Supporting MOWRAM in Capacity Building on End-to-End Multi Hazard Early Warning System in Cambodia through Seasonal Forecasting, SESAME program and activation of Monsoon Forum in Cambodia

August 2019

FARM Field School Training of Trainers' Manual

Table of Contents

List of Figures

List of Tables

Acronyms

CCA	Climate Change Adaptation
DHRW	Department of Hydrology and River Works
DOM	Department of Agriculture
GDA	General Directorate of Agriculture
EWS	Early Warning System
GDP	Gross Domestic Product
IWRM	Integrated Water Resources Management
NMHS	National Meteorological Hydrological Services
RIMES	Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
WMO	World Meteorological Organization

Introduction

Agriculture is a key economic sector in Cambodia. The Agriculture Ministry estimates that as of June 2017, the sector employs 40% of the country's population, and contributes about 26.66% of the GDP. Rice is the most important product, contributing about half of the agricultural GDP and using an estimated 3.3 million hectares of land.

Subsistence agriculture is the main income source for most of the country's rural population. Smallholder farmers generally have one rice crop each year, mostly rainfed since cropped area equipped with irrigation is estimated at only 10% of total agricultural production area.[1]

The sector is affected by various problems including limited infrastructure, underdeveloped value chains, water resource and land degradation, and plant pests and diseases. It is also highly vulnerable to climate-related hazards like droughts, floods, storms and strong winds. But while climate poses risks to agricultural production, inter-annual and inter-seasonal variability can also provide valuable resources. This means that information on climate fluctuations could help inform decisions for effective management of farm-related risks and resources.

Currently, weather and climate information from the Department of Meteorology (DOM) is not fully integrated into farm-level planning and decision-making due to the following gaps:

- Lack of mechanisms to identify farmers' climate information needs and requirements
- Limited access to climate information by farmers
- Lack of guidance in processing climate information into potential impacts and advisories
- Weak or non-existent feedback mechanisms between end-user farmers and DOM

The Forecast Application and Risk Management (FARM) School program addresses some of these gaps in forecast generation and application in the agriculture sector. Designed as a season-long series of interfacing among forecasters, extension workers, and farmers, the FARM School is a multi-tier learning-by-doing capacity building program customized for farmers in specific areas.

In general, the FARM School process aims to enhance farmers' understanding and use of multi-timescale forecasts in farm-level planning and decision-making, thereby increase agricultural production, optimize use of limited resources, and maximize economic benefits. At the end of the season-long program, farmers will be able to:

- Identify weather, water and climate-related issues and constraints in relation to agricultural production,
- Familiarize different weather/climate parameters, terminologies and instruments,
- Understand the importance of multi-timescale information (i.e., historical observation, short-, medium- and long-range forecasts as well as climate projections) in farm operations,
- Identify appropriate risk and resource management response options,
- Utilize location-specific and cost-effective risk and resource management strategies as applicable and necessary to address weather, water and climate-related risks,
- Assess the economic value of integrating multi-timescale information in planning and decision-making,
- Document experiences, insights, and good practice cases for dissemination and further adoption.

[1] Raitzer, D.A., L.C.Y. Wong and J.N.G. Samson (2015). Myanmar's Agriculture Sector: Unlocking the Potential for Inclusive Growth. ADB Economics Working Paper Series. https://www.adb.org/sites/default/files/publication/177652/ewp-470.pdf

RIMES' FARM School curriculum and training materials is customized for Cambodia context by technical experts from the General Directorate of Agriculture (GDA), Department of Meteorology (DOM), Agriculture Research Institutes and Extension Office among others.

The FARM School Program

The season-long FARM School Program is very participatory, practical-oriented and discovery learning-based. Composed of four parts divided into 11 modules, the program starts with a Training of Trainers (TOT) with experts from relevant agencies, agricultural technicians, extension workers and farmer leaders as participants. Trained agricultural technicians, extension workers and farmer leaders will subsequently train progressive farmers. The latter training may be conducted each season until capacity of all local farmers is enhanced (see Figure 0-1).

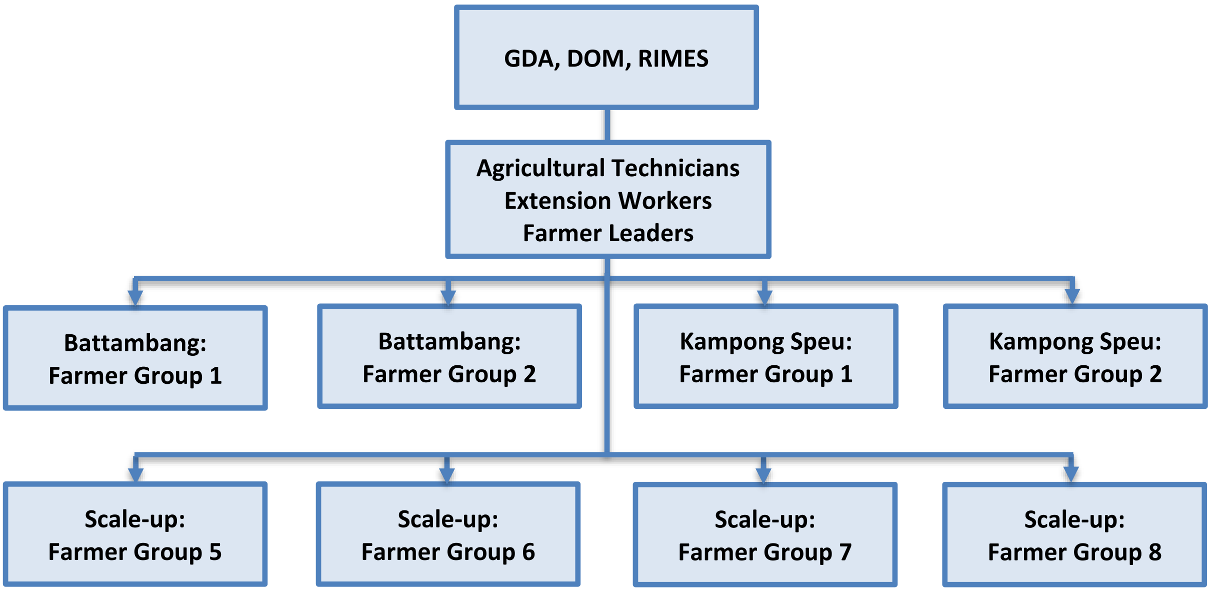


Figure 0-1. The FARM School program

The FARM School program is piloted in the provinces of Battambang and Kapong Speu, in the districts of Samroang Torng and Thmor Koul respectively. At least one farmer group is formed for each district/province during the pilot run of the program. This may be scaled up in the next season based on insights, receptivity of relevant agencies and local agriculture staff as well as on availability of resources.

FARM School Modules and Sessions

The program is comprised of four parts divided into 11 modules with 1-3 sessions per module. Table 0-1 outline the modules and sessions

Table 0-1. Modules and sessions

	Module	Session	Outline
Part A. The FARM School Program			
1	Introduction to the FARM School Program	1.1 Learning Contract 1.2 Profiling and Assessment	- Define objectives of the FARM School Program - Set expectations and ground rules - Conduct assessments of farmer and farm characteristics, of climate information use, information needs and requirements
Part B. Weather and Climate, and Forecast Products			
2	Weather and Climate	2.1 Weather and Climate	- Define weather and climate

	Module	Session	Outline
			- Discuss the climatology of Battambang and Kampong Speu (historical trends and projections for rainfall and temperature)
3	Weather Forecasts and Climate Outlooks	3.1 Forecast Products and Services of DOM 3.2 Forecast Terminologies and Probabilities 3.3 Introduction to SESAME	- Present the different forecast products in DOM (daily, 3-day, 7-day, monthly, seasonal) - Discuss terminologies/classifications used by DOM (below normal, normal, above normal) - Provide background information on SESAME
4	Weather Observation – Field Visit	4.1 Process of Rain Formation 4.2 Field Visit to Weather Station	- Discuss the process of rain formation - Show different kinds of weather instruments through a visit to a local weather station - Highlight the importance of data and local feedback (verification) in forecasting
Part C. Application of Weather and Climate Information in Farm Operations			
5	Weather and Cropping Strategies	5.1 Weather and Cropping Plan	- Understand the importance of using climate information in crop planning - Prepare crop patterns and crop calendars using crop parallelogram
6	Soil Water Balance	6.1 Soil Water Balance	- Understand the characteristics of different soil types - Estimate irrigation requirements using the water balance concept for different soils
7	Weather and Fertilizer Inputs	7.1 Weather and Fertilizer Inputs	- Discuss the correlations between weather, fertilizer inputs and crop growth - Outline proper method and timing of fertilizer application
8	Weather, Pests and Diseases	8.1 Weather, Pests and Diseases	- Discuss the correlations between weather and crop pests and diseases - Identify effective mechanisms for preventing, controlling and managing pests and diseases (IPM)
9	Climate Information Application for Risk and Resource Management	9.1 Climate Information Application for Risk and Resource Management	- Identify local flood and drought control programs to mitigate the impact of extreme events (e.g., establishing deep wells, ponds, rainwater tanks, irrigation canals, etc) - Identify techniques for effectively managing farm water resource (e.g., drip irrigation, mulching, using organic matter, etc) - Discuss flood and drought support systems in the pilot provinces (e.g., source of drought or flood-resilient crops and varieties, irrigation advice, financial support, etc)
Part D. Assessment			

	Module	Session	Outline
10	Assessing the Economic Value of Climate Information	10.1 Economic Value of Weather/Climate Information	- Discuss basic expense-income analysis to assess the benefits of weather/climate information - Identify livelihood options that help mitigate the socio-economic impacts of weather/climate hazards
11	Farm Visit	11.1 Farm Visit	- Visit a demo farm - Discuss ways to document outcomes and lessons learned - Develop mechanisms to sustain the FARM School program

1. Module One: Introduction to the FARM School Program

This module introduces the FARM School program, outlines the program objectives and expectations. It also assesses for participants and also collects background information

1.1 Learning Contract

The FARM School program uses practical methods of teaching and learning, encouraging participants to steer their own learning process. Because of this, a session on learning contract is required for trainers and participants to discuss expectations and set agreements on the following:

- Foster good relations with trainers and co-participants
- Encourage participation and sharing of experiences/insights/good practices of everyone
- Promote openness to learn new things and remain updated of practices and technologies related to agriculture and climate
- Emphasize continuous learning and improvement based on insights from the field and from research
- Ensure sustainability of the program by sharing experiences/insights/good practices to other farmers

Participants must understand and agree to the above from day 1 of the training.

1.1.1 Objectives

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

- Appreciate the FARM School program and process
- Identify their expectations as well as commitment to completing the program
- Discuss the goal, results and expected outcomes of the program
- Know the trainers and co-participants

1.1.2 Session Time

The session takes about 30 minutes.

1.1.3 Materials Needed

10 Photos (20x10cm size) of weather, water and climate-related events (e.g., sunny/cloudy/rainy weather, flood, drought, etc) cut in half
Meta-cards
Flip charts
Marker pens

1.1.4 Guide

Step 1. Introduce the FARM School program, speakers and participants

The session starts with an activity. The facilitator introduces the activity, which requires participants to take one half of the cut-out photos. Once all participants have his/her half photo, they should find the other half. On finding the other half, the pair introduces each other and discusses the photo they get. After a 3-minute introduction, pairs are called to introduce each other's *name*, *background* and FARM School program *expectations* to the bigger group. They are also asked to identify/describe the photo they got. The facilitator notes the participants' description of the photos as well as their expectations in the flip chart.

Once everybody has introduced themselves, the facilitator goes through the photo description and work with participants in identifying a common theme – weather, water and climate, which is the basis of the Forecast Application for Risk Management (FARM) School Program. The facilitator subsequently presents the FARM school program, an initiative between GDA and DOM with support from UNDP and technical assistance from RIMES. The facilitator discusses the FARM School program goal, process, content and implementation timeline.

Step 2. Discuss expectations of participants and facilitators/trainers
The facilitator goes through the list of participant expectations and categorizes these into three as can be seen in the following table.

Table 1-1. Sample expectations

Within the Program	May be Accommodated	Cannot be Managed
Learn about weather and climate	Discuss fertilizer and pest management	Provide financial support to buy farm equipment
Discuss impacts of natural disasters on agriculture productivity	Identify potential suppliers of farm inputs	Provide credit line and loan
Identify ways to manage climate risks	Identify potential market and price for produce	Get support to market/sell farm produce

Discussion of participant expectations is important in order to manage the said expectations early in the program. Once expectations are clarified, the facilitator outlines the FARM School program expectations as follows.

Table 1-2. Program expectations

Group	Individual
Teamwork and collaboration in completing activities and learning	Attendance and punctuality
Willingness to share experiences, insights and good practices with other participants	Openness to learn and try new ideas and practices
Willingness to share experiences, insights and good practices to other farmers in the community	Accountability when making decisions based on advisories

Step 3. Establish implementation arrangements for the FARM Field School.
After outlining the program expectations, the facilitator shall discuss with participants their preferred implementation arrangements for the FARM School program based on participants' availability and other factors.

Table 1-3. Implementation options

Venue	Timeline	Remarks
Pilot district	Program delivered weekly over 8-10 weeks	Participants go to the district office
Pilot district	Program delivered over 1 week	Participants go to the district office
Pilot Commune	Program delivered weekly over 8-10 weeks	Facilitator goes to commune
Pilot Commune	Program delivered over 1 week	Facilitator goes to commune

1.2 Profiling and Assessment

This session focuses on gathering background data on the participants and the target commune/district. It assesses the practices, vulnerabilities, existing capacities, needs as well as requirements of farmers. The profiles and assessments are then integrated in the modules and sessions, where possible.

1.2.1 Objectives

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

- Outline their background, vulnerabilities, capacities, needs and requirements
- Discuss common weather, water and climate-related challenges in their commune/district

- Identify potential strategies and solutions to address the challenges

1.2.2 Session Time

This session takes about 60 minutes.

1.2.3 Materials Needed

Assessment survey qustionnaire (please see Appendix A)
Flip charts
Marker pens

1.2.4 Guide

Step 1. Filling out of the assessment survey questionnaire

Ideally, this form should be completed days before the training to ensure that responses are integrated in the FARM School program. In case participants were not able to accomplish the form prior to the training, they may be asked to answer this before the start of the first day of training. Participants must be guided in each question to ensure they understand and are able to respond as accurately as possible. Additionally, the facilitator must ensure that participants who are unable to read and write will be guided accordingly.

Step 2. Develop a hazard, exposure/vulnerability as well as resource map

The facilitator asks participants to form 4 groups according to commune/district/province, and instructs each group to draw in one flip chart their commune/district/province and indicate the most common weather-, water-, and climate-related hazards that affect specific areas. Participants are also asked to identify the location of their farms as well as the nearest water sources, agricultural centers/offices, markets, etc. where they get any means of support/assistance.

The groups are then asked to outline in another flip chart the most common challenges that they encounter in their farms, and how they manage these challenges. They may also list their proposed strategies for managing the problems (see Table 4-1.

Table 1-4. Sample challenges and proposed solutions

Challenges	Current Strategies to Address Challenges	Other Proposed Strategies
Low yield due to drought	Rainwater harvesting	- Improve existing water sources and irrigation - Introduce drought-resistant crop varieties - Provide drought forecasts
Pest outbreaks during the dry season	Use of costly pesticides and insecticides	- Guidance on integrated pest management method (IPM) from agriculture office
Crop damage due to heavy rainfall	None	- Forecasts of heavy rainfall from DOM - Advise on appropriate response strategies from agriculture office

2. Module Two: Weather and Climate

Weather is the condition of the atmosphere at any given time while climate is commonly defined as the weather averaged over a long period of time with the standard averaging period of 30 years. The difference between both terms is summarized by the popular phrase "climate is what you expect, weather is what you get”. Weather shows the condition of elements in a given location and short time period, whereas climate shows the general or average condition at larger scales and longer time periods.

2.1 Weather and Climate

The climate of a specific location is affected by its latitude, altitude, terrain, persistent ice or snow cover as well as nearby oceans and their currents. Climate can be classified using parameters such as temperature and rainfall, which are used to define specific climate types.

2.1.1 Objectives

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

2.1.2 Session Time

This session takes about 20 minutes.

2.1.3 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

2.1.4 Guide

Step 1. Identify weather and climate elements

The facilitator introduces a game where participants choose a piece of paper that contains weather/climate elements and non-weather/climate elements. Each is 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 2-1. Clarification for this is carried out with the participants and the facilitator giving their opinions to enhance participants’ capacity to distinguish weather/climate elements from those that are not.

Table 2-1. Weather/climate elements

Weather/Climate Elements	Non-Weather/Climate Elements
Temperature	Flood
Rainfall/Precipitation	Sky
Humidity	Water
Wind	Rain gauge
Atmospheric pressure	Cold
Topography	Map
Ocean currents	Soil

Step 2. Differentiate weather and climate

The game is continued to build understanding about the differences between weather and climate by choosing a piece of paper containing short statements that describe either weather or climate. Participants are divided into sub-groups for discussion, with at most 6 people per group. The facilitator asks each group to discuss the statement in the piece of paper, and attach this to either the weather or climate column until all statements are cateogrized in a similar way as the table below.

Table 2-2. Weather and climate

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

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.

2.2 Forecast Terminologies and Probabilities

To facilitate informed farm planning and decision-making, farmers need to be able to understand and contextualize forecast information. Forecasts are often given along with terms like below normal (i.e., lower than 80% of the 30-year average), normal (i.e., within 80% to 120% of the 30-year average) and above normal (i.e., above 120% of the 30-year average). Forecasts also come with uncertainties, the understanding of which is key to meaningful application in risk and resource management.

The facilitator must link the insights from this session with discussions in Modules 5 and 9 to highlight how forecasts may be used in crop planning and risk management.

2.2.1 Objectives

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

- Explain relevant terms like below normal, normal and above normal
- Understand forecast probabilities within the context of accuracy, and its implications on planning and decision-making
- Develop the capacity to interpret and use forecasts in farm-level planning and decision-making

2.2.2 Session Time

This session takes about 60 minutes.

2.2.3 Materials Needed

Monthly climatological rainfall data for pilot locations
Flip chart with definition of below normal, normal and above normal (see Table 3-2)
Marker pens

2.2.4 Guide

Step 1. Differentiate below normal, normal and above normal

The facilitator provides background on the basic science of forecasting, including methods based on statistical techniques and numerical models. For instance, rainfall occurrence can either be predicted based on historical observation or in terms of other parameters that have high correlation with rainfall such as temperature, humidity, wind speed and pressure. Numerical prediction is based on the evolution of the surface boundary conditions and its interaction with atmospheric properties. Outputs from numerical or statistical models provide forecast in the form of probabilities of raianfall as below normal, normal and above normal.

The facilitator asks participants to form four groups, provides each group with monthly rainfall data for pilot locations of Battambang and Kampong Speu, and asks each group to identify the monthly rainfall range for below normal, normal and above normal from January to December using the following criteria.

Table 2-3. Rainfall classification and range

Category	Range (% of 30-year average)
Below Normal	< 80%
Normal	80-120%
Above Normal	> 120%
Excess	
Deficit	

Each group develops their own table, indicating below normal, normal and above normal rainfall values for their assigned location as shown below[2].

Table 2-4. Rainfall classification and range for Battambang and Kampong Speu

Month	Battambang			Kampong Speu		
	Below Normal	Normal	Above Normal	Below Normal	Normal	Above Normal
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						

On filling the above table with values, the facilitator must point out the differences in the value range for below normal, normal and above normal between Battambang and Kampong Speu provinces. This means the definition is location- and time-specific. Normal values in one province may be considered above normal in Kampong Speu or another province. Similarly, normal values in one month maybe below normal in another month.

After the above-mentioned activity, the facilitator discusses the climate profile of the pilot provinces of Battambang and Kampong Speu. Pleasase refer to Appendices B and C respectively.

Step 2. Discuss the nature of deterministic and probabilistic forecasts

The facilitator begins by explaining the uncertainties associated with forecasts, and emphasizes that forecasts are not always correct. Forecast have certain levels of probability. If the probability of rain is high, it means rainfall is most likely to occur. Similarly, if rainfall probability is low, then rainfall is less likely to occur.

To explain the concept further, the facilitator introduces a game of probabilities using marbles of two colors, where white indicates correct forecast and green means wrong forecast. The facilitator asks a

[2] To save time, the facilitator may ask Group 1 to work on the first six months (Jan-Jun) for Battambang province and Group 2 for the last six months (Jul-Dec), Group 3 for the first six months (Jan-Jun) for Kampong Speu province and Group 4 for the last six months (Jul-Dec).

participant to take (without looking) one marble from a container with 40 white marbles and 10 green marbles. The participant identifies the marble color then returns the marble in the same container while the facilitator notes the marble color in the flip chart, which outlines a table similar to the following.

Table 2-5. Game of probabilities

Participant	White	Green
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Total		
% of Total		

The process of taking and returning marbles is repeated until 10 participants have identified marble colors. The facilitator then counts the total number of white and green marbles and everybody identifies the percentage of white and green marbles against total. For instance, 7 white marbles out of 10 is 70% correct forecast.

Step 3. Discuss with participants their receptivity to use forecast with 70% probability
The facilitator asks participants their openness to use forecasts, including the level of probability/accuracy/forecast skill that they may be willing to integrate the information in their plans and decisions (see Table 2-6).

Table 2-6. Accuracy levels for multi-timescale forecasts

Forecast	Farmer Requirements	Remarks
Daily		
3-day		
7-day		
Monthly		
Seasonal		

Forecast accuracy differ across different timescales – short-range forecasts are more accurate than long-range forecasts. The forecasts are also used differently by various users. Therefore, it is important that training participants (i.e., extension workers and farmers at various levels) discuss their information needs and requirements from DOM.

3. Module Three: Weather Forecasts and Climate Outlooks

Weather forecasts and climate outlooks are very important for farmers to take immediate remedies to address unexpected changes in weather or to alter their long-term plans and strategies.

3.1 Forecast Products and Services of DOM

The Department of Meteorology (DOM) is the agency mandated to observe, monitor and provide meteorological products and services in Cambodia. This session encapsulates the key services, mandates and products of DOM.

3.1.1 Objectives

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

- List the information products and services of DOM
- Discuss the potential uses of weather and climate information products in agricultural production

3.1.2 Session Time

This session takes about 20 minutes.

3.1.3 Materials Needed

Flip charts
Marker pens

3.1.4 Guide

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

The facilitator asks participants to talk about their knowledge of DOM products and services, the channels in which they access these forecasts and the ways in which they use DOM forecast products in planning or decision-making. The facilitator lists the participants' answers in the flip chart, and notes whether participants are fully aware of DOM products and services, and their relevance.

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

The facilitator presents the weather and climate information products released by DOM through various channels as follows.

Table 3-1. DOM products and services

Product/Service	Release Day/Time	Dissemination Channel	Parameters	Use
Nowcasts				Forecasting rainfall, thunderstorm, gust
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 DOM forecasts by end-user farmers

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

3.2 Introduction to SESAME

RIMES has developed a decision support tool called Specialized Expert System for Agro-Meteorological Early Warning (SESAME) which facilitates timely, actionable and relevant forecast based advisories for end users in the agriculture sector. The tool is customized for Cambodia in 2018 and it has been assisting agriculture officers and extension workers in automating the process of translating weather/climate information into agricultural advisories that could be provided to farmers, for informed and better management of resources and risks. This session discusses the SESAME tool, including the features, functions and application in farm-level operations.

3.2.1 Objectives

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

- Familiarize the SESAME user interface
- Identify critical elements such as the multi-timescale forecasts and parameters, crop information and crop advisories
- Appreciate the potential application of SESAME and its outputs in farm-level planning and decision-making

3.2.2 Session Time

This session takes about 40 minutes.

3.2.3 Materials Needed

Android smart phones
Mobile data

3.2.4 Guide

Step 1. Introduce SESAME tool to participants

The facilitator provides a general background of SESAME tool to participants, then asks them to work in pairs and download the SESAME mobile app for Cambodia. He/she assists participants in navigating through the tool and familiarizing with its functionalities.

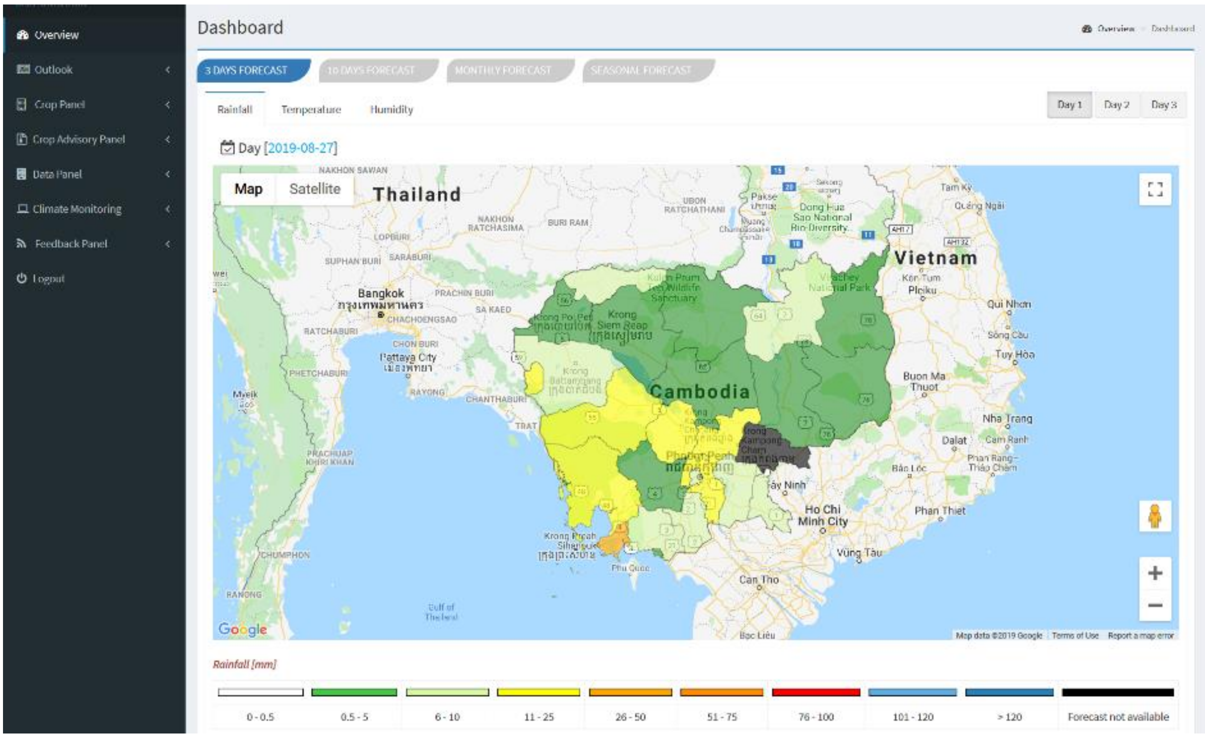


Figure 3-1. SESAME tool interface

Figure 3-1 shows the main components of the system. The left navigation includes dashboard for forecast/outlook, crop, crop advisory, data on dissemination and feedback panel.

Step 2. Introduce critical elements of the tool

In this step, the facilitator discusses the three important elements of SESAME: i) forecasts and parameters, ii) crop information, and iii) agro-advisories.

The weather forecast panel provides forecasts for 3 days (using weather research forecasting, WRF), 10 days (from European Center for Medium-Range Weather Forecasting, ECMWF), monthly and seasonal outlooks. The 3-day forecasts include parameters like rainfall, temperature (Tmax, Tavg, Tmin), humidity and wind speed. Similarly, the 10-day forecasts include information for rainfall, temperature (Tmax, Tmin), potential evapotranspiration (PET), humidity, number of rainy days and spell. Figure 3-2 shows a snapshot of the weather forecast panel.

The crop information panel provides a list of crops, the growth stages, crop activity, information on ideal conditions with which the crop grows, and the crop calendar. Figure 3-3 shows a sample view of the crop panel. The third panel on crop advisory integrates the information on various forecast parameters (i.e., rainfall, temperature, humidity, wind, evapotranspiration) with the crop's required conditions. Agro-advisories are generated based on the combination of both. There is also a data panel for users who subscribed to getting advisory alerts and notifications from the tool.

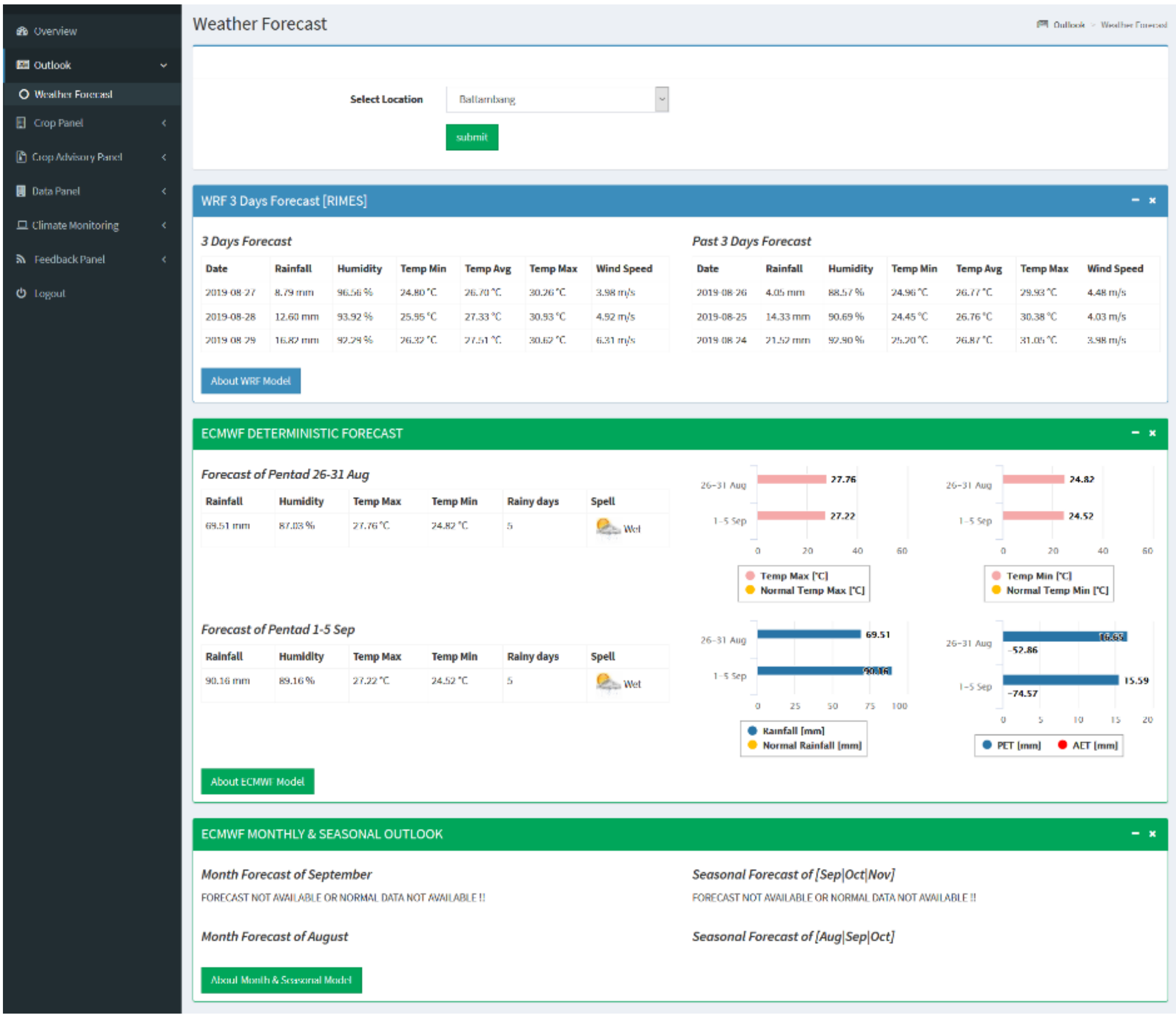


Figure 3-2. SESAME forecast panel

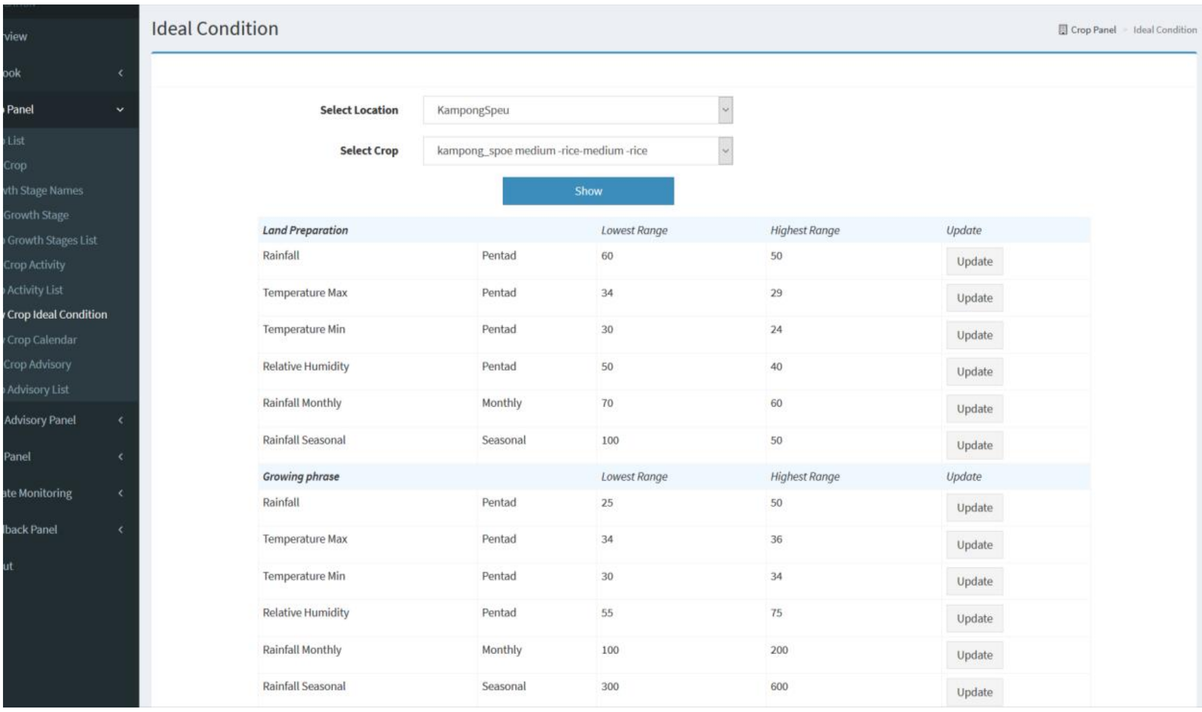


Figure 3-3. SESAME crop information panel

Step 3. Discuss the application of SESAME in farm-level planning and decision-making

After presenting the important elements of SESAME app/web-based interface, the facilitator discusses with participants the application of the app in planning and decision-making at the farm-level, from crop planning and "timing" of land preparation and sowing, to "timing" of putting fertilizers and harvesting.

4. Module Four: Weather Observation

Weather and climate are environment variables that impact greatly on crop growth and development. But even if many agriculture workers know their impacts, there remains limited knowledge on how to utilize weather and climate information to support agriculture-related activities. One of the reasons is the unavailability observation equipment and data to support research and analysis of information for use by the agriculture sector.

4.1 Process of Rain Formation

Rain is a very important climate element especially in rainfed areas which rely on rainfall for crop production. It varies considerably with time and location. For instance, it might rain in a specific area and remain sunny in another area nearby, or even if it's raining in both areas, one is probably more than the other. This is understandable because rain is formed from water (i.e., surface water or from plants' leaves) that evaporates and becomes clouds that always move depending on where the wind blows. The circulation of air in the atmosphere transport water vapor to various parts of the earth as an integral part of the earth's normal weather pattern. When conditions are suitable, water vapor is returned to the land or ocean as water droplets or rain. Rain reaching the earth's surface may be intercepted by vegetation, may infiltrate the ground surface, run off the surface or evaporate.

The distribution of forests is a consequence of climate and soil conditions. Forests generally decrease surface runoff compared to areas with lesser/shorter or without vegetation. The denser the forest, the more water can be retained and the greater the potential for increased dry season flows.

4.1.1 Objectives

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

- Understand the process of rain formation
- Recognize the importance of forests in retaining rainwater

4.1.2 Session Time

This session takes about 45 minutes.

4.1.3 Materials Needed

Small stove
Pan containing 1 liter of water
Rectangular iron sheet or foil (50 cm x 60 cm) (2 pcs)
Measuring glass for water
Ice blocks
Stop watch
Rectangular iron sheet or foil (50 cm x 60 cm) with nailed holes 1 cm apart both ways
Piece of mat (50 cm x 60 cm)

4.1.4 Guide

Step 1. Exercise on rain formation

The session starts with an experiment on rain formation to demonstrate the many factors that affect its magnitude and its spatial and temporal variability. The facilitator uses the following steps in the experiment.

i. Boil the water in the pan. Place above the pan the iron sheet that has no holes and cooled by ice. After a few minutes, note how i) the water in the pan boils/evaporates/turns into vapor, reaches the iron sheet, and condenses into droplets of water. Condensed water on the iron sheet is collected through a water collector under the stove and measured using the measuring glass. This is carried out continuously until the water in the pan has completely evaporated (i.e., the pan is already dry). Figures 4-1 and 4-2 show the set-up for the experiment on rain formation.

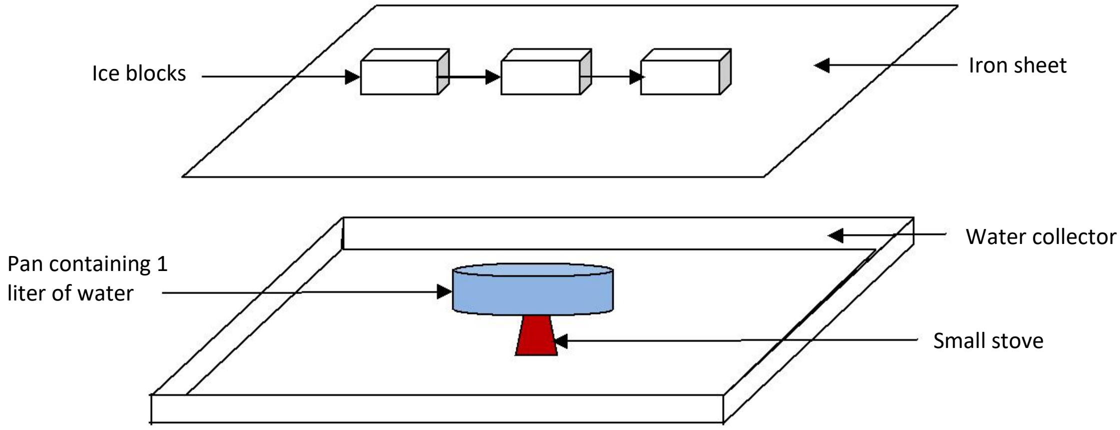


Figure 4-1. Schematic representation of the rain formation process

Figure 4-2. Demonstration on rain formulation process

ii. Compare the volume of condensed water with the volume of water, which evaporated from the pan.
iii. Discuss with participants potential reasons why the amount of condensed water is not the same as that, which evaporated from the pan. This generally happens because not all water vapor become rain; some are lost due to other factors like wind. Sometimes, water that condenses may be more than that, which evaporates because the vapor around the iron sheet has condensed from the ice on the iron sheet. This means that the vapor can come from other sources and have significant effect on local rain formation.

Step 2. Experiment on forest cover and surface runoff
The facilitator introduces another experiment to illustrate how forests help retain the amount of rainwater and consequently limit surface runoff. The facilitator uses the following steps.

i. Take a measured amount of water in the pan and pour it into the holed iron sheet evenly. The water that passes the holed iron sheet acts as rainfall and is collected by the slanted sheet placed below. The water that flows from the slanted sheet surface is collected again and the volume of the collected water is measured. The time it takes for the last drop to reach the iron sheet surface is recorded with a stopwatch. This process is repeated with a mat placed in the slanted iron sheet on the entire surface. The mat acts as a forest. The amount of water collected in the two processes and the time it takes for the last drop to flow is then compared. Figure 4-3 shows a schematic of the experiment.

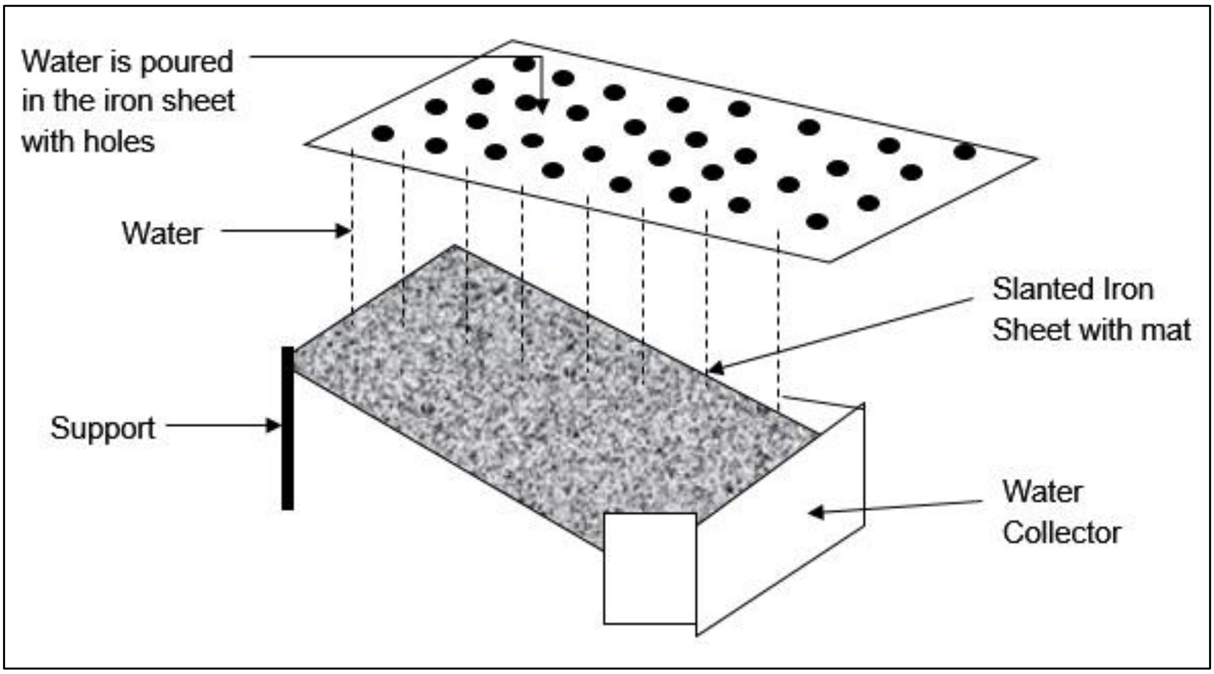


Figure 4-3. Schematic of the experiment on surface runoff in forests

ii. Participants are asked to discuss the results. After which, the facilitator explains how the mat can hold water, before releasing it into the pan. This shows how forests help retain more water in the soil and make it available during the dry season.

4.2 Field Visit to Weather Station

The visit to a weather station aims to introduce different types of equipment that can be used to measure various elements of weather/climate. The visit also highlights the importance of observation data in research/analysis, for the provision of information and guidance for the agriculture sector.

4.2.1 Objectives

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

- Identify important weather measurement equipment like rain gauge and thermometer
- Understand the importance of observation data
- Observe local conditions based on experience and using equipment that can be easily made using local materials

4.2.2 Session Time

This session takes about 90 minutes.

4.2.3 Materials Needed

Equipment (e.g., rain gauge, etc)

4.2.4 Guide

Step 1. Show critical observation equipment and their functions

The facilitator coordinates with the local observer in the weather station for the latter to provide a brief tour of the station and equipment. The orientation must focus on equipment used to measure parameters useful to agriculture such as rainfall, temperature, soil moisture, humidity, wind pressure.

The local observer also discusses with the participants traditional methods of forecasting. For instance, participants may discuss with the local observer the process of observing various cloud types to forecast rainfall.

Step 2. Discuss observed data available in the station

The local observer discusses with participants the observation data available in the station, how this was archived, and continuously used in forecasting as well as research. The facilitator must emphasize that without observation data, it is difficult to conduct analysis of climate trends, develop/verify forecasts and/or make high-resolution projections.

Step 3. Demonstrate ways to fabricate a simple rain gauge

The local observer and facilitator may demonstrate to participants how to develop a simple rain gauge using locally available materials. Having a rain gauge in the farm is important in verifying the accuracy of rainfall forecasts. This also helps farmers monitor local rainfall. Please see Appendix D for more information and guidance.

5. Module Five: Weather and Cropping Strategies

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. Also, 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 and/or reduce crop loss or damage.

5.1 Weather and Cropping Plan

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 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.

5.1.1 Objectives

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

- Recognize the importance of the crop plan to maximize rainfall utilization and minimize irrigation application
- Prepare a cropping pattern and calendar using a cropping parallelogram[3]

5.1.2 Session Time

This session takes about 60 minutes.

5.1.3 Materials Needed

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

5.1.4 Guide

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 are divided into sub-groups with maximum 6 people per group. They are asked to accomplish the following (please refer to Figure 5-1 for the 10-day histogram and Table 5-1 for sample water requirement of selected crops).

i. Prepare a rainfall data chart (histogram) for 1-year period normal and forecasted rainfall using the graphing paper.
ii. Draw a horizontal line in a transparent plastic sheet with a length equivalent to the growing period of the selected crops at similar scale as the rainfall chart.

[3] A cropping parallelogram is a simple instrument/geometric tool that can be used to test a potential cropping pattern, sequence or area to be cultivated versus available water supply.

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.

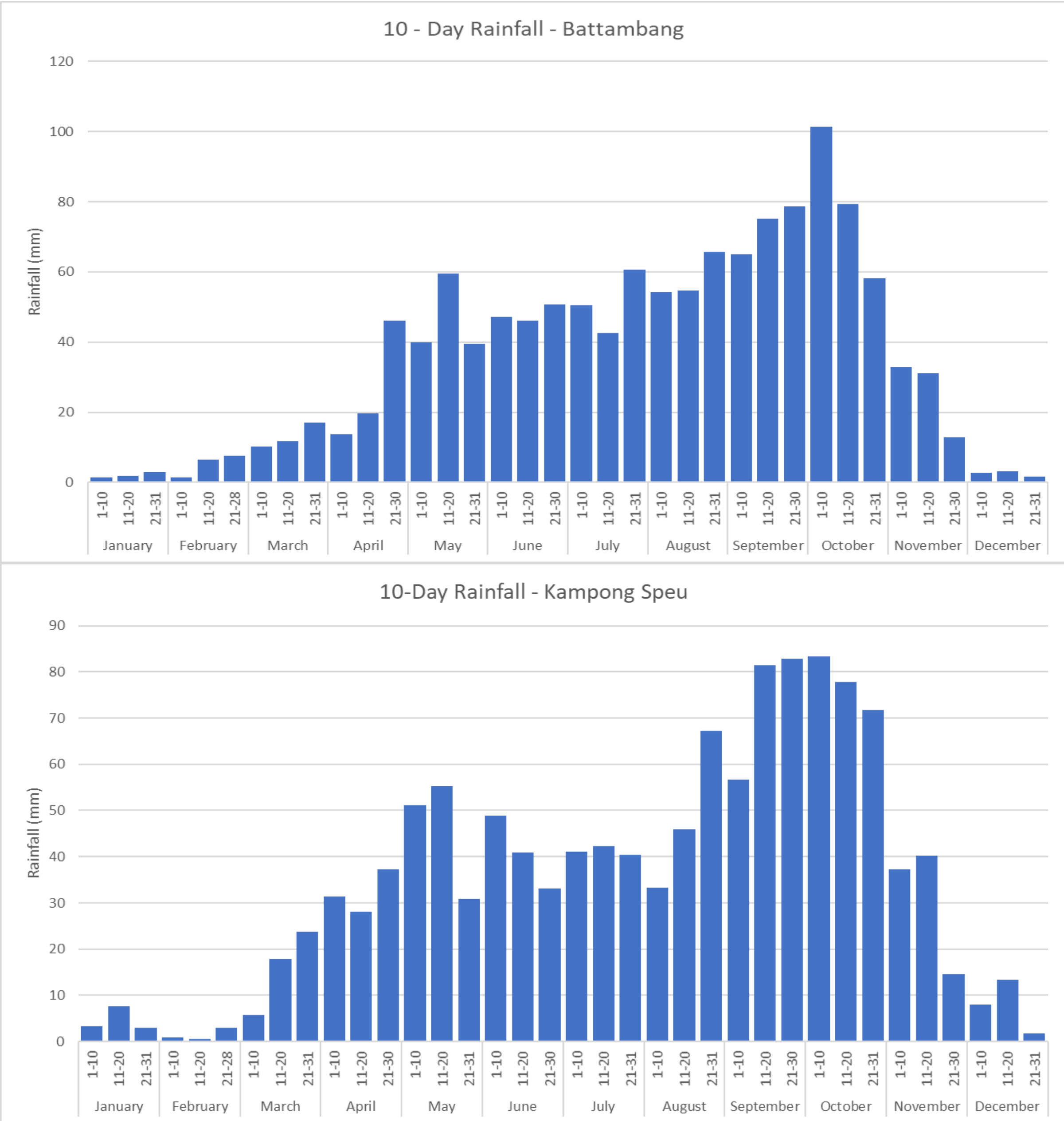


Figure 5-1. Histogram of annual 10-day rainfall of Battambang and Kampong Speu

Table 5-1. Sample crop water requirement and growing period of selected crops[4]

	Crop	Growing Period (days)	Average Daily Water Requirement (mm)	Total Crop Water Requirement (mm)
Sample from the Philippines				
1	Pepper	70	3.3	231

[4] Data from this table is based on information from the Philippines and Tamil Nadu Agriculture University (http://agritech.tnau.ac.in/agriculture/agri_irrigationmgt_waterrequirements.html). Cambodia's Ministry of Agriculture and Rural Development (MARD) may have different values.

	Crop	Growing Period (days)	Average Daily Water Requirement (mm)	Total Crop Water Requirement (mm)
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	Garlic	120	2.2	264
11	Eggplant	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	Soy bean	110	4.8	530
Sample from Tamil Nadu, India				
1	Rice	110	11.36	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	Blackgram	65	4.31	280
9	Soybean	85	3.76	320
10	Sesame	85	1.76	150
11	Sunflower	110	4.09	450
12	G. Gramm	70	3.6	250
13	B. Gramm	70	3.6	250

Step 2. Discuss the relevance of crop planning

The facilitator asks participants to brainstorm on the following.

i. What is 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 possibility of water shortage during the dry season? What strategies do you use to address the problem?
v. Do you have alternative cropping plans and/or planting strategies to maximize rainfall utilization and minimize irrigation?

6. Module Six: Soil Water Balance

Rainfall is the main source of water for crops. But much of the rainwater cannot be used by plants. Some evaporate back to the atmosphere and others flow to rivers and eventually to the sea. If the drainage system is not good and there is excess rainfall, water will accumulate and eventually result in flooding. On the other hand, during the dry season when rainfall is rare, the water that evaporates will come from the soil so that the land will eventually become dry. Without irrigation, plants will suffer from drought.

6.1 Soil Water Balance

Water balance is the balance between the amount of water supplied to the land through rain and irrigation versus the amount of water used to fill the soil with water including water used by crops and lost either through evaporation or runoff. The analysis of field water balance is simply a process of accounting the volume of water within a system, that is, identifying the i) inflows from rainfall and/or irrigation, ii) outflows through evapotranspiration, surface runoff, seepage and percolation, and iii) change in storage within the system (see Figures 6-1 and 6-2).

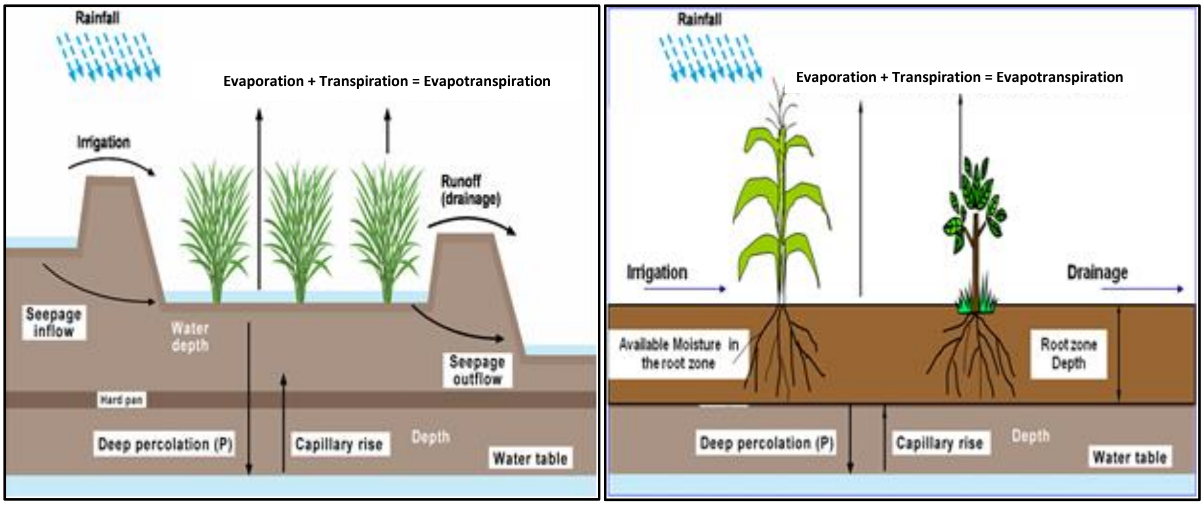


Figure 6-1. Water balance in flooded fields (left) versus dry fields (right)[5]

The water balance concept can be expressed as Rainfall (Rf) + Irrigation (Ir) = Evapotranspiration (Et) + Seepage and Percolation (S&P) + Drainage (D) + Change in Water Status (ΔS).

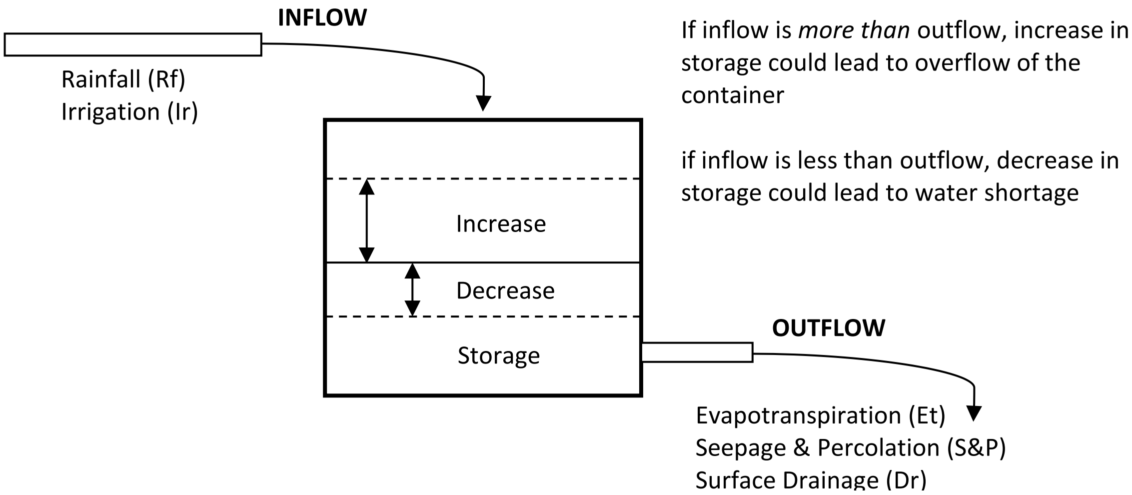


Figure 6-2. Water balance concept

[5] In areas without standing water, moisture within the root zone need to be maintained to ensure plant growth.

Evaporation from land and plants is called evapotranspiration (ETP). Potential rate of evapotranspiration is about 5mm per day or 150mm per month. If the monthly rainfall is less than 150mm, the soil's water is used to compensate the need for evapotranspiration. If the monthly rainfall is more than 150mm, then the excess will flow back to rivers through the drainage system. Indeed, during the rainy season when there is excess rainfall and the drainage is not big enough to tap the water, flooding may occur. In flooded fields, this is being contained and controlled through bunds or levees. But in dry land cultivation, after satisfying soil infiltration this may result to runoff flowing to streams and their tributaries. During the dry season when rainfall is not enough to satisfy crop water requirements, the soils become dry. With the first drop of rain at the onset of the next rainy season, the soil's water holding capacity (which varies according to soil types) within the root zone is first satisfied and then rainwater percolates deeper. Flooding may again occur when there is excess rainfall.

6.1.1 Objectives

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

- Understand the importance of water and soil elements on plant growth and development
- Explain the water balance concept
- Estimate irrigation requirement as well as possibility of floods

6.1.2 Session Time

This session takes about 60 minutes.

6.1.3 Materials Needed

Eight plastic bottles

Soil samples enough to fill 1/3 of the plastic bottle: i) dry clayey soil (e.g. clay loam) representing dry land, ii) wet clayey soil with compacted layer representing paddy field, iii) dry sandy soil (e.g. sandy loam), and iv) wet sandy soil

Graduated cylinder

Timer

6.1.4 Guide

Step 1. Group exercise on water holding capacity

The facilitator asks participants to form four groups based on the soil samples: i) dry clayey soil, ii) wet clayey soil, iii) dry sandy soils, and iv) wet sandy soil. The groups are asked to prepare the necessary materials as shown below.

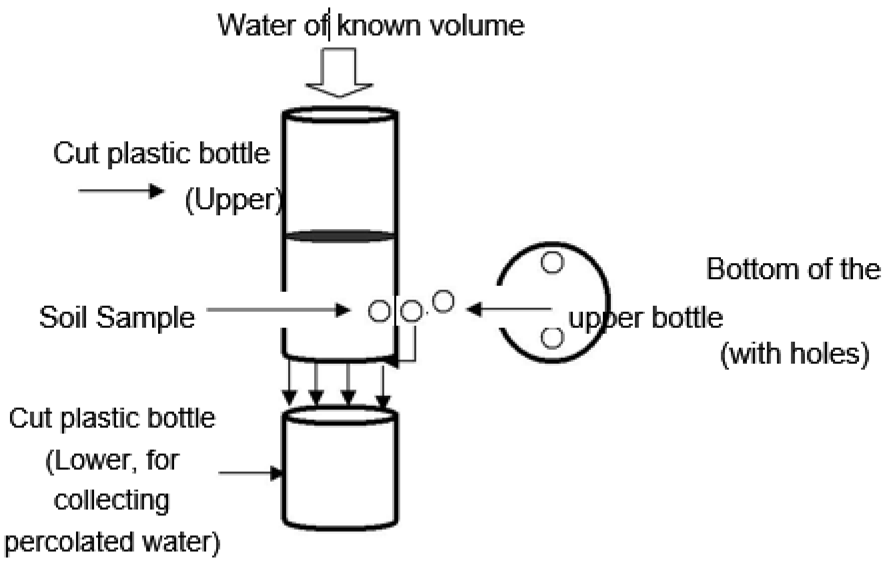


Figure 6-3. Typical set-up for the exercise on water balance concept

Four plastic bottles with different soils samples are 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 note 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 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.

The facilitator asks participants to pour more water of known volume into the plastic bottles with soil samples. Once again, participants note the time until the last drop is finished. In this case, there might be potential increase in the amount of percolating water as the water holding capacity is satisfied. A water pond may develop in the soil sample with compacted layer representing the paddy field.

Step 2. Discuss observations and insights related to the water balance concept

At the end of the exercise, participants are asked to discuss among group members their observations and insights. The facilitator may point out that the amount of water collected in the lower bottle is less than the amount poured as some of it is absorbed by the soil (by filling soil pore spaces) and the rest evaporate. The water held in the container represent percolating water while temporary accumulation of water above the soil surface represents flood, which in the case of paddy field is contained and controlled through bunds or levees.

Discuss further what potential sources of irrigation are available in the farmers' areas and what support is expected by the farmers so that the potential of water resources can be used optimally.

7. Module Seven: Weather and Fertilizer Inputs

Moisture and temperature affect the yield potential of crops. Moisture is required for seed germination and plant development while temperature is critical to plant physiology and nutrient uptake. When planning fertilizer applications, it is important to know the short- and medium-term weather forecast. Timely and moderate rainfall can help dissolve dry fertilizer and move nutrients into the soil rooting zone while excessive rain may lead to losses due to increased runoff, volatilization and leaching of nutrients such as nitrate, sulfate, chloride, and boron. Temperature also influences chemical and biological processes like seed germination, root development, and nutrient uptake.

7.1 Weather and Fertilizer Inputs[6]

Agro-climatic information helps improve decisions related to fertilizer application. However, crop-specific application requires planning with agronomists and complete understanding of the soil and nutrient requirements at various stages of crop growth and development.

7.1.1 Objectives

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

- Identify methods of applying solid and liquid fertilizers
- Identify the general advantages and disadvantages of the methods of applying fertilizers
- Identify the "timing" of fertilizer application with reference to short- and medium-term forecasts

7.1.2 Session Time

This session takes about 60 minutes.

7.1.3 Materials Needed

Flip charts with diagram of the application methods for solid and liquid fertilizer
Marker pens

7.1.4 Guide

Step 1. Discuss methods of applying solid fertilizers

The facilitator discusses the methods of applying solid fertilizers as shown in Figure 7-1.

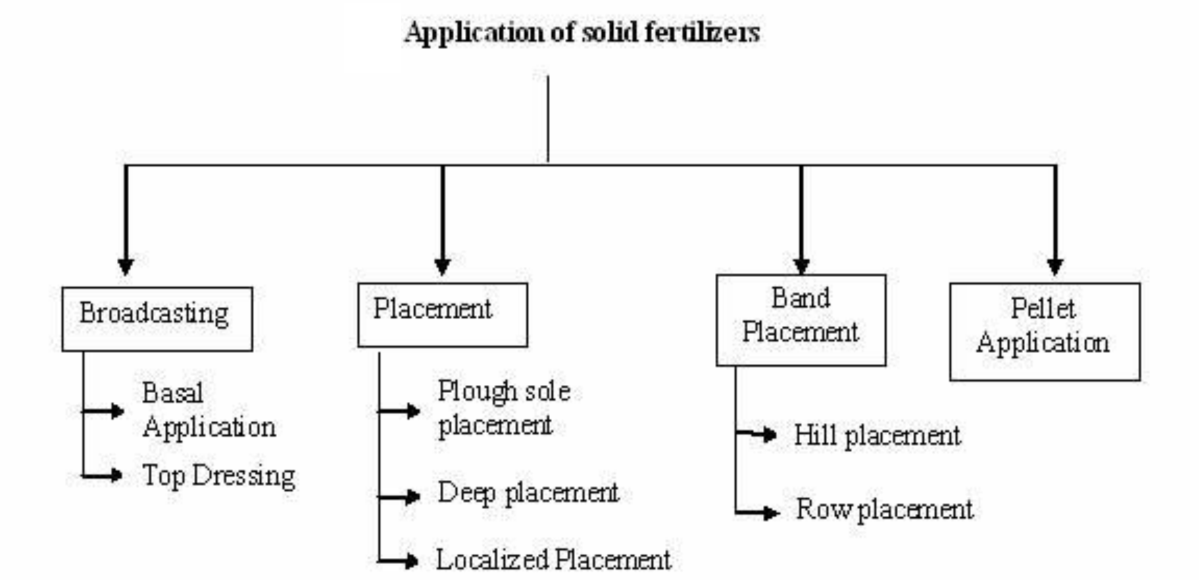


Figure 7-1. Methods of applying solid fertilizers

[6] Information on the methods for applying fertilizers (including the figures) is taken from Tamil Nadu Agriculture University Agritech Portal at http://agritech.tnau.ac.in/agriculture/agri_nutrientmgt_methodsoffertilizerappln.html.

i. **Broadcasting** involves spreading fertilizers uniformly into the soil. It allows even distribution of nutrients throughout the root zone and is often considered the best method for obtaining maximum yields. Broadcasting is suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are used. It may be done in two ways.
   a. Broadcasting at sowing or planting (i.e., basal application) to uniformly distribute the fertilizer over the entire field and to mix it with soil.
   b. Top dressing, which involves broadcasting of fertilizers (particularly nitrogenous fertilizers) in closely sown crops like paddy and wheat, to provide nitrogen in readily available form to growing plants.

   Broadcasting produces higher yields if enough extra phosphorous (P) is applied to make up for increased tie-up. However, limited-resource farmers generally have several yield-limiting factors like marginal land and insufficient capital. Other disadvantages to this method of application include the following.
   a. Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.
   b. Weed growth is stimulated.
   c. Nutrients are fixed in the soil. Fertilizers containing P need to be worked well into the topsoil when broadcast, and not all farmers have the time, labor or equipment to do this.

ii. **Placement** involves putting of fertilizers in soil at a specific place with or without reference to the position of the seed. Placement methods are typically the best for limited-resource farmers whose capital, management, and other limiting factors point toward using low to moderate rates of fertilizers. It is also recommended in applying phosphatic and potassic fertilizers, when the development of the root system is poor, and soil has a low level of fertility. Some of the most common methods of placement include the following.
   a. Plough sole placement where fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing. This method is suitable for areas where soil becomes relatively dry up to a few centimeters below the soil surface and soils having a heavy clay pan just below the plough sole layer.
   b. Deep placement involves putting ammoniacal nitrogenous fertilizers in the reduction zone of soils particularly in paddy fields, where ammoniacal nitrogen remains available to the crop. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.
   c. Localized placement involves the application of fertilizers into the soil close to the seed or plant to supply adequate nutrients to the roots. The common methods of placing fertilizers close to the seed/plant are as follows.
      - Drilling involves applying fertilizers at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this is suitable for the application of phosphatic and potassic fertilizers in cereal crops, germination of seeds and young plants may be damaged due to higher concentration of soluble salts.
      - Side dressing refers to the spread of fertilizers in between the rows (e.g., of maize, sugarcane, cotton, etc.) and around plants (e.g., mango, apple, grapes, papaya, etc.).

iii. **Band placement** refers to the placement of fertilizer in bands. This can be done in two ways.

a. Hill placement is practiced for the application of fertilizers in orchards. Fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of the crop.
b. Row placement refers to the application of fertilizers in continuous bands on one or both sides of the row for crops like sugarcane, potato, maize, cereals, etc.

iv. **Pellet application** involves placement of nitrogenous fertilizer in the form of pellets between 2.5 to 5 cm deep between the rows of the paddy crop. The fertilizer is mixed with the soil in the ratio of 1:10 and made small pellets of convenient size to deposit in the mud of paddy fields.

The main advantages of placement are as follows.

- When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, thereby reducing nutrient fixation.
- The weeds cannot make use of fertilizers.
- Residual response of fertilizers is usually higher.
- Utilization of fertilizers by the plants is higher.
- Loss of nitrogen by leaching is reduced.
- Being immobile, phosphates are better utilized when placed.

Step 2. Discuss methods of applying liquid fertilizer
The facilitator discusses the methods of applying liquid fertilizers as shown in Figure 7-2.

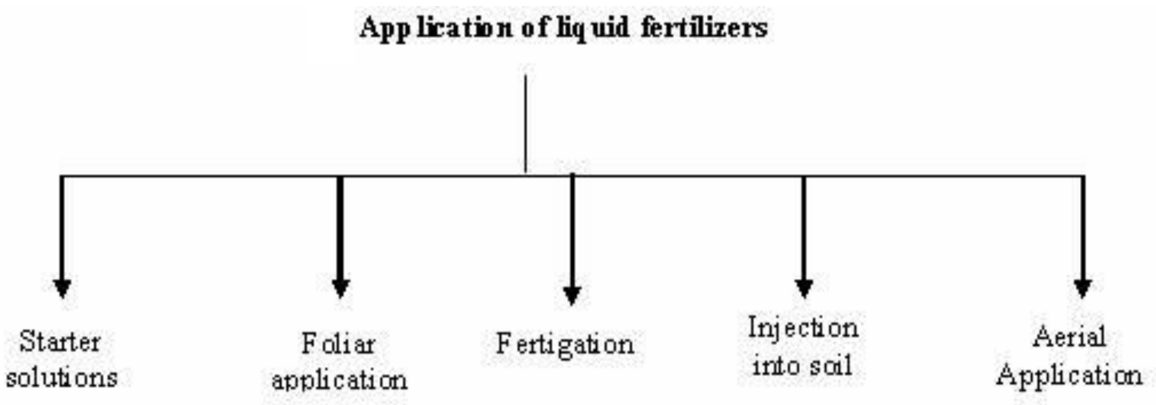


Figure 7-2. Methods of applying liquid fertilizers

i. **Starter solution** involves the application of solution of N, P2O5 and K2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting. Starter solution helps in rapid establishment and quick growth of seedlings. However, it requires extra labor, and the potential for phosphate fixation is higher.

ii. **Foliar application** refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them. Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers. The concentration of the spray solution must be controlled; otherwise, serious damage may result due to scorching of the leaves.

iii. **Fertigation** involves application of water-soluble fertilizers through irrigation water. Nitrogenous fertilizers are generally applied through irrigation water.

iv. **Injection into soil** can be done in either pressure or non-pressure types. Non-pressure solutions may be applied either on the surface or in furrows without appreciable loss of plant nutrients under most conditions.

v. **Aerial application** is useful in areas where ground application is not practicable. The fertilizer solutions are applied by aircraft in hilly areas, forest lands, grass lands or sugarcane fields.

Step 2. Discuss the advantages and disadvantages and identify suitable methods as well as "timing" of application vis-à-vis weather forecasts

After presenting the different methods of applying fertilizers, the facilitator asks participants their current methods of applying fertilizers. Participants also discuss their challenges and insights in using/applying fertilizers for various crops. They then identify the most suitable methods as well as the "timing" of applying fertilizers with respect to forecasts they receive from DOM/SESAME. The facilitator may use the following table for the discussion.

Table 7-1. Advantages and disadvantages of different application methods

	Methods Currently Used	Advantages and/or Disadvantages	Insights: Suitable Methods and Timing
1			
2			
3			
4			
5			
6			
7			

8. Module Eight: Weather, Pests and Diseases

The CGIAR notes two critical challenges and issues in Cambodian farmers' agricultural practices. These include improper and excessive use of fertilizers and application of unsafe or counterfeit pesticides[7]. These practices not only add an unnecessary expense; they also potentially result in the unintended outcome of reinforcing pest outbreaks through increased pest resistance. This is because repeated insecticide/pesticide treatments are likely to induce resistance in most insect/pest populations such as the brown plant hopper (BPH).

8.1 Weather, Pests and Diseases

The application of agro-climatic information to control and manage pests and diseases on plants and animals 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 pest/disease triangle comprised of the plant or animal host, environment (conditions suitable for disease/pest development), and the pest/pathogen (see Figure 8-1).

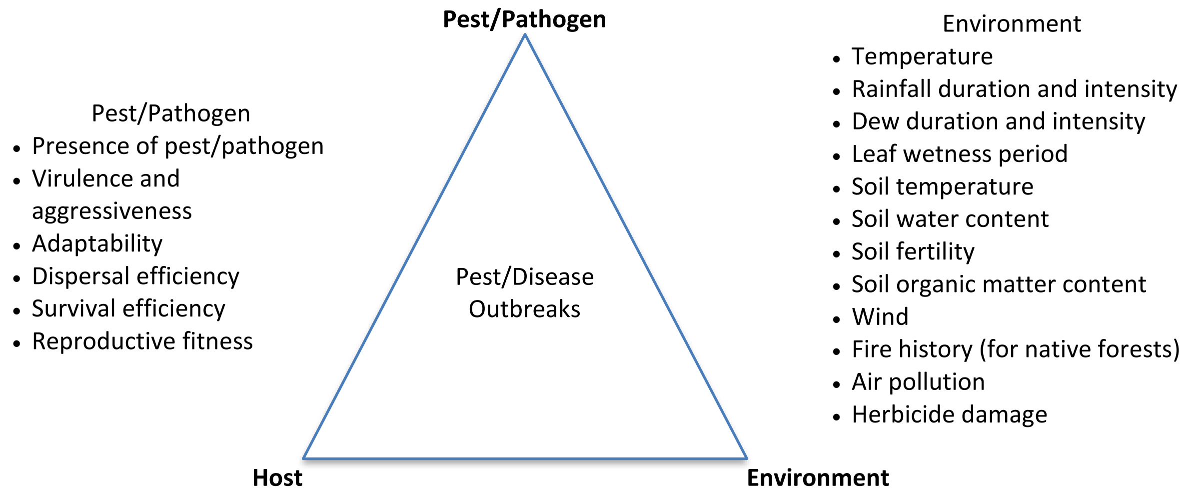


Figure 8-1. Pest/disease triangle

The concept helps describe the situation for virtually all known pests and diseases. As a rule, all three sides of the triangle contribute to the development or minimization of pest/disease incidence. Figure 8-1 shows critical climate-related factors that affect the growth and development of host plants and animals as well as pests and disease pathogens. It is therefore important to consider parameters like temperature, rainfall, soil water content and wind when addressing the pest and disease problem.

8.1.1 Objectives

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

- Explain the relations between pest/disease, the plant/animal host as well as environmental factors that contribute to outbreaks
- Identify weather, water and climate-related factors (e.g., rainfall, temperature, moisture, etc) that contribute to the development of pests and diseases
- List down common pests and diseases that affect crop growth as well as the current management strategies used by farmers in the pilot provinces
- Discuss strategies and methods to prevent, minimize and/or manage pest and disease outbreaks

[7] See https://ccafs.cgiar.org/blog/developing-pest-smart-farmers-cambodia#.XWD2nXsxVPY

8.1.2 Session Time
This session takes about 60 minutes.

8.1.3 Materials Needed
Photos of common pests and diseases for paddy, cassava, mango, lettuce and brassica family vegetables
Drawing of pest/disease triangle
Flip chart
Marker pens

8.1.4 Guide
Step 1. Discuss the pest/disease triangle
The facilitator shows the pest/disease triangle and discusses certain factors within the environment, pest/pathogen and plant host that potentially increase the incidence of pest/disease outbreaks. The facilitator highlights weather/climate-related factors (e.g., increased temperatures, too little or too much rainfall) that further enhance the growth or spread of insects/pests/diseases.

In general, higher temperatures and increased periods of rain can speed up pest cycles. The latter is also considered to worsen the phytosanitary condition of rice crops, for instance. On the other hand, extended droughts can lower the resistance of, for example, rice plants to grasshoppers while stronger winds can hasten the spread of Brown Plant Hopper (BPH).

Step 2. Identify common pests and diseases as well as management strategies used by farmers
For this step, the facilitator asks participants to form four groups. Each group is asked to list down the crops commonly planted in their commune/district as well as the pests and diseases that typically affect these crops at different growth stages. They may compare their list with the sample list in the following table.

Table 8-1. Pest incidence in selected crops[8]

Rice		Cassava		Mango	
Seed					
Broadcasted seeds	- Ants	-	-	-	-
Sown seeds	- Ants - Rice/Corn seedling maggot	-	-	-	-
Seedling Stage					
Transplanted Seedlings	- Armyworm - Cutworm - Golden apple snail - Rice/Corn seedling maggot	-	-	-	-
Stem	- Armyworm - Cutworm - Golden apple snail	-	-	-	-

[8] Information on pest incidence at various growth stages is taken from http://www.oisat.org/cropsmap.htm. A comprehensive list of non-chemical pest management strategies is available at http://www.oisat.org/pestsmap.htm while various control methods using parasitoids, predators, microbials, plants and other substances, cultural and physical methods and other approaches can be found at http://www.oisat.org/controlmap.htm.

<table>
<tr><th colspan="2">Rice</th><th colspan="2">Cassava</th><th colspan="2">Mango</th></tr>
<tr><td>Leaves</td><td>-Armyworm
-Cutworm
-Golden apple snail</td><td>Leaves</td><td>-Cassava mealybug
-Cassava green spider mite
-Cassava hornworm
-Scales
-Thrips</td><td>Leaves</td><td>-Leaf miner
-Mango mealybug
-Mango shoot caterpillar
-Whitefly</td></tr>
<tr><td colspan="6">Vegetative Stage</td></tr>
<tr><td>Tillers</td><td>-Armyworm
-Cutworm
-Grasshoppers
-Green leafhopper
-Mealybug
-Rice black bug
-Rice caseworm
-Rice gall midge
-Rice leaffolder
-Rice/Corn seedling maggot
-Thrips
-White grub
-Whorl maggot</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Whorl</td><td>-Grasshoppers
-Whorl maggot</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Stems</td><td>-Armyworm
-Rice stem borer
-Whorl maggot</td><td>-</td><td>-</td><td>Shoots</td><td>-Mango leafhopper
-Mango shoot caterpillar
-Mango tip borer
-Spider mites</td></tr>
<tr><td>Leaves</td><td>-Aphids
-Cutworm
-Green leafhopper
-Locusts
-Rice black bug
-Rice leaffolder</td><td>Leaves</td><td>-Cassava mealybug
-Cassava green spider mite
-Cassava hornworm
-Grasshoppers
-Locusts
-Scales
-Thrips
-Whitefly</td><td>Leaves</td><td>-Mango leafhopper
-Mango mealybug
-Spider mites</td></tr>
<tr><td colspan="6">Reproductive Stage</td></tr>
<tr><td>Panicle</td><td>-Aphids
-Armyworm
-Green leafhopper
-Locusts
-Rice black bug
-Rice caseworm
-Rice leaffolder
-Rice stem borer
-Thrips</td><td>-</td><td>-</td><td>Flowers</td><td>-Mango leafhopper
-Mango mealybug
-Mango tip borer
-Scales
-Thrips</td></tr>
</table>

Rice		Cassava		Mango	
Grain	-Brown planthopper -Rice bug -Stink bug	-	-	-	-
Maturation Stage					
Grain	-Rice bug	Tubers	-Termites	Fruits	-Fruit fly -Mango shoot caterpillar -Mealybug

After discussing the list of pests and diseases that affect specific crops at particular stages, the facilitator ask each group to discuss and provide the management strategies they use to minimize and/or manage each pest and disease, and to rate each strategy according to cost and effectiveness.

Step 3. Discuss integrated pest and disease management strategies

The pest/disease triangle is introduced to participants to determine the factors that contribute to the incidence and spread of pests and diseases. The same triangle can be used to outline non-chemical strategies and methods to prevent, mitigate and/or manage pests and diseases. The facilitator discusses some of these strategies and methods, their purpose/target, implementation process and effectiveness (see Figure 8-2)[9].

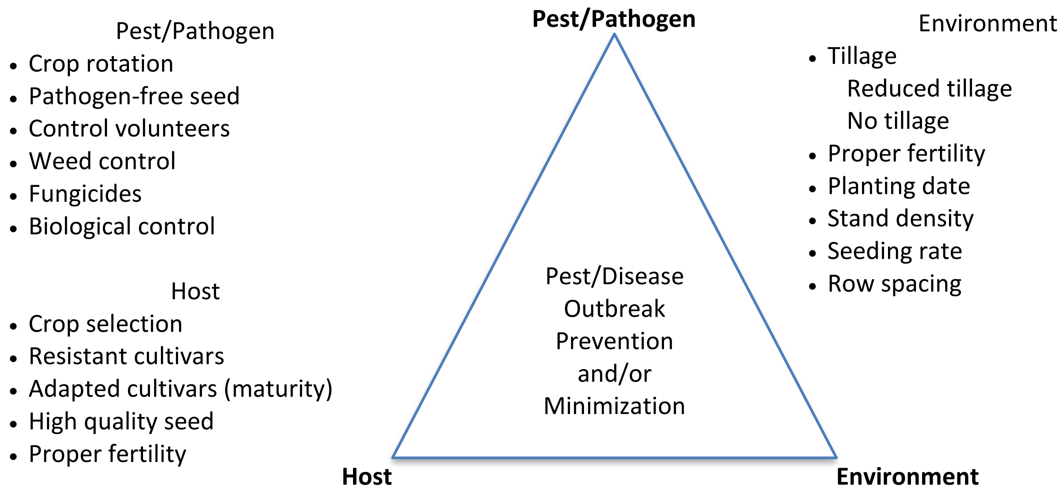


Figure 8-2. Pest/disease management strategies

[9] Although this section covers plant pest and disease management, it shall only focus on strategies that are simple, affordable, and proven to be effective in simultaneously addressing multiple problems. For more details related to plant pathology and/or entomology, farmers should be referred to appropriate agencies/agriculture extension workers/organizations whose research and program focus relate to pest and disease management.

9. Module Nine: Climate Information Application for Risk/Resource Management

The availability of multi-timescale forecast information allows for multi-timescale planning and response as shown in Table 9-1.

Table 9-1. Use of multi-timescale forecast information in risk/resource management

Planning Horizon	Forecast	Decisions
Short-term	-Warnings/Alerts (hours) -Forecasts (1-, 3-, 10-day)	**Operational Plans** -Protection of property (e.g., harvests, livestock, farm equipment) -Logistics (e.g. scheduling of planting/harvest)
Medium-Term	-Monthly	**Tactical Plans** -Crop management (e.g. fertilizer/pesticide use)
Long-Term	-Intra-Seasonal (3-6 months)	**Strategic Plans** -Crop type (e.g. wheat or chickpea) -Crop sequence (e.g. long or short fallows) or stocking rates Crop rotation (e.g. winter or summer crops)

Short-term forecasts are useful for day-to-day operations while medium-term forecasts are critical to strategic planning. Flood warnings, for instance, can be used in making decisions such as protecting one's harvests. On the other hand, seasonal forecasts can be used in the selection of crop types and varieties.

9.1 Climate Information Application for Risk and Resource Management

Cambodia has abundant water resources during the wet season and limited supply during the dry season. Overabundance during the rainy season causes floods while scarcity during dry periods increases concern for droughts. Indeed, two of the most important hazards that affect the country's agriculture sector are floods and droughts. Between 1998 and 2002, floods accounted for 70% of rice production loss, droughts for 20% and pest and disease outbreaks for the remaining 10%[10]. Drought loss for farmers in rainfed areas is estimated at USD 51.47 per hectare while for farmers in supplementary-irrigated areas the loss is estimated at USD 23.01 per hectare[11].

9.1.1 Objectives

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

- Discuss weather, water and climate-related hazards that affect the farmers
- Identity current strategies used to address these hazards
- Outline multi-level, multi-agency initiatives that could help mitigate and manage the hazards and their impacts on farmers

9.1.2 Session Time

This session takes about 60 minutes.

9.1.3 Materials Needed

Flip chart
Marker pens
Map of pilot provinces
Case studies (e.g., Myanmar)

[10] Sithirith, M. (2017). Water Governance in Cambodia: From Centralized Water Governance to Farmer Water User Community. Resources. 6 (44)
[11] Chhinh, N., H. Cheb and N. Heng (2014). Drought Risk in Cambodia: Assessing Costs and a Potential Solution

9.1.4 Guide

Step 1. Discuss the hazards that affect farmers

The facilitator asks the participants to form groups according to commune or district/province. In the case of the ToT, two groups may be formed – one for Battambang and another for Kampong Speu. Each group is asked to draw a hazard, vulnerability and resource map of the province, identifying the common hazards that affect specific areas and indicating the vulnerable populations and their resources and capacities. Participants are given 15 minutes to do the above. After which, they will present their drawings as the facilitator writes down all hazards in the flipchart.

Step 2. Identify existing strategies used by farmers, agencies and authorities

The facilitator goes through all the hazards listed on the flipchart and ask participants current strategies used to address each at various levels.

Table 9-2. Strategies used to address local hazards

Hazard	Agency Level	Sample Management Strategies
Drought[12]	Individual/Farm-level	- Let the land fallow - Prepare the water pond/other water sources - Maintain the water level - Properly "time" the planting - Plant drought-tolerant crops - Alter the physical farm environment (e.g., plant windbreaks) - Adopt integrated farming systems (use rice "mina" especially during the rainy season; "sorjan" cropping system combining annual crops and rice; other techniques that combine seasonal crops, annuals and livestock) - Diversify income sources by engaging in alternative livelihoods
	Farm Association/ Commune	- Establish small farm reservoirs to collect and store rainwater during the wet season - Set up communal rainwater tanks - Dig deep well for communal use
	District	- Small diversion dam
	Province	- Update the irrigation program
Flood	Individual/Farm-level	- Improve farm drainage - Plant flood-resilient crops - Diversify income sources by engaging in alternative crops or farming activities
	Farm Association/ Commune	- Establish small farm reservoirs
	District	- Establish small diversion dams to help reduce flood peak
	Province	- Update the flood management program

A sample plan and design for a farmers-managed small reservoir project is provided in Appendix F.

Step 3. Discuss government initiatives to address floods and droughts

The facilitator discusses the government's strategies and initiatives in relation to flood and drought monitoring, mitigation, preparedness and management as outlined in the following table.

Table 9-3. Government-led programs and initiatives related to flood and drought

Program	Critical Activities	Remarks
		-
		-

[12] Please refer to Appendix E for more information on managing rice in drought-prone locations.

10. Module Ten: Assessing the Economic Value of Weather/Climate 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 and this is limited by various factors including the data and techniques available, 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.

10.1 Economic Value of Weather/Climate Information

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

10.1.1 Objectives

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

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

10.1.2 Session Time

This session takes about 60 minutes.

10.1.3 Materials Needed

Flip chart
Cardboard
Marker pens
Cost and return data of some crops
Alternative economic activities as identified in discussion with the participants

10.1.4 Guide

Step 1. Discuss 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 occur) are generally provided by national meteorological and hydrological services (i.e., Department of Meteorology in Cambodia). 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 are 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 guides participants in identifying alternative livelihood activities apart from farming. This could include working as laborer in a dominant/potential industry in the participants' area (e.g. laborer in salt mining), or planting crops other than rice (e.g. maize which requires less water and/or takes shorter time to grow). The facilitator lists on the flipchart as many alternatives as the participants can give. These alternatives are then ranked according to the most economically viable.

> **Example**. 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; labor and equipment for land preparation and management). The facilitator must ask farmers 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/or information from their respective areas.

Step 2. Conduct an exercise on response strategies

The facilitator presents 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 then asks participants to form four sub-groups based on the abovementioned four response categories. The facilitator explains the paddy farmers' profit and/or 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 discusses with each group the total income and loss resulting from the decisions taken by each group, and together the groups compare and identify which profited and/or 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 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 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 realizing 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

Exercise 1. Forecast of Deficit Rainfall. Paddy farmers are preparing for the upcoming season. They received 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.

Table 10-1. Forecast of below normal seasonal rainfall forecast at 60% probability[13]

Actor	Advisory/Response	Remarks
Forecast from DOM/SESAME	- 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 Agriculture 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 USD216, then this group saves USD216 - Total money they have at the end of the season is USD216
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 USD360 (.9/bird) and earned USD646 (1.6/bird), then they earned USD286 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 USD79/ha and earned USD287/ha, then they earned USD208 in addition to their savings of USD216 - Total money they have at the end of the season is USD424
Group 4	- Does not follow the advisory and keeps on planting drought-vulnerable plants (e.g. paddy)	- IF total cultivation cost is USD216, then this group lost USD216 - Total money they have at the end of the season is -USD216

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.

Table 10-2. Forecast of above normal 7-day rainfall at 80% probability

Actor	Advisory/Response	Remarks
Forecast from DOM/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		

[13] In this exercise, the seasonal forecast was correct.

Actor	Advisory/Response	Remarks
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 USD11 per ha, then they saved USD11/ha if they delayed the sowing to avoid the rain
Group 2. Vegetative phase	- During this phase, fertilizers are crucial, but application should be "timed" to avoid potential erosion and nutrient loss due to heavy rainfall	- IF total fertilizer cost is estimated at USD9 per ha, then they saved USD9/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 spikelets - 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 USD9 per ha, then they saved USD9/ha if they delayed fertilizer application to avoid the rain - 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 USD135/ha and loss from early harvest is USD58, then the group saved USD77 (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.

Table 10-3. Forecast of above normal 7-day rainfall at 80% probability

Actor	Advisory/Response	Remarks
Forecast from DOM/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. 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 USD11 per ha, then they saved USD11/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 USD14/ha and the group decides to only plough once followed by direct seeding after the rain, they are able to save USD14/ha
Group 3. Fields recently sown direct	- Heavy rainfall may cause sown seeds to go deep into he 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 USD4/ha, cost of draining is USD2/ha, and the group decides to drain instead of 2nd sow, then they are able to save USD2/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

11. Module Eleven: Farm Visit

The FARM School program can be used to communicate weather and climate information to end-users (i.e., farmers). It can also be used as a venue for demonstrating how information can be integrated in farm-level planning and decision-making, where farmers take appropriate measures to mitigate the impact of extreme climate events. For this reason, it is essential to conduct a Farm Visit to reinforce the concepts taught, and to demonstrate to other farmers and the community the benefits of the program. Similarly, the evaluation is critical to assess the facilitators, the content, process as well as delivery of the program so that it can be improved.

11.1 Farm Visit

Following the module/session outline, the facilitator starts the farm visit with a brief discussion on cropping strategies and soil water balance with all participants. They then discuss fertilizer as well as pest and disease symptoms found in the field.

11.1.1 Objectives

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

- Show understanding of cropping strategies and field water balance
- Discuss common nutrient deficiencies and pest and disease symptoms found in the farm
- Share their experience of the FARM School program to other farmers

11.1.2 Session Time

This session takes about 2 hours.

11.1.3 Materials Needed

Camera
Photos of nutrient deficiency symptoms for macro-nutrients
Photos of pests and diseases

11.1.4 Guide

Step 1. Discuss cropping strategies and field water balance

The facilitator asks participants about the cropping cycle and calendar, the type of soil, and sources of water for the crops. This is followed by a discussion of the rainfall pattern in the area vis-à-vis the crop water requirements.

Step 2. Identify nutrient deficiencies, and pest and disease symptoms

The facilitator asks participants to observe the crops (e.g., stem, leaf, flower, fruit) and identify signs and symptoms of nutrient deficiency, pest and/or disease incidence. After which, they identify the type of nutrient missing and the required fertilizer. They also identify the pest and/or disease and identify the management strategy for addressing the problem/s.

Step 3. Sharing of experiences and insights from the FARM School program

The facilitator asks participants to briefly share their experience and insights from the program. This experience and insight sharing may be conducted in the presence of other farmers and the wider community.

Appendix A. Assessment Survey Questionnaire

Farmer’s Name : ____
Age : ____
Farmers’ Group Name : ____
Commune : ____
District : ____
Province : ____
Date of Survey : ____

Background Information					
Farm Size (Please tick):	Less than 2,500 sqm	2,501-5,000 sqm	5,001-7,500 sqm	7,501-10,000 sqm	More than 10,000 sqm
Landholding (Please tick):	Owner	Tenant	Sharecropping	Others (please specify):	
Irrigation Type (Please provide area per type):	Rainfed:	Semi-permanent irrigation:		Permanent irrigation:	
Income per Year (Please provide amount per type):	Paddy:	Perennial Crops:	Animals:	Fisheries:	Salt Production:
	Cash Crops:	Forestry:	Other income sources (please specify):		
Farm System (Please provide area per type):	Paddy rice with permanent irrigation:	Rainfed:	Mixed Crops:	Rice-Fish Culture:	Others:

Rice crop per year for the last 10 years	Cycle 1 Planting/Harvesting Dates	Cycle 2 Planting/Harvesting Dates	Cycle 3 Planting/Harvesting Dates
1. 2010	1.	1.	1.
2. 2011	2.	2.	2.
3. 2012	3.	3.	3.
4. 2013	4.	4.	4.
5. 2014	5.	5.	5.
6. 2015	6.	6.	6.
7. 2016	7.	7.	7.
8. 2017	8.	8.	8.
9. 2018	9.	9.	9.
10. 2019	10.	10.	10.

Cash Crops (Please list): 1. 2. 3. 4. 5.	Planting Date/s 1. 2. 3. 4. 5.		Harvest Date/s 1. 2. 3. 4. 5.
Perennials (Please list): 1. 2. 3. 4. 5.	Harvest Date/s 1. 2. 3. 4. 5.		
Income per year (Please indicate amount):			
Weather/Climate-related Information			
Rainy Season Dry Season	Onset (Month and week #)		Withdrawal (Month and week #)
Negative impact caused by weather/climate-related hazards on the farm 1. Gust wind 2. Flood 3. Drought 4. Heavy rainfall 5. Others	Crop Stage 1. 2. 3. 4. 5.		Please indicate frequency of impact with a = never, b = rarely, c = often and d = always[14] 1. 2. 3. 4. 5.
Use of Traditional Forecast			
Traditional forecast used 1. Clouds, etc 2. Indicator trees 3. Indicator animals/insects	Please rate your frequency of use with a = never, b = rarely, c = often and d = always. 1. 2. 3.		

[14] Rarely means 2-3 times, often is 5-6 times, and always is more than 8 times during the last 10 years.

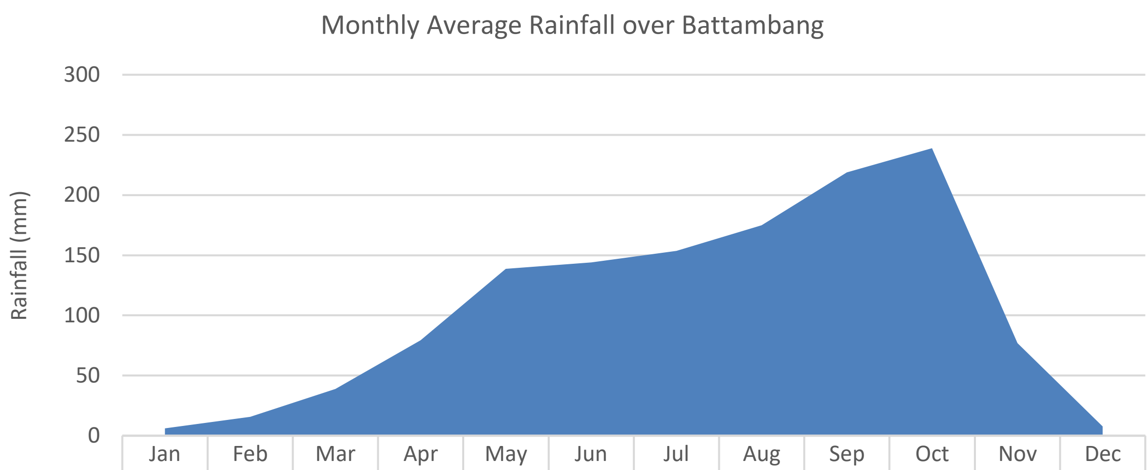
4. Others (please specify)	4.				
Source of traditional forecast 1. Oldest man/woman 2. Commune Leader 3. Others (please specify)	Please rate the frequency of release of traditional forecast with a = never, b = rarely, c = often and d = always. 1. 2. 3.				
Farmers in the commune using traditional forecast (please tick):	Nobody	10-25% of the time	26-50% of the time	51-75% of the time	More than 75% of the time
Level of success/accuracy of traditional forecasts (please tick):	0% / Failure	10-25% of the time	26-50% of the time	51-75% of the time	More than 75% of the time
Current Use Forecasts					
Forecast information currently used 1. Daily 2. 7-day 3. Monthly 4. Seasonal 5. Others	Please indicate frequency of use with a = never, b = rarely, c = often and d = always. If not using the information, please explain why. 1. 2. 3. 4. 5.				
Dissemination channel used to access information 1. Radio 2. TV 3. Newspaper 4. Commune meetings 5. DOM Website 6. Social Media (e.g., Telegram, FB, etc) 7. Mobile application 8. Others (please specify)	Please rate the frequency of using the dissemination channel with a = never, b = rarely, c = often and d = always. 1. 2. 3. 4. 5. 6. 7. 8.				
View of risks associated with probabilistic forecast	Acceptable		Not acceptable		Comments:

Forecast Information Needs and Requirements					
Rainy season	Forecast information needed, and lead-time required at each stage				
1. Seeding	1.				
2. Transplanting	2.				
3. Tillering	3.				
4. Flowering	4.				
5. Harvesting	5.				
Dry season					
1. Seeding	1.				
2. Transplanting	2.				
3. Tillering	3.				
4. Flowering	4.				
5. Harvesting	5.				
Minimum forecast accuracy willing to tolerate (please tick):	50%	60%	70%	80%	More than 90%

Appendix B. Climate Profile and Projections for Battambang Province

1. Rainfall Pattern

The rainy season in Battambang occurs from May to October. Highest rainfall is likely to occur and the end of the rainy season, in October, in which August to October is defined as the wettest months. The annual average rainfall of Battambang is 1300 mm. Figure 1 indicates the average monthly rainfall.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	6.14324	15.6135	38.9141	79.4486	138.784	143.935	153.573	174.868	218.786	238.939	76.8703	7.66216

Figure B-1. Monthly average rainfall over Battambang, 1981-2017

Inter-annual variability could be observed in Battambang in the 37 years of analysis (1981-2017). Accordingly, there were thirty (30) years with normal rainfall (±20% of average), along with three (3) years where above normal rainfall was observed and four (4) years were seen to have received below normal rainfall. The highest rainfall was observed in 2011, with 1707 mm. The driest year in the considered period was 2014 having received only 878 mm of rainfall.

2. Wet and Dry Season Rainfall

An estimated 83% of Battambang's annual rainfall is from the wet season. However, deviation from this pattern is quite common, having occurred in 1981, 1999, 2002, 2008 and 2017 where dry season rainfall was observed to have higher contribution, surpassing its average of 225 mm. Figure 2 indicates the variability of wet and dry seasonal rainfall in Battambang.

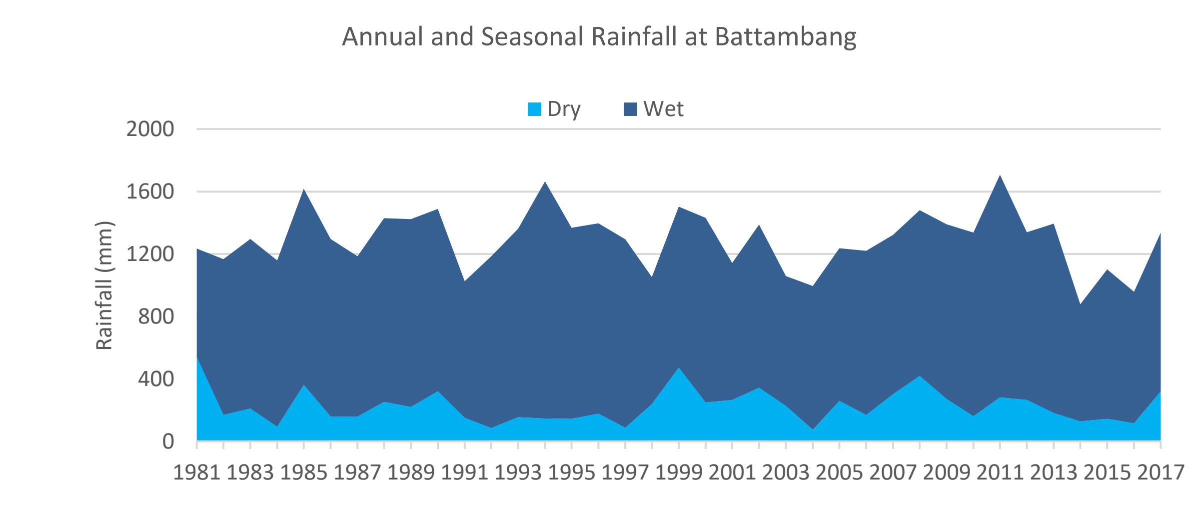


Figure B-2. Variability in wet and dry season contribution to annual rainfall

Highest contribution from the dry seasonal rainfall is observed in 1981 which accounts for 44% of total rainfall of the year, while lowest contribution is observed in 2004 with a contribution of just 73.4 mm (7% of total rainfall of 2004). In the year 2014, where the lowest rainfall for the period was recorded, the wet seasonal and dry seasonal contribution was 750 mm and 128 mm respectively.

Battambang has an average of 100 rainy days per year, out of which 18 are likely to occur in the dry season. During the considered period, the highest number of annual rainy days occurred in 1985 with a total of 122 rainy days while the lowest was recorded to be 77 days which occurred in 1998.

3. Rainfall Extremes

The highest daily rainfall values recorded in Battambang for the period 1981-2017 are indicated below.

Table B-1. 24-hour extreme rainfall events of ≥100mm in Battambang

Rainfall Amount	Date Recorded
170 mm	19 May 1994
138 mm	04 October 1990
109 mm	13 April 1981
108 mm	14 October 2010
102 mm	23 April 2011
101 mm	08 October 1995

4. Rainfall Trends and Projections

Annual and wet seasonal rainfall indicates decreasing trend in terms of both quantity and number of rainy days for the period 1981-2017. Similar pattern of decreasing trend was observed for dry seasonal rainfall, although the number of rainy days in the dry season indicated a positive trend. However, the trends in the number of rainy days for both wet and dry season were insignificant. Therefore, a decrease in the quantity of rain is observed in Battambang. In contrast, the projections indicate an increasing trend as shown in the following figure[15].

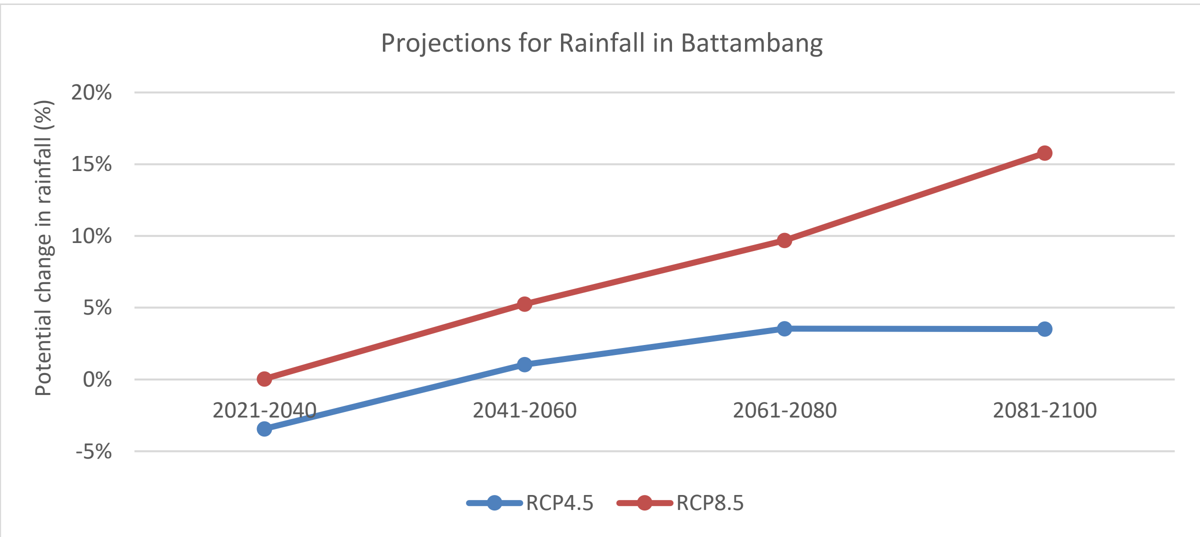


Figure B-3. Projected rainfall under RCP4.5 and RCP8.5

A potential increase in the rainfall is observed under both scenarios except for the period 2021-2040 where a decrease in rainfall is observed for RCP4.5 and no change is indicated for RCP8.5 relative to model baseline.

[15] Projections of rainfall in Battambang were obtained from downscaled NEX-NASA data for four 20-year time periods. These are presented under two scenarios of Representative Concentration Pathways (RCPs): RCP4.5 and RCP8.5. The values are obtained with reference to the model baseline for 1986-2005.

5. Average Monthly Temperature

Since the availability of temperature data is limited the analysis was conducted for the period 2004 to 2016. Highest daytime temperature in Battambang is recorded in April with an average of 36.39⁰C and the lowest daytime temperature is 31.10⁰C recorded in December. In the case of nighttime temperature, highest and lowest recorded temperature are 25.83⁰C recorded in May and 20.62⁰C recorded in January respectively. The average monthly daytime and nighttime temperature as shown below.

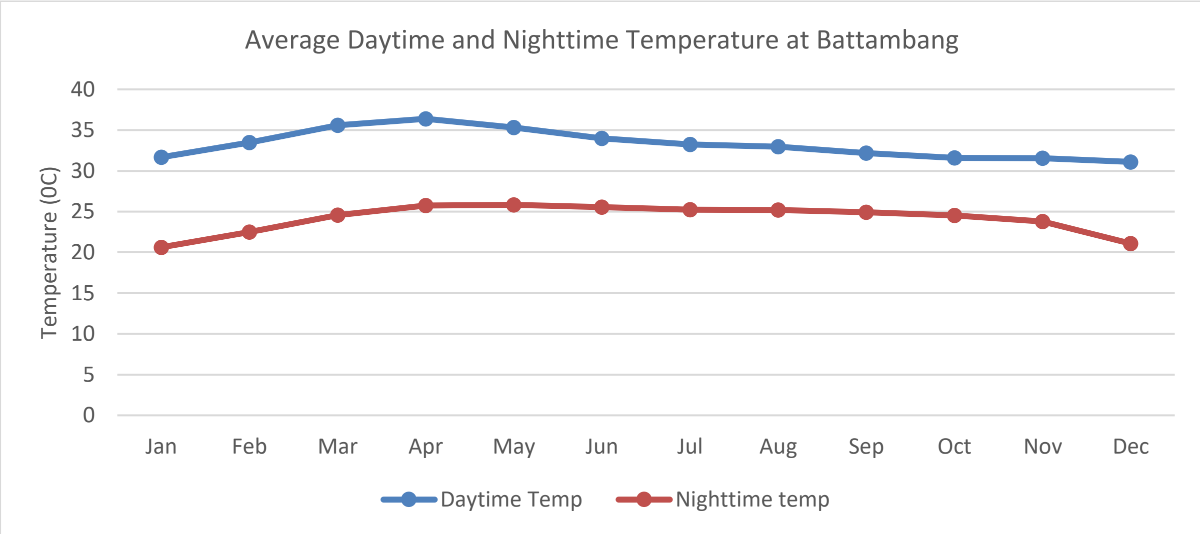


Figure B-4. Average daytime and nighttime temperature, 2004-2016

6. Temperature Extremes

The highest daytime temperature in Battambang was recorded on 11th of April 2016 at 41.1⁰C. This year indicated to have 96 days with temperature higher than 35⁰C, 46 days with temperature greater than 38⁰C and 9 days with temperature greater than 40⁰C. Figure 4 indicates the variation of number of days with temperature higher than 38⁰C.

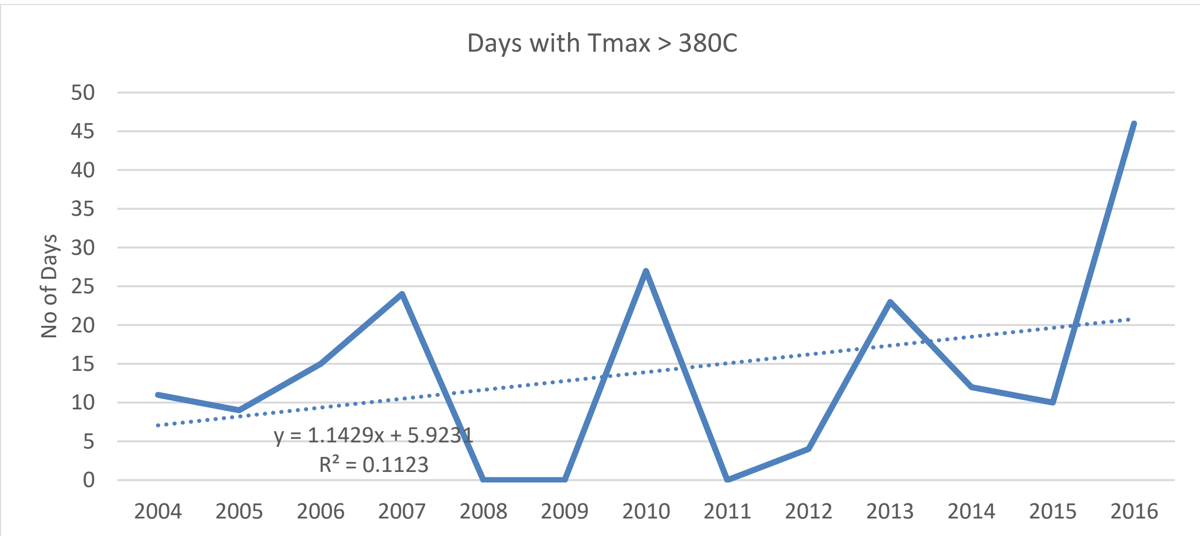


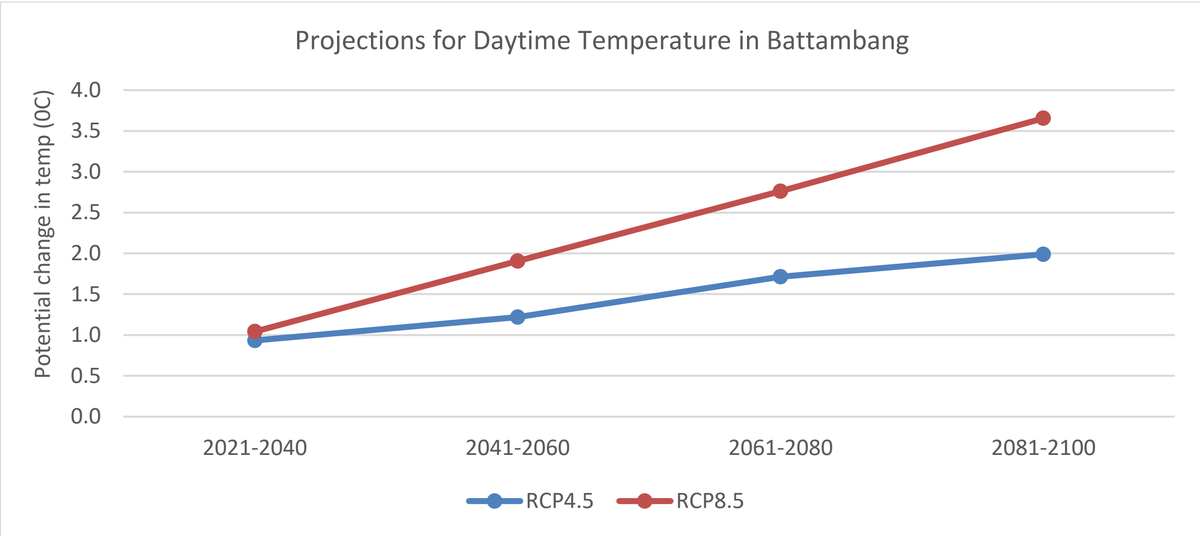
Figure B-5. Extreme daily temperature of >38⁰C in Battambang

Coolest daytime temperature was recorded at 24⁰C, observed on two occasions, 5th January 2008 and 3rd November 2009. On the other hand, the highest nighttime temperature was 30.4⁰C on 3rd April 2008. Highest number of nights with temperature greater than 25⁰C was in 2015 with 213 nights followed by 2016 with 206 nights. Only these 2 years have had more than 200 nights with temperature higher than 25^{0}C for the period 2004-2016. The coolest nighttime temperature recorded was 11.8^{0}C on 23rd May 2016.

7. Temperature Trends and Projections

Increasing trends are observed for both daytime and nighttime temperature with nighttime temperature having a higher slope than daytime temperature, indicating warmer days and nights for the period 2004-2016. Extreme temperature also indicates increasing trend for the said period. However, the available 13-year data is not sufficient for conclusions regarding trends.

Using downscaled NEX-NASA data and baseline model data for the period 1986-2005, projections for maximum and minimum temperature for the province of Battambang were obtained. The projections made were under RCP4.5 and RCP8.5 scenarios as shown in the following figures.



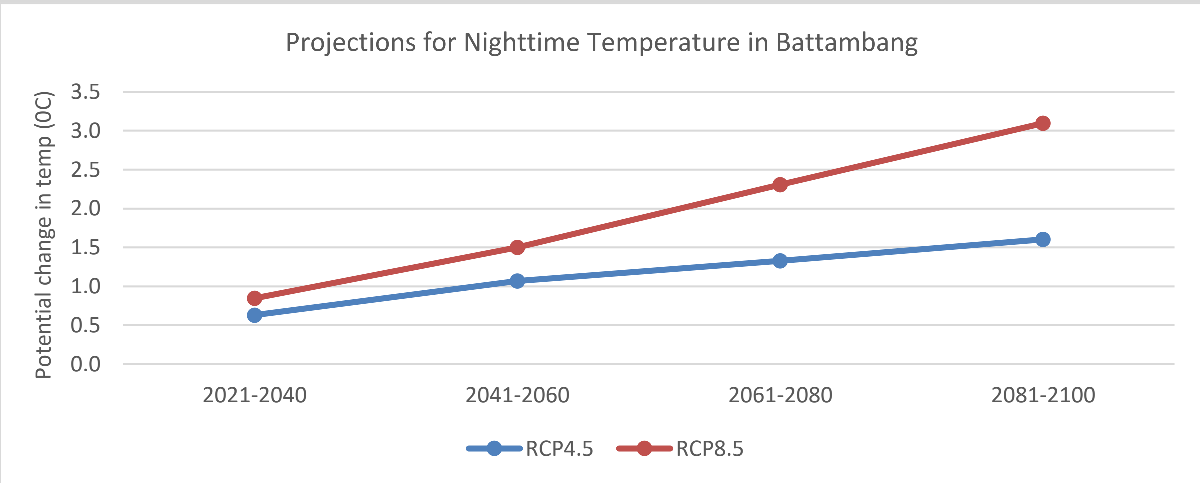


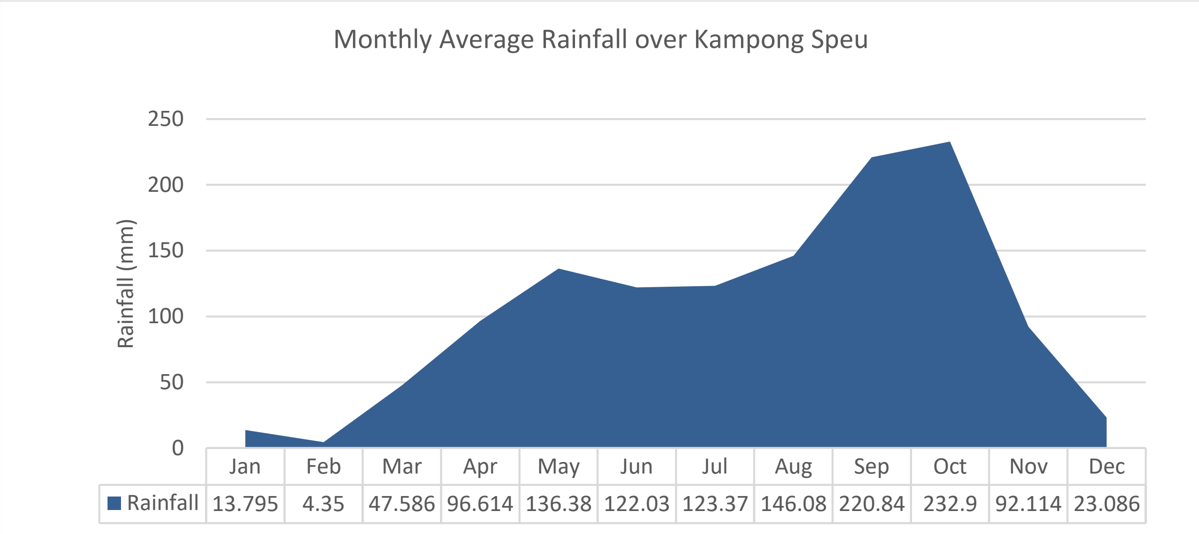
Figure B-6. Projected daytime (above) and nighttime (below) temperature

Under both scenarios, potential increase in temperature is observed for both daytime and nighttime temperature for the province of Battambang with increases under RCP8.5 scenario being more substantial.

Appendix C. Climate Profile and Projections for Kampong Speu Province

1. Rainfall Pattern

The rainy season in Kampong Speu occurs from May to October. The average annual rainfall of this province is recorded to be 1260 mm and the rainfall pattern appears to be dual peaked, with the first peak occurring in May and the second in October. The highest rainfall is recorded in the month of October. Figure 1 depicts the monthly average rainfall over Kampong Speu.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	13.795	4.35	47.586	96.614	136.38	122.03	123.37	146.08	220.84	232.9	92.114	23.086

Figure C-1. Monthly average rainfall over Kampong Speu, 1996-2017

Inter-annual variability in rainfall can be observed in the province of Kampong Speu, where out of 22 years (1996-2017), 16 years were observed to have normal rainfall (±20% of average), 2 years have above normal rainfall and 4 years with below normal rainfall. The highest rainfall was observed in 2001, with 1768 mm, while the lowest rainfall was 868 mm in 2015.

2. Wet and Dry Season Rainfall

Wet seasonal rainfall accounts for 78% of annual rainfall. High contributions from dry seasonal rainfall could be observed in 2002 and 2013, where dry seasonal rainfall accounted for 37% and 35% of the annual rainfall, respectively. Lowest contribution from the dry season is observed in 1997 which was 52 mm. Figure 2 indicates the variability of wet and dry seasonal rainfall in Kampong Speu.

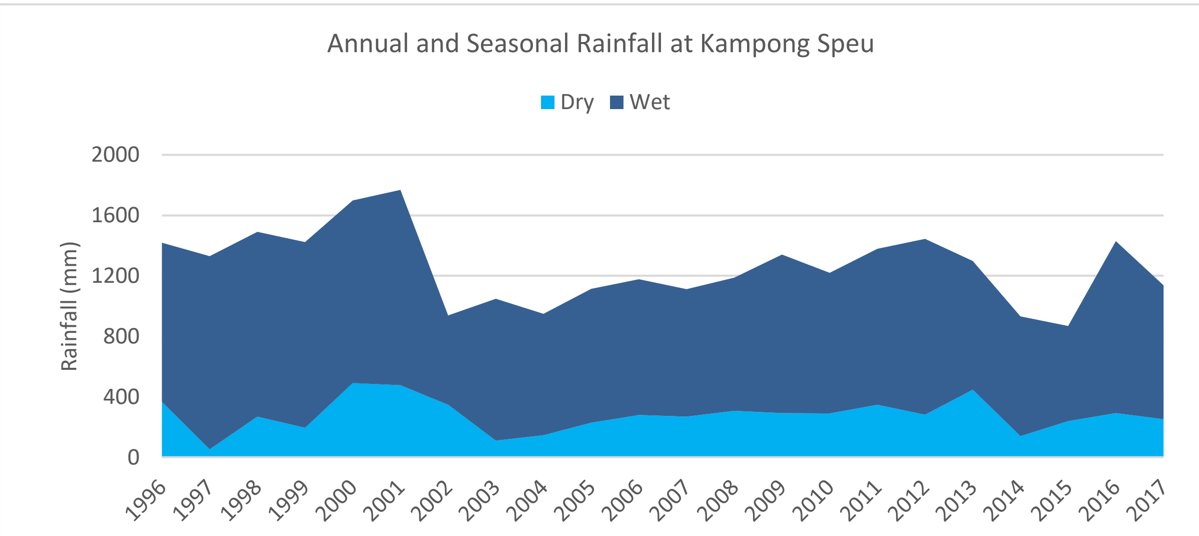


Figure C-2. Variability in wet and dry season contribution to annual rainfall

The average number of rainy days in a year is 82 days, out of which, 18 occur in the dry season. The highest number of rainy days occurred in 2010, with a total of 110 rainy days while the lowest was 56 days in 2007.

3. Rainfall Extremes

The highest recorded one-day rainfall in Kampong Speu are shown in the following table.

Table C-1. 24-hour Extreme rainfall events of ≥100mm in Kampong Speu

Rainfall Amount	Date Recorded
112 mm	23 August 2002
110 mm	27 September 2000
105 mm	15 March 2011
103 mm	25 March 2010
100 mm	17 October 2008

4. Rainfall Trends and Projections

The period 1996-2018 shows a decreasing trend in wet seasonal rainfall and number of rainy days during the wet season. This indicates a trend toward relatively dryer days during the wet season. Although an increasing trend is observed in the quantity of rainfall during the dry season, a decreasing trend is observed in the number of rainy days. This indicates heavy rainfall. Rainfall projections are inconclusive as shown in the following figure.[16]

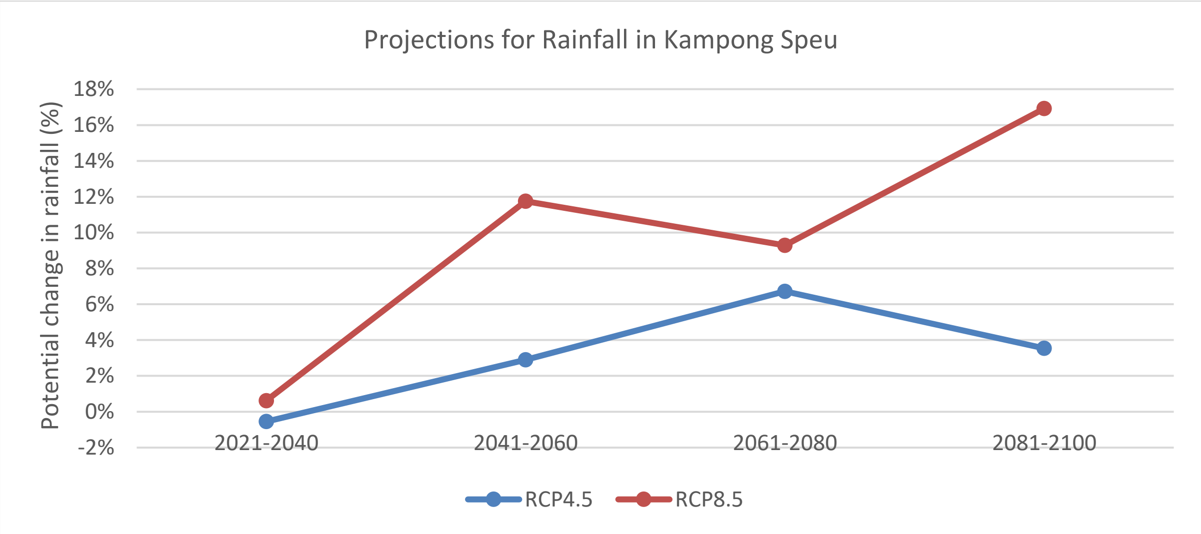


Figure C-3. Projected rainfall under RCP4.5 and RCP8.5

During the period 2021-2040, rainfall has decreased under RCP4.5. However, it is expected to increase by 2-6% in 2041-2080 until it decreases in 2081-2100. RCP8.5 shows a different pattern, where a constant increase is observed until 2060. Rainfall is considered to decrease by 2061-2080 and again increase in 2081-2100. Under this scenario, the rainfall had been higher than that of baseline throughout the future period.

[16] Projections of rainfall in Kampong Speu were obtained from downscaled NEX-NASA data for four 20-year time periods. These are presented under two scenarios of Representative Concentration Pathways (RCPs): RCP4.5 and RCP8.5. The values are obtained with reference to the model baseline for 1986-2005.

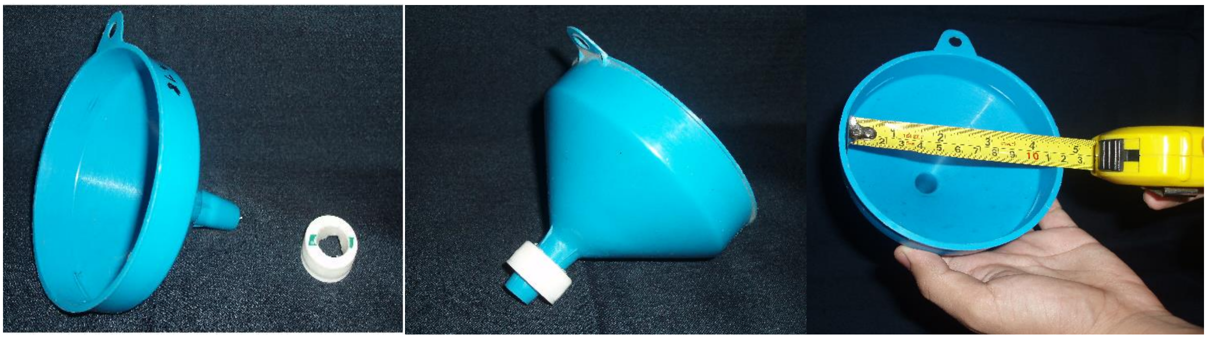
Appendix D. Fabricating a Rain Gauge

Exercise 1. Making the Rain Gauge

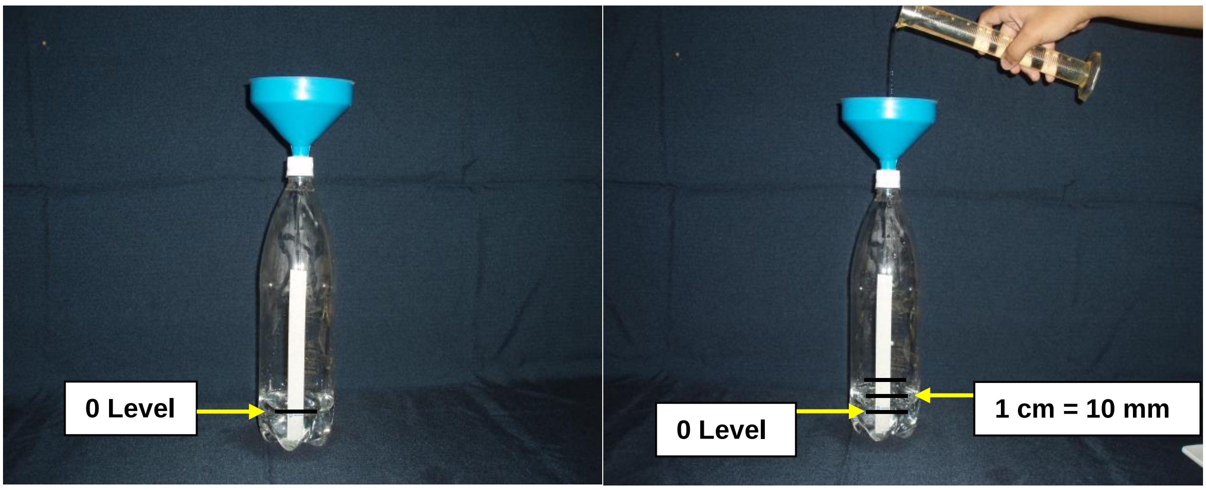
Materials:
1.5 – liter empty plastic bottle of soft drinks (preferably with uniform shape or diameter)
Plastic funnel (receiver of rainfall)
Adhesive
Drill/cutter
Permanent marker
Graduated cylinder

Procedures:

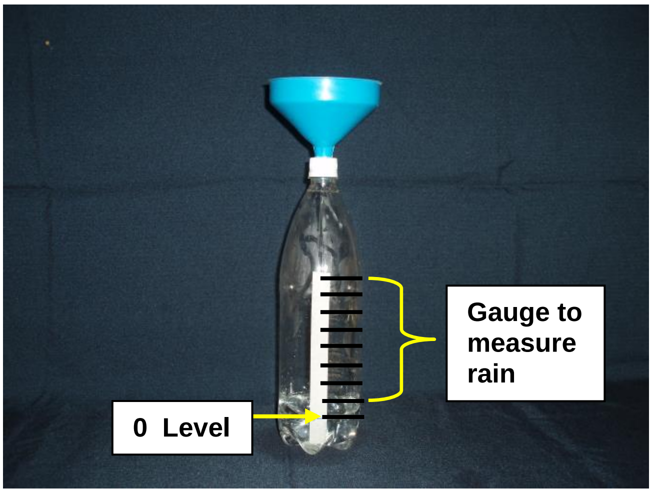
i. Make a hole at the cover of the empty bottle. Be sure that the tip of the funnel could fit in into this hole (see below figure).



ii. Secure the funnel into the plastic cover by a tape or any adhesive. Ensure that the funnel is levelled.
iii. Measure the inside diameter (d) of the funnel.
iv. Compute the volume (V) of the water/rainfall, assuming 1cm depth of rainfall using the formula: V = (3.1416/4) x d x d x 1 cm = ____ cu cm.
v. Make a calibration at the side of the empty bottle to facilitate reading, starting from 0 at the uniform shape of the bottle.
vi. Pour water inside the empty bottle up to the "0" level mark.
vii. Measure the computed volume of water using the graduated cylinder.
viii. Pour the measured volume of water in the graduated cylinder inside the bottle.
ix. Note and mark the level of water. This level of water corresponds to 1 cm of rainfall.



x. Measure the same volume of water and pour it again inside the container, and level and mark this as 2 cm and so on up to the maximum capacity of the bottle.
xi. Then, remove the water inside the container down to the “0” level.
xii. The simple rain gauge is ready for use. The site for installation must be free from any obstruction, and secure from wind and animals



Exercise 2. Calibrating the Rain Gauge

Materials:
Graphing paper
Pencil
Ruler
Calculator
Rainfall data obtained from standard rain gauge and simple rain gauge

Procedures:

i. Place the simple rain gauge beside the standard rain gauge. Make sure that the funnel of the simple rain gauge is at the same elevation with that of the standard rain gauge.
ii. Record and compare the rainfall depths using the same observation date.
iii. Prepare a curve of rainfall readings from the standard rain gauge and simple rain gauge. Draw the calibration line that could be applied for the simple rain gauge rainfall readings.
iv. A game on plotting calibration line and reading rainfall from the line may be introduced as below.

Plotting calibration line and reading rainfall from the calibration line

i. Plot the rainfall data below in a graphing paper with the readings from the simple rain gauge in the horizontal axis and the readings from the standard rain gauge in the vertical axis.
ii. Participants are then asked to draw the calibration line (i.e., a line that nearly touches all the data points) in the plotted points.
iii. The participants are divided into several groups.
iv. As an exercise, the facilitator will give 10 assumed readings from a simple rain gauge and will require the participants to provide the readings from standard rain gauge using the calibration line.
v. Each group will present their results and will be checked by members of the other group.

Table D-1. Sample data from standard rain gauge and simple rain gauge

Data No.	Readings from Simple Rain gauge (mm) *	Readings from Standard Rain gauge (mm)	Data No.	Readings from Simple Rain gauge (mm) *	Readings from Standard Rain gauge (mm)
1	5	8	9	39	43
2	8	9	10	40	44
3	10	11	11	42	45
4	13	10	12	48	51
5	19	20	13	50	52
6	23	21	14	53	56
7	25	23	15	60	58
8	36	38	16	65	70

Readings in cm will be multiplied by 10 to convert to mm.

Appendix E. Water Management for Rice in Drought-Prone Areas[17]

Various strategies exist for farmers to minimize risks and reduce losses in drought-prone and rainfed rice-producing areas. These focus mainly on the following: varietal selection, timing of planting to minimize drought damage, maintenance of water level, cultural practices aimed at conserving water or improving drought resistance and altering the physical farm environment.

1. Varietal selection

- Select drought-tolerant varieties if drought is likely to occur. In general, IRRI found droughttolerant rice varieties to have long, dense and thick roots. Traditional varieties like BE-3, Peta and Intan tolerate some drought but yields are lower than modern varieties. The IRRI varieties IR6, IR46 and IR64 also withstand mild drought although IR36 and IR64 are prone to tungro disease.
- Plant very short-duration varieties to avoid the drought period entirely.

2. Timing of planting

- Plant the rice such that the vulnerable reproductive stage does not fall during the drought season (see below figure and refer to Session 5.1). This presupposes a regularly occurring drought in a region which the farmers anticipate and plan around.
- Synchronize planting with neighboring farmers to minimize irrigation water wastage.

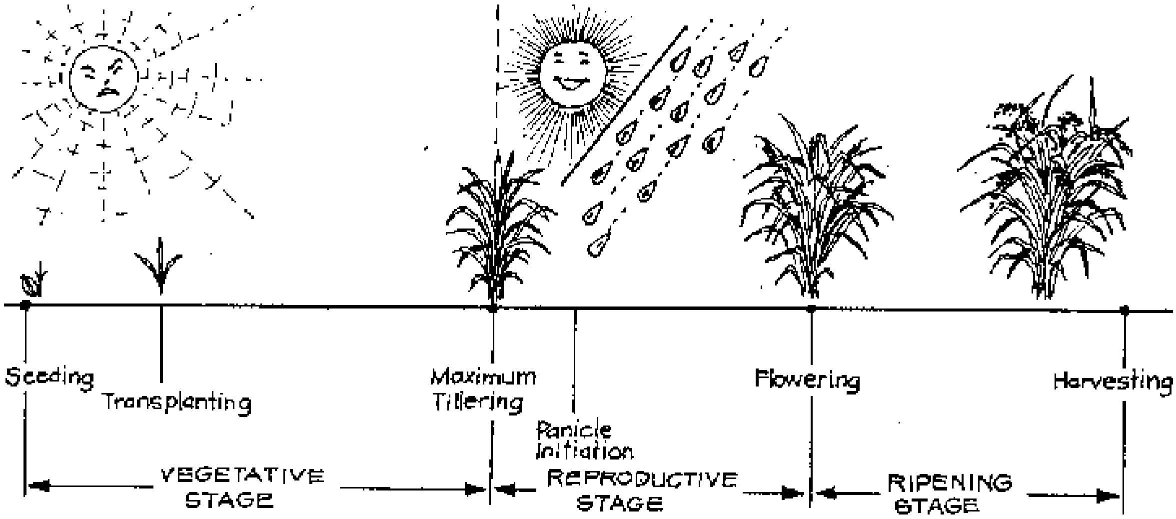


Figure E-1. Timing of planting

3. Maintenance of water level

- It is important to provide the crop enough water to induce maximum tillering (formation of stalks) for a good cover (canopy) so that water losses by evaporation would be minimized.
- Water is essential during flowering on from 55-70 days after transplanting of the short-duration varieties. If simultaneous planting is done, 800-1,000 mm of water would be minimum requirement.
- Fields need only be kept moist (not flooded) all the time with a 1-2 mm layer as minimum. Using this strategy gives a 30-50% cut requirements without yield losses.

4. Other cultural practices

- Maintain rice paddy dikes to minimize seepage and clean irrigation ditches regularly.

---

[17] Content in this Appendix is taken from Low-external Input Rice Production (LIRP): Technology Information Kit, IIRR, 292 p. http://www.nzdl.org/gsdlmod?e=d-00000-00---off-0fnl2%2E2--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-10&cl=CL1.3&d=HASHd3b46cd4916b56b3547bcc.4.5&gt=1

- Establish good weed control. Most weeds are much more efficient than rice in exploiting soil moisture.
- Supply nitrogen (N) and other fertilizers early. If using less than 30 kg N/ha, apply all of it basally. If applying more than 30 kg N/ha, use the best split (2/3 basal and 1/3 topdress 5-7. days after panicle initiation [DAP]). This improves the plant's drought resistance by encouraging faster root growth and, thus, more soil area can be exploited for soil moisture.
- Increase soil organic maker (OM) content. OM improves the soil's water absorption and retention capacity.
- Minimum tillage (one plowing and one harrowing) reduces the water requirement for land preparation and speeds crop establishment, lowering the risks of an end-of-season drought. Minimum tillage is possible in fields where perennial weeds are few.
- Direct seedling of pregerminated seed can be used where there is not enough water to thoroughly prepare the land for transplanting. Direct seeding also results in a stronger root system. This gives the crop batter capacity to survive during short drought.
- Farmers should use the early rains of May for land preparation since this water largely goes to waste.

5. Altering the physical farm environment

- If feasible, impound water in one-fifth of the land area. A 200 sq.m structure will be enough to supply the water for a half hectare of rice crop and could also be used for fish production.
- Reduce the area planted to rice to increase the amount of irrigation or residual rainfall water available. The Sorjan system developed by farmers in Indonesia is one such method of water management. Tests done in Indonesia show that this system nearly doubled the amount of available water for rice production. Devote low-lying areas of the farm to rice and plant the upper areas with dryland crops. The rice crop can take advantage of the higher water table in the lower areas and can utilize runoff from the upper areas. (See the technology sheet on Sorjan: Towards Rice-based Integrated Cropping System.)
- Plant windbreaks to reduce evapotranspiration of the rice crop.
- At the national level, deforestation is the main cause of irrigated water shortages for rice production. For long-term sustainability, the nation's mountainous area must be reforested.

Appendix F. Sample Plan and Design for Farmers-Managed Small Reservoir Project

Extreme climate aberrations are probably the most disastrous to the farming community. These impinge the hydrological system in most river basins and may result in either "too much" or "too little" water. When water becomes too much due to high intensity rainfall and other extreme weather conditions, the potential effects include flooding from overflowing rivers, excessive runoff from sloping lands and damaged water infrastructures like dams, irrigation and drainage systems. On the other hand, higher temperatures and decreased precipitation could lead to limited water supply, deterioration in the quality of freshwater bodies and potential strain on the fragile balance between supply and demand.

With insufficient infrastructure facilities for managing the overabundance and/or lack of water, farmers and their activities are often vulnerable to the impacts of extreme climate events. To minimize the impacts, it is important to increase farmers' resilience and coping capacity. They should be trained to undertake collective efforts to address the problem using appropriate low-cost technologies. These include small-scale infrastructures like small farm reservoirs and small diversion weirs which could be constructed, operated and maintained by farmers themselves (see below figure).

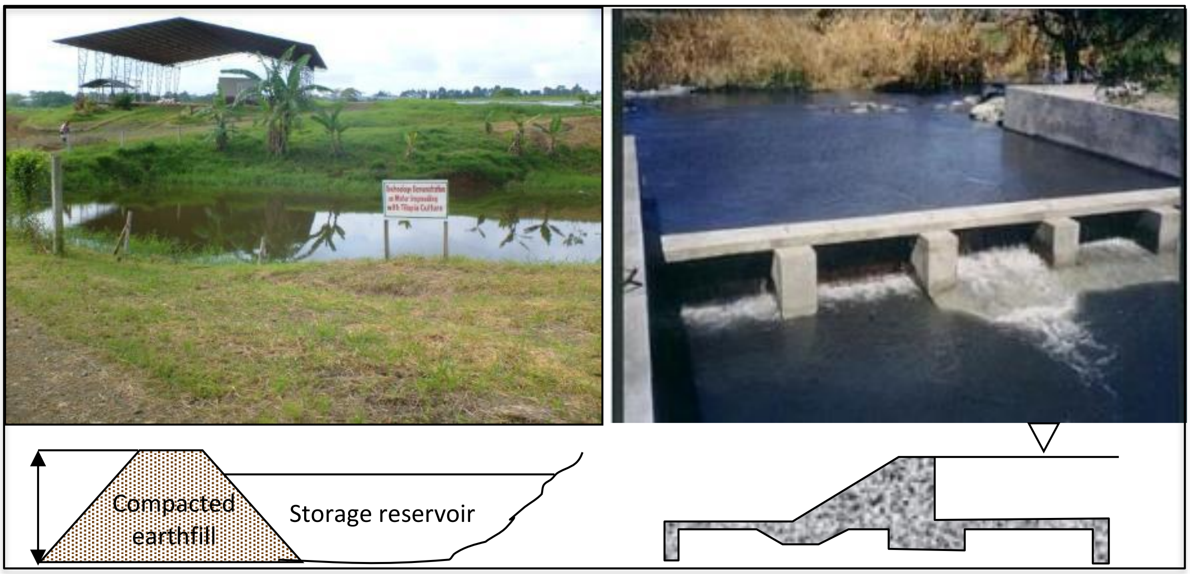
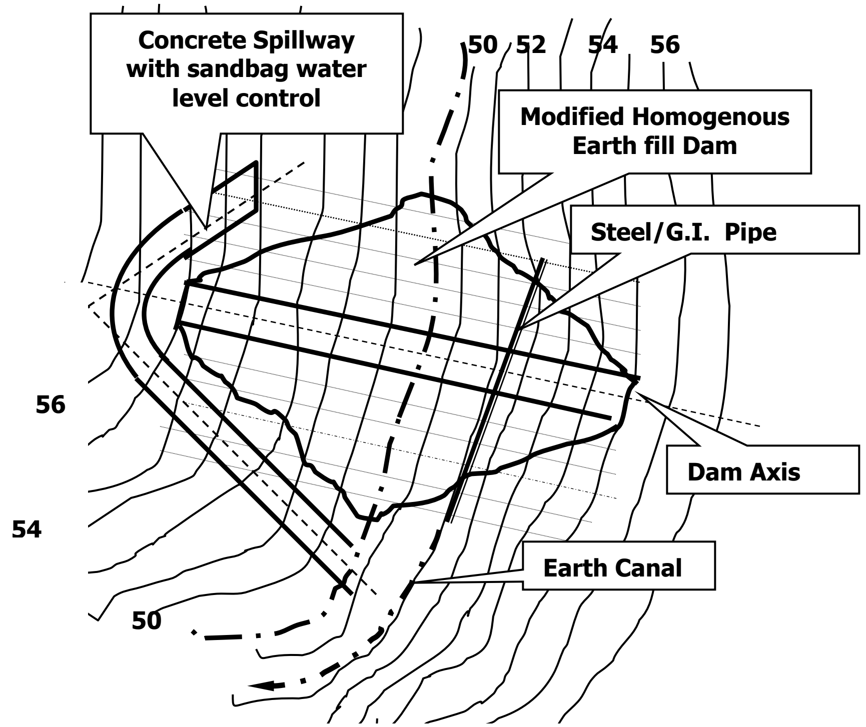


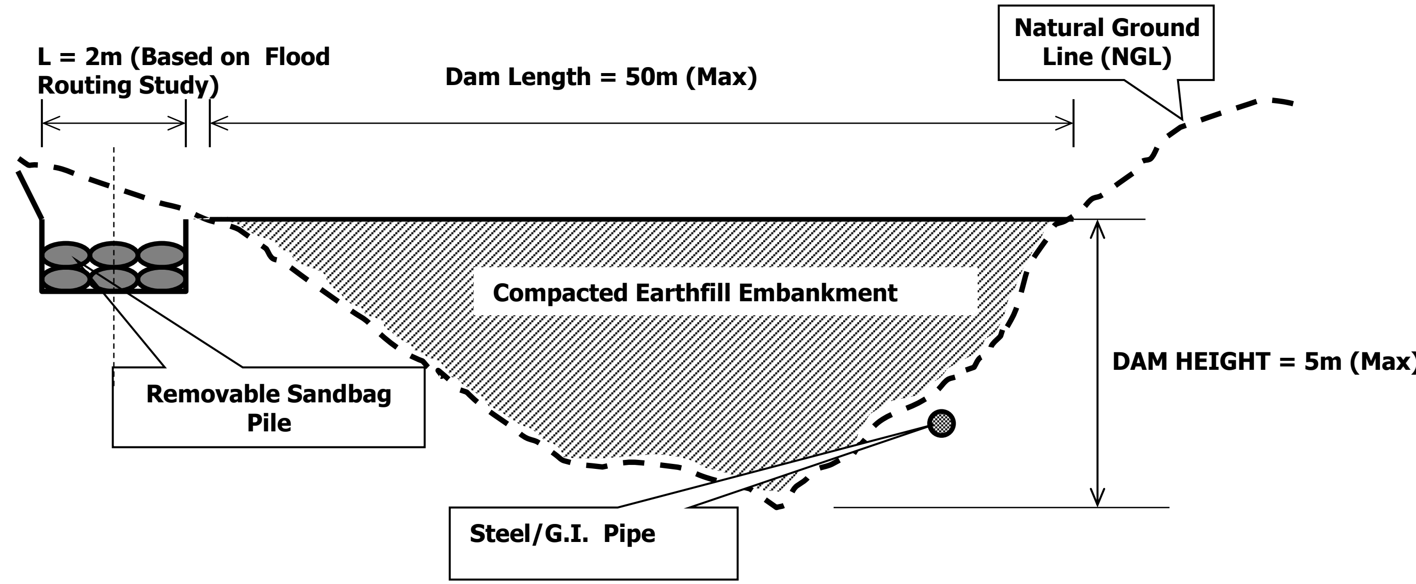
Figure F-1. Small farm reservoir (left) and diversion dam (right)

There is a need to familiarize farmers to these various technologies using simple design. For instance, they could be equipped with some knowledge on how to define the optimum size of drainage to help drain excess rainwater during the rainy season and minimize floods. They may also need to be equipped with some knowledge on how to decide the size of the water container/water pool/pond based on the expected amount of rainfall as well as how to measure the size of land, which can be irrigated based on the available water.

The following pages show a typical design of a small reservoir. The embankment consists of a modified homogenous earth fill structure which can be constructed using a bulldozer or manually by farmers. The spillway which discharges excess water can be either a grass waterway with nearly level gradient or concrete lined chute structure. The outlet works consist of an underground conduit which conveys water from the reservoir to the distribution canal going to the service area. The project cost is lower in smaller structure (i.e. lower dam; watershed < 5 ha; reservoir area of about 2,000 sqm) with simpler design to irrigate a single farm. The spillway could also be easily constructed by the farmers themselves. In all cases, the service of a licensed engineer is required to construct and design the structure.

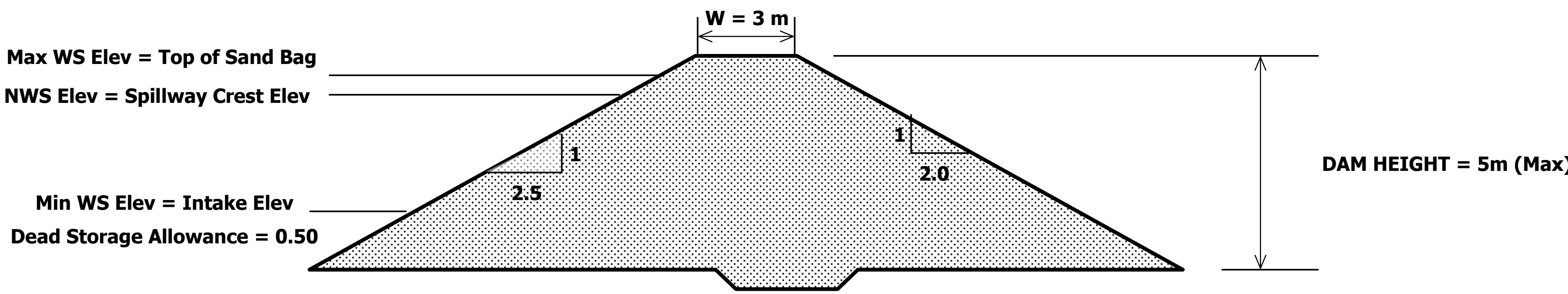
Sample Plan and Design of Farmers-Managed Small Reservoir Project





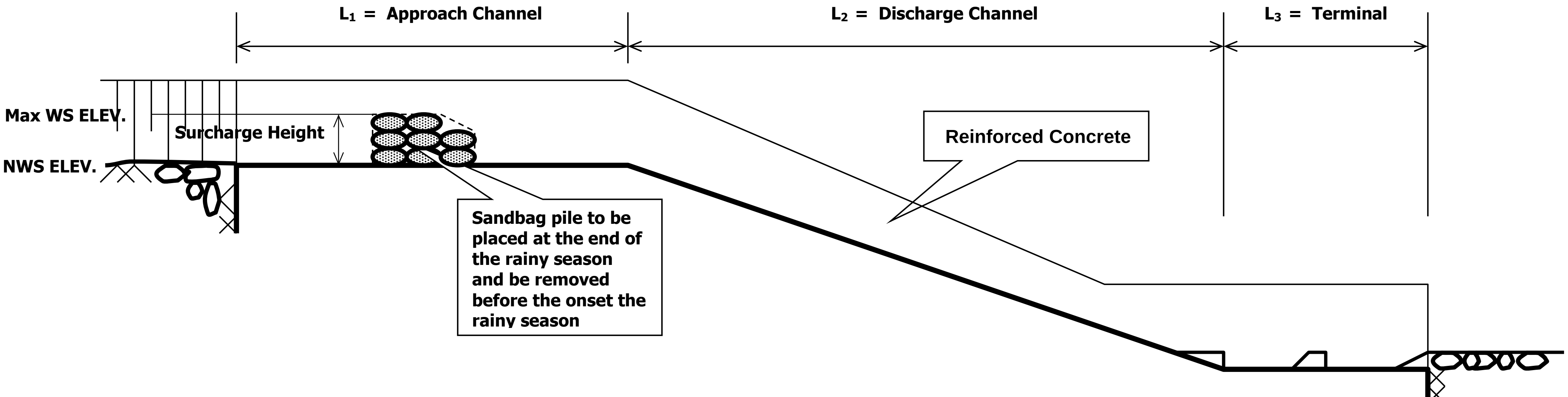
PROFILE ALONG DAM AXIS

NOT DRAWN TO SCALE



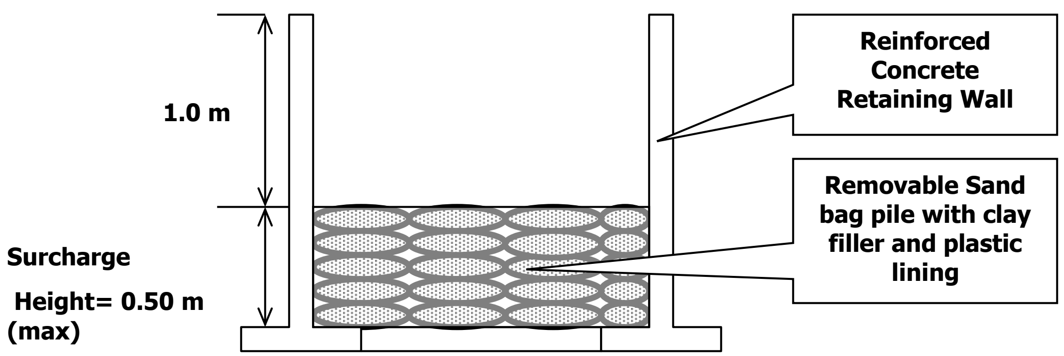
MAXIMUM DAM SECTION

NOT DRAWN TO SCALE



SECTION ALONG CENTERLINE OF SPILLWAY

NOT DRAWN TO SCALE



SPILLWAY CROSS SECTION @ APPROACH

NOT DRAWN TO SCALE

Warning! **Sandbags will only be placed right the end of the rainy season to store residual inflow as additional water for the second cropping; those will be removed before the start of the rainy season so that excess water could be discharged freely from the spillway.**

While a national program is of great importance, a local program that could contribute in addressing a climate-related problem, with farmers as the key players, could be undertaken. A group of farmers could work together in their respective area and build a small rainwater harvesting structure of their own to capture rainfall during its abundance (i.e. when water is too much) so that the conserved water can be utilized during the dry season (i.e. when water is too little). In this case, farmers need to be equipped with some knowledge on site selection and validation, simple design, and method of construction. This could be facilitated with the technical guidance and assistance of a licensed engineer. The site selection criteria for the establishment of a farmers-managed small reservoir project that is within the farmers' capacity to construct and manage are as follows:

i. Presence of a narrow depression or canyon for the construction of embankment with a length of not more than 50 meters and a height of not more than 10 meters on both side with respect to the lowest creek bed at the centerline of the proposed embankment (dam axis);
ii. Watershed area (i.e. the area that contributes to flow of a water body (e.g. creek, or stream) of about than 3 – 5 ha. The site is located in areas that could store water for a long period of time (limestone area should be avoided);
iii. Reservoir area of > 2,000 m^2
iv. Service area for rice and vegetables production of > 1.0 hectare
v. Presence of suitable materials embankment construction (i.e. light clay materials) and concrete aggregates;
vi. Suitable site for grass spillway;
vii. Sites with high infiltration rate should be avoided (e.g. limestone area) to avoid costly lining of the reservoir;
viii. No right of way and land acquisition problem;
ix. Group of farmers who are willing to construct the project manually (i,e, in the absence of bulldozers and other equipment)

It is very important to define the boundary of a watershed or drainage area. During high intensity rainfall, excessive runoff may occur that may result to flooding downstream. This could be controlled through upland watershed management (e.g. reforestation and forest protection) and putting some provisions to capture excess water such as rainwater harvesting (e.g. construction of small reservoirs). The construction of drainage canals in lowland areas could also facilitate the timely evacuation of flood water. Controlling drought also involves the construction of pond or reservoir and other rain harvesting technologies (e.g. collecting rainfall from the roofs into a concrete tank or similar storage facility).

Appendix G. Training Evaluation Form

I. Facilitator. Please mark with an (x) the column that best represents your judgment on the facilitator's ability with 1 = bad, 2 = fair, 3 = good and 4 = very good. Kindly provide your comments in the remarks column.

Category	1	2	3	4	Remarks
Mastery of training materials					
Mastery of methods					
Effectiveness of training materials					
Completeness of supporting materials and teaching aids					
Clarity of instruction					
Discipline					
Sensitivity to participants' needs					
Style and enthusiasm					
Ability to create relaxing but serious atmosphere					

II. Content. Please mark with an (x) the column that best represents your judgment on the module and session content with 1 = useless/should be excluded, 2 = not very useful/needs improvement, 3 = useful and 4 = very useful. Kindly provide your comments in the remarks column.

Module/Session	1	2	3	4	Remarks
M1S1. Learning Contract					
M1S2. Profiling and Assessment					
M2S1. Weather and Climate					
Climate Profile of the Pilot Provinces					

Module/Session	1	2	3	4	Remarks
M3S1. Forecast Products and Services of DOM					
M3S2. Forecast Terminologies and Probabilities					
M3S3. Introduction to SESAME					
M4S1. Process of Rain Formation					
M4S2. Field Visit to Weather Station					
M5S1. Weather and Cropping Plan					
M6S1. Soil Water Balance					
M7S1. Weather and Fertilizer Inputs					
M8S1. Weather, Pests and Diseases					
M9S1. Climate Information Application for Risk and Resource Management					
M10S1. Economic Value of Weather/Climate Information					
Farm Visit					

III. Participant Knowledge and Understanding. Please mark with an (x) the column that best represents your knowledge and understanding of the module and session content with 1 = very low and 10 = very high improvement in knowledge and understanding. Kindly provide your comments in the remarks column.

Module/Session	1	2	3	4	5	6	7	8	9	10	Remarks
M1S1. Learning Contract											
M1S2. Profiling and Assessment											
M2S1. Weather and Climate											

Module/Session	1	2	3	4	5	6	7	8	9	10	Remarks
Climate Profile of the Pilot Provinces											
M3S1. Forecast Products and Services of DOM											
M3S2. Forecast Terminologies and Probabilities											
M3S3. Introduction to SESAME											
M4S1. Process of Rain Formation											
M4S2. Field Visit to Weather Station											
M5S1. Weather and Cropping Plan											
M6S1. Soil Water Balance											
M7S1. Weather and Fertilizer Inputs											
M8S1. Weather, Pests and Diseases											
M9S1. Climate Information Application for Risk and Resource Management											
M10S1. Economic Value of Weather/Climate Information											
Farm Visit											

IV. Recommendations. Please provide your recommendations for improving the FARM School Program in terms of content, process and delivery.

Module/Session	Content	Process/Delivery
M1S1. Learning Contract		
M1S2. Profiling and Assessment		
M2S1. Weather and Climate		

Module/Session	Content	Process/Delivery
Climate Profile of the Pilot Provinces		
M3S1. Forecast Products and Services of DOM		
M3S2. Forecast Terminologies and Probabilities		
M3S3. Introduction to SESAME		
M4S1. Process of Rain Formation		
M4S2. Field Visit to Weather Station		
M5S1. Weather and Cropping Plan		
M6S1. Soil Water Balance		
M7S1. Weather and Fertilizer Inputs		
M8S1. Weather, Pests and Diseases		
M9S1. Climate Information Application for Risk and Resource Management		
M10S1. Economic Value of Weather/Climate Information		
Farm Visit		

Please write below any topic that you wish to be included in the FARM School program.

____

____

Please share your overall impression of the FARM School Program.

____

____