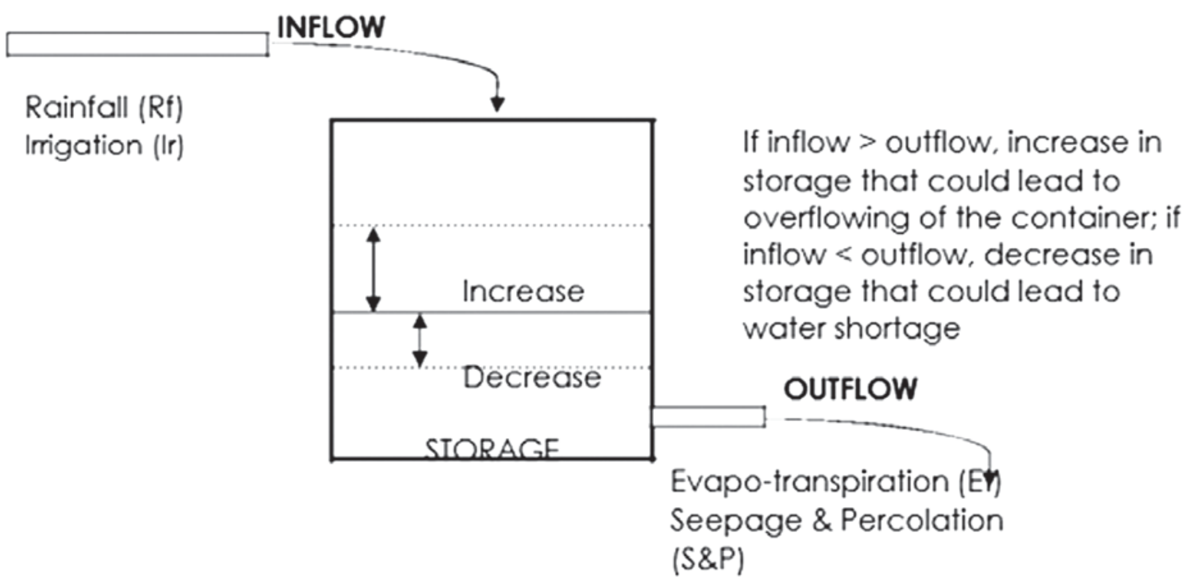


Figure 17. Schematic to explain the concept of water balance in the field

To explain the concept the Participants will observe the difference in water movement in dry land and paddy field during this exercise. The process will be followed as below:

Step 1.

1) The necessary materials for the exercise will be prepared as shown in below Figure The participants will be divided into some groups based on the soil samples: dry clayey soil (e.g. clay loam) representing dry land, wet clayey soil within compacted layer representing paddy field, dry sandy soil (e.g. sandy loam), and wet sandy soil.

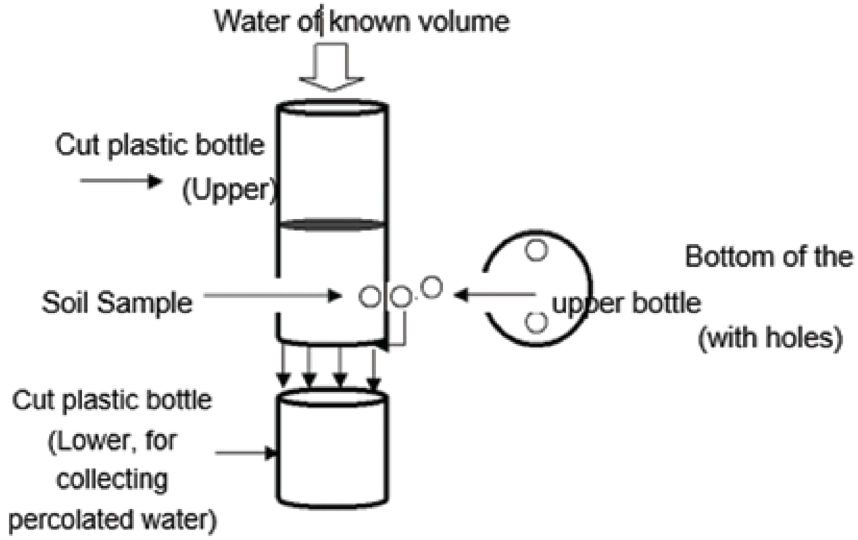


Figure18. Typical Set-up for the group exercise on field water balance concept

2) The activities will be conducted as: Four plastic bottles with different soils samples will be prepared. In each group, participants pour water of known volume (e.g. 50 ml) into the plastic bottles. They are required to observe and measure the amount of water that percolates down into the collecting bottle and take note of the time until the last drop is finished. For dry soil sample, initially, there might be no percolation at all as the amount of water poured is just within the soil water holding capacity. The same condition might happen in the sample with the compacted layer (i.e. paddy field) that minimizes soil water percolation. In all these cases, participants provide their observation and simulate them to actual field condition.

3) In the next step, more water of known volume is poured again into the plastic bottles with soil samples. Once again participants take note of time until the last drop is finished. In this case, there might be a potential increase in the amount of percolating water as the soil water holding capacity which varies according to soil types is satisfied. There is the potential of water pond developing in the soil sample with a compacted layer that represents the paddy field in the second water application.

Session III: Droughts in Bangladesh

A drought is an event of prolonged shortages in the water supply, whether atmospheric (below-average precipitation), surface water or groundwater. It can last for months or years or maybe declared as few as fifteen days. In Bangladesh, drought is defined as the period when the moisture content of the soil is less than the required amount for satisfactory crop-growth during the normal crop growing season. Droughts are common in the northwestern districts of Bangladesh. The return period of drought is said to be five years, but the seasonal and local drought is very common in major drought-prone areas especially in the northern districts of the country.

Drought can be classified in general as three types as follows:

Meteorological Drought: It is based on the degree of dryness or rainfall deficit and the length of the dry period.

Hydrological Drought: It is based on the impact of rainfall deficits on the water supply such as streamflow, reservoir and lake levels, and groundwater table decline.

Agricultural Drought: It refers to the impacts on agriculture by factors such as rainfall deficits, soil water deficits, reduced groundwater, or reservoir levels needed for irrigation.

Drought affects our lives in many different ways because water is such an important part of so many activities. Agriculture production is largely dependent on water availability. When farmers are unable to manage enough water for agricultural activities because of a drought, production might be adversely affected.

Drought Monitoring and Forecasting

There are several ways to monitor and predict drought. One of them is using the Standard Precipitation Index (SPI). It is used to determine basically the extent of meteorological drought. The value of SPI ranges from +2 to -2. The different values indicate the different extent of meteorological drought.

Table 12. SPI Ranges

Value	Meaning
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2 and less	Extremely Dry

(Source: Standardized Precipitation Index tool for drought monitoring- Examples from Slovenia)

The key advantage of SPI is that it can be calculated for both short and long term. It is very straightforward as it is only based on one parameter, rainfall. The standardization makes SPI very accurate to ensure the frequency of extreme events at any location and any timescale.

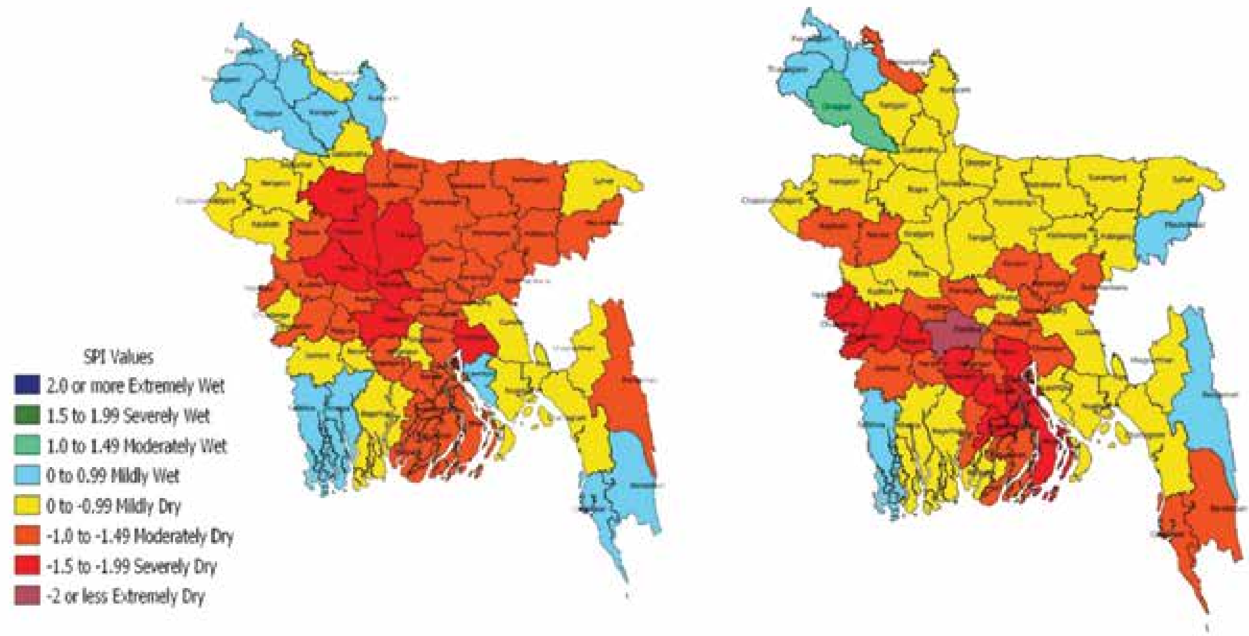


Figure 19. Example Standardized Precipitation Index short (21st August to 17th September 2019 in left) and long(29th May to 17th September 2019 in right) period in Bangladesh from BAMIS portal

Group Activity

The participants will be divided into two groups and instructed to analyze the last four-week SPI and seasonal SPI from BAMIS portal.

Objectives:

The main objectives of this session are:

- Understand the significance of SPI
- Correlate the SPI in agricultural activity

Material Required:

The internet connection with access to BAMIS Agromet portal should be made available for the participants for this exercise.

Step 1:
The participants will be divided into two groups. One group will select the short-range SPI and another will select the long-range SPI. Then they will analyze the different SPI ranges in a different location based on agricultural impact and precautions.

Step 2:
Each group will present their findings as a discussion and make a final precautionary and advisory list from the discussion.

Session IV: Water Use Efficiency

Good irrigation management is required for the efficient and profitable use of water. The major part of any irrigation management program is the decision-making process for determining irrigation dates and/or how much water should be applied to the field for each irrigation. This decision-making process is referred to as irrigation scheduling. The agronomic concept of irrigation scheduling is to apply water to the crop in the correct amounts and at the proper times to maximize crop production and/or profit, while maintaining reasonably high irrigation efficiency.

The consumptive water use efficiency is the most significant one regarding agrometeorology. Consumptive use of water means the quantity of water required by the plant to meet its evaporation-transpiration and to meet metabolic activities. This can be expressed as follows:

$$C.U = ET + Wm$$

Where, C.U = Consumptive use

ET = Evapotranspiration

Wm =Water requirement for metabolic process

Consumptive use is necessary for planning the crop pattern for a particular locality depending upon the availability of water and climatic conditions. The consumptive use efficiency can significantly be improved by utilizing the weather information in conjunction with irrigation scheduling.

Irrigation scheduling during pre-monsoon and monsoon season

At the end of previous exercise, participants are required to brainstorm among group members their findings and the facilitator assisted in directing the discussion so that it leads the participants to comprehend that the amount of water which is collected in the lower bottle is less than the amount they pour, because part of it is absorbed by the soil (by filling soil pore spaces) and another part evaporates. Meanwhile, the water which is held in the container represents percolating water while some temporary accumulation of water above the soil surface may represent flood which in case of paddy field, is contained and controlled through bunds or levees.

Figure 20: Alternate wetting and drying (AWD) technique for water management

This helps participants to understand the irrigation scheduling and amount of water required. The requirements will vary depending on the time of the year they apply irrigation. During the dry season or at the beginning of the monsoon season when soil is dry, the requirements are higher while during monsoon season the irrigation requirement is lower.

Farmers can be suggested to install a tube in their fields to assess the level of water in the soil. The facilitator can discuss the usual practice of irrigation which is followed and can also suggest the actual criteria is recommended.

Irrigation scheduling and water application programming are very effective tools for effective water use in an open field and/or protected agriculture. Irrigation scheduling and amount of irrigation may be further adjusted as per the weather forecast for the region. The main methods used for the purpose can be classified as water balance method based on determining crop water requirements from climatic data, weather forecasts; and use of soil sensors. The objective is to minimize the adverse effects of: 1. soil waterlogging; 2. reduced soil aeration; and 3. soil erosion produced by surface runoff. Reliable precipitation forecast and climate condition information are needed. Computer models (e.g. CROPWAT) can be used for real-time irrigation scheduling in combination with rainfall forecast to compute the time and amount of irrigation. The reliability of the output will depend on the accuracy of the inputs. In general most of these models currently in use globally which provide reasonably accurate results over short time periods.

Session V: Floods in Bangladesh

Flood is the most common of all of the natural hazards in Bangladesh. 20-25% of the country is flooded annually during normal years. Bangladesh lies at the downstream end of the transboundary Ganges-Brahmaputra-Meghna (GBM) river basins and around 80% of the country consists of floodplains. With 92% of floodwater coming from upstream and mostly flat topography, Bangladesh is one of the most flood-prone countries in the world. Floods in Bangladesh predominantly affect the poor rural population living in the floodplains and char islands.

Figure 21: Ganges-Brahmaputra-Meghna (GBM) River basins

Floods in Bangladesh can be classified into four categories: i) Flash Flood, ii) Riverine Flood, iii) Localized rain-fed flood and iv) Coastal flooding

Flash Flood, it is characterized by rapid rise and attenuation in streamflow or water levels with duration ranging from a few minutes to few hours. It occurs mostly in the north-eastern, south-eastern and north-western part of the country.

Local Rain-fed flood, occurs generally in the Gangetic deltas in the south-western part of the country, and in the flood plains. This type of flood is caused by excessive local rainfall and drainage congestion.

Riverine Flood, is a common phenomenon in the country caused by bank overflow and occurs mainly during the monsoon. 80% of total rainfall and river discharge occur during this period. The skewed temporal distribution of streamflow and rainfall results in abundance of water in monsoon, frequently resulting into floods and occasionally causing water scarcity during the dry season.

The country incurs a huge amount of agricultural losses around every year due to flood. On an average, flood causes a loss of TK 2,400.00 (USD 33.8) per year to a poor rural household, whereas the overall Gross National Income (GNI) per capita is USD 1785. The catastrophic flood of 1998 that affected around 68% of the country, caused an overall decrease of 48 percent of agricultural production in rural households. The flood of 2007 damaged around 604,481 metric tons of crops nationwide (BBS) and that damage is worth around 5.91 billion Taka (about 84.4 million U.S. dollars). In 2017, a dreadful flash flood occurred in the north eastern region of Bangladesh which resulted in significant production loss of Boro rice.

More than a third of the country's population is concentrated on the 100-year's floodplains. The primary source of livelihood of these people is climate-sensitive agriculture. Therefore, when a major flood hits the country, these people suffer the most.

Flood Monitoring and Forecasting in Bangladesh Flood Forecasting and Warning Center (FFWC) of the Bangladesh Water Development Board (BWDB) is the mandated organization for monitoring and forecasting floods in Bangladesh. BWDB has more than 300 water level measuring manual staff gauges in the major rivers of which 95 of them are used for flood monitoring. FFWC was established in 1972 when they only provided 24-hour forecast based on gauge to gauge correlation. In the 90's they started using computer simulation-based modelling and forecasting.

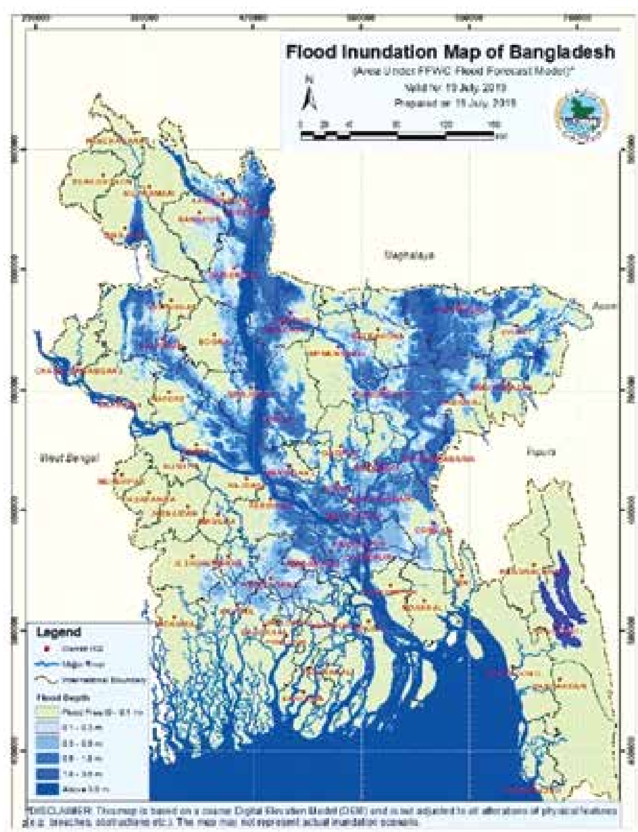


Figure 22: FLood Inundation Map of Bangladesh

FFWC currently has 5 days deterministic and 10 days probabilistic flood forecasting system. The deterministic forecast provides a single value for future date while the probabilistic forecast provides a range (max-min-average). The deterministic forecast uses transboundary water level data obtained daily during monsoon from India. The probabilistic forecast uses precipitation forecast from European Center for Medium Range Weather Forecast (ECMWF) and other observed precipitation data from satellite and global sources. The 10 days probabilistic forecast is especially recommended for agricultural purposes as it provides longer lead time taking actions by detecting the future trends and extreme events. FFWC also generates a national scale flood inundation mapping. It is a coarse resolution product but it can provide an overview of the overall flood situations. The flood forecast products are available in FFWC's website www.ffwc.gov.bd as well as BAMIS portal.

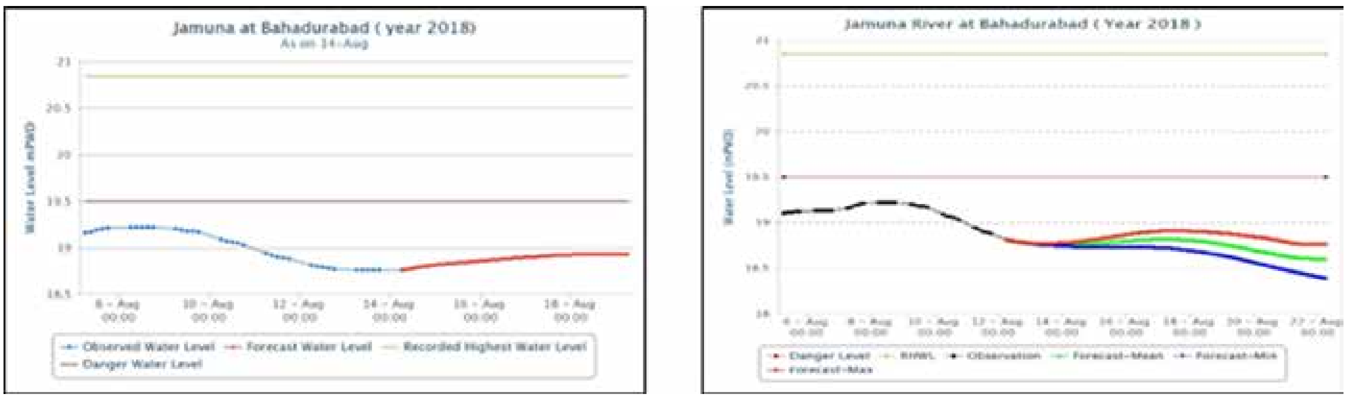


Figure 23. Five days deterministic (L) and ten days (R)

Group Activity

Outcome:

At the end of the session, participants should be able to:

1. Interpret flood forecast from flood hydrograph;
2. Learn to use different type of forecast (probabilistic) in conjunction;
3. Understand the importance of forecast consistency.

Session Time: This session takes about 60 minutes.

Materials:
Poster paper, Marker

Concept:
The facilitator will explain the characteristics of different kinds of forecasts (e.g. deterministic forecasts are more accurate at a shorter range up to 3 days) and ways to interpret the forecast. Participants should also be made aware of depleting forecast skill with increased leadtime. The participants will be divided in three groups and a series of forecast hydrographs/narratives will

be shared with them with an interval of 10 minutes. The forecast series should consist of one forecast 8-10 days before a flood, one forecast 7 days ahead of the event and the other should depict the attenuation of flood in next 10 days. The participants will fill up the table below during the 10 minutes interval on the poster papers supplied. They will write down the actions they will take upon receiving that particular forecast and what advisory they are going to provide. A group might chose refrein from taking actions (i.e. keep the action colum blank for a particular forecast). After completing the task, the groups shall present their poster with 5 minutes allocated to each. At the end of each presentation, participant may ask questions to the presenter. At the end of the presentation, the facilitator will discuss with the participants about the importance of checking the consistancy of forecast and differences in actions and advisories by different the three groups and what could have been done better.

Forecast	Actions	Advisory
Bulletin 1: 10 days before the flood event		
Bulletin 2: 7 days before the flood event		
Bulletin 3: After the peak flood, at receding stage		

Module 8

Introduction to the BAMIS Portal

Session

- Introduction to the BAMIS Portal and Kiosk
- Preparation of Agricultural Advisories using the information available on the BAMIS portal and Kiosk

Learning Objectives

Get to know about BAMIS Web portal developed by the Department of Agriculture Extension (DAE), Bangladesh and various tools available on the web portal

Duration

[1 hour 45 minutes]

- Introduction to the portal: 30 minutes
- Exercise: 60 minutes
- Discussion: 15 minutes (at the end of the module)

MODULE 8: INTRODUCTION TO BAMIS PORTAL AND IT'S VARIOUS COMPONENTS

Session I: Introduction to BAMIS Portal

The Bangladesh Agro-Meteorological Information System (BAMIS) portal is one of the significant web portals developed for agriculture information dissemination to the users of climate information in Bangladesh.

The data from BMD (Bangladesh Meteorology Department) and Bangladesh Water Development Board (BWDB) has used for the production of Agro-Met advisories and other sets of information for around 30,000 lead farmers. The information will be translated and verified by the Technical committee at the Department of Agricultural Extension (DAE), Bangladesh. The objective of this chapter is to introduce the participants on the various products and information available at the BAMIS portal and how to access this information for its use by the agriculture sector user.

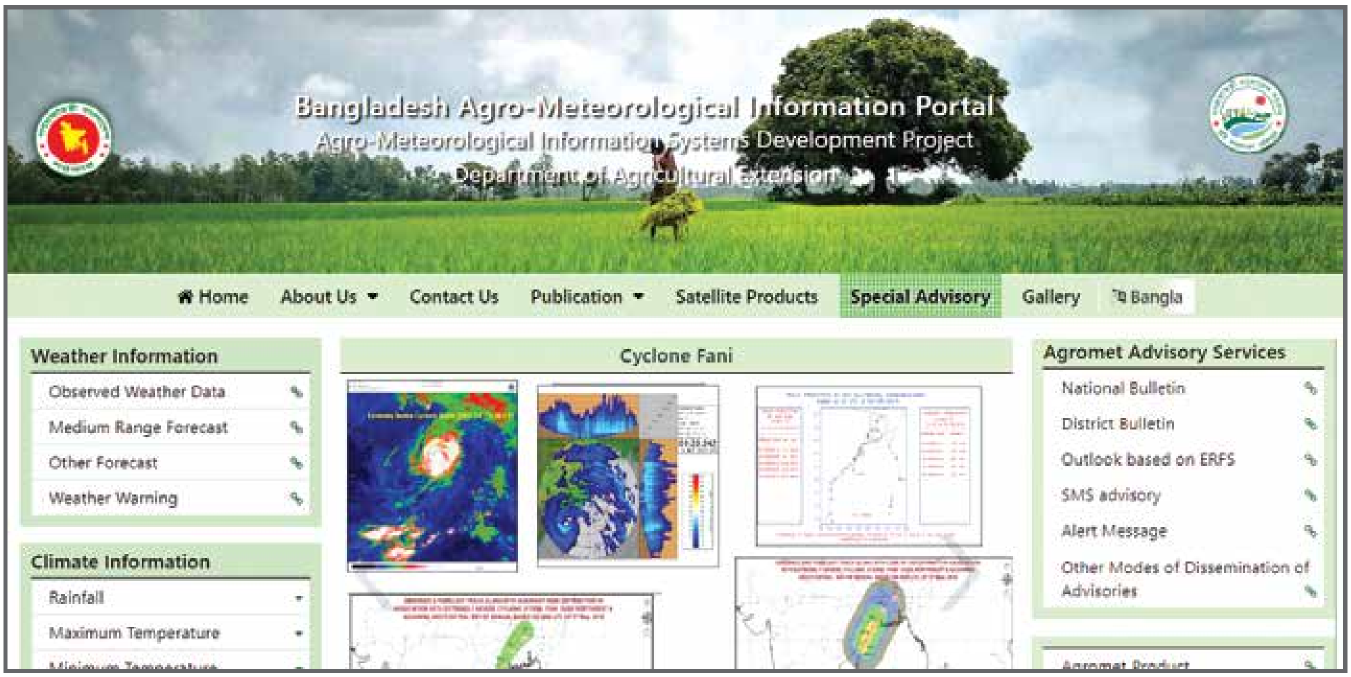


Figure 24. The landing page of the BAMIS Portal (www.bamis.gov.bd)

Objective:

The facilitator will introduce participants to the newly developed BAMIS portal and elaborate on the Agro-met information available on the portal. The hands-on exercise will assist the participants in using the Agro-met portal to get the required weather, climate and agro-advisory related information and use it most appropriately and effectively.

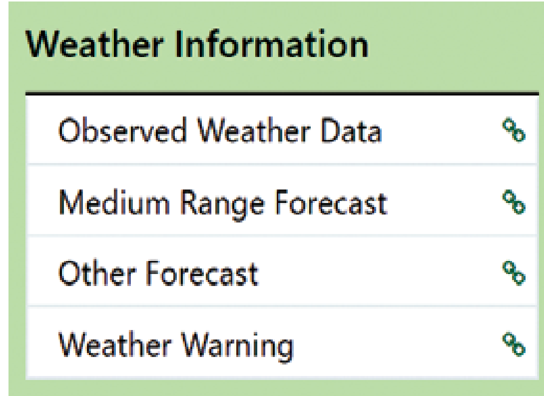
Session Time:

This session takes 30 minutes

Instructions:

The session will start with facilitator introducing basic features of the BAMIS portal. The purpose and products available for the users will be briefly introduced to the participants. The facilitator should encourage participants to visit the web portal and search for the required information from the web- portal.

Weather Information



The top left corner of the web portal, one could see tab "Weather Information". The tab includes four options. i.e. Observed weather data, Medium Range Forecast, Other Forecast and Weather Warning.

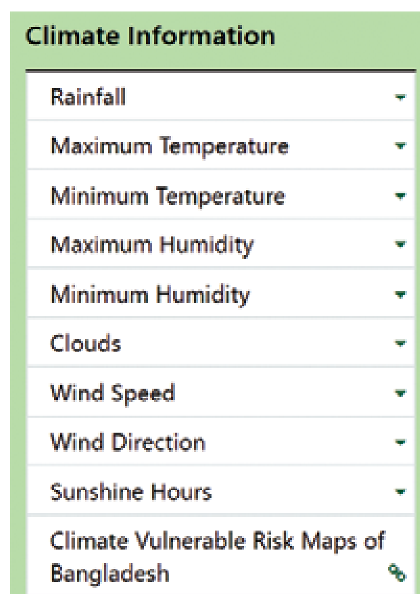
1.Observed Weather Data: This include the information about 10 selected weather parameters i.e. Humidity, Rainfall, Cloud Amount, Surface Horizontal Visibility, Maximum Temperature, Minimum Temperature, Dew Point, Wind Direction and Wind Speed observed up to last 7 days for all the districts of Bangladesh. The output is available in 3 formats i.e. Map, Table and Graph. All the information is available from Bangladesh Meteorology Department (BMD).

2. Medium Range Forecast: The medium range forecast tabs enable users to see the next 7 days forecast in the formats similar to observed weather data tab i.e. Map, Table and Graph overall district of Bangladesh.The parameters include Humidity, Soil moisture,Rainfall(cm), Cloud Fraction High,Cloud Fraction Medium, Cloud Fraction Low, Temperature, Wind Direction and Wind Speed

3. Other Forecast: The other forecast tab gives user option to check the forecast outlook for Short Range (24 hours), One Month Outlook (current month), Three Months Outlook (general condition for the current month and next 2 months), WRF Forecast (various WRF products) and Other Weather Information.

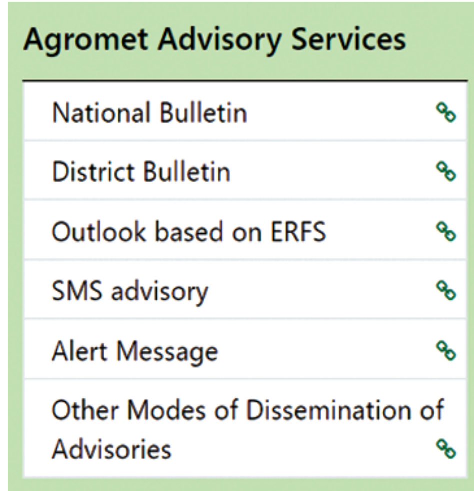
4. Weather Warning: The last tab is about weather warnings. Mainly five types of warning available for the user in the tab. i.e. Kalbaishakhi warning, Fog warning, Heavy rainfall warn ing, Marine warning and Riverport warning. The warnings will appear only if it is given by the Bangladesh Meteorology Department, Bangladesh. If no warning, it will show that there is no warning urgently. The user will be encouraged to visit each tab and check the information available.

Climate Information:

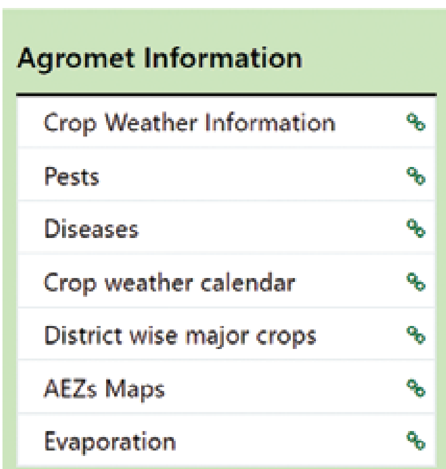


The second top left corner of the web portal, one could see tab "Climate Information". As the name suggests most of the climate-related information could be found in this tab. The selected nine parameters i.e. rainfall, max. temp., min. temp., max. humidity, min. humidity, clouds, wind speed, wind direction and sunshine hours were available for the user. The monthly and weekly climate normal information for the abovementioned parameters is available. Users have options to select on climate parameter (shown in fig.), climate information interval (monthly/weekly) and weather station (available in the list). The output will be available in the two formats (i.e. graph and table)

The national agro-meteorological advisory service bulletins available on the "Agromet Advisory Services" tab on the web portal. The advisory being generates on each Wednesday of the week. The previous advisories also could be found through the "Archive" option. The pdf file contains salient agro-met advisories issued over Bangladesh for the standing crops in the field, livestock, poultry and fisheries sector. The advisories also feature realized weather at the different locations in the country, the spatial distribution of weather parameters for the previous week, the weather forecast for next upcoming week, quantitative weather forecast for next 5 days and different satellite product over Bangladesh.

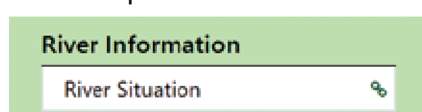


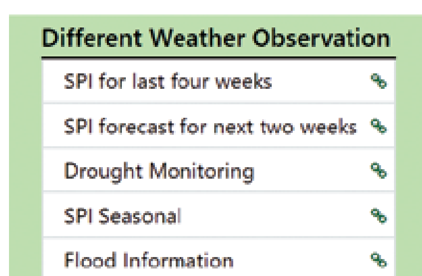
While the "District Bulletin" tab gives access to the user, interested in the agromet advisories for the particular district. The user could select his/her district and the advisory for the selected district is available in the pdf format. The user could save and print the advisory, if required. The advisory is being generated on Sunday and Wednesday (for next 5 days). The advisory will have two important sections. The first section is about Weather conditions over the district for the next 5 days and the second section will be crop advisories as per the weather condition prevailing on the particular districts.



The next important section of the web portal is "Agromet Information" tab. The lifecycle of any crop is very sensitive to the climatic conditions it grown into. The various climatic factors such as temperature, rainfall, humidity etc. play vital role in the production of any crop. The Crop-Weather Information section consists of information about the crops and its sensitivity to the climate. The ideal climatic conditions for the particular crop are available for the users. The information of nine important crops is available in the "Pest" section. The stage-wise pest information and favorable weather conditions for them is available for the users. Similarly, the disease information is also available for all the nine crops along with the control measure to be adopted. The other features include crop-weather calendar, district-wise major crops and agro-ecological zoning maps for Bangladesh. The evaporation potential (mm/day) at different district in a year is also available in the table and graph format for the user in the "Evaporation" section.

The BAMIS portal is also providing real time River situation and Flood information. The information is updated regularly when the information is updated by the FFWC (Flood Forecasting and Warning Center) of BWDB.





The facilitator should encourage participants to visit the agro-met portal and try to understand from the variety to information available for them. Next, Exercise will be conducted in the group that will encourage the participants to visit the Agro-met portal and access the various tabs from the web-portal.

Session II: Kiosk

A KIOSK free-standing physical structure that displays information or provides a service. KIOSK means a one-stop, where can be got many items at a single place. One of the major objectives of BAMIS portal is to establish Agro-Meteorological touch screen kiosks in 487 Upazilas with data display screens, printers installed in the Upazilla Agriculture Offices. These will allow users to navigate information on a number of aspects including current weather data, Agro-Meteorological Advisories, crop cultivation practices, agriculture inputs, crop diagnostic kit, crop management time table, farm machinery, market information etc.

Figure 25: A Kiosk

Figure 26: Automatic Rain Gauge

Session III: Automatic Rain Gauge

An automatic rain gauge collects rainfall data and then automatically shows or transfer the data to an adjacent monitor or to a remote database server without any manual labour. Under Agro Meteorological Information Systems Development Project, 4051 automatic rain gauges have been installed in 4051 Union Parishad. These will incorporate the union level rainfall data which would significantly improve the location-based agro-advisory. Union level rainfall data will be available for both centrally and the respective authority.

Session IV: Weather Display Board

Agromet display boards provide agrometeorological forecast and advisory services for the farmers twice in a week. Agromet division of BMD provides agromet forecast for the farmer with the support from Department of Agricultural Extension advisories are displayed in the weather board. Weather boards are already installed in 4051 Union Parishad. DAE officials are provided with training to manage the information. According to the District Agromet Bulletin. These board helps the farmers for decision support system for regular agricultural practices.

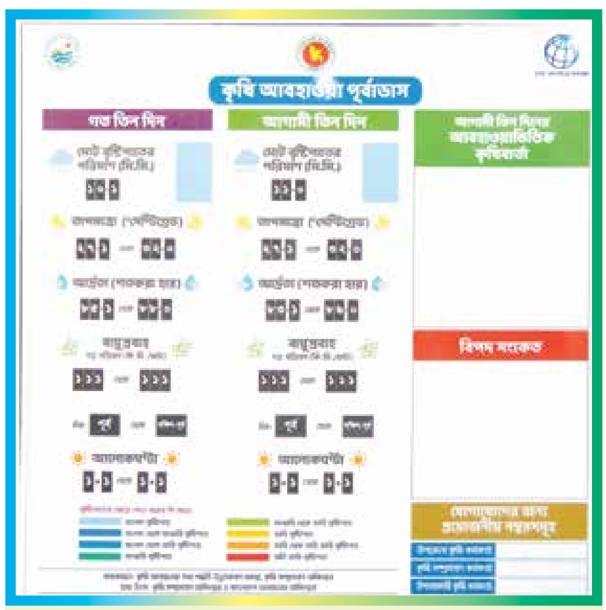


Figure 27. Weather display board

Session V: Preparation of Agricultural Advisories using the information available on the BAMIS portal

Background Information:

Agriculture is always being the site-specific so the use of climate information for preparation of agromet advisories is a very difficult and complicated task. Farming practices vary spatially and temporally with respect to weather conditions. In developing countries like Bangladesh, agro-meteorology is still evolving and required an expert team to develop the agromet contents. The extension officers also have limited knowledge about the weather dynamics and its relation to crop development, so it necessary that the developing content should be easy to understand and apply.

(Mahadevaiah et.al, 2010)[9] suggested framework for the development of the content to improve the agro advisories services in India. The process of content development can be divided into the following parts: crop-related information, weather-based influences on the crop, and region-specific crop and weather-related dynamics. In addition, the content should be developed by considering malevolent weather.

Four parts of content development framework:

Sl. No.	Name	Nature	Scope
1	General overview of the crop	Both region and weather independent	Contains general information of the crop
2	Agro-climatology of the crop	Region independent and weather dependent	Contains information about agro-climatology of the crop
3	Region specific agro-climatology of the crop	Both region and weather dependent	Contains region-specific agro-climatology of the crop.
4	Region specific contingency crop production strategies	Both region and weather dependent	Contains contingency measures against malevolent weather.

Guidelines for Preparing District Level Agromet Advisory Service Bulletin

1. There are three components of the bulletin: Past weather, Forecast & Advisories.
2. As far as the forecast is concerned, both qualitative (next 24 hours) as well as quantitative (medium range: next 5 days) are considered.
3. Weather information & Forecast need to be obtained from BMD. Such mechanism is already in place.
4. Knowledge of Major crops grown and the life cycle and stages and the period of a particular stage in the district is essential.
5. Complete knowledge of package of practices for a particular crop (i.e. land preparation, irrigation schedule, irrigation requirement, fertiliser application, harvesting etc) for a particular district is required.
6. The most important is sensitivity of weather to crop, vegetables, horticultural crops, livestock, poultry, fishery is very important. We need to understand how the prevailing weather and forecast weather influence the crop growth.
7. Similarly, it is also important to know what are the pests & diseases usually damage the crop at what stage and also its relation with weather and what insecticide, fungicide need to apply.

[9]*For detail information participants are encourage to read the research article available athttp://14.139.82.23/res/-ContentAFITA2012.pdf*

8. Ultimately, based on this information, prepare the advisories
9. Advisories in case of extreme weather condition and standing crop, livestock, poultry and fishery to be known.
10. It is requested to see the bulletins and especially the advisories from the data based already been generated and kept as archive in BAMIS PORTAL.
11. Most of the static information on crop, pests and diseases, their sensitivities with weather etc. are already kept in BAMIS PORTAL.

Guidelines for Preparing National Level Agromet Advisory Service Bulletin

1. This is comparatively easier than preparation of district level Agromet Advisory Service Bulletin as most of the information already been available in district level bulletins are incorporated here to present a major event in the country.
2. At first, salient weather information (last 24 hours as well last 4 days & weather forecast (next 24 hours as well as quantitative medium range: next 5 days) are considered.
3. Using GIS software, preparation of maps for all the weather elements (both observed & Forecast) is required.
4. Maps on different parameters obtained from Satellite (NOAA) at district level are also prepared to understand different stress condition.
5. Map on SPI is also prepared to understand drought condition at district level.
6. At last, salient advisories with respect to prevailing weather & weather forecast applicable for most of the districts in the country are mentioned.

Outcomes:

At the end of the session, participants should be able to:

- Recognize the usefulness of the BAMIS portal
- Prepare agriculture advisories using the information available at the BAMIS portal

Session Time: This session takes 30 minutes.

Materials: The internet connection with access to BAMIS Agro-met portal should be made available for the participants for this exercise.

Step 1: The participants will be divided into some smaller groups (6-7 people in each group). The number of groups depends on the total number of participants available for the training. Each group will choose one district in Bangladesh.

Step 2: Each group will act as an expert committee responsible for the preparation of the agro-met advisories using the information available at the BAMIS portal. Before the exercise, each group will select the crop (including the stage of the crop) over which they will prepare the agro advisories for next week.

Step 3: Each group will also use the kiosk and explore the features available in it. They can use the kiosk while preparing the agro advisories.

Step 4: The facilitator should encourage the participants to look into various tabs/ parameters available on the BAMIS portal or kiosk to prepare the Agromet advisory. They should at least visit the four important sections explain earlier in the chapter and include the information in their agro-advisories. At the end of the session, each group will present their Agro-advisories to other groups. The facilitator will initiate the group discussion and Q & A session during the presentation from each group. In the end, each group will briefly tell about the lesson they learn during the exercise.

Module 9

Cutting-Edge Technology In Agrometeorology

Session

- Introduction on Remote Sensing, Basic components of remote sensing- signals, sensor and sensing systems
- Agrometeorological Indicators and Indices
- Making use of operational satellite products for model ing crop production/yield and agro-advisories generation
- Exercise

Learning Objectives

- Get to know the applications of satellite images in agrometeorology, especially for monitoring agricultural and meteorological parameters to model the crop production/yield.

Duration

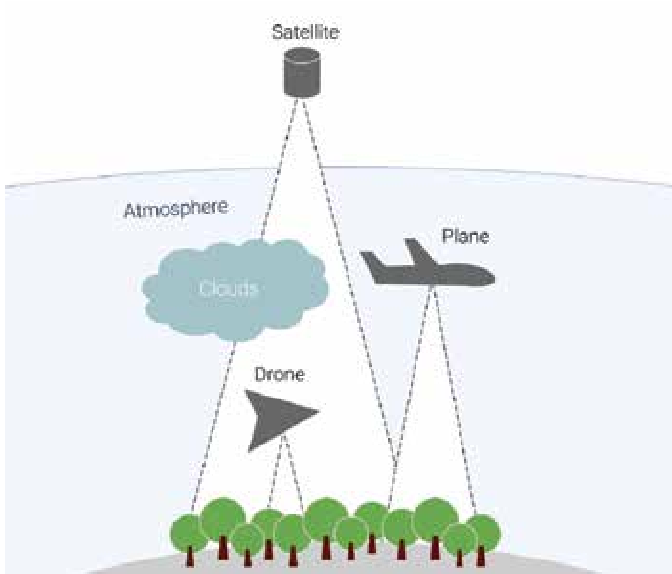
[1 hour 15 minutes]

- Presentation - 30 minutes (10 minutes for each session)
- Discussion - 15 minutes (5 minutes for each session)
- Exercise - 30 minutes (at the end of the module)

MODULE 9: CUTTING-EDGE TECHNOLOGY IN AGRO-METEOROLOGY

Session I: Remote Sensing

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance from the targeted area (USGS[10]). Remote Sensing data are obtained from a variety of platforms, such as satellites, aircraft, unmanned aerial vehicles, and drones (as shown in Figure 28.).



(Source: Open Forests)

Figure 28. Observing Earth from Space

Remote sensing is mainly two types, Active Remote Sensing and Passive Remote Sensing

Active Remote Sensing: Active remote sensing uses active sensors which emit energy in order to scan objects and areas and after that, a sensor detects and measures the radiation that is reflected or back scattered from the target. RADAR and LIDAR are the examples of active remote sensing where the time delay between emission and return is measured, establishing the location, speed and direction of an object.

Passive Remote Sensing: Passive remote sensing uses Passive sensors to gather radiation that is emitted or reflected by the object or surrounding areas. Reflected sunlight is the most common source of radiation measuredby passive sensors. Examples of passive remote sensors including film photography, infrared, charge-coupled devices, and radiometers.[11] Based on the surface reflectance from an object, remote sensing products are able to provide the characteristics of vegetation, the water content in the surface. Such products are very useful for monitoring and predicting drought conditions for taking necessary precautionary measures for managing the agricultural risk.

[10] https://www.usgs.gov/faqs/what-remote-sensing-and-what-it-used?qt-news_science_products=3#qt-news_science_products
[11] https://www.geospatialworld.net/videos/active-and-passive-remote-sensing/

Session II: Agro-meteorological Indicators or Indices

There are multiple agrometeorological indicators/indices available for applications such as monitoring crop condition, modelling crop yields, forecasting drought, and others. Indicators are variables or parameters (e.g. precipitation, temperature, streamflow, groundwater and reservoir levels, soil moisture) used in agro-meteorological applications such as monitoring drought. Indices are numerical representation derived from single/multiple parameters. Sample list of indices/indicators are provided in the below table 13

Table 13. List of Agrometeorological indicators/indices

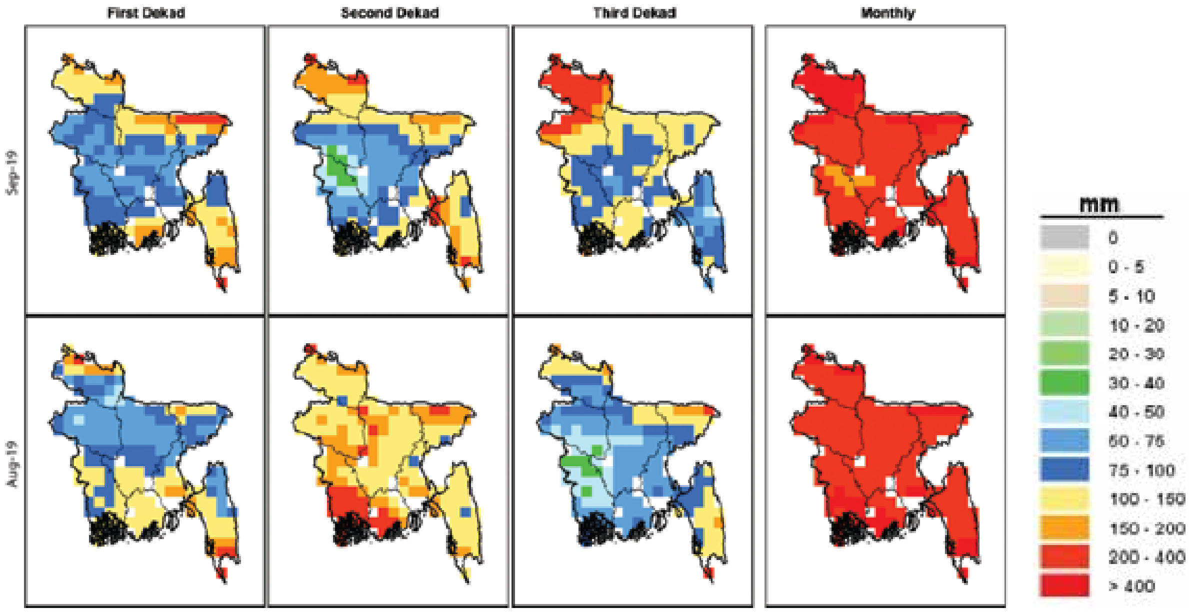
	Indicators	Indices
Weather	• Precipitationactual/anomaly	• Standard Precipitation Index (SPI)
Vegetation	• Crop sown area • Crop height	• Normalized Difference Vegetation Index (NDVI) • Vegetation Stress Index (VSI) • Vegetative Health Index (VHI) • Agricultural Stress Index (ASI) • Drought Intensity

The web portal of FAO's Global Information and Early Warning System on Food an Agriculture (GIEWS) provides global and country-specific indicators/indices for agrometeorological applications. GIEWS utilizes remote sensing data to provide information on weather, water availability and vegetation health during the cropping seasons. The list of indicators/indices available through GIEWS is provided below with descriptions and sample maps.

FAO GIEWS Website: http://www.fao.org/giews/earthobservation/country/index.jsp?lang=en&code=BGD#

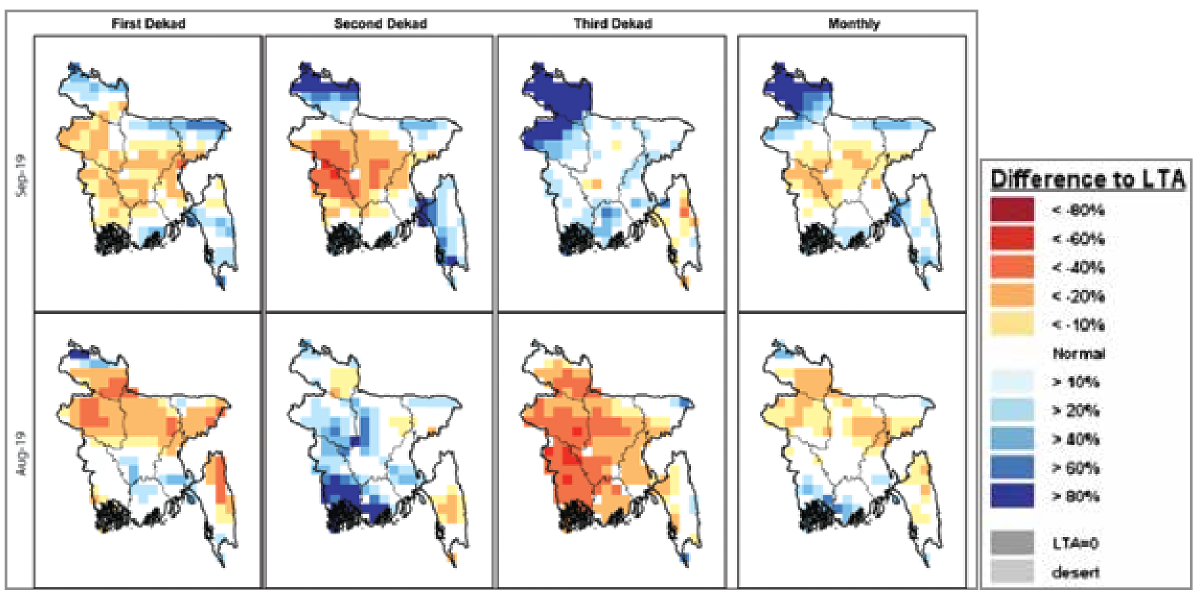
Precipitation Actual/Anomaly

Dekad (a 10-day period) and monthly cumulative rainfall, and its anomaly from long term average over Bangladesh are available through GIEWS web portal (as shown in figure 29 and 30).



(Source FAO-GIEWS)

Figure 29. Dekadal and monthly cumulative rainfall amount during Aug and Sep 2019 in Bangladesh

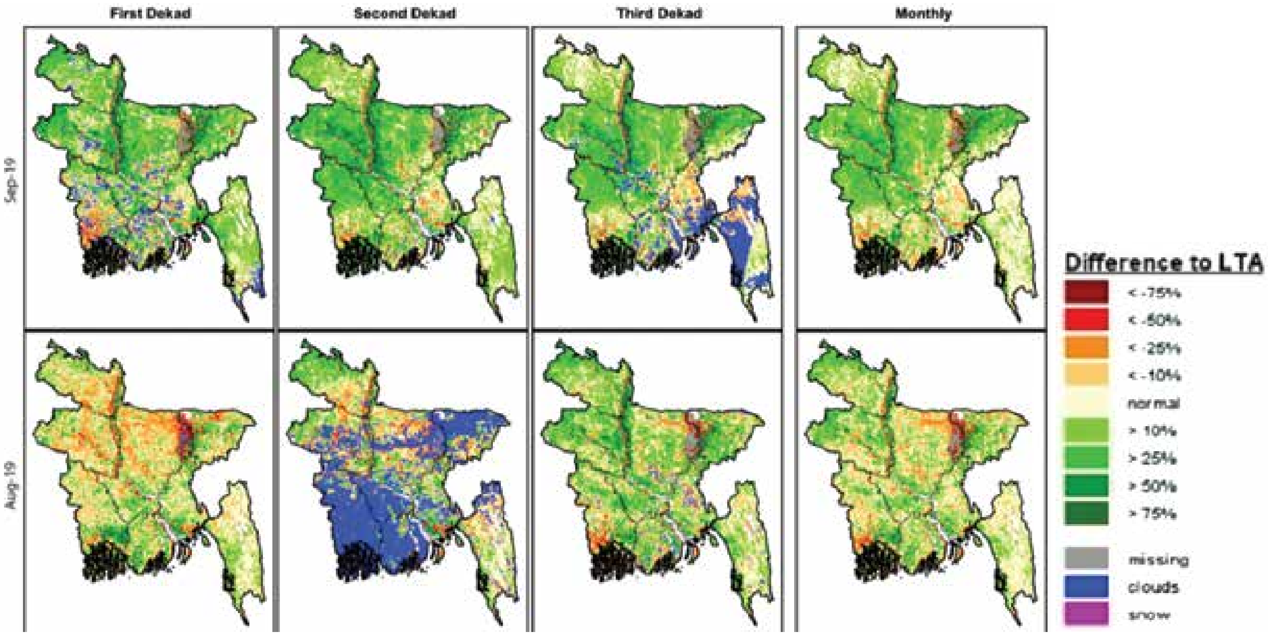


(Source FAO-GIEWS)

Figure 30. Dekadal and monthly rainfall anomaly during Aug and Sep 2019 in Bangladesh

Normalized Difference Vegetation Index (NDVI) Anomaly:

NDVI indicates the vegetation health based on the "greenness" of ground cover. NDVI values are represented from +1 to -1, with high positive values corresponding to dense and healthy vegetation, and low and/or negative NDVI values indicating poor vegetation conditions or sparse vegetative cover. The NDVI anomaly for a dekad/month is a deviation from the long-term average, where a positive anomaly value indicates enhanced vegetation conditions and negative anomaly value indicate comparatively poor vegetation conditions when compared to average conditions. Sample NDVI anomaly product over Bangladesh is shown in Figure 31.

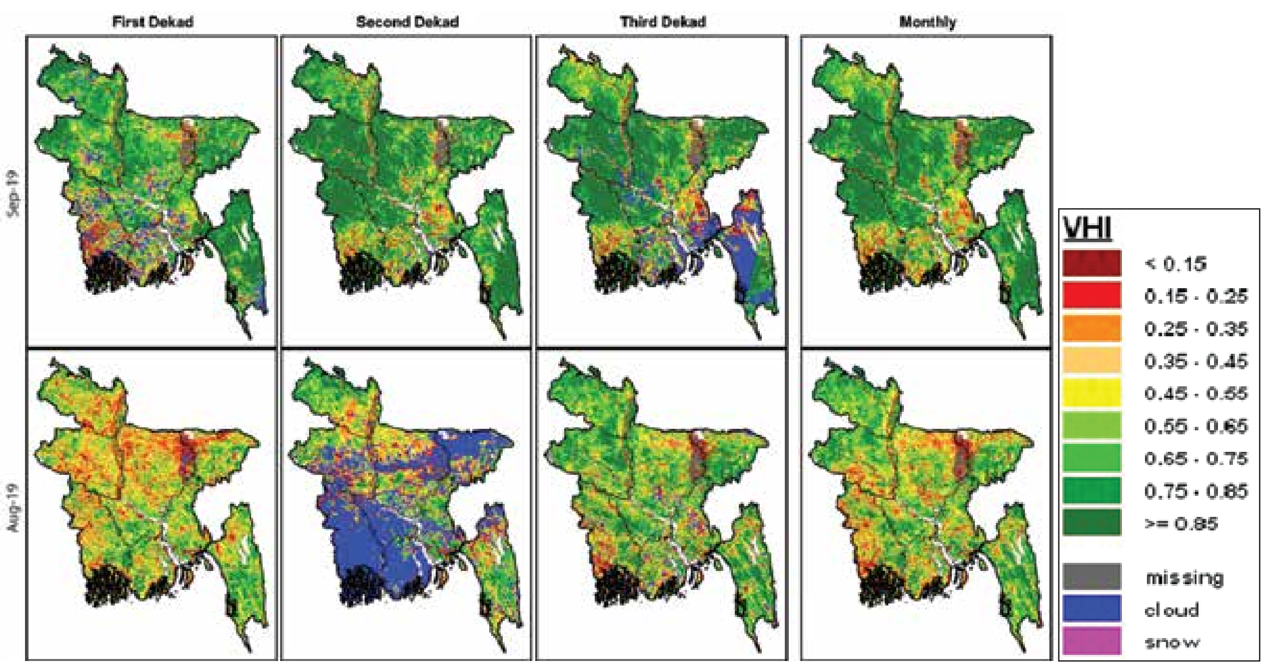


(Source FAO-GIEWS)

Figure 31. Dekadal and monthly NDVI anomaly during Aug and Sep 2019 in Bangladesh.

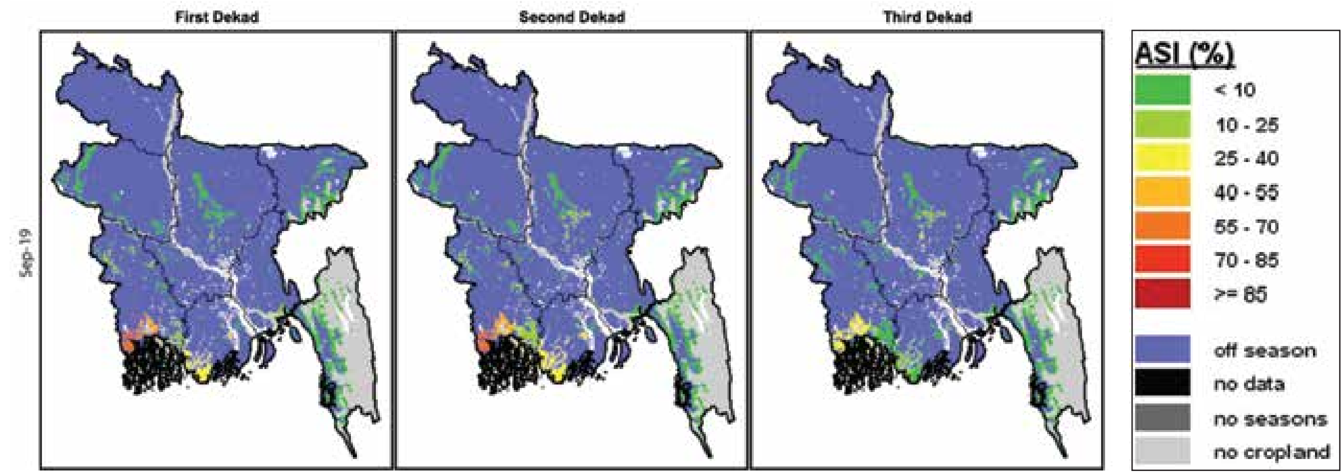
Vegetation Condition Index (VCI):

The Vegetation Condition Index (VCI) evaluates the current vegetation health in comparison to historical trends. The VCI relates current dekadal Normalized Difference Vegetation Index (NDVI) to its long-term minimum and maximum, normalized by the historical range of NDVI values for the same dekad. The VCI was designed to separate the weather-related component of the NDVI from the ecological element. Sample VCI product is shown in Figure 32.



(Source FAO-GIEWS)

Figure 32. Dekadal and monthly VCI during Aug and Sep 2019 in Bangladesh



(Source FAO-GIEWS)

Figure 34. Dekadal and monthly ASI during Sep 2019 in Bangladesh

Standardized Precipitation Index (SPI):

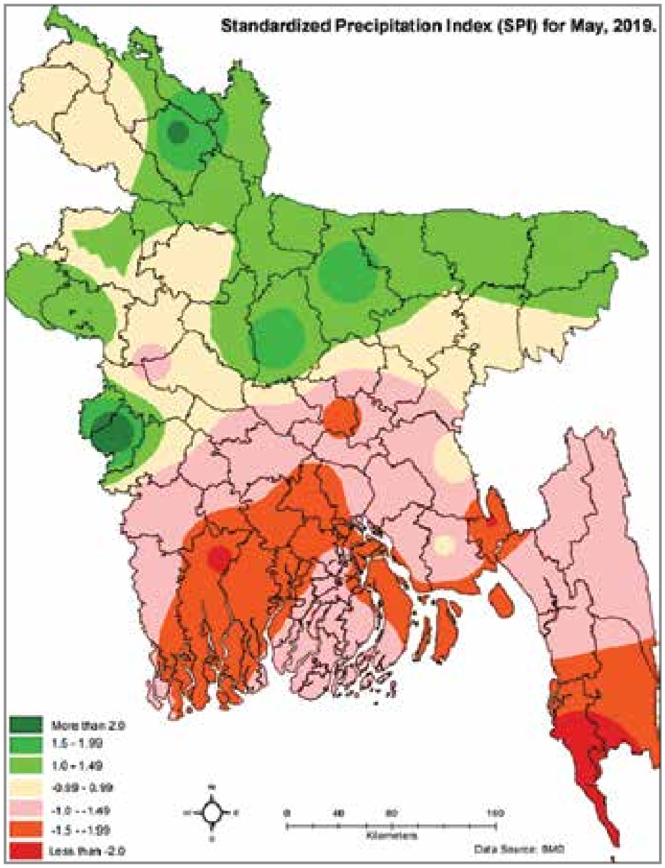
The SPI was designed to quantify the precipitation deficit for multiple timescales. It is a very simple index and precipitation is the only input parameter required for calculation of SPI. But It can only quantify the precipitation deficit; values based on preliminary data may change, and values change as the period of record grows. Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow and reservoir storage reflect the longer-term precipitation anomalies. For these reasons, McKee and others (1993) originally calculated the SPI for 3, 6,12, 24 and 48-month timescales.

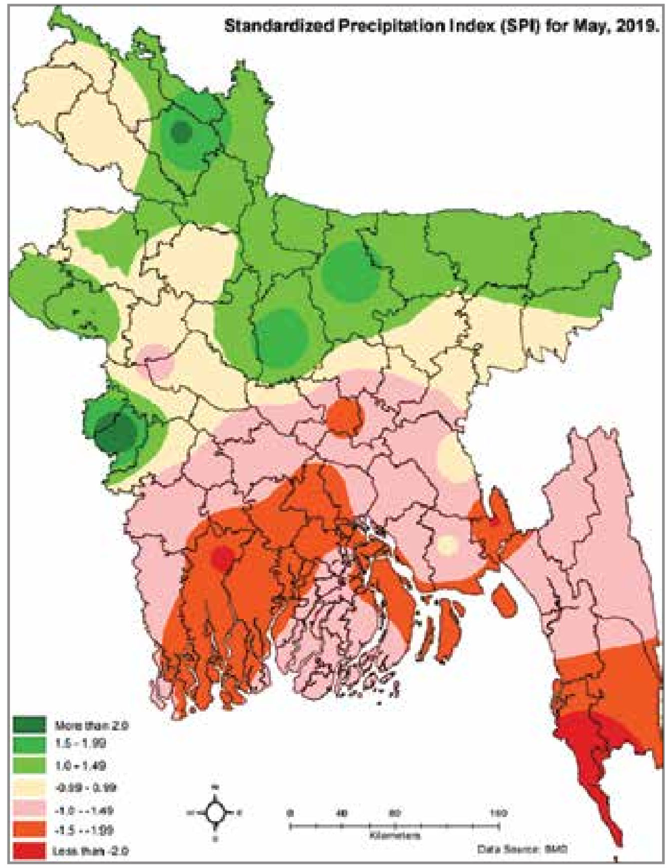
1- month SPI

1-month SPI map is very similar to a map displaying the percentage of normal precipitation fora 30-day period. For example, 1-month SPI at the end of May (fig. 35) compares the 1-month precipitation total for May in that particular year with the May precipitation totals of all the years on record. Interpretation of the 1-month SPI may be misleading unless climatology is understood. In regions where rainfall is normally low during a month, large negative or positive SPIs may result even though the departure from the mean is relatively small.

3- months SPI

The 3-months SPI provides a comparison of the precipitation over a specific 3- months period with the precipitation totals from the same 3- months period for all the years included in the historical record. In other words, a 3- months SPI at the end of May compares the March–April–may precipitation total in that particular year with the March–May precipitationtotals of all the years on record for that location(fig. 36) Each year data is added, another year is added to the period of record, thus the values from all years are used again. In primary agricultural regions, a 3- months SPI might be more effective in highlighting available moisture conditions than the slow-responding Palmer Index or other currently available hydrological indices.





(Source; BMD, Bangladesh)

Figure 35. 1-Month SPI

Figure 36. 3-Months SPI

Session III: Making use of operational satellite products for modelling crop production / yield and agro-advisories generation

Crop Simulation Models uses soil (soil moisture), weather (precipitation and temperature) and vegetation (NDVI, VCI, VHI, LAI) condition to forecast crop production and yield. Remote sensing images made the required parameters available for a large spatial extent, which can be used to simulate the crop models better.

Decision Support Systems enabled automatic and manual integration of datasets from various sources into a one-stop platform to generate and communicate user-specific and location-specific risk information. A case of agriculture decision support system used in RIMES member countries is presented in the box below:

Case Study: Specialized Expert System for Agrometeorological Early Warning (SESAME)
RIMES developed an agricultural decision support system called Specialized Expert System for Agrometeorological Early Warning (SESAME) to provide agriculture risk information based on planning agricultural operation at farm level for different lead time. The dynamic nature of the hazard variable (rainfall) and exposure elements (crop stages) and its interactions are considered while deriving the risk information in SESAME. The water requirement for various stages of crops helps to understand rainfall being optimal or at risk. The agricultural advisories are decimated to the farmers through a mobile application. Currently, the system is being piloted in Bhutan, Cambodia, Fiji, India, Myanmar, Papua New Guinea, and Sri Lanka.

The system has a functionality to incorporate satellite-based information such as gridded precipitation data available and vegetation indices such as NDVI to monitor the current status as well as to model the future using sophisticated and straightforward crop models. The cutting-edge technology made it possible to integrate multiple information into a single platform from direct observations and satellite products to automatically generate risk information and communicate such information through mobile applications.

SESAME is being developed for Bangladesh also and is currently in testing mode. The participant could visit and check the web tool at http://sesame-bmd.rimes.int/index-.php/overview. The participants should request RIMESfor username and password in order to examine the SESAME tool and give their feedback.

EXERCISE

Based on the learning from the module, answer the following questions

- List out the satellite-based products you will use for your operations (e.g. crop status monitoring, drought monitoring, etc.
- How these products will transform the operations from the way your usual approach.
- What are the capacity building requirements for integrating remote sensing products into your operations?
- What do you understand by 1-month and 3-months SPI for Bangladesh? How the SPI could be useful in your field ?
- Please document a recommendation for your department, how remote sensing products can be used for making the operations better and capacity requirements?

Module 10

Field Visit

Session

- Introduction
- Bangladesh Meteorological Department (BMD)
- Flood Forecasting and Warning Center (FFWC) of Bangladesh Water Development Board (BWDB)

Learning Objectives

- To know about the working activity of Bangladesh Meteorological Department and Bangladesh Water Development Board and how both organization disseminate meteorological and flood forecast for national and rural level.

Duration

[8 hour]

- BMD: 4 hours
- FFWC under BWDB: 4 hours

MODULE 10: FIELD VISIT

Session I: Introduction

It is essential to know the source of climate information (i.e. where and how it is being generated) to the participants of the workshop. The practical field visits are proposed at the end of the 5 days training workshop for the participants. These are

1. Visit to Bangladesh Meteorological Department (BMD).
2. Visit to Flood Forecasting and Warning Center (FFWC) of Bangladesh Water Development Board (BWDB).

Session II: Bangladesh Meteorological Department (BMD)

The facilitator should contact BMD, Bangladesh in advance and give an idea and schedule of the possible visit by the participants to the staff the BMD. The meeting should also be arranged with the Meteorologist of BMD, where participants could ask the questions and clear their doubts. The other objectives of the visit to BMD are as follows.

1. Know about activities involved in daily forecasting;
2. Know the difference sources required to generate the daily forecasting;
3. To know about the various activities and services of BMD.

Session III: Flood Forecasting and Warning Center (FFWC) of BWDB

The phenomenon like "Flooding" is very common for the people of Bangladesh and important factors influencing agriculture and other livelihoods in general. The FFWC is one of the major agencies under the Bangladesh Water Development Board (BWDB) to generate and provide flood forecast and warning information to all important national agencies and local communities. The agency through its various products involved in flash flood forecast, flood risk management, community-based flood warning and structural based forecasting. It will be excellent opportunity for the participants to know and visit the FFWC, Bangladesh as a part of the training workshop. The other objectives of the visit are as follows.

1. Know about the products and services of the FFWC ;
2. Know about how to access this information and to use in the actual situations;
3. Understand the meaning of the various warning issued by the FFWC.

MODULE 11: WORK PLAN, EVALUATION AND CLOSING CEREMONY

Objectives:

- To prepare a work-plan based on the experience gained from this training;
- To review important topics ;
- To get the summarize of the topics discussed in the sessions;
- To know the opinions of the participants and evaluate the training;
- Formal closing of the training.

Duration: 45 Minutes

Equipment: Board, Flipchart, Marker

Training Method

Open discussion, experience sharing, speeches, question-answer session, and group discussion.

Discussion Procedure

Step-1
Discuss the overall topics covered in the training and conduct a participatory open discussion.

Step-2
Participants will prepare a work-plan in a group discussion which will illustrate what they will do after the training. The trainer will assist in developing the work-plan for participants.

Step-3
If there is any inconsistency in work-plan from group discussion, the trainer will help to point that out and provide advice.

Step-4
The training facilitator will explain the importance of the evaluation.

Step-5
The training facilitator will share the evaluation forms (Annex – I and Annex - II) with the participants and request to fill up. The participants can maintain anonymity while providing their opinion.

Step-6
The training facilitator will request some of the participants to share their experience and followed by a formal closing of the training.

References

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ANNEX - I

Training Evaluation Form

Name *(Optional):*	
Address *(Optional):*	
Designation *(Optional):*	
Contact Number *(Optional):*	

Instructions: Please tick your level of agreement with the statements listed below	Strongly Agree	Agree	Disagree	Strongly Disagree	Not relevant to this event
1. The objectives of the training were met					
2. The presentation materials were relevant					
3. The content of the course was organised and easy to follow					
4. The course length was appropriate					
5. The pace of the course was appropriate to the content and attendees					
6. The exercises/role play were helpful and relevant					

7. What was most useful?

8. What was least useful?

9. What else would you like to see included in this event? Are there any other topics that you would like to be offered training courses in?

10. Would you recommend this course to colleagues? Yes/No Why?

11. Any other comments?

Thank you for completing this Training Evaluation Form!

ANNEX – II

Trainer Evaluation Form

Instructions: Please tick your level of agreement with the statements listed below	Strongly Agree	Agree	Disagree	Strongly Disagree	Not relevant to this event
1. The trainers was engaging					
2. The trainers were well prepared and able to answer any questions					
3. The trainers were helpful					
4. Trainers maintained schedule properly					
5. The trainers were open to question in open discussion					

6. What was most positive thing about the trainer?

7. What was the least positive thing about the trainer?

8. What would be your suggestion for trainer?

9. On a scale of 05 where 1 is worst and 5 is best, how you would rate the trainer (Use✔mark)

1	2	3	4	5

Thank you for completing this evaluation form!

ANNEX – III

Pre-Training Evaluation Form

Name: Position: Organization: Email Id: Mobile Number:	
What are your expectations from the training? What do you hope to gain by participating in the training?	
Which part of this training course do you think will be particularly valuable for you?	
According to You, how will the skill you learn benefit you in your role?	
What do you think you could do differently after completion of the training?	
How would you rate your level of knowledge / skills / ability in understanding weather, climate and its applications on scale of 1 to 5, 5 being very good before you attend this training course?	

Thank you for completing this evaluation form!

Government of The People's Republic of Bangladesh

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