Food and Agriculture
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TRAINING MANUAL

AGROMETEOROLOGY FOR AGRICULTURE EXTENSION OFFICERS

IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

TRAINING MANUAL
AGROMETEOROLOGY FOR AGRICULTURAL EXTENSION OFFICERS IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Strengthening agro-climatic monitoring and information (SAMIS) systems to improve adaptation to climate change and food security in Lao People's Democratic Republic (GCP/LAO/021/LDF)

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Abstract

Agricultural meteorology deals with the meteorological, hydrological, pedological and biological factors that affect agricultural production as well as the interaction between agriculture and the environment. This training manual is developed for the Training of Trainers (TOT) to effectively implement agro-meteorology at the local level through multiple methodologies tested in Lao PDR, such as climate field schools and group approaches, public announcement systems (loudspeakers), and school programmes. The manual is developed for the use of the Laos Climate Service for Agriculture (LaCSA) online system developed under the Global Environment Facility (GEF)-funded project Strengthening Agro-climatic Monitoring and Information Systems (SAMIS) to improve adaptation to climate change and food security in Lao PDR. It is aimed for TOT, and the design is flexible so that any modules or lessons can be extracted and applied in field-level staff training with some local adjustments. The training can also help fill gaps between the producers of agrometeorological services and the farmers' actual needs to improve their livelihood.

Abbreviations and acronyms

AEIA	Agrometeorological extension intermediary close to farmers
AEIB	Agrometeorological extension intermediary at centre
AESA	Agro-ecosystem analysis
AEZ	Agro-ecological zoning
AWS	Automatic Weather Station
CAgM	Commission for Agricultural Meteorology
CAmD	Climate and Agrometeorology Division of the DMH
CBO	Community-based organizations
CDI	Combined Drought Index
CFS	Climate Field School
CIAT	International Centre for Tropical Agriculture
CRFM	Climate-responsive farming management
CSR	Climate-smart recommendations
DAFO	District Agriculture and Forestry Office
DALaM	Department of Agricultural Land Management
DAS	Days after sowing
DAT	Days after transplanting
DMH	Department of Meteorology and Hydrology
DoES	District Office of Education and Sport
DONRE	District Office of Natural Resources and Environment
ENSO	El Niño/Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmers Field School
GDD	Growing Degree Days
GEF	Global Environment Facility
GFCS	Global Framework for Climate Services
hPa	Hectopascal Pressure Unit (1 hPa=100 pascals)
HTU	Helio-thermal unit
HTUE	Helio-thermal unit use efficiency
HUE	Heat use efficiency
IK	Indigenous knowledge
IPM	Integrated pest management
LaCSA	Lao Climate Service for Agriculture
Lao PDR	Lao People’s Democratic Republic
LNR	Laos National Radio
LRMIS	Land Resources Information Management System
MAF	Ministry of Agriculture and Forestry
MJO	Madden-Julian Oscillation
MoES	Ministry of Education and Sport
MONRE	Ministry of Natural Resources and Environment
MS Excel	Microsoft Excel
NAEZ	National Agro-Ecological Zoning
NAFRI	National Agriculture and Forestry Research Institute

NGO/s	Non-government organization/s
PAFO	Provincial Agriculture and Forestry Office
PET	Potential evapotranspiration from crop
PoES	Provincial Office of Education and Sport
PONRE	Provincial Office of Natural Resources and Environment
PoP	Probability of precipitation
PPC	Plant Protection Centre
PRT	Platinum resistance thermometer
PTI	Pheno-thermal index
RH	Relative humidity
ROI	Return on investment
RUE	Radiation use efficiency
SAMIS	Strengthening agro-climatic monitoring and information systems
SMS	Short message services
TOT	Training of Trainers
TV	Television
UHF	Ultra high frequency
URL	Universal resource locator
VFI	Village Focus International
WMO	World Meteorological Organization
WR	Water requirement for crop

INTRODUCTION

Agricultural production needs appropriate management practices and favourable environmental conditions. This management involves decisions taken by the farmers about crops and animals, their varieties and breeds, technology and institutional matters affected by available farm resources, the farmers' motivation and their knowledge, skills, and information. Knowledge of environmental conditions is the primary information farmers need to identify and adopt appropriate management practices. The environmental conditions include biophysical factors like weather, climate, water, soil, pests and land available (FAO, 2019). Farmers have acquired indigenous knowledge (IK) on management practices and biophysical factors through their parents and neighbours. Such IK, however, may not be as effective in the changed climatic conditions. Weather-sensitive decision-making can be facilitated by the use of such IK and scientific analysis of long-term climate data and weather forecasts using agrometeorology.

Agrometeorology (or agricultural meteorology) refers to the interaction between meteorological and hydrological factors in agriculture, including field crops, horticulture, animal husbandry and fisheries. Agrometeorology deals with the meteorological, hydrological, pedological (soil science) and biological factors that affect agricultural production, as well as the interaction between agriculture and the environment (a glossary of terms is available at Appendix I).

The main objectives of agrometeorology are to (i) study the agroclimatic resources, (ii) assess their impacts (positive and negative) on agriculture, and (iii) use the knowledge to improve crop yields. The influence of weather and climate on agricultural production and various climatic factors has been used to determine agro-climatological or agro-ecological zones (AEZ), according to the potential distribution of a range of crops (FAO, 2019). Agrometeorology aims to describe these effects by applying this supportive knowledge and information through agrometeorological services (WMO, 2012).

The primary agrometeorological services that farmers need are weather forecasting, seasonal climate forecasting, climate change projections, statistical assessments of the future frequency of extreme weather and climate events, and agrometeorological crop monitoring and advisories (FAO, 2019).

In the specific conditions of agrometeorology in Lao PDR, the scope of the services is two-fold. First, agrometeorology enables farmers to get easy access to previously unavailable weather and climate data and to increase awareness about the use of digital agriculture in the field. Second, the agrometeorological national database can harmonise data and information at the national level, and help to improve coordination and collaboration between different government entities and sub-sectors to establish common datasets.

The reliable development and proper use of the weather and seasonal forecasts and the agrometeorological advisories can effectively decrease climate risks in agriculture, providing end-to-end information transfer from basic support systems to the livelihood of farmers (WMO, 2009). Farmers can learn to use agrometeorology to improve their crop yields and income by better informed decision-making on irrigation, storage, agroforestry, floods, drought, erosion and desertification, frost, wind, simple artificial growth conditions like green houses, and sustainable farming (WMO, 2006). However, farmers need supports from trained extension workers to access, interpret and use the agrometeorological services for their benefit.

Education and training about agrometeorological extension can be provided for two kinds of agrometeorological extension intermediaries (Stigter, 2003). The first kind of agrometeorological extension intermediary (AEIA), such as agricultural extension officers, works closely with farmers and operates or supports Climate Field School (CFS), farmers' groups or similar extension and agricultural teaching models. Extension officers can best serve farmers and communities by learning to discern and articulate the needs of farming communities and recommend appropriate agrometeorological components. Extension officers need effective communication skills to be able to share agrometeorological information with farmers and gather feedback to inform those developing agrometeorological services.

The second kind of agrometeorological extension intermediaries (AEIB) are the centres like Department of Meteorology and Hydrology (DMH) and related institutions responsible for generating agrometeorological information and tailoring them to fit the needs of decision-makers in agricultural production. The AEIB intermediaries also include those working on the research and development interface and those involved in developing agrometeorological services. They develop client-friendly products such as weather and climate forecasts, monitoring and early warning products for crises such as drought and floods, and advisories for agrometeorological services to help increase the population's preparedness. Such AEIBs generally require training in farmers' needs as well as in effective implementation of agricultural meteorology (Stigter, 2007).

Although this agrometeorology training syllabus is designed for the users of agrometeorological services, particularly in-service training of AEIAs (A-Domain agrometeorological extension intermediaries) (as defined by WMO, 2009), it may also be useful for AEIB intermediaries, the producers of agrometeorological services, to understand the real agrometeorological service needs of farmers.

Training can also bridge existing information gaps between AEIA intermediaries and AEIB intermediaries, enhancing their confidence in exchanging research findings and field-level information and encouraging more and better coordination. It can also strengthen Research and Development (R&D) interface by increasing usability of research findings in the field and credibility of action research results from the field level, which can be tested further for scientific validity.

This training manual was developed in consultation and interaction with Department of Agricultural Land Management (DALaM) staff to meet the requirements of its central staff and extension workers at subnational and local levels in Lao PDR. Needs were also identified from a literature review (FAO & MAF 2020).

Purpose of the Manual

This training manual is developed for the Training of Trainers (TOT) to effectively implement agrometeorology at the local level through multiple methodologies tested in Lao PDR, such as climate field schools and group approaches, public announcement systems (loudspeakers), and school programmes. The manual is developed under the Global Environment Facility (GEF)-funded project *Strengthening Agro-climatic Monitoring and Information Systems (SAMIS)* to improve adaptation to climate change and food security in Lao PDR (Manivong & Petri, 2019). Further information can be accessed from http://www.fao.org/in-action/samis/en/.

This training manual is prepared under component 3 of the SAMIS project (Manivong et al. 2019). It is aimed for TOT, and the design is flexible so that any modules or lessons can be extracted and applied in field-level staff training with some local adjustments. The training can also help fill gaps between the producers of agrometeorological services and the farmers' actual needs to improve their livelihood.

Structure of the Manual

This training manual is organized into three modules:

- module A: agrometeorology and weather forecasts;
- module B: climate farmers' field schools;
- module C: dissemination of agrometeorological services.

Each module includes a number of lessons. Each lesson includes learning objectives, materials required, introduction, training content, and activities to be performed by the trainees during the session.

The training includes practical exercises where trainees are divided into groups in order to discuss the topic and solve the given problem before reporting back to the plenary. These exercises are essential as they aim to draw on trainees' own knowledge and experience. The trainees are likely to have a wealth of knowledge and experience about their local agrometeorological practices. Facilitators should draw on this knowledge as much as possible by asking the trainees to share their experiences and to explain or develop solutions to agrometeorological problems in the field.

MODULES OF AGROMETEOROLOGICAL TRAINING

Module A: AGROMETEOROLOGY AND WEATHER FORECASTS

Module A comprises the following lessons:

1. Introduction to agrometeorology
2. Major weather parameters in agriculture and field-level instruments for measurements
3. Station-level agrometeorological instruments and their handling
4. Farmers' needs for agrometeorological services
5. Importance of agrometeorology for rice growing
6. Lao Climate Service for Agriculture
7. Seasonal forecast
8. Weekly weather bulletin
9. Weather-based forecasting of insect pests and diseases in major crops
10. Indigenous knowledge and climate information
11. Measurement of growing degree days and heat use efficiency

Lesson A1: Introduction to agro-meteorology

Learning objectives

The trainees will be able to:

a. explain basic concepts of agrometeorology; and
b. identify agrometeorological parameters.

Materials required

- Flip Chart Paper
- Markers
- Projector

What is agro-meteorology?

Climate is the combination of the long-term prevailing weather factors and can be represented by a long-term average (30 years) of specific elements, together with their variation, or the frequency of extreme weather conditions. The climatic conditions of a locality shape agricultural production practices in the area. The climate provides a unique weather pattern, cyclical but stable over the years. Local farmers have adapted to this weather pattern and their accumulated experiences on farming are considered indigenous knowledge (IK). However, due to the changing climate, the IK may no longer fit well with the present and future weather conditions.

Weather is the short-term state or condition of the atmosphere at a specific place and time (as represented by weather elements such as air temperature, pressure, humidity, precipitation, wind, solar radiation) (WMO, 1992). The weather conditions influence agricultural production, affecting crop and animal growth and yield. Knowing the likely weather conditions in advance allows farmers to make better decisions to maximize their harvest, or minimize their losses.

Agro-meteorology is the study of weather and climate in relation to agricultural practices. When properly applied, agrometeorology can achieve the sustainability of agricultural production system through efficient management of agro-climatic resources and crop microclimate modification. Each and every plant developmental phase is decided by meteorological parameters. Every genotype has its own optimum climatic requirements for expression of its full potential. Therefore, the knowledge of meteorological parameters and their influence on crop growth and yield is essential for agricultural stakeholders.

[1] Hydrology: is the science dealing with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere.
[2] Pedology: is formation, characteristics, and distribution of soils.
[3] Biology: is the study of living organisms (plants, animals and microorganisms), their morphology, physiology, anatomy, behaviour, origin, and distribution.
[4] Relative humidity (RH) is the ratio of the vapour pressure (e) of the moist air to its saturation vapor pressure (es) at its temperature, which is expressed in %. RH = (e/es)Ã—100%
[5] Precipitation includes any form of water converting from vapour to liquid or solid form. The liquid forms of precipitation are rainfall, dew and fog, whereas the solid forms are snow and hailstone.

Agro-meteorology includes the interaction between meteorological and hydrological[1] factors and the effect on agriculture, including field crops, horticulture, animal husbandry and fisheries. It deals with the meteorological, hydrological, pedological and biological[3] factors that affect agricultural production, as well as the interaction between agriculture and the environment (WMO, 2012). Agrometeorology seeks to explain these effects by applying this knowledge and information through agrometeorological services.

Objectives of agrometeorology

Agrometeorology's overall objective is to help farmers avoid the adverse effects associated with climate variability and assist them in making optimal use of available resources, including climate resources such as solar radiation, heat and water.

More detailed objectives are to:

- study the agroclimatic resources;
- assess their impacts (positive and negative) on agriculture; and
- use this knowledge to improve crop yields.

Agrometeorology is concerned with all the weather-sensitive elements of agriculture production, including pollination, animal migration, insect pests and pathogens. Use of agrometeorological tools can provide a current and future assessment of the impact of climate variability on crops (i.e. date of planting, length of the growing season, yield, weather-based index, etc.) at regional, national and local levels (FAO, 2019).

Importance of agrometeorology

Agrometeorological services include:

- specific weather forecasts, seasonal forecasts and agro-advisory services produced by the Laos Climate Services in Agriculture (LaCSA) system for better risk management in agriculture;
- microclimate management or manipulation based on information provided by the LaCSA;
- measures provided by the LaCSA to reduce the impacts and mitigate the consequences of weather- and climate-related natural disasters for agricultural production;
- monitoring and early warning; and
- development and validation of adaptation strategies to address the increasing climate variability and climate change (WMO, 2009).
- Agroclimatology is slightly different from agrometeorology as defined in Box 1

Box 1: What is agroclimatology?

Agroclimatology is the study of the behaviour of the atmosphere and changes in temperature, pressure, and other atmospheric factors affecting crops, including length of the growing season, and relation of growth rate to crop yield to various climatic factors.

Source: WMO, 1967.

Agrometeorological parameters

The programme at agricultural meteorological stations should include observations of some or all of the following variables characterizing the physical environment:

- solar radiation,
- sunshine and cloudiness,
- air temperature,
- soil temperature,
- air pressure,
- wind speed and direction,
- relative humidity[4],
- soil moisture,
- evapotranspiration, and
- precipitation[5].

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: List the weather parameters announced through local media such as radio and newspapers.

Activity 2: Identify the importance of each weather parameter to the farmers in your locality.

Lesson A2: Major weather parameters affecting agriculture and farm-level measuring instruments

Learning objectives

The trainees will be able to:

a. handle simple manual agrometeorological instruments in the field and take their readings; and
b. explain the meaning of observations.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Field-level agrometeorological instruments (like manual rain gauge, thermometers, hygrometer)

Rainfall

Rainfall is measured in terms of depth of water pool on the ground if all the water falling in that place is collected without any loss. Rainfall that occurs when crops really need water is called agriculturally relevant rainfall.

A pluviometer or rain gauge is used to collect and measure the rainfall every day (Figure 1). A manual pluviometer is a simple device that is used to collect rainwater over 24 hours.

Installation of manual pluviometer

1. Install the pluviometer in an open area away from obstructions if possible. Ideally, it should be at a distance equal to four times the height of the closest obstacle. For example, if the height of the maize plant is 1.5 m, the pluviometer should be placed 6 m away from the maize plant.
2. The height of the pluviometer from the ground should be 1 m.
3. Make sure the pluviometer is in a level position, without any tilt. Place a carpenter's level across the opening of the collection funnel of the pluviometer and adjust for balance. The bubble of the carpenter's level should be at the centre.

Measuring rainfall

1. The rainfall is measured at 9 am daily.
2. Transfer the water collected in the pluviometer to the graduated measuring cylinder. The measuring cylinder is graduated on the the face of the rain gauge. The measuring cylinder of one size of the pluviometer should not be used for another size of pluviometer.
3. Read the level of water in the cylinder in millimetres and one-tenth of a millimetre.
4. If a glass pluviometer is used, the measurement can be observed directly.
5. Record the observation in a register with the date.
6. Empty the pluviometer after the observation to record rainfall for the next day.
7. Observe the rainfall in the field to compare to the recorded measurement with observations.
8. Relate the measurement with your local indigenous measurement of the rainfall.
9. Summarize the total rainfall every ten days as dekade (10 days) rainfall.

The daily observation of the rainfall is aggregated to find monthly and annual rainfall. The average annual rainfall in Laos is generally between 1,200 and 2,200 mm per year in the plains and can exceed 3,000 mm on mountain slopes. One millimetre of rainfall in one square meter of area is equivalent to one litre of water.

Maintenance of rain gauge

- Keep the pluviometer level. This can be checked with a carpenter's level placed across the opening of the collection funnel. Adjust the pluviometer until it is level.
- Clean the collection funnel. Dirt, fallen leaves, insects, etc. can sometimes block the funnel and rainwater may spill over. The funnel should be checked and cleaned regularly.
- Clean the water collection chamber. If soil is deposited at the bottom of the water collection chamber, it overstates the rainfall reading. It should be cleaned from time to time.

Temperature

Temperature is a measure of how hot or cold a substance is. Air temperature and soil temperature are important for agriculture as they can affect crops and crop pests. Recording air and soil temperature of farms is recommended.

Figure 1. *SAMIS Farmer Field Schools in Sing District, Luang Namtha Province. (left) Plastic Manual pluviometer from the Community Collaborative Rain, Hail and Snow Network (CoCoRAHS); (right) Trainer demonstrating how to measure the amount of rainfall*

[6] **Alcohol in thermometers are also available in the market with coloured alcohol which is easier to observe.**
[7] **Some thermometers are available in Fahrenheit scale. Water freezing point is 0°C or 32°F.**
Conversion formula is °C = (°F-32)/1.8

A mercury-in-glass thermometer is used for measuring temperature[6]. Heating expands the volume of any matter. As the temperature of the bulb increases, the mercury expands and the line in the tube becomes longer, measuring the temperature. The glass tube is graduated in degrees centigrade[7].

Air thermometers should be situated to allow free passage of air while sheltered from exposure to the sun. Soil thermometers are placed at different depths in the soil (at 5 cm, 10cm, 20 cm, 50 cm and 100cm). Observations of the air and soil temperature are recorded in a register with the date and time of observation.

Relative Humidity

Humidity is the amount of water vapour in the air and can vary depending on the season and weather conditions. A hygrometer is used to measure air humidity.

At a certain temperature the air has the capacity to carry a certain load of humidity. Relative humidity (RH) is calculated as the percentage of the maximum capacity of water vapour that the air can hold at the time of observation, assuming this maximum capacity as one hundred,

RH = (partial pressure of water vapour / equilibrium vapour pressure of water) X 100.

Evaporation

Conversion of water into vapour is called evaporation. Since understanding evaporation is very important for water management in crops, on-farm measurement of evaporation is recommended (Box 2).

Box 2: Note to the resource person, or trainer

Discuss with the farmers why wet washed clothes dry faster during the dry season, than during the rainy season.

[Note: During the dry season, the air has very low water vapour level (low level of relative humidity), and the water in the cloth evaporates quickly. But during the rainy season, the air is almost saturated by water vapour and cannot carry much of the water from the cloth].

Ask why we feel cool when we sit in front of a fan, though the fan does not cool the air.

[Note: A fan creates movement of air which picks up water, or sweat from the body and converts it into vapour. Converting water into vapour requires energy. Thus, the evaporating water vapour takes heat away from our body and we feel cool].

Also discuss with the farmers that the evaporation causes a loss of water from the ground and bodies of water as well as plants. The loss of water from the plant is called transpiration.

An evaporimeter is used to measure the evaporation. The evaporimeter is a large open container filled with water and placed under the sun. The decrease in the water level is an indicator of the amount of evaporative water loss. If rainfall occurs during the observation period, the evaporation is calculated after adjusting for the rainfall.

A transparent plastic bucket, or jar containing a scale, can also be used as a simple evaporimeter at farm level. The level of water inside the bucket can be easily read from the outside.

Reading an evaporimeter

1. Place the bucket in an open area near the manual pluviometer.
2. Fill the bucket with water and measure the water level using the scale and record the observation.
3. Observe the water level decrease after 24 hours and record the change in water level in millimetres. You will find that the water level will drop. All the readings are made in millimetres.
4. Discuss the decrease in the water level. The decrease in water level is due to evaporation. If the weather is dry the water level will drop more than on cloudy days.
5. If rainfall occurred within the last 24 hours, the evaporation can be calculated adjusting the rainfall to the original reading.
6. Evaporation = (original reading on evaporimeter + rainfall) – current reading.
7. If there has been no rainfall, just put zero in the formula above to get the measurement of evaporation.
8. The rise in temperature increases the loss of water through evaporation and transpiration.

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Observe and operate each of the available meteorological devices at the farm-level.

Activity 2: Take readings of the thermometer and hygrometer and interpret the results.

Activity 3: Simulate rainfall and measure the rainfall using the manual pluviometer.

[8] https://www.semanticscholar.org/paper/Internet-enabled-tipping-bucket-rain-gauge-Raghava-Wani/ace1649b56b9a533e3e1726943ddcd564d6f1cff

Lesson A3: Weather station level agrometeorological instruments and their handling

[9]Scintillation is a flash of light produced in a transparent material by the passage of a particle like electron, alpha particle or water drop).

Learning objectives

The trainees will be able to:

a. handle standard manual agrometeorological instruments and take their readings, or observe automatic sensors and the online download of data, if present;
b. describe the fundamentals of measurement techniques, theory and working principles of various instruments used in manual stations and/or sensors in automatic weather stations, as available; and
c. take readings of manual agrometeorological instruments, if available, and explain the observations.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Agrometeorological instruments (including rain gauge, thermometers, hygrometer, sunshine recorder, open-pan evaporimeter, anemometer, soil thermometers) or a visit to a nearby manual agrometeorological station.

Rain gauge

Conventional manual rain gauge.

A chart recording rain gauge collects water in a container which houses a float that rises as the water accumulates, moving a pen up a chart on a cylinder which is driven by a clockwork mechanism. When full, the container empties by siphoning, with the process starting again.

A storage gauge, useful for remote locations, collects a week's or a month's rainfall.

Errors in the rain gauge can include:

a. Splash-out, in-splash, evaporative losses and errors due to the gauge not being levelled accurately.
b. Errors due to the wind speeding up as it passes over the gauge, carrying some of the raindrops away that should have fallen into the gauge

Remedies to minimise errors: place the gauge in a pit so that the opening is at ground level, surrounded by a grating to minimizes eddies and prevent in-splash (Rodda, 1967).

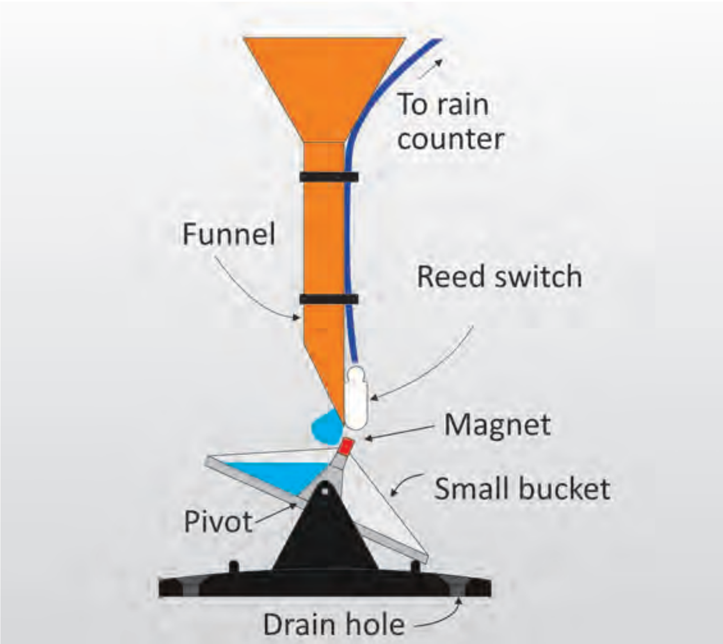


Figure 2. *Schematic representation of tipping bucket rain gauge Source: www.semanticscholar.org*[8]

Automatic sensor

A tipping bucket rain gauge consists of a funnel that collects and channels the precipitation into a small seesaw-like two-sided container (Figure 2). The two-sided container tips when one side is filled with pre-set amount of water (corresponding to 0.1, 0.2, 0.25, 0.5 or 1 mm of rain), dumping the water collected. Rain is then collected in the other side container, repeating the seesaw. Thus, each side becomes alternately filled with rainwater and emptied and sending an electrical signal. The number of tips of the bucket is detected by a switch and counted. The tip counts are either recorded in a data logger, or directly communicated to central server through a communication device. The funnel and two-sided containers with sensor are housed in a cylindrical container and mounted (Figure 3).

Such gauges may suffer from:

- evaporation loss;
- water sticking to the bucket instead of running off;
- water continuing to flow into it while it tips; and
- poor adjustment, so it does not tip for the precise amount of rain.

An infrared light rain gauge is used to measure rain drops as they fall by detecting the scintillation[9] they produce as they pass through a beam of infrared light.

Limitations of infrared light rain gauge:

- it is more costly than other pluviometer; and
- it requires power to operate.

Figure 3. *Tipping bucket rain gauge from DMH, Vientiane*

Thermometers and hygrometers

A number of sensors are used in Lao PDR stations.

Dry and wet bulb thermometers are often still being used for daily reading. In synoptic stations these thermometers are read at regular fixed times every day.

Readings of dry and wet bulb thermometers can be used to measure Relative Humidity (RH). For RH's measurement, 'wet bulb temperature' is measured using a thermometer, with its bulb covered by a wick dipped into a container of distilled water. Wet bulb temperature is lower than dry bulb temperature due to evaporation from the wick. The wet bulb depression is used to calculate the RH using a Psychrometric Table (Appendix II). Observe the dry bulb temperature in the first column and depression of the wet bulb temperature in the top row and find the RH. (Note this does not work below freezing point).

Thermo-hygrograph in a screen records a dual trace of temperature and humidity on a paper chart. Temperature is sensed by a bimetallic strip which bends as the temperature changes, while humidity is sensed by a bundle of human hair which changes in length with humidity, both moving pens across the chart. The screen records the temperature continuously, from which we can find the maximum and the minimum temperature for the day.

Soil temperature sensors measure the temperature of short grass and bare soil and ground temperatures at several depths (5 cm, 10cm, 20 cm, 50 cm and 100cm) using thermometers in tubes at regular intervals (Figure 4).

Platinum resistance thermometer (PRT) is a small coil of fine platinum wire which varies in resistance with temperature. The change in resistance changes electric voltage: these changes in voltage are recorded in a data logger in the form of temperature readings.

Figure 4. *Air temperature (left) and soil temperature sensors (right) from DMH, Vientiane*

A potentiometer is a three-terminal variable resistor in which the resistance is manually varied to control the flow of electric current. It works by varying the

Electronic sensors comprise a small thin-film capacitor a few millimetres square, allowing water vapour to diffuse into it, changing its capacitance relative to the air's humidity. An electronic circuit converts the small capacitance changes into a voltage for logging.

Anemometer and Vane

An anemometer measures wind speed and a vane indicates its direction.

a. **A cup anemometer** comprising three cups on a vertical shaft is used for measuring wind speed. As the pressure on the open side of the cups is higher than that on the back, it rotates the shaft mechanically and the 'run of wind' is measured.
b. **A vane,** exposed at a reasonable distance from any obstacle, shows wind direction.

A modern wind speed sensor has the same primary detection method as the mechanical wind sensor in that it uses the rotating-cup principle (Figure 5). The method of sensing the revolutions of the shaft is similar to the tipping bucket rain gauge's magnetic switch, although optical methods are also used with the logger simply counting and storing the number of pulses. As it must be kept facing into the wind, it is combined with a wind direction vane. The vane's position is converted into an electrical signal for logging, using potentiometer[10] or digital encoded disc.

In more recently installed automatic agrometeorological stations, two anemometers and a vane are used. The first one is placed at the regular 10m height as per WMO standard and is used for weather forecasts. A second one is placed at 2.5m, as this elevation is more relevant for crop relevant observation and modelling.

Figure 5. *Modern wind speed sensor from DMH, Vientiane*

Sunshine-hours Recorder

A sunshine-hours recorder (also called Campbell-Stokes recorder) comprises a glass sphere mounted in such a way that its focus burns paper with a trace during sunny hours (Figure 6). The glass ball focuses the rays and burn the paper. The length of the trace mark is measured to estimate the number of hours the sun was visible. However, when the intensity of light is low particularly during sunrise, sunset or patchy clouding, the trace in the card is difficult to observe and measure.

Figure 6. *Sunshine recorder in DMH, Vientiane*

A **bimetallic actinograph** is used to measure sunshine hours. The Actinograph comprises of black and white strips of metal that are exposed to the sun, under a protecting dome. The surface of the black strip absorbs more solar energy than the white, causing differential heating proportional to the energy received from the sun. The expanding strip moves a pen across a paper chart marking total energy received. The mark in the chart records sunshine hours which can be easily measured.

Pyranometer (also called solarimeter) is a type of actinometer used for measuring solar radiation. It measures solar radiation by comparing the heating effect of the radiation upon two metallic strips, one blackened and another not. A thermocouple connected to the strips measures dissimilarities in temperature between the two surfaces. The two strips and thermopile are covered by a glass dome (Figure 7). It is designed to measure the solar radiation flux density in watts per square meter (W/m^2). The pyranometer should be installed 1 to 2 m over the ground surface. It measures photosynthetically active solar radiations (Batista et al. no date).

Figure 7: *Pyranometer*
Source: www.agriexpo.online

Evaporimeter

An evaporimeter is a large open container filled with water and placed in the sun (Figure 8). Any decrease in the level of water, after adjusting for any rainfall, is an indicator of the amount of water loss by the evaporation. The open pan evaporimeter needs to be protected from birds and animals so that they do not take water from the pan. A screen can be laid over the pan and any decrease in the evaporation due to the screen need to be adjusted during calibration.

Figure 8. *Open pan evaporimeter from DMH, Vientiane*

Penman-Monteith equations are estimated by operating temperature, humidity, wind speed and net radiation sensors together as an Automatic Weather Station (AWS). These give better estimates than that obtained from an evaporation pan. An AWS includes sensors for wind direction, solar radiation and rainfall, providing a comprehensive climatological station (Strangeways, 1985). Further details on Penman-Monteith equations are presented in Box 3.

Box 3: Applications of Penman-Monteith equations

Considering the mathematical complexity of the original Penman-Monteith equation, FAO derived a simpler method with strong likelihood of correctly predicting the reference crop evapotranspiration in a wide range of locations and climates (Allen at al., 1998). The crop evapotranspiration under standard conditions (ET_c) is calculated in millimetres per day by multiplying reference crop evapotranspiration (ET_o) with crop coefficient (K_c):

$$ET_c = ET_o * K_c$$

The ET_o (in mm d^{-1}) is calculated by the following equation:

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

Where,
R_n is the net radiation at the crop surface (MJ m^{-2} d^{-1}),
G is the soil heat flux density (MJ $m^{-2}d^{-1}$),
Δ is the gradient of the vapour pressure curve (kPa $^oC^{-1}$),
γ is the psychrometric coefficient (kPa $^oC^{-1}$),
T is the mean daily temperature (^oC),
u_2 is the wind speed at 2 m height (m $^{s-1}$),
e_s–e_α is the saturation vapour pressure deficit (kPa),
e_s is the saturation vapour pressure (kPa) and
e_α is the actual vapour pressure (kPa).
The crop coefficient K_c needs to be estimated on a daily basis for each crop. It is simply the ratio of ET observed for the crop studied over that observed for the well calibrated reference crop under the same conditions.
Further information is available in Allen et al. 1998 and Tsouni et al. 2008.

Barometer

A mercury barometer has a glass tube closed at the top and open at the bottom that is placed in a dish of mercury. The height of the mercury in the tube adjusts itself in response to the atmospheric pressure on the dish. As the pressure increases, the mercury is forced up the tube. The tube is marked with a series of measurements that track the units in atmospheres (atm), or bars. An atm is a unit of measurement equal to the average air pressure at sea level at a temperature of 15ºC. The mercury barometer is now replaced by aneroid barometers.

An aneroid barometer has a sealed metal chamber consisting of one or more shallow capsules with the air pumped out. As the atmospheric pressure changes, the capsules expand or contract and this movement is magnified mechanically to move either a pen across a clockwork-driven chart, or a pointer across a dial (Figure 9). It has a circular display that indicates the number of atmospheres (atm) as the unit of measurement, much like a clock. The terms stormy, rain, change, fair, and dry are often written above the numbers on the dial face to make it easier to interpret the weather.

Barographs are aneroid barometers with a mechanical tool to track the changes in atmospheric pressure over a period of time. The barometers are connected to needles that make marks on a roll of graph paper. The barograph records the number of atmospheres on the vertical axis and units of time on the horizontal. A barograph's tracking tool will rotate, usually once every day, week, or month. The spikes in the graph show when air pressure was high or low, and how long those pressure systems lasted. A severe storm, for instance, would appear as a deep, wide dip on a barograph.

Digital barometers measure and display complex atmospheric data more accurately and quickly. Many digital barometers display both current barometric readings and previous 1-, 3-, 6-, and 12-hour readings in a bar chart format, much like a barograph. They also account for other atmospheric readings such as wind and humidity to make accurate weather forecasts. The digital barometer is now an important tool in many smartphones. This type of digital barometer uses atmospheric pressure data to make accurate elevation readings.

Figure 9. *Barometer*

Source: www.wisegeek.com

Data Loggers and Telemetry

Data loggers are microprocessors with solid-state memory. The user programs them via a computer to accept whichever sensors are to be used, along with the ranges of the variables and the frequency of logging. The stored data are extracted periodically by downloading to a laptop. The user can also store the data on 'smart card', for reading back at base.

Telemetry is the transmission of real-time data for weather forecasting and river management from an outstation to base. A telemetry outstation is simply a data logging station with a communications channel added, which can be a telephone line, a ground-based UHF radio link or communication via satellite. However, UHF radio links only operate over line-of-sight distances because radio waves in this frequency band behave like light and do not bend far beyond the horizon (Strangeways, 1997).

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Visit nearby manual agrometeorological station.

Activity 2: Take readings of the manual meteorological instruments and interpret the results.

Activity 3: Also visit an Automatic Weather Station (if available) and learn about different sensors used.

Lesson A4: Farmers' needs of agrometeorological services

Learning objectives

The trainees will be able to:

a. explain the farmers' agrometeorological needs;
b. explain what weather information farmers need at what crop season; and
c. explain what climate smart recommendations farmers the farmer need at what crop season.

Materials required

- Flip Chart Paper
- Markers
- Projector.

The need for agrometeorological services

Agrometeorological services are necessary for reducing the loss of agricultural production due to the vagaries of weather. Agriculture is the livelihood of farmers for adequate stocks and flows of food and cash to meet basic needs, together with reserves and assets to offset risks, ease shocks, and meet contingencies (Chambers, 1990).

Farmers need accurate weather forecasts to help them make farm decisions, including water resource management depending on how much rain is expected (Das et al., 2010).

Agrometeorological services can help farmers to address their suffering from weather and climate and assist them in making the best use of opportunities that microclimate offers them. Early warning agrometeorological services support farmers to prepare for risk of climate extremes.

In addition, the agrometeorological services support the short and medium term farmers' decision making for crop management, including land preparation, soil fertility management, planting time and density, pruning, harvesting time. Furthermore, an important part of the services include the support to weed and pest and disease management.

Climate services for farmers

Agriculture needs to be more multi-functional and to simultaneously achieve economic, social and environmental sustainability by restoring biological resources and natural capital (soil fertility, water, forests, etc.), livelihoods (nutrition, health, culture, equity, income), and agroecological processes (nutrient and water cycles, pest and disease control, etc.) (Leakey et al., 2010; De Melo-Abreu et al., 2010).

The main weather elements affecting farm planning and/or operations include:

- Solar radiation,
- Hours of sunshine and cloud coverage,
- Temperature (maximum, minimum and dew point),
- Soil temperature,
- Air pressure,
- Wind speed and direction,
- Relative humidity,
- Soil moisture,
- Evapotranspiration,
- Precipitation,
- Extreme events such as heat and cold waves, fog, frost, hail, thunderstorms, wind squalls and gales, low pressure areas, different intensities of depressions, cyclones, tornadoes.

Climate services to farmers tend to be identified with weather information only. However, the farmers services need and can obtain are far wider and more detailed. The weather elements can be elaborated to obtain a certain number of services related to:

- Weather forecast;
- Extreme events risk (drought, flood, heat and cold stress, etc.);
- Agricultural risks (pest and diseases, heat and cold stress, etc.); and
- Climate smart recommendations.

Weather forecasts

Weather forecasting is the application of science and technology to predict the atmospheric conditions for a given location and time. Weather forecasts are made by collecting quantitative data about the atmosphere's current state at a given place and using meteorology to predict how the atmosphere will change. "Most of the time, the forecaster expresses a combination of degree of confidence and real coverage. If the forecaster is only 50% sure that precipitation will occur, and expects that, if it does occur, it will produce measurable rain over about 80 percent of the area, the probability of precipitation (PoP) (chance of rain) is 40%."[11]

Weather forecasts is a main element of climate services for farmers and can be used for a number of purposes. Weather warnings are important to protect life and property. Since outdoor activities are severely curtailed by heavy rain, snow and wind chill, forecasts can be used to plan activities around these events and plan ahead and survive them.

Forecasts of temperature and precipitation are important to agriculture, and therefore to traders within commodity markets. Temperature forecasts are used by utility companies to estimate demand over coming days.

Farmers rely on weather forecasts to decide what work to do on any particular day. For example, farmers can use it to determine what to plant during this season and when farmers should harvest their product to avoid significant damage from climate change.

The LaCSA provides the most critical weather and climate information such as (Figure 10):

- Three-hour weather forecast;
- Daily weather forecasts;
- Weekly agrometeorological bulletins;
- Three monthly climate outlooks updated each month (seasonal climate outlooks);
- Historical climate data at province level;
- Observed weather data;
- Advisories and alerts for extreme climate events such as droughts and floods.

[11] www.wmcactionnews5.com/2019/04/25/breakdown-what-does-rain-percentage-really-mean-you/

Figure 10. *Farmers get the first seasonal forecast for rainy season rice at Laonard village, Champhone district, Savannakhet province*

[12] In Lao People's Democratic Republic, these farmers' services are provided by a tool called Land Resources Information Management System (LRMIS)

Climate risks

Climate risk in agriculture represents the probability of a defined hydro-meteorological hazard affecting the livelihood of farmers and livestock herders. Risk refers to a probability that can be estimated from prior information (Selvaraju, 2012). The same author explains that uncertainty applies to situations in which probability cannot be estimated. Both risks and uncertainties contribute to choice of appropriate management practices by the decision-makers in agriculture.

Climate risk advisory help farmers making the best management responses. Farmers have a traditional knowledge about their area and landscape, and are generally able to manage risk and uncertainty. However, due to climate change the uncertainty is increasing and consequently the capacity of farmers to make appropriate decision declined.

The main climate risk alerts that constitute LaCSA early warnings to farmers include:

- Severe weather alerts such as storms, tornados, cyclone, drought spells, and cold and heat shocks;
- Prolonged Severe Weather Alerts such as drought and heat waves or a season characterized by excessive rainfall. These events require to be communicated to farmers well in advance so that appropriate crop season planning is possible (appropriate crop varieties, digging furrows for channelling excessive water out of the field, etc.);
- Biological alerts such as crop specific risk of pest and diseases due to the temperature and relative humidity at a specific time of the crop cycle;

The telephone LaCSA app will present a push-up alert system for the main monthly and weekly alerts.

The use of climate smart recommendations based on the risk assessment

Climate-smart recommendations for farmers are technical practical written text suggesting the field operations that should be done in the next week or month, thereby strengthening farmer ability make appropriate farming decisions and increase the climate resilience of smallholder farmers. In order to produce recommendations, the LaCSA interpolate the most critical agrometeorological information such as:

- Growing degree days for rice, a measure of heat accumulation used by farmers to predict crop and insect pest development rates, such as how long it takes for a flower to bloom, a crop to reach maturity, or an insect pest to complete its life cycle;
- Expected cumulative rainfall, a measure of rainfall accumulation for a defined period to predict plant and pest development effects;
- Effective drought index (EDI), considering weighted contribution of daily rainfall over the past 60 days. The index indicates moderate or severe drought and wet conditions, respectively. Drought directly affects rainfed farming such as rice production, while wet condition may result in waterlogging, soil erosion, etc.;
- The Combined Drought Index (CDI) that helps to identify agricultural drought and is currently under evaluation.

The LaCSA provides the most critical pest and desease information such as:

- The Insect Pest Index indicates a potential risk of insect pest infestation during a defined rice cropping period, calculated with heat accumulation (growing degree days) and rainfall effect on insect population buildup.
- Disease index indicates a potential risk of disease epidemic during a defined rice cropping period, calculated with complex effects of temperature, relative humidity, and rainfall on infection development.

Although LaCSA shows publicly only the indexes for rainfed rice, the system also monitor irrigated rice, upland rice, cassava, coffee, cabbage, pumpkin, maize and banana.

The interpolation of growing degree days with soil moisture and relative humidity allows to develop detailed recommendation based on local conditions, such as land preparation, water management, soil fertility management, planting time and density, pruning, harvesting time and weed and pest and disease management. The recommendations have been prepared by experts of the NAFRI and the CIAT and will be published separately. Farmers can use agrometeorological services for:

a) Adopting physical adaptive measures based on long-term climatic trends and variations and future scenarios[12]:

- Development and maintenance of link canals, irrigation, water harvesting, storage facilities for retaining water;
- Construction of drainage facilities;
- Micro-climate manipulation through tree plantations, watershed development, greenhouse farming and animal shed improvement;
- Increase soil organic matter for better absorbing water and increasing soil microbial activities to combat and mitigate the effects of droughts;
- Application of soil amendments (Figure 11).

b) Adjusting existing agricultural practices to match anticipated risks based on seasonal forecasts:

- Adjustment of cropping pattern;
- Selection of adapted varieties of crops;
- Diversification of cropping and/or farming systems;
- Better storage of seeds and fodder;
- Dry seedbeds;
- Switch to more resilient alternative crops;
- More efficient use of irrigation water on rice paddies, more efficient use of nitrogen application on cultivated fields, improved water management including water harvesting.

c) Tactical day-to-day planning of farm operations based on three hour, daily, three day and weekly forecasts:

- Fertilizer application
- Irrigation
- Transplanting
- Sowing
- Planting distance
- Integrate Pest Management or pesticide spray
- Staking
- Harvesting
- Marketing of the farm products.

Figure 11. *PAFO staff lead farmers on soil improvement at Kadarn village, Champhone district, Savannakhet*

Examples of effects of rainfall forecasts on-farm decisions

Lack of irrigation and uncertainty of rainfall can make smallholder farmers less inclined to invest in crop production. Increasing farmers' control over water such as rainwater, soil moisture, water bodies and aquifers can help increase farmers' confidence in farm investment (Van der Zaag, 2010). For example, seasonal forecasts of rainfall above or below the normal will affect several farming decisions in non-irrigated farmlands (Table 1). Based on the forecasts, farmers can decide for transplanting rice crop (Figure 12).

Table 1. Key decisions in pre-planting and planting periods based on seasonal forecast for rainfall

	If rainfall forecast is above normal	If rainfall forecast is below normal
1	Adopt measures to affect the drainage of excess rainfall	Land preparation and pre-plant tillage oriented towards rainwater retention
2	Choice of higher water requirement crops like rice, with particularly desirable traits and large potential yields and returns	Lower water requirement crops and drought-tolerant varieties which offer insurance for the family food supply
3	Choice of inter-cropping two or more crops in the same plot, known to be advantageous with adequate rainfall	Legume integration to ensure ground cover and moisture conservation
4	Planting in narrow rows, with high seed densities to maximise production	Wide rows (lower densities), reduced seed rates for more assured and cost-effective food production with limited water
5	Apply the recommended dose of fertilizers	Apply a smaller dose of chemical fertilizers and a higher dose of organic matters and mulch for soil moisture retention
6	Dry planting prior to the onset of rains	Planting delayed until the soil contains sufficient water to germinate and support seedlings through possible early season dry spells

Source: Adapted from Pfeiffer, 2002

Figure 12. *Farmers transplanting rice based on rainfall forecasts on-farm decisions in Sing district, Luang Namtha province*

List of potential use of agrometeorological information

Primary producers use agrometeorological information for decision-making with a range of scales that can vary from several days to the entire cropping season, or inter-annual time periods. Strategic planning and marketing decisions mostly use climate information for the following year (FAO, 2019). Key farm decisions that can be impacted by climate information are presented in Table 2.

Table 2. Key farm decisions impacted by climate information during the cropping season

	Key Farm Decision	Key Climate Variables that Inform the Decisions
A	**Before sowing**	Agrometeorological crop risk analysis to assess the most suitable crop(s) based on crop water requirements Statistical analysis of rainfall for the determination of the optimum planting date(s)
1	Choosing crops	Total seasonal rainfall forecast and its intra-seasonal distribution
2	Choosing crop varieties	Onset of monsoon
3	Timing and amount of tillage and stocking rates	Weather forecast
4	Planting mixed crops	Forecasts of below-normal rainfall
5	Planting summer vegetables in plastic tunnel or greenhouse during winter season	Forecast of cold waves
6	Sowing time	Onset of monsoon
7	Alternative crops	Delays or breaks in rainfall
B	**During the crop season**	3-day weather forecasts for rainfall and temperature Predictions of extreme weather events such as drought, heavy rains and strong winds Weekly agrometeorological advice on better adaptation of farmers' practices
8	Mulching and crop cover to protect crops	During sudden variations in temperature
9	Cover nursery beds with thatch or plastic	Frost during winter season causing cold injuries
10	Irrigation management – in terms of timing of irrigation and quantity of water to be applied	Total rainfall less evapotranspiration
11	Resource use allocation – both labour and finance	Total rainfall forecast and its intra-seasonal distribution
12	Fertilizer application – the quantity and type of fertilizer as well as the timing of application of fertilizers on crops	Forecast of the distribution of rainfall across the crop growth stages
13	Timing of pesticide application	Wind direction, wind speed and distribution of rainfall across the crop growth stages
14	Fungicide applications (such as for potato, tomato crops)	Relative humidity and maximum temperature
15	Direction of pesticide application	Wind direction
16	Staking of crops (like banana, sugarcane)	Wind direction and speed
C	**At the time of harvest**	3-day weather forecasts for rainfall Forecasts of extreme weather events such as hailstones and strong winds
17	Time of harvest	Forecast of the distribution of rainfall during the crop maturation stages, sunshine hours
18	Relay cropping	Soil moisture

Source: Adapted from Madhavan and Rengalakshmi, 2015.

Farmers need other information in addition to climate information (Box 4).

Box 4: Additional information farmers need that can be provided by the LaCSA system:

- Information on why certain seeds may have failed and how to prevent it.
- Mechanization possibilities on the farm
- New mechanization techniques to reduce the cost of cultivation and new machines for harvesting and sowing seeds
- Sharing new research results on agriculture
- Precision of use of fertilizers
- Dealing with wild animals, particularly those attacking crops and farmers
- Storage facilities
- Market produce prices
- How to switch to organic farming. Those farmers already using organic farming need more specific and detailed information

Source: Authors

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Mock interviews of people role-playing drought-prone farmers to understand their needs for agrometeorological services.

Activity 2: List agrometeorological information needed by rice farmers, maize farmers and livestock herders, separately.

Activity 3: List the effect of lack of rainfall in farming processes

Lesson A5: Importance of agrometeorology in rice crops

Learning objectives

The trainees will be able to:

a. explain effects of agrometeorological parameters on rice crops; and
b. identify effects of major agrometeorological extreme events during the rice crop season.

Materials required

- Flip Chart Paper
- Markers
- Projector.

Agrometeorological services for rice crops

Agrometeorological information is helpful for farmers in agriculture, especially rice cultivation. More specifically, it is crucial to help shape the cropping calendar, understanding crop requirements such as water, temperature, light and wind, and designing farm management processes such as control of pests and diseases.

How is the weather forecast important for rice cultivation?

The trainer needs to summarise the crop-specific recommendations of the LaCSA's guidance on irrigated rice, rainfed rice and upland rice and explain the links to farm management, climate data and the cropping calendar.

Weather forecasting is important for different stages of the rice crop in:

a) Land preparation

Irrigated rice farmers can prepare land well in advance, but farmers in rainfed areas and upland areas typically plough after the rainfall to stock water in the soil and prevent water from running away. Weather forecasts will help the farmers to plan when to start ploughing.

b) Germination stage

Low temperatures depress the rate of germination and prolong it beyond the desirable span of 6 days. High temperatures of 35 ºC or more halt the germination because of the high respiration rate of the seeds. The optimal temperatures for rice seed germination range between 20-25ºC. Temperature forecasts can help farmers to decide when nursery raising is appropriate.

c) Seedling nursery

Weather forecasting helps farmers to plan when to start seedling preparation. Low temperatures adversely affect the dry seedling matter since low temperatures decrease the photosynthetic activity of rice seedlings. The optimum temperature for leaf emergence is about 25 ºC and elongation is about 30 ºC.

d) Transplanting

Transplanting requires water in the field. Sometimes farmers wait a long time for rainfall so that the seedlings are too old (more than 25 days). Old seedlings can reduce rice tillering and yield. Between 200-300 mm precipitation per month is considered the minimum rate of rainfall for rainfed rice.

e) Tillering (Vegetative stage)

Excess or low rainfall during the tillering stage can lead to adverse effects on the crop establishment and growth, but there may not be a significant effect on the grain yield. Rice field needs alternative drought and wet conditions to activate the tillering. Farmers need to be able to control water levels by draining and filling up if an irrigation facility is available.

The optimum temperature range for the rice crop is between 25-31ºC. High temperatures during the tillering stage can induce tillering but reduce the rice yield. Temperature and the level of sunlight will affect the tillering. With a low level of sunlight, some tiller buds may not develop into tillers because of lack of carbohydrate, which is necessary for growth. When the light is adequate, high temperatures can increase the number of tillers. Temperature above 28 ºC during the vegetative stage can reduce the number of days for heading and shortens the life cycle of the rice crop, thereby reducing the yield.

f) Fertilizer application

Too much rainfall, or flooding, may wash away fertilizers while drought conditions can lead to loss of nitrogen due to aeration. This is a problem for nitrogen supplied especially as urea. Farmers need to check the rainfall before applying any type of fertilizer.

g) Insect Pests and Diseases

Climatic factors such as temperature, relative humidity, rainfall and wind all affect the distribution, development, survival, behaviour, migration, reproduction, population dynamics, and outbreaks of insect pests of rice. These climate factors usually act in a density-independent manner (regardless of the number of insect pests per unit area), affecting insects to a greater or lesser extent depending on the situation and the insect species. For example, the temperature range of 25º to 27ºC is the most favourable for the outbreak of rice gall midge (*Orseolia oryzae*). Paddy water temperature above 35ºC is believed to be a main factor affecting the sudden decrease of rice stem borer (*Chilo suppressalis*) population during July and August, as in the case in Taiwan (Change, 1968).

h) Flowering stage (Reproductive stage)

During the flowering stage, high water levels are needed for rice reproduction. If the rice lacks water for ten days during this stage, it can reduce the yield by 50%. Thus, farmers should keep the water level consistent during the flowering stage. However, strong wind and high rainfall during this stage can have a negative effect on the yield.

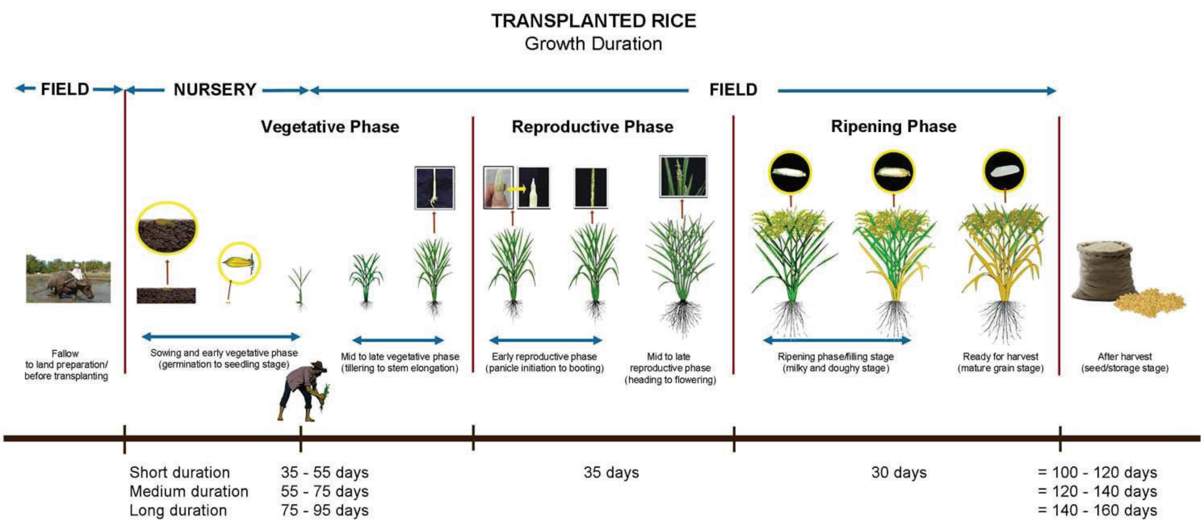
High temperatures during ear initiation can also reduce the yield. Generally, high temperatures can accelerate the floral initiation, while low temperatures can delay floral initiation. The critical minimum is about 15ºC and the optimum should be between 25-30 ºC.

i) Harvesting (Maturity stage)

Generally, grain yield is high when the temperature during the ripening stage is low, due to a balance between photosynthesis and respiration. Low temperatures can increase the grain weight while low daily mean temperatures increase the length of ripening period. Temperatures below 28ºC during grain filling can increase the duration of the maturity stage and seed size.

Rice should be harvested at optimum maturity and on time to secure good quantity and quality, with minimal loss:

a. Optimum harvesting time is between 35-25 days after the rice panicle initiation or reproduction stage, or the grain moisture during the mature stage between %28- 22;
b. Observe the field with %85-80 maturity or in 80% of the grain in panicle are ripened;
c. The grain is hard and has a white colour when peeled;
d. Make sure there is no rainfall during the harvesting to make the rice dry enough after harvesting. The rice crop stages are summarised in Figure 13.



Source: http://www.knowledgebank.irri.org

ACTIVITY TO BE COMPLETED BY THE TRAINEES:

Activity 1: List extreme weather events at different rice crop stages (nursery, vegetative, reproductive and maturity) that affect rice production under irrigated, rainfed and upland conditions.

Lesson A6: Lao Climate Service for Agriculture

Learning objectives

The trainees will be able to:

a. explain the LaCSA and its importance to farmers; and
b. access the LaCSA website and app and use the latest information for planning farm practices for the rice crop.

Materials required

- Flip Chart Paper
- Markers
- Projector.

Laos Climate Services in Agriculture (LaCSA) system

The LaCSA system was initiated in May 2019 and brings weather data from all the stations in Lao PDR in one database (Figure 14). The newly collected weather data together with the recorded historical data are fed to weather and climate models to generate short and medium term weather forecasts and seasonal forecasts. LaCSA is a centralized integrated database system for climate data covering all DMH-weather climate stations all around the country for more than 80 stations. Manual station observation is uploaded manually into the system by weather data management section of Climate and Agrometeorology division (CAgM) of DMH daily. Automatic weather station data are automatically acquired and transferred to the network automatically every hour.

The weather data are combined with agricultural information like soil, crop, insect pest and disease data to generate advice and warnings necessary to the farmers, other value chain workers and planners. It gives management recommendations for the most widely grown crops depending on the province and districts. The list of crops includes rice, cassava, maize, coffee, banana and cabbage, and it is still growing). LaCSA informs the farmers about insect pest and disease risks and best management options for them.

The LaCSA system also provides crop specific indices such as the estimated number of plant growing and maturation days (growing degree days, GDD), and crop yield forecasts with management recommendations. All information is summarized in a user-friendly format and provided free of cost as weekly or monthly bulletins.

National Agriculture and Forestry Research Institute (NAFRI) supports training for the LaCSA to PAFO/DAFO and PONRE/DONRE. NAFRI has developed a training manual in Pasalao. The NAFRI is mandated to undertake integrated agriculture, forestry and fisheries research in order to provide technical information, norms and results. The technical information helps to formulate strategy in accordance with the government policies.

The inputs for the implementation of LaCSA come from both Ministry of Natural Resources and Environment (MONRE) and the Ministry of Agriculture and Forestry (MAF). The MONRE and DMH mainly provide climate data which consist of observation data (e.g. rainfall, temperature, relative humidity, soil temperature, and wind speed & direction), weather forecasting (three hours and seven days), seasonal forecasting (three to six months ahead), extreme alerts, and site agronomic data. MAF has different centres and departments to provide data and information. For example, pests and diseases management options and monitoring are provided by the Plant Protection Centre (PPC); soil and crop land use data are supplied by the Department of Agricultural Land Management (DALAM); crop calendars are provided by DALAM and NAFRI; agricultural data, and farming practices and technologies are provided by the NAFRI; and PPC and NAFRI provide pest and disease farming practices. Finally, real time crop stage information is collected by the DONRE offices monthly for the main crops through an online questionnaire that has been developed by International Centre for Tropical Agriculture (CIAT) and SAMIS using the Kobo toolbox.

Climate services consist of daily weather forecasts (3 hours and seven days) and seasonal climate forecast ahead 3 to 6 months (rainfall and temperature). The agrometeorological services include weekly and monthly bulletins, indexes (like GDD, accumulated rainfall, drought, insects, diseases, heat stress, cold stress, livestock heat stress), drought monitoring map, climate smart recommendations, and pests and disease calendar, real-time agronomic data, incidence of pests and diseases report and their management options.

Rainfall Intensity:

Rainfall intensity is classified according to the rate of precipitation, which depends on the considered time. It is a part of LaCSA training as it is a highly useful information for farmers to decide for their farm operations. The following categories are used to classify rainfall intensity:

- Light rain — when the precipitation rate is < 2.5 mm per hour;
- Moderate rain — when the precipitation rate is between 2.5 mm - 7.6 mm or 10 mm per hour
- Heavy rain — when the precipitation rate is > 7.6 mm per hour, or between 10 mm and 50 mm per hour;
- Violent rain — when the precipitation rate is > 50 mm per hour.

Wind scale:

The Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea or on land (Table 3). The LaCSA system uses Beaufort scale to explain the wind intensity.

Table 3. Beaufort wind force scale

Beaufort number	Description	Wind speed	Wave height	Land conditions
0	Calm	< 2 km/h < 0.5 m/s	0 m	Smoke rises vertically
1	Light air	2–5 km/h 0.5–1.5 m/s	0–0.3 m	Direction shown by smoke drift but not by wind vanes
2	Light breeze	6–11 km/h 1.6–3.3 m/s	0.3–0.6 m	Wind felt on face; leaves rustle; wind vane moved by wind
3	Gentle breeze	12–19 km/h 3.4–5.5 m/s	0.6–1.2 m	Leaves and small twigs in constant motion; light flags extended
4	Moderate breeze	20–28 km/h 5.5–7.9 m/s	1–2 m	Raises dust and loose paper; small branches moved
5	Fresh breeze	29–38 km/h 8–10.7 m/s	2–3 m	Small trees in leaf begin to sway; crested wavelets form on inland waters
6	Strong breeze	39–49 km/h 10.8–13.8 m/s	3–4 m	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty
7	High wind, moderate gale, near gale	50–61 km/h 13.9–17.1 m/s	4–5.5 m	Whole trees in motion; inconvenience felt when walking against the wind
8	Gale fresh gale	62–74 km/h 17.2–20.7 m/s	5.5–7.5 m	Twigs break off trees; generally, impedes progress
9	Strong/severe gale	75–88 km/h 20.8–24.4 m/s	7–10 m	Slight structural damage (chimney pots and slates removed)
10	Storm whole gale	89–102 km/h 24.5–28.4 m/s	9–12.5 m	Seldom experienced inland; trees uprooted; considerable structural damage
11	Violent storm	103–117 km/h 28.5–32.6 m/s	11.5–16 m	Very rarely experienced; accompanied by widespread damage
12	Hurricane force	≥ 118 km/h ≥ 32.7 m/s	≥ 14 m	Devastation

Source: https://www.weather.gov/mfl/beaufort

Weather is one of the strongest factors influencing agricultural production. It defines when to plant and what to plant, how to manage a crop and whether the harvest will be plenty or meagre. Knowing how the weather will allow producers to make the right decisions to maximize their yield or minimize their losses. Over the past millennia, farmers everywhere in the world learned to "read the sky" and could tell from past experience what the next day, week or even months would bring. This was possible because weather patterns were cyclical and stable.

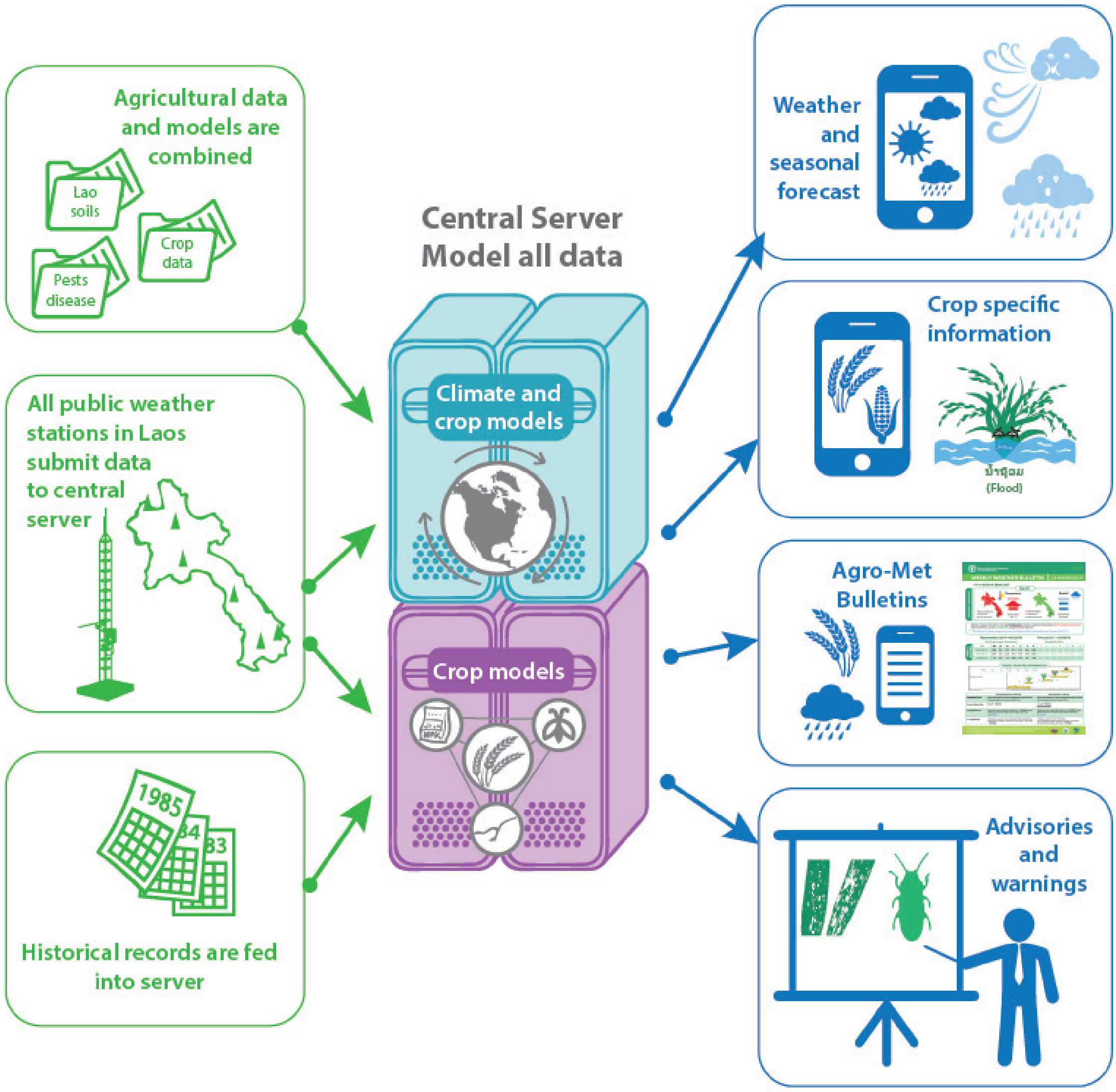


Figure 14. *Summary of LaCSA system*

Source: FAO, 2020

LaCSA system provides information for better decision making to producers, service providers and planners (Figure 15).

a) Farmers get critical information for choosing:
   - a suitable crop and making good management decisions;
   - the most appropriate agricultural practices to minimize risk and improve productivity and food security.
b) Farm service providers and input suppliers receive information necessary for:
   - planning of input supply and service delivery at the time of need;
   - training extension staff in specialized knowledge to fit the requirement.
c) National planners of agricultural commodity trade and food security can:
   - have an outlook into the next cropping season;
   - plan months before a situation of shortage or overproduction arises.

Figure 15. *Farmers trained by PAFO/DAFO on how to use the information from the bulletin and LaCSA system in (left) Champhone district, Savannakhet province and (right) Namtha district, LuangNamtha province*

Information generated by LaCSA system

LaCSA site can be accessed to get the following information:

- Three-hourly forecast for temperature, rainfall, humidity, cloud cover and wind;
- Seven-day daily forecast for maximum and minimum temperature, rainfall, humidity and wind;
- Seasonal forecast over six months with monthly average data on temperature and rainfall;
- Seasonal forecast maps for the whole country with separate predictions for each province;
- Agrometeorological indices (Agromet index) for each weather station for a given planting date:
    - Growing degree days (GDD): provides a measure of heat accumulation over a period of time to predict plant and pest development rates;
    - Rainfall amount and distribution;
    - Drought intensity and length;
    - Likelihood of insect pest disease outbreaks.

The bulletins are available through PONRE, PAFO and online in LaCSA and Facebook (www.facebook.com/samisdmh). They can also be received by requesting access to the mailing lists: samisdmh@gmail.com. All of the above can be accessed through the app.

The LaCSA information are available in the following distribution tools:

- **Seasonal bulletin** for each province of the country updated at the end of every month, for a total of 17 bulletins produced in English and Pasalao every month.
- **Weekly bulletin** for each district with weather forecast, climate smart agriculture recommendations and pest and diseases risk advisory, for a total of 141 bulletins produced in English and Pasalao every week automatically, complemented with crop forecasts and recommendations, including crop phenology, yield estimates and different management scenarios.
- **The data produced** by LaCSA are also made available through a dedicated app that contains all the data described above, and that is freely available for users both in English and in Lao language (Figure 16).

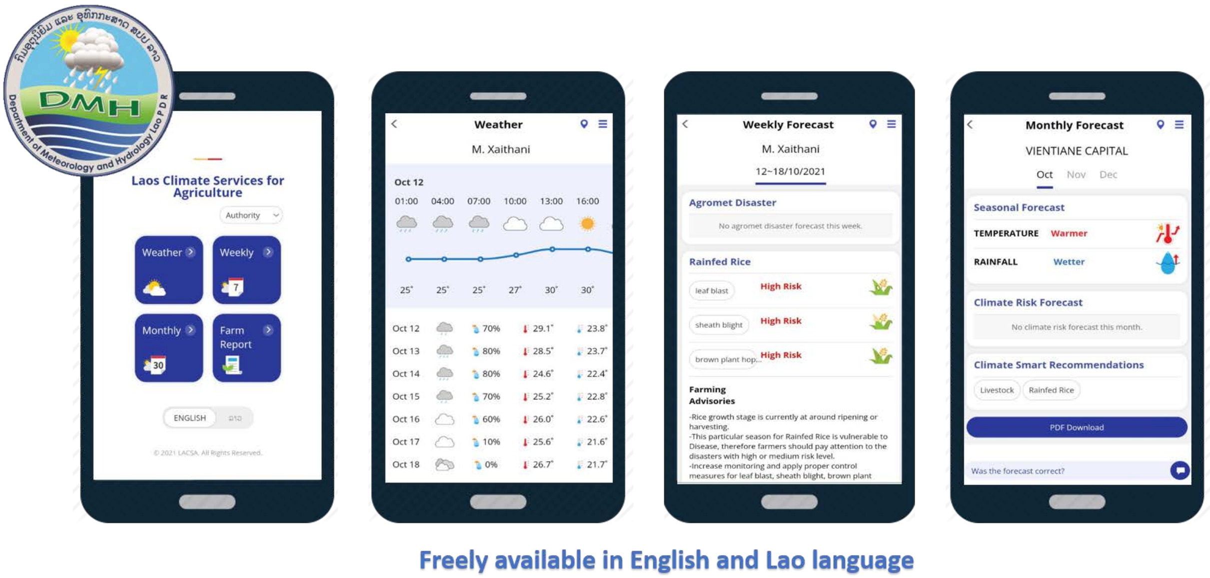


Figure 16. *LaCSA app*

Source: FAO, 2020

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1:

Activity 2: Simulate past periods in the agrometeorological index and access older bulletins. Compare the older data with the present one and describe the differences.

Activity 3: Access Lao app and list weather parameters forecasted for the coming week.

Lesson A7: Seasonal forecasts

Learning objectives

The trainees will be able to:

a. give a broad overview of the LaCSA system;
b. explain the importance of the seasonal forecasts; and
c. propose farm decisions based on the seasonal forecasts.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Examples of a seasonal forecast bulletin downloaded from: ___

An example of seasonal forecast is available in Figure 17. However, the bulletin is produced monthly, so the trainer should download various bulletins. The training should cover multiple periods of the year and multiple crops, including the most important crops in the area of the training. Also, the training should be based on multiple bulletin for various periods of the year such us:

- Crop varieties selection period;
- Planting period;
- Harvest period;
- Periods with risks of cold and heat shocks.

What is the seasonal forecast?

The seasonal forecast is a description of averaged temperatures and rainfall, expressed as a departure from the normal in percentage (i.e. deviation, variation and anomaly). The seasonal forecasts provide guidance on large-scale weather patterns over a season. Such forecasts are made three to six months in advance and updated on monthly basis. As agrometeorological sciences advance, the forecasts may be updated more frequently in the future. They often include climate forecasts for variables such as precipitation, surface air temperature, mean sea-level pressure, 500 hPa geopotential height; forecasts of tropical storm activity; and large-scale climate variability phenomena such as El Niño/Southern Oscillation (ENSO) and the Madden-Julian Oscillation (MJO) (WMO & GFCS, 2016). The LaCSA system provides seasonal bulletins to forecast average seasonal conditions over a province, based on three to six months of averaged temperature and rainfall.

The seasonal forecast bulletin is updated in the first week of each month and includes:

- Seasonal forecasts;
- Climate trend of past normal years (+30 years history);
- Agricultural climate risk forecast; and
- Climate smart recommendation for main crops.

The main crops for each province are defined based on a crop calendar that has been prepared by NAFRI, with the support of the CIAT. The system selects the crop that is most likely to be cropped in a single province automatically so that crops can change over the course of the year.

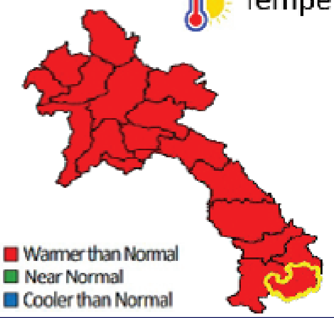
P. ATTAPU
SEASONAL FORECAST BULLETIN
[JUL~SEP / 2020]

issued on 07/01/2020

SEASONAL FORECASTS

JUL-SEP

Temperature

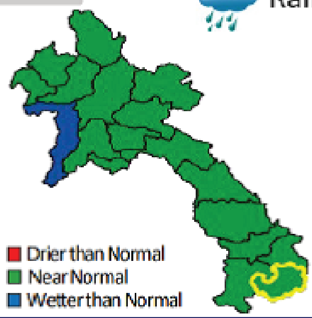


WARMER

0.6°C

27.6°C
(Normal years)

Rainfall



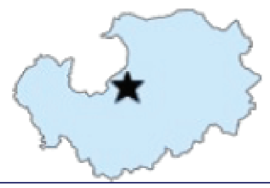
(Normal years)
439.6mm

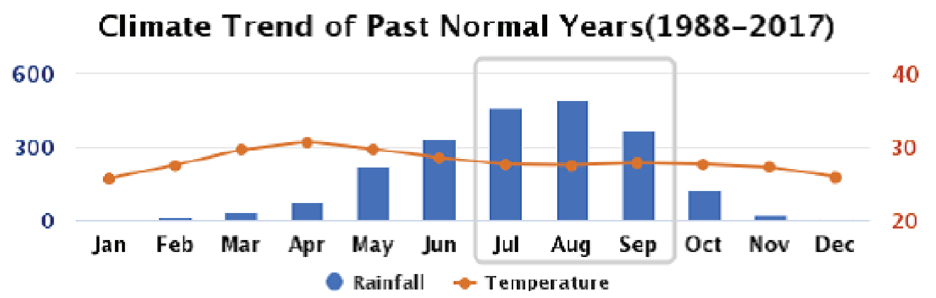
NORMAL

Based on seasonal forecast for *JUL-SEP*, **P. ATTAPU** province is expected to have an enhanced probability of **warmer temperature (70.0%)**, and **normal rainfall** compared to Normal Years.

☞ *"Normal Years" indicates average temperature and total rainfall for JUL-SEP of the past 30 years (1988-2017)*

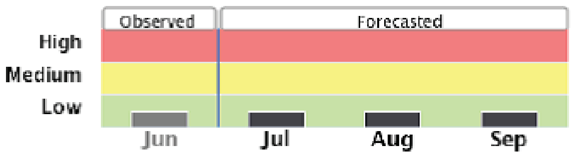
Climate Observation Point	
Name of Station	**Attapeu**



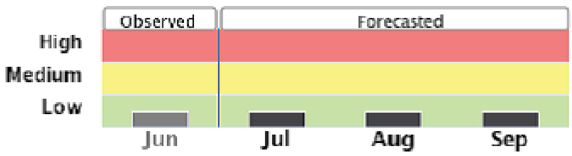


AGRICULTURAL CLIMATE RISK FORECASTS

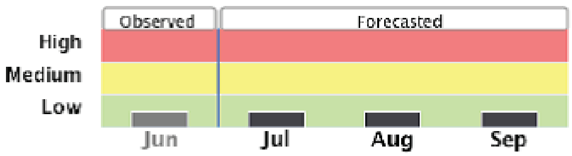
AGRICULTURAL DROUGHT



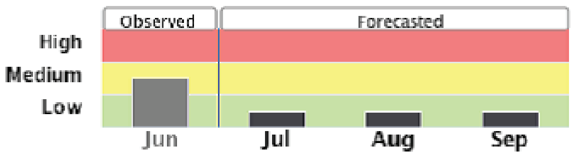
FLOODING



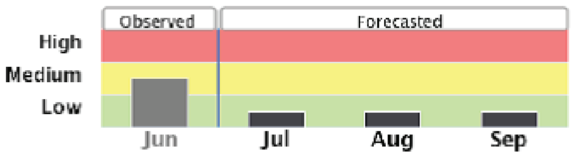
DISEASES



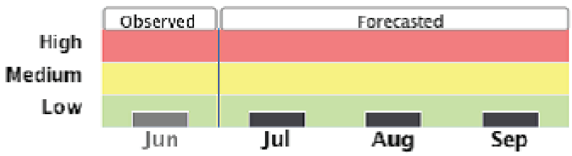
INSECT PESTS



HEAT STRESS



COLD STRESS



SEASONAL FORECAST BULLETIN

Climate Smart Recommendations for Cabbage

[FARMING MANAGEMENT]

Irrigation	☐ Water daily until plants are fully established. Water when wilting happens, or irrigate 2-3 times a week by hand or overhead irrigation. Minimize watering when plants start to develop heads.
Weeding	☐ Weed 1-2 weeks before transplanting. Continue weeding as needed. Use mulching materials, especially green manure. Place dried rice straw between plants horizontally following plot length.
Hilling Up	☐ Hill up 30 days after transplanting. Apply organic compost between rows then cover with soil together with plant base. Sidedressing of organic fertilizer is also recommended during hilling up.
Pest and Disease Management	☐ Integrated Pest Management (IPM) is recommended. Manage according to requirements of pests (insect pests, cutworm/looper/webworm, cabbage moth/white butterfly, thrips) and diseases (head rot, leaf spot, clubroot, blackleg and black rot).
CLIMATE RISK	☐ Historically, this time of the year was vulnerable to **Flooding** damage, leading to a significant yield loss, Be aware and take preventive measures if necessary.

Climate Smart Recommendations for Rainfed Rice

[FARMING MANAGEMENT]

Nutrition Management	☐ If using transplanting method, apply basal fertilized before planting. Use 200 kg/ha of 15-15-15 for sandy soils, and 150 kg/ha of 16-20-00 for clay soils. Apply 2 split of Urea (46-00-00) at 65 kg/ha as top dressing at 20 and 40 DAT for early maturity varieties, and 25 and 45 DAT for medium and late maturity varieties. If direct-seed sowing, same rate of basal fertilizer is recommended. Apply 2 split of Urea (46-00-00) at 65 kg/ha 30-35 DAT and 60-65 DAT.
Water Management	☐ Maintain water level from vegetative until maturity stage, particularly 3 weeks before after flowering.
Pest and Weed Management	☐ Monitor regularly and use pesticides only when necessary. Maintain water level regularly. If no standing water in field, control weeds until 45 days after transplanting or until soil is covered with leaves. Eliminate weeds at least 1/3 – ½ of the growing season.
SIMULATED YIELD	☐ Based on observed and forecasted weather conditions, riceyield for this season is predicted to be **Similar to Normal** years.

[PEST&DISEASE MANAGEMENT]

Bacterial Leaf Blight	☐ **On-farm monitoring:** Regularly monitor for green-yellow spot at the tip of leaves, which turns to yellow later ☐ **Non-chemical:** RD5 and RD7 are known resistant varieties.; (Before planting)Use balanced amounts of plant nutrients, especially nitrogen; Soak lime 1 kg / 5 liters of water, preferably overnight, and then apply to the water before spray 2 liters / 5 liters of water; Spray Trichogramma 1kg/ 20 liters of water; (During growth) Avoid overhead irrigation, especially during cool, wet weather.; Irrigate less frequently to keep relative humidity lower ; (After harvest)Collect and burn or bury the remains of the crop, including the stubble as soon as possible. ☐ **Chemical:** To control this disease, spray 75 g Agrimycin-100 + 500 g copper oxychloride in 500 litres of water per hectare. Spray three to four times. First spraying on appearance of the disease and otherwise as needed at intervals of ten days.; Or spray a streptomycin sulphate + tetracycline combination 300 g + copper oxychloride 1.25 kg/ha. If necessary, repeat 15 days later.
Brown Planthopper	☐ **On-farm monitoring:** Monitor for BPH presence at the bases of the plants (tillers) 30 days after transplanting at weekly intervals. At ear emergence in the field, if BPH presence exceeds three to four adults per tiller, this is usually considered a high population warranting more intensive observation and possibly chemical controls. ☐ **Non-chemical:** Varieties resistant to BPH are: IR26, IR32, IR36, IR56, IR72 and IR74.; (Before planting)Avoid staggered planting and destroy ratoons of the previous rice crops; Use a balanced dose of fertilizer. Apply urea at the rate of 100 to 150 kg/ha; Avoid dense planting by planting rice seedlings 20x20 cm apart; and Avoid unnecessary use of pesticides.; (During growth)Drain water completely from the field for a week. Then apply intermittent (weekly) irrigation to reduce the BPH population; Allow ducks to forage for BPH in rice fields; and Some beetles, bugs, and spiders can be deployed against BPH as recommended by DAFO.; (After harvest) Do not ratoon the crop, i.e. allow it to resprout and continue growing after harvest; and Plough the field after harvest, removing the stubble that would otherwise allow the BPH to continue to breed. ☐ **Chemical:** If BPH is at 5 to 10 adults/tiller to ear emergence in the field, spray the following insecticides: Thiamethoxam, Imidacloprid, Deltamethrin (4g-phase drug in 20 litres of water) or Abamectin (20 cc in 20 litres of water).

This is an initial and temporary version of the provincial level seasonal forecast. For more details and information, please contact DMH 021 510030. Please receive more information at http://www.fao.org/in-action/samis/en/ and at https://www.facebook.com/samisdmh. The online system is accessible at the web page: https://147.46.250.219:8081/

Figure 17. An example of a seasonal weather forecast bulletin (Source: LaCSA)

What is a seasonal forecast risk assessment?

Climate risk in assessment is probability of a defined hydro-meteorological hazard estimated based from prior information. The seasonal forecast risk assessment assesses the current month (observed) and the next three months (forecasted) situation of agricultural risk for decision making on crop selection, and what and when to plant. For example, farmers can use it for selecting rice varieties that resist drought. Based on the drought forecast, farmers might search for an additional water source for sowing rice during the drought period, or decide to postpone the transplanting stage if a delay in rainfall is forecasted.

The seasonal forecast risk assessment is available for drought, heat, insect pests, and major crops diseases. The seasonal forecast risk assessment or agricultural climate risk forecast is the third part of seasonal forecast bulletin which includes:

- Agricultural drought;
- Excessive rainfall;
- Diseases;
- Insect pests;
- Heat stress; and
- Cold stress.

What are Climate Smart Recommendations for crops in the LaCSA?

Climate-smart recommendations are written text suggesting the field operations that should be done in the forecasted period. The climate smart recommendations (CSR) for crops include rotating crops based on the crop calendar. Based on the season development, recommendations are available one to two crops per province per month. The CSR informed advisory services for rice, maize, banana, cabbage, cassava and coffee in Lao PDR. The CSR plays an increasingly important role in providing timely and farm-specific agricultural advisory services to farmers for more informed crop management decisions. The main crops of 18 provinces use recommendations on CSR part-produced by NAFRI and CIAT for the following phases:

- Farm management
- Variety selection
- Field selection
- Land preparation
- Nutrient management
- Maintenance
- Prevention and packing
- Seeding establishment
- Water management
- Weed management
- Climate risk
- Simulated yield
- Pest and disease management
- On-farming monitoring
- Non-chemical management
- Chemical management.

Figure 18. Farmers use pest management recommendation on the bulletin to manage on their farming in Sing district, LuangNamtha province

How to use the seasonal forecast for crop variety selection?

Seasonal forecasts are essential for the choice of crops and cultivars. The LaCSA crop calendar provides a selection of the major crops and livestock for each province. The major crops listed in the crop calendar are irrigated rice, rainfed rice, upland rice, cassava, coffee, cabbage, pumpkin, maize and banana. The presence of the crops in the bulletin depends on the crop calendar for the selected provinces in a certain month.

The LaCSA technical management guidelines list the recommended crop cultivars suitable under seasonal forecast of normal conditions, wetter than normal conditions and drier than normal conditions (Table 4).

Table 4. Recommended rice varieties for rainfed conditions based on seasonal forecast

Province	Seasonal forecasts		
	Wetter than Normal Conditions	Normal Conditions	Drier than Normal Conditions
Phongsali	TDK1_sub1, TDK1 to 11, and local varieties	TDK1 to 11, RD10, Homegnai and Kipdeo (local variety)	Early maturity varieties (kaodor) like TDK9 to 12, PGN1 to 3, Namthan 1 and some local varieties (Kainoy, Homyai & Homnoy and Kipdeo)
Luang Namtha	TDK1_sub1, TDK1 to 11, and local varieties	TDK1 to 11, Kainoy and Takaed (local variety)	Early maturity varieties (kaodor) like TDK9 to 12, PGN1 to 3, Namthan 1 and some local varieties (Kainoy, Homyai & Homnoy and Kipdeo)
Bokeo	TDK1_sub1, TDK10, and RD 6 to 8	TDK1 to 11, RD6 to 15, TSN1 to 5 and PNG1 to 3	Early maturity varieties (kaodor) like TDK9 to 12, PNG1 to 3, RD10 to 15 and local varieties

Province	Seasonal forecasts		
	Wetter than Normal Conditions	Normal Conditions	Drier than Normal Conditions
Oudomxai	TDK1_sub1, TDK1 to 11 and local varieties	TDK1 to 11, and local long maturity	Early maturity varieties (kaodor) like TDK9 to 12, PNG1 to 3, RD10 to 15 and local varieties
Luang Prabang	TDK1_sub1, TDK10, and RD6 to 8	TDK1 to 12, VT450-1&2, RD6 to 8 and local varieties	TDK9 to 12, RD10 and Namthan1
Houaphan	TDK1_sub1, TDK10, XBF2 and RD6 to 8	TDK1 to 10, XBF2 and Kainoy (popular local varieties)	Early maturity varieties (kaodor) like TDK9 to 12, PNG1 to 3, RD10 to 15 and local varieties
Xaignabouli	TDK1_sub1, TDK10, and RD6 to 8	TDK1 to 11, VT450-1 and 2, RD6 to15 and local varieties	Early maturity varieties (kaodor) like TDK9 to 12, RD10 and Namthan1
Xiang Khoang	TDK1_sub1, TDK10, and RD6 to 8	TDK1 to 12, TSN1 to 5, PNG1 to 3, RD6 to15 and Kainoy	Early maturity varieties (kaodor) like TDK9 to 12, PNG1 to 3, RD10 and RD15
Xaisomboun	TDK1_sub1, TDK10, and RD6 to 8	TDK1 to 11, VT450-1 and 2, RD6 to15 and local varieties	Early maturity varieties (kaodor) like TDK9 to 12, RD10 and Namthan
Vientiane and Vientiane Capital	TDK1_sub1, TDK4 to 10, XBF1 to 4 and RD6 to 8	TDK1 to 11, VT450-1 and 2, Homsungtong, XBF1 to 4, RD6 to15 and local varieties	Early maturity varieties (kaodor) like RD5, TDK15, and local varieties
Bolikhamxai	TDK1_sub1, TDK10, XBF1 to 4 and RD6	TDK1 to 12, VT450-1 and 2, TSN1 to 5, PNG1 to 3 and RD6 to15	Early maturity varieties (kaodor) like TDK9 to 12, PNG1 to 3, RD10 and RD15
Khammouan	TDK1_sub1, TDK10, XBF1 to 4 and RD 6	TDK 1 to 12, VT450-1&2, TSN1 to 5, PNG1 to 3 and RD6 to15	Early maturity varieties (kaodor) like TDK 9 to 12, PNG1 to 3, RD10 and RD15
Savannakhet	TDK1_sub1, TDK10, XBF1 to 4 and RD 6	TDK1 to 11, Homesavan, TSN1 to 11, PNG1 to 6, and RD6 to12	Early maturity varieties (kaodor) like TDK11, PNG1 to 3 and XBF2 and local varieties
Salavan	TDK1_sub1, TDK10, XBF1 to 3 and RD6	TDK1 to 11, TSN1 to 11, PNG1 to 6, and XBF1 to 4	Early maturity varieties (kaodor) like TDK8, PNG5 XBF2 and local varieties
Xekong	TDK1_sub1, TDK10, and RD6	TDK1 to 11, VTE450-1 and 2, TSN1 to 11, PNG1 to 3, and RD6 to 10	Early maturity varieties (kaodor) like TDK9 to 12, PNG1 to 3, RD10 and KDML105
Champasak	TDK1_sub1, XBF1 to 4, RD6 and KDML105	TDK1 to 11, PNG1 to 6, TSN1 to 11, XBF1 to 3, KDML105 and RD6 to 12	Early maturity varieties (kaodor) like TDK11, PNG1 and 2, XBF2 and local varieties
Attapeu	TDK1_sub1, XBF2, RD6, TDK10	TDK1 to 12, VTE450-1 and 2, PNG1 to 6, TSN1 to 11 and RD6 to 12	Short maturity varieties (kaodor) like Thadokkham 9, Thadokkham 11, Thadokkham 12, Phongnam 1, Phongnam 3, and Namthan 1. Medium or light sensitive varieties can also be used in lower fields. Thadokkham9, Thadokkham11, Thadokkham12, sebangfay4, Namtan1, RD10, RD15, Phongnam3, Kao hommali105, and Kao peunmeung (early maturity varieties)

Source: *Table of rice varieties recommendation produced by NAFRI and CIAT for the provinces in Lao People's Democratic Republic and used in LaCSA.*

Seasonal forecasts also help farmers make decisions for crop management to reduce the impact of losses if a drought or flood is predicted. They also help decide the planting date and are used to forecast when and where disease outbreaks are likely to occur. Land preparation, method of cultivation and management of plant nutrients, water, weeds, insect pests and diseases are recommended in the LaCSA, and these recommendations are partly based on the seasonal forecast.

Why is a seasonal forecast important for crops?

Seasonal forecasts (Figure 17 presents the monthly bulletin) help farmers plan the next cropping season, developing an appropriate crop calendar and assess potential strategies against weather extremities. Effective use of the seasonal forecasts and related agrometeorological advisories can minimize impacts from climate risks in crop production.

For example, the main factors that have the strongest influence on paddy rice production are air temperature, soil temperature, rainfall and solar radiation.

- High air temperature during tillering can reduce the rice yield.
- High air temperature at night will increase the respiration, therefore decreasing the yield.
- Low water availability in the early days of the crop increases weed infestations.
- Low water availability at the reproductive phase decreases rice productivity.
- Low level of solar radiation will lead to a low rate of photosynthesis. The decreases photosynthesis and increased respiration decreased net photosynthesis, reducing the crop yield. The net photosynthesis per day is calculated as the total photosynthesis less the respiration. Mathematically,
    - o *Net Photosynthesis = Photosynthesis - Respiration.*

Farm management decisions need to be adjusted based on the seasonal weather forecast, particularly for rainfall below normal rainfall conditions (Table 5).

Table 5. *Management decisions by farmers using seasonal rainfall forecasts*

If forecast is below normal rainfall	If forecast is normal to above normal rainfall
Plant drought tolerant crops species like cassava, sweet potato, sesame and cotton and drought resistant varieties of rice	Chose the crop species and varieties that give the highest returns. Plant flood tolerant varieties of rice in flood prone areas.
Decrease seed rate by 25 to 50%	Use normal seed rate
Adjust planting time as per the forecast of onset of the rainfall	Plant in the normal time
Use smaller quantity of labour to save costs	Use full quantity of labour to maximize production
Use smaller quantity of chemical fertilizers and more organic matter	Apply full dose of chemical fertilizers
Adopt water conservation technologies such as subsurface irrigation, drip irrigation and mulching where possible	Improve terraces and construct ridges/dykes to reduce erosion and surface run-off. Also, adopt rainwater harvesting to store water for the next season crop

Source: Authors

Seasonal forecast crop advisory – How to use it for the planting period?

The bulletins are sent to the Lao National Radio (LNR), DAFO and village public announcement newsreaders to inform the farmers about weather information a few months before the season. Farmers can therefore plan what and when to plant during this coming season. For example, they can change the variety to one that is drought resistant, or postpone the planting date to a suitable time.

Seasonal forecast crop advisory – How to use it for the growing period?

Farmers can use the advisory (Figure 17 and others) by following the recommendations for farming management to improve soil nutrient maintenance, on-farm monitoring, water level management in each stage, weed control, climate risk management, preventing loss and packaging fruits. They can also choose how they are going to manage pest and disease by using chemical or non-chemical methods.

Seasonal forecast crop advisory – How to use it for the harvest period?

During the harvesting period, farmers can use the advisory to define the appropriate harvesting date to avoid production damage from climate stress events. If the seasonal forecast bulletin forecasts that it will be wetter/higher rainfall in any area, farmers be alert for stress event announcements from DMH and Thai news to plan for harvesting on a suitable date.

Problems related to seasonal forecasts

- The seasonal forecasts cannot give information on day-to-day weather information and extreme events.
- They are not specific enough for the needs of local scale agricultural decision-making due to low spatial resolution.
- The forecasts lack specific information on intra-seasonal rainfall distribution.
- Poor distribution of the forecast due to lack of communication channels. The forecast often reaches farmers when the event has already occurred, or without allowing enough time to modify the management (Mafongoya & Ajayi, 2017).
- Poor interpretation and communication of forecasts can lead to misunderstanding and low dissemination rates.
- Another problem is farmers' inability to respond to forecasts due to their lack of access to seed, fertiliser, labour and credit, which would allow them to make adjustments in relation to the expected seasonal climate.
- Farmers can take precautions based on the seasonal forecasts, but the costs of such precautions must be weighed against the savings that would be made if the unwanted climate event occurred. Users of the seasonal forecasts could, for example, be more actively engaged in economic evaluation assessments (Richardson, 2000) to get an idea of the potential benefits and costs in preparing for unfavourable weather situations.

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Download the latest seasonal forecast bulletin and describe its three parts.

Activity 2: Download older seasonal forecast bulletin and compare it with the latest one.

Activity 2: Identify what a rice farmer can do when below-normal rainfall is forecast.

Lesson A8: Weekly forecast bulletin

Learning objectives

The trainees will be able to:

a. explain the importance of weekly forecasts in agriculture; and
b. propose farm decisions based on the weekly forecasts.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Example of a weekly weather forecast bulletin with recommendations, downloaded from: http://147.46.250.219:8081/makeWeeklyAgrometBulletin.do

An example of weekly forecast is available in Figure 19. However, the trainer should download various bulletins. First, the training should cover multiple crops, including the most important crops in the area of the training. Also, the training should be based on multiple bulletin for various periods of the year such us:

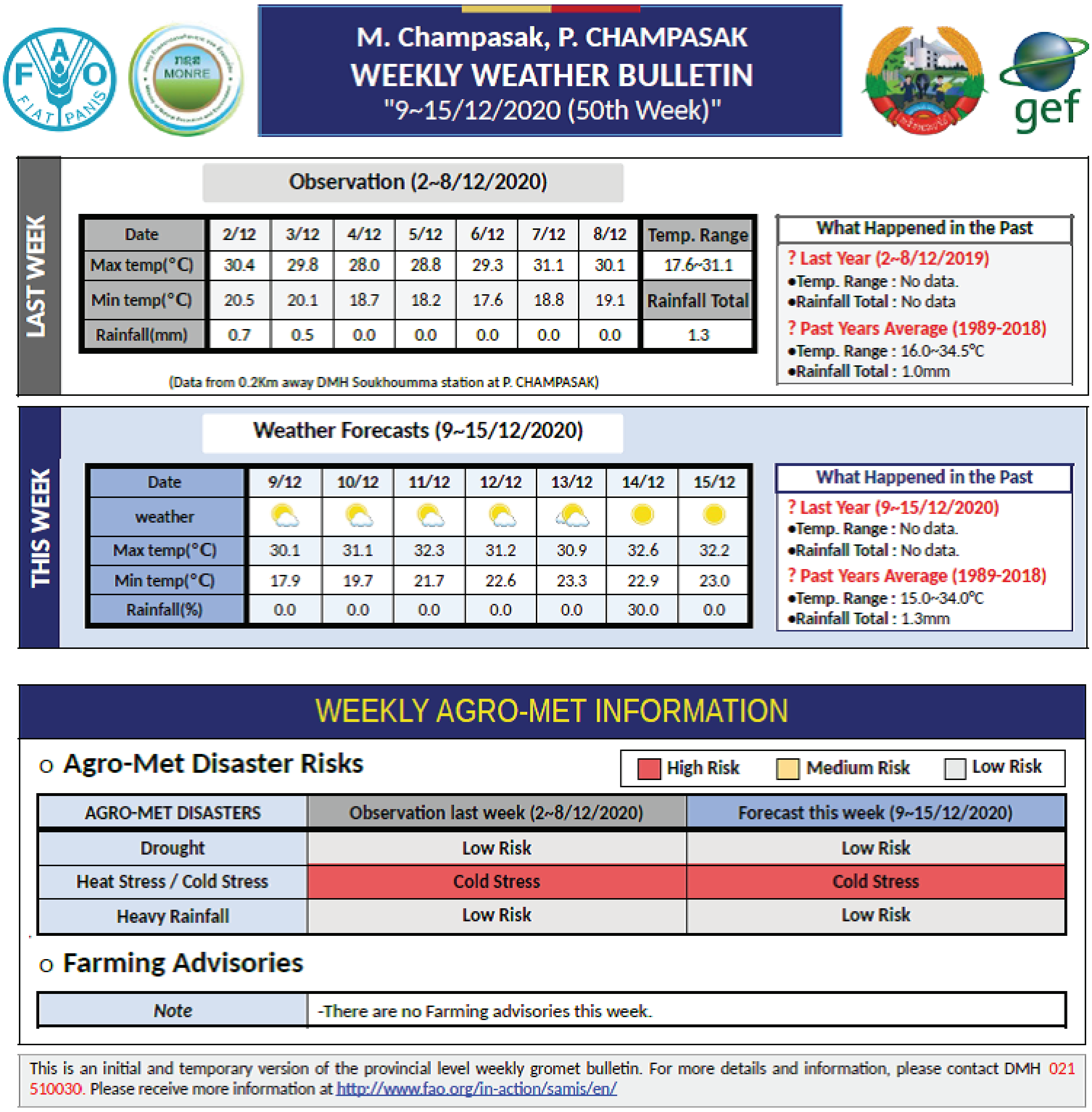
- Crop varieties selection period;
- Planting period;
- Harvest period;
- Periods with risks of cold and heat shocks.

What is a weekly forecast?

The weekly weather forecast includes rainfall, and minimum and maximum temperature weather observations for the past seven days and forecasts for the next seven days.

A weekly forecast is produced by summarising the main weather parameters such as temperature, relative humidity, and rainfall for a week, expressed as departures from the week's average climate values. The weekly weather forecast is disseminated to farmers to provide forecasts and advisories in advance.

The farmers use the weekly forecasts for deciding farm practices such as water control in the paddy field. The forecast informs when and where extreme weather events and pest/disease risks are likely to occur this week. It also helps the farmers to know whether some actions are necessary to reduce the impact of losses if a drought or flood is forecast. The farmers should focus on dates when measurable rain forecast to be over 80 percent and on the highest/lowest temperatures.



M. Champasak, P. CHAMPASAK
WEEKLY WEATHER BULLETIN
"9~15/12/2020 (50th Week)"

LAST WEEK

Observation (2~8/12/2020)

Date	2/12	3/12	4/12	5/12	6/12	7/12	8/12	Temp. Range
Max temp(°C)	30.4	29.8	28.0	28.8	29.3	31.1	30.1	17.6~31.1
Min temp(°C)	20.5	20.1	18.7	18.2	17.6	18.8	19.1	Rainfall Total
Rainfall(mm)	0.7	0.5	0.0	0.0	0.0	0.0	0.0	1.3

(Data from 0.2Km away DMH Soukhoumma station at P. CHAMPASAK)

What Happened in the Past
? Last Year (2~8/12/2019)
•Temp. Range : No data.
•Rainfall Total : No data
? Past Years Average (1989-2018)
•Temp. Range : 16.0~34.5℃
•Rainfall Total : 1.0mm

THIS WEEK

Weather Forecasts (9~15/12/2020)

Date	9/12	10/12	11/12	12/12	13/12	14/12	15/12
weather							
Max temp(°C)	30.1	31.1	32.3	31.2	30.9	32.6	32.2
Min temp(°C)	17.9	19.7	21.7	22.6	23.3	22.9	23.0
Rainfall(%)	0.0	0.0	0.0	0.0	0.0	30.0	0.0

What Happened in the Past
? Last Year (9~15/12/2020)
•Temp. Range : No data.
•Rainfall Total : No data.
? Past Years Average (1989-2018)
•Temp. Range : 15.0~34.0℃
•Rainfall Total : 1.3mm

WEEKLY AGRO-MET INFORMATION

o Agro-Met Disaster Risks

High Risk | Medium Risk | Low Risk

AGRO-MET DISASTERS	Observation last week (2~8/12/2020)	Forecast this week (9~15/12/2020)
Drought	Low Risk	Low Risk
Heat Stress / Cold Stress	Cold Stress	Cold Stress
Heavy Rainfall	Low Risk	Low Risk

o Farming Advisories

Note	-There are no Farming advisories this week.

This is an initial and temporary version of the provincial level weekly gromet bulletin. For more details and information, please contact DMH 021 510030. Please receive more information at http://www.fao.org/in-action/samis/en/

Figure 19. Example of a weekly forecast (Source: LaCSA)

Weekly Bulletin

The weekly bulletin (Figure 19) is produced automatically by the LaCSA system at district level (more than 140 districts) and includes the following information:

- Weather forecast compared to observed data from the previous week.
- Agrometeorology advisory forecast for drought, floods, pest, disease, heat and cold compared to the previous week.
- Climate smart recommendations list crop varies for the district and based on the cropping season.

Weather forecast

Weather forecasts is a main element of climate services for farmers and can be used for a number of purposes. Forecasts of temperature and precipitation are important to agriculture, and therefore to traders within commodity markets. Temperature forecasts are used by utility companies to estimate demand over coming days. Farmers rely on weather forecasts to decide what work to do on any particular day. For example, farmers can use it to determine what to plant during this season and when farmers should harvest their product to avoid significant damage from climate change.

Weekly disaster risk (drought, heat, insect pests and diseases in major crops)

Climate risk in assessment is probability of a defined hydro-meteorological hazard estimated based from prior information. The agrometeorology disaster risks include observations of the last week and forecasts for this week for drought, heavy rainfall, heat or cold stress, and major crop insect pests and diseases. The disaster risk advisory is presented as push up alert to the app users, and allow to have early information on the following week. The early warning system help to reduce economic losses and mitigate the crop and livestock damages from a disaster, by providing information that allows farmers to make effective anticipatory actions.

Weather-based farming advisory

Climate-smart recommendations are written text suggesting the field operations that should be done in the forecasted period. The weather-based crop advisory are rotating in LaCSA based on the crop calendar and includes a general introduction on crop advisory and how crops should be managed this week. The crop advisory is based on real crop stage from the LaCSA system and provides advice on how to maintain crops, use nutrients, manage water, and monitor and manage pests and diseases.

Weekly forecasts helps in farm operations

Farmers can benefit in many ways from the weekly forecast. The forecast helps farmers to plan their farm operations, including:

- Short-term planning for land preparation: ploughing land before rainfall to allow water to infiltrate in the farmland during the dry season, ploughing land after rainfall for rice transplanting.
- Short-term planning for seedling preparation: preparing seedling beds and broadcasting seed in time to secure good germination.
- Short-term planning for planting: transplanting, direct seeding of rice using the dry method just before rainfall, direct seeded rice using the wet method after the rainfall.
- Water management: irrigation of crops based on rainfall forecast.
- Application of fertilizers: based on temperature, moisture conditions and rainfall forecast.
- Disease and pest spread: disease and pest development depends on weather conditions and alerts are provided in LaCSA risk assessment.
- Short-term planning for crop harvesting: when no rainfall is forecast.

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Observe the below weekly weather forecast and answer the following questions.

- When and where is the weekly weather bulletin issued?
- Is the forecast temperature normal, above normal or below normal?
- Is the forecast rainfall normal, above normal or below normal?
- What are the levels of risk for water control, extreme events, insect pests and diseases?
- If risk is medium or high, what are the recommendations?

[13]This lesson is not yet tested in Lao People's Democratic Republic.

Lesson A9: Weather based forecasting of insect pests and diseases in major crops[13]

Learning objectives

The trainees will be able to:

a. describe interactions between agrometeorological variables and management of agricultural insect pests and diseases; and
b. explain forecasts of insect pests and diseases based on weather forecast data.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Example of a LaCSA seasonal or weekly weather forecast bulletin with pest and disease recommendations for multiple crops

Weather based forecasts of pests and diseases

Weather parameters play a major role in growth and development of crop diseases and insect pests. Diseases and insects have an optimum temperature range and humidity in which they grow rapidly. Each insect has a minimum and maximum threshold temperature and no development occurs when temperatures go below the minimum threshold, or above the higher threshold. These threshold values are employed in forecasting insect attack and disease appearance on crops during the growing season.

Reliable disease and insect predictions help farmers use better control measures and reduce unnecessary environmental pollution from pesticides and prevent crop yield losses (Seijo-Rodrıguez et al., 2018). Hourly and daily data on leaf wetness, temperature and relative humidity obtained from agrometeorological stations can be used to estimate insect pests and disease incidence and determine appropriate timing for pesticide applications (FAO, 2019).

Weather conditions for disease prevalence

The late blight is more likely to infect plants with increased moisture. However, powdery mildew species tend to thrive in conditions with lower moisture. Host crops with canopy-holding moisture in the form of leaf wetness or high canopy relative humidity for longer periods, increase risk from pathogen infection (Coakley et al., 1999).

With each 1℃ warming, late blight would occur 4 to 7 days earlier, and the susceptibility period extend by 10 to 20 days (Kaukoranta, 1996). This would translate into an additional 1 to 4 additional fungicide applications for potato farmers – increasing both farmer costs and environmental risk.

A warmer winter lowers the mortality of insects, increasing their populations (Harrington et al., 2001). Rising temperatures could result in more insect species attacking more hosts in temperate climates (Bale et al., 2002). Temperature change also affects the relations of the pests to their predators and parasites (Awmack et al., 1997). However, soil-borne insects are less affected by air temperature change due to the insulating properties of the soil (Bale et al., 2002).

Precipitation also affects disease, pests, insect pest predators, and parasites. Some insects, such as pea aphids, are not tolerant of drought (McVean et al., 2001). High humidity can encourage fungal pathogens of insects.

Forecasting potato blight

Predictive models for potato late blight (caused by *Phytophthora infestans*) show that the fungus infects and reproduces most successfully during periods of high moisture that occur when temperatures are between 7.2°C and 26.8° (Wallin and Waggoner, 1950). Simple meteorological rules related to the life cycle of *P. infestans* can be used so that measurement of rainfall, temperature and humidity over 12–48 h periods can be used to predict its spore production (“critical periods”) and possibly subsequent periods when the risk of infection is greatest (WMO, 2012).

This method can predict critical periods using the following general rules:

a. Minimum temperature >10°C for a period of between 12 to 48 hours;
b. Relative humidity >90 per cent for the same time period;
c. Rainfall in the period following (4 hours to 10 days later).

Evidence of disease is expected between 7 and 21 days after a critical period has been predicted, and a suitable crop protection strategy can be put in place (WMO, 2012, p 9-12).

Forecasting rice pests

Rice production is affected by several insect pests. Rice yield loss due to brown planthopper (BPH) (*Nilaparvata lugens)* in India is estimated to be 10 to 70%, yellow stem borer (*Scirpophaga Incertulus*) 25 to 30%, gall midge (*Orseolia oryzae*) 15 to 60%, leaf folder (*Cnaphalocrocis medinalis*) 10% and other pests 25% (Krishnaiah & Varma, 2012).

Continual weather monitoring and accurate forecasting of pest populations during the crop growing period can help prevent yield loss. For example, temperature, rainfall and evening relative humidity influence BPH (Yadav et al., 2010; Prasannakumar and Chander, 2014). The BPH existence depends on pest, hosts, physical environment (rainfall, temperature, humidity), and biotic environment (natural enemies, competitor organisms) (Susanti et al., 2010). They reported that the climate factors that have a coefficient of correlation of greater than 0.4 with the BPH infestation area were:

- rainfall,
- maximum temperature,
- maximum temperature 2 weeks before the BPH incidence,
- minimum temperature,
- minimum temperature 2 weeks, 4 weeks and 6 weeks before the BPH incidence,
- maximum humidity,
- minimum humidity,
- minimum humidity 2 weeks before the BPH incidence,
- average humidity, and
- average humidity 2 weeks before the BPH incidence (Box 5).

Box 5: Prediction of brown planthopper (BPH) attack

The extent of BPH attack area can be predicted based on climate information using the equation as follows (Susanti et al., 2010):

$Log\_LS = 10.44 - 0.32\ T_{min-2} - 0.00112\ RH + 0.182 T_{max-1} - 0.27\ T_{min}$, or

$Log\_LS = 11.05 - 0.32\ T_{min-2} + 0.209\ T_{max-1} - 0.33\ T_{min}$

Where, Log_LS is the BPH attack areas in ha.

T_{min-2} is the minimum temperature with two weeks lag,

T_{min} is the minimum temperature for the same week,

T_{max-1} is the maximum temperature with one week lag,

RH is the relative humidity.

The coefficient of multiple determination (R^2) is 33.33%, meaning that one-third of the pest occurrence variations can be determined by this equation.

Source: Susanti et al., 2010.

Similarly, temperature, rainfall, and relative humidity influence white-backed planthoppers' populations (*Sogatella furcifera*) during the rainy and summer seasons (Win et al., 2010). Timely analysis of climatic factors can forecast these planthoppers and enable farmers to prepare.

LaCSA forecast of insect, pests and diseases

LaCSA include a vast variety of recommendations on pest and diseases. Figure 20 presents a list of LaCSA examples. Details vary with the crop and the season. The seasonal forecast has a detailed list of recommendation for multiple crops pest and disease that depend on local crop calendar, temperature, and relative humidity.

Climate Smart Recommendations for Rainfed Rice

[FARMING MANAGEMENT]	
Water Management	☐ Maintain water level from vegetative until maturity stage, particularly 3 weeks before after flowering.
Pest and Weed Management	☐ Monitor regularly and use pesticides only when necessary. Maintain water level regularly. If no standing water in field, control weeds until 45 days after transplanting or until soil is covered with leaves. Eliminate weeds at least 1/3 – ½ of the growing season.
[PEST&DISEASE MANAGEMENT]	
Stemborers	☐ **On-farm monitoring:** Female moths can be seen easily during the daytime on the leaf blades of rice plants while males remain hidden deep in the canopy. Egg masses can also be seen on the leaf blades. Larvae and bore holes are not visible. Deadheart and whitehead damage symptoms are easily visible, particularly whiteheads at the flowering to milky stages due to their high contrast against the green canopy. ☐ **Non-chemical:** The resistant varieties include ASD16, ASD20, Birsa Dhan 201, Chandina, Chianan 2, Co45, CR 712-3-38, IR36, IR72, IRSA69, IRSA76, Majhera 7, Paichung 16, Ptb 10, Ratna, Su Yai 20, TKM 6, TNAU90012, TNAU90094 and WC1263D.; (Before planting)Handpick and destroy egg masses in the seedbed and during transplanting; Raise the level of irrigation water periodically to submerge the eggs deposited on the lower parts of the plant; Before transplanting, cut the leaf tops to reduce carry-over of eggs from the seedbed to the field; and Ensure synchronous planting ; (During growth)Encourage using biological control agents recommended by DAFO; Apply nitrogen fertilizer using the recommended rates and times of application ; (After harvest) Remove the larvae in the stubble and the stubble and volunteer rice intrusion, plough and flood the field ☐ **Chemical:** Deadheart and whitehead symptoms are visible one to two weeks after larval penetration of the rice stem. Because the control of older larvae in the stem is more difficult, sprays targeting the peak periods for moth and egg deposition are more effective than sprays after damage symptoms have appeared. ; Spray with Thiamethoxam or Imidacloprid (4g-phase drug in 20 litres of water).

Climate Smart Recommendations for Coffee

[FARMING MANAGEMENT]	
Fertilization Management	☐ For newly transplanted seedlings, for 1st year, use 16-8-8 at 30 g/plant and 46-00-00 at 40 g/plant twice a year; for 2nd year, use 16-8-8 at 60 g/plant twice a year; for 3rd year, use 15-15-15 at 90 g/plant twice a year; for 4th year, use 13-13-21 at 120 g/plant twice a year; for 5th year, use 13-13-21 at 150 g/plant twice a year. Chemical fertilizer 120-120-60 (N-P-K) should be used for non-bearing coffee trees and 120-60-120 for bearing coffee trees.
Canopy Pruning and Management	☐ Maintain appropriate number of plants (2-3). Prune twice a year at post-harvest and onset of rainy season before fertilizing. Do not prune at the first year or after 7 years. Monitor productivity level after 6 years. If yield declined by 30% compared to previous season, cut old tree 30 cm from soil surface. Keep one branch to stimulate development of new sprouting.
Weed and Pest Management	☐ Remove weed 1 month after transplanting, and 3-4 times a year. Prune and cut dead and infected branches to prevent and reduce disease damage. Consult local agricultural technicians for appropriate prevention methods.
Harvesting	☐ Harvest should be done 2-3 times a day every 15-20 days.
Processing System	☐ Maintenance should be done using wet, dry, and semi-wet methods.
CLIMATE RISK	☐ Historically, this time of the year was vulnerable to **Low Temperature** damage, leading to a significant yield loss, Be aware and take preventive measures if necessary.

Climate Smart Recommendations for Maize

[FARMING MANAGEMENT]	
Water Management	☐ During dry season production, apply water daily during first 10 days through furrow irrigation until seed germinates. At growing stage (10-50 DAS), water once or thrice a week. At flowering stage (50-80 DAS), water every 3 days to avoid water stress. At harvesting stage (>80 DAS), do not water.
Weed and Pest Management	☐ Remove weeds 15-20 DAS, and 25-30 DAS before applying Urea fertilizer.If using herbicide, dissolve it per 300 liters of water (or depending on specific guidelines), and spray 1-2 days after sowing to allow germination. Use proper pesticide types and quantities. Plant hybrid maize in between rows as protection. Remove and burn plants with any diseases.
[PEST&DISEASE MANAGEMENT]	
Fall armyworm	☐ **On-farm monitoring:** The FAW caterpillar attacks all stages of maize, i.e. seedling, vegetative, tasseling and grain filling stages. Check for small to large irregular and elongated holes on the leaves. Window panes of translucent patches are caused by small FAW in the first to second instars while large irregular elongated holes on leaves are caused by bigger FAW in the third to sixth instars. Partial resistance is present in some sweet corn varieties but is inadequate for complete protection. ☐ **Non-chemical:** (Before planting)Use sex pheromone traps for monitoring populations of fall armyworm in the field. Destroy the eggs, larvae and pupae in the crop residues after previous harvest by burying the plant residues deep in the soil (at least 12 cm deep). ; (During growth)Probably the most practical option for small farmers is simply to monitor fields carefully and crush egg masses and young larvae. Lime, soap, ash, sand, sawdust or dirt can be placed into whorls. Sugared water can be sprayed into whorls to attract predatory ants. Neem biocide (Azadirachtin) can be used as a foliar spray (acts as an antifeedant and insect growth inhibitor); and These treatments must be applied at the early larval stages. ; (After harvest)Deep tillage and removal of plant residue after harvest may interfere with FAW activity. ☐ **Chemical:** If 10 out of 50 randomly selected maize plants are affected, pesticides must be sprayed early in the morning before 10am or in the late afternoon/early evening from 4 to 7pm because FAW actively feeds at night.; Use pesticides with active ingredients: Spinetoram, Indoxacarb and Chlorantraniliprole are most effective for controlling older larvae. Emamectin benzoate 5% (5g-phase drug in 100 litres of water) can also be used.

Figure 20. *Climate smart recommendations with pest and disease recommendations for rice in Savannakhet in October 2020, coffee in Champasack in December 2020, and maize in Xieng Khouang in August 2020.*
(Source: LaCSA)

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Identify the rice diseases and insect pests affected by humidity and rainfall.

Activity 2: Using weekly T_{min} and T_{max} data from LaCSA for the current and the last two weeks, estimate the possible areas that would be affected by BPH.

Activity 3: Download multiple LaCSA bulletins from multiple periods and compare the pest and disease outbreaks for multiple crops.

[14] This lesson is not yet tested in Lao .

Lesson A10: Indigenous knowledge and climate information[14]

Learning objectives

The trainees will be able to:

a. discuss indigenous knowledge as a tool for weather forecasting; and
b. assess the reliability of indigenous forecasting in agriculture.

Materials required

- Flip Chart Paper
- Markers
- Projector

Indigenous knowledge

Science is unable to predict the duration and distribution of seasonal rainfall reliably. Integration of scientific forecasts with indigenous knowledge (IK) might allow for making some deductions in this regard. IK is a combination of local and traditional knowledge developed by the community unique to a culture or society. It passes from generation to generation, usually by word of mouth and cultural rituals and provides locally developed problem-solving strategies. However, this body of knowledge is often abstract and under-utilized in the development process due to difficulties in collection and translation. The IK is tacit knowledge represented by individual or group experience and expertise, but rarely documented and scientifically verified.

Farming with indigenous knowledge

Farmers make decisions related to farm management practices based on their accumulated experience and other quantitative and qualitative information available to them. Local farming systems are developed over generations for field practice, and its evolution is continuously integrating changing environmental and socio-economic conditions. Farming practices are fine-tuned at a micro-agroecological zone (AEZ) level by learning by doing and using IK to minimise crop failure risk.

Indigenous knowledge of weather information

Farmers are the experts on practical solutions in their own farm situations: involving them in the application of scientific weather forecasting can help better meet their needs. Farmers can report their observations about local weather and climate which may be useful for agrometeorologists to understand the needs of the farmers. The farmers can also relate their practices and technologies they adopt when there are weather-related problems like extreme weather events.

The IK can help in development investigation process such as:

- How the local cropping system has evolved over years?
- Why farmers are adopting certain species and varieties of crops in the location?
- Why farmers have developed certain practice of irrigation?
- How can farmers use modern weather forecasts in conjunction with their IK?

IK about Climate Information

Farmers integrate their experiences about their climate conditions, weather events and natural resources in their farming practices. However, the IK is not expressed in quantitative terms. It is related to specific micro-climatic observations and qualitative changes observed over the years. In many cases, IK describes phenomena correctly, but it can draw conclusions that tend to be inaccurate. Nevertheless, IK offers the basis for new observations and helps to arrive at more accurate conclusions (FAO, 2019).

Embedding IK into Agrometeorological Tools

The IK on agrometeorology is an integral part of every local community or society's culture and history. Building communication approaches on existing IK of weather and climate are essential to developing agricultural advisory services for vulnerable communities.

The IK can be combined with modern climate information to support farm practices and an effective communication system for backing informed decision-making of the farmers. Farmers generally blend their IK with extension advice in farming, such as adding local forecasting knowledge to environmental observations and spiritual traditions (Roncoli

[15] Indigenous technology knowledge for watershed management in upper north-west Himalayas of India (GCP/RAS/161/NET) http://www.fao.org/docrep/X5672E/x5672e00.htm#Contents.

The IK-based forecasts mainly consider rainfall characteristics relevant to farming practices such as time of onset, duration, and rainfall distribution. The traditional systems of short-term weather forecasts by farmers are based on sky colour, or development of specific living organisms and other local observations. Farmers examine seasonal rainfall based on the number, type, and timing of rains. Long-term beliefs are developed based on the use of environmental indicators, such as:

- timing and abundance of fruit production of specific local trees;
- behaviour of insects and birds;
- weather during moon period changes and their significant impact on the new moon period;
- seasonal forecasts based on specific pre-season climatic conditions; and
- specialised "prediction" knowledge and claims and beliefs of direct command over rains.

Climate variability has weakened farmers' confidence in IK-based forecasts of rainfall patterns. Farmers' forecasts may differ from the scientific ones.

Farmers recognize that the same rainfall amount may have different implications for different crop species according to when and how the rainfall occurs. Crop water needs depend on species and phenological stages. The farmers' forecast is subjective, based on their perception about effects on crop stand and yield. They use behaviour of plants, animals, insects and meteorological and astronomical indicators. For example, in Zimbabwe, ducks flapping wings frequently and frogs croaking profusely indicate imminent rains (Tanyanyiwa, 2017). In Lao PDR, if cicadas (*Ambragaeana stellate*) call for several consecutive days, this is taken as an indicator of a prolonged drought, and if ants move to higher places this is an indicator of potential flood (UNDP, WREA & GEF, 2009).

Farmers rely more on IK as it works well with their culture and has been tested over the years in a language they understand (Makwara, 2013). But the reliability of such predictions is changing due to increasing variability in climate. Smallholder farmers in rainfed areas take risks on raising rice nursery when information on rainfall onset is not available. Farmers also have to choose whether to dry plant before the rains start, or to wait for adequate soil moisture and this choice is challenging due to lack of rainfall forecasts. Then they use their IK to decide.

Local knowledge is self-explanatory: knowledge held locally, by local people. This is more complex than it may appear[15], for example,

- IK may be generated locally and refer to local situations and circumstances.
- It may originate from elsewhere but be locally adapted to match local circumstances.
- It is often the product of many minds spread over generations and geographical areas, which is added to, or adapted as it develops over time.
- Many indigenous practices are spread across many countries, regions, or even other parts of the globe.

The IK is a crucial component that must be integrated into agrometeorological data and information collected at the farming level for climate-responsive farming management approach. Local people believe in IK, but its reliability is yet to be tested.

IK and changing risks

Farmers understand the risks and uncertainties of climate at their location and optimize the management practices based on years of experience. However, Selvaraju (2012) explain that growing demand, changing climatic conditions, intensification and spread of agriculture to marginal production environments warrants improved climate risk management and decision support systems to enable appropriate choice of practices and strategies to match the current and future climate risks.

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: List indigenous knowledge that predicts imminent rainfall.

Activity 2: Rank the indigenous knowledge of forecasting the rainfall based on their reliability for use in agriculture.

Activity 3: Find past observations of rainfall and other extreme events from a nearby agrometeorological station and compare the observations with the indigenous knowledge about the weather forecasts and the actual events that happened, based on the memories of the participants.

Lesson A11: Measurement of growing degree days and heat use efficiency (especially for facilitators, researchers and extension workers)

Learning objectives

The trainees will be able to:

a. describe the growing degree days and its relation to crop phenological stages; and
b. estimate different heat supply units.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Laptop

Growing Degree Days

Temperature is the most crucial growth determining factor among the various weather elements like sunshine hours, rainfall, wind velocity and relative humidity.

The GDD is a measure of heat accumulation that farmers can use to predict crop and insect pest development rates. It can be used for predicting the phenology and crop yield such as how long it takes for a flower to bloom, a crop to reach maturity, or an insect pest to complete its life cycle.

Each plant or insect has its own heat requirement to complete a stage. Higher GDD accumulation than last year indicates earlier development of crops and insect pests during the present cropping season. If the GDD is lower, it takes a longer time for crop maturity and incidence of insect pests.

Biofix Date: The biofix date is the date to begin accumulating degree days. It varies with the species based on specific biological events such as planting dates, or the first pest occurrence.

Growth response: of rice crop is influenced largely by microclimate like interception of photosynthetically active radiation, air and leaf temperatures, relative humidity, prevailing wind speed, CO_2 concentration and soil moisture availability (Nishad, et al. 2018). The climate extremities, particularly high temperatures affect the plant growth and reduce the rice yield significantly (Satake & Yoshida, 1978). Effects of temperature and solar radiations on crop biomass yield are measured in terms of growing degree days, helio-thermal units, heat use efficiency, radiation use efficiency and phenol-thermal index.

The GDD can be calculated using daily average temperature over and above the base temperature. Then the GDD can be used for estimation of heat use efficiency using the formulae below:

i. Growing degree days (GDD)

GDD=(Maxi Temp + Mini Temp)/2-Base Temp.

Where, Base Temp is the base temperature of 8-10^{0}C for summer crops and 4-6^{0}C for winter crops. Below the base temperature, the plant or insect stops growing.

ii. Helio-thermal unit (HTU) = GDD x Duration of sunshine hours

The HTU measures accumulated product of GDD and bright sunshine hours between the developmental thresholds for each day. The HTU directly or indirectly affect the grain yield by affecting flowering and grain formation. The HTU is measured in ° days hrs. Accumulated HTU is estimated using ∑GDD x Cumulative Sun Shine Hours from sowing to physiological maturity.

iii. Heat use efficiency (HUE) = Biomass yield (kg/ha) ÷ GDD

The heat use efficiency is the heat utilized to produce one plant biomass unit, which depends on crop type, genetic factors, and sowing time. The HUE is efficiency of utilization of heat in terms of dry matter accumulation which depends on crop type, genetic factors and sowing time (Rao et al. 1999) which is measured as kg/ha/°days of rice cultivars at different growing environment.

iv. Helio-thermal unit use efficiency (HTUE) = Biomass yield (kg/ha) ÷ HTU

The HTUE is calculated by dividing the total dry matter recorded at respective days by the accumulated helio-thermal units and expressed as kg per ha per °days per hrs. It is affected by the date of sowing.

v. Radiation use efficiency (RUE) = Biomass yield (kg/ha) ÷ Radiation hours

RUE is the relationship between the accumulations of biomass relative to the light intercepted by a crop. It is a useful parameter to relate canopy photosynthesis to crop yield (Loomis & Amthor 1999). It combines both the amount of solar radiation captured by the crop and the efficiency of the crop to produce dry matter, assuming other factors are not limiting.

vi. Pheno-thermal index (PTI) = GDD/ Calendar days of the crops

PTI (measured in °degree per day) is the highest during the sowing to emergence of crop. With growth of the crop with successive phenophases, its value decreases slowly and attains the minimum at physiological maturity stage.

For example, groundnut cultivars' thermal units to reach maturity were 2 247 GDD in Sudan (Ishaq, 2000). The heat units to flowering for groundnut have suggested a base temperature of 13°C–14°C, below which reproductive development stops (Emery et al., 1969; Mills, 1964). The thermal time requirement for maturity of the same variety seems different for different sowing dates and locations (WMO, 2012).

Heat supply forecast

A heat supply forecast is required in certain heat-loving plants to assess the most likely thermal conditions during the next growing season. GDD during the growing season is used to indicate the thermal conditions (Table 6). Information on GDD is useful for:

- taking precautionary measures against insect pest and disease attacks on crops;
- estimating the development stage of pathogens such as fungi;
- scheduling irrigation at critical growth stages;
- predicting crop harvesting time;
- drying seeds to the required moisture content;
- marketing fresh products;
- estimating the development stage of plants.

Table 6. GDD at different phenological stages of rice cultivar Rajshahi in Bangladesh

Phenological stages	DAT	Growing Degree Days (ºC day)
Seedling establishment	13	252
Initial tillering	17	324
Maximum tillering	60	1 139
Booting	68	1 272
Heading	75	1 389
Anthesis	78	1 484
Milking	83	1 510
Dough	85	1 569
Maturity	102	1 755
Harvesting	116	1 918
Heat Use Efficiency (kg/ha/ C day)		1.51

Source: Islam & Sikder 2011

DAT = Days after transplanting

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Find maximum and minimum temperatures for the last 30 days in your location and calculate GDD for the month, assuming rice's base temperature is 14 C.

Activity 2: Estimate the pheno-thermal index (PTI) using the data given in Table 6.

Module B: CLIMATE FARMERS FIELD SCHOOLS FOR RICE CROPS

Module B comprises the following lessons:

a. Climate Farmers Field Schools (CFS) for rice crops
b. Development of CFS Curricula for rice crops
c. Preparation for CFS for rice crops
d. Implementation of CFS for rice crops
e. Special topics and discovery learning

Lesson B1: Climate Farmers Field Schools (CFS) for rice crops

Learning objectives

The trainees will be able to:

a. explain the principles of Farmer Field Schools (FFS); and
b. differentiate FFS and CFS.

Materials required

- Flip Chart Paper
- Markers
- Projector

What are Farmer Field Schools?

The concept of FFS is fundamental, and the trainer needs to communicate it to the trainees clearly. The trainer should ask about five trainees "why do we participate in the FFS?" and write everyone's answers up on the flip chart.

The trainer points out the keywords, or guides the trainees to the keywords and explains them for the farmers who participated in the FFS.

Keywords

- **Interactive learning: participants in** the learning session will have the chance to share their experiences in rice growing practices and learn from others in the village.
- **Problem solving:** farmers can share their problems with rice cultivation with a trainer and other farmers. The solution to each problem will be discussed and solved during the FFS.
- **Discovery-based learning:** during the FFS, farmers will have a chance to see the different types of pests and natural enemies of each pest.

Then, the trainer needs to summarize the concept of FFS as follows:

> *The FFS approach is an innovative, participatory and interactive learning approach that emphasizes problem solving and discovery-based learning.*

Farmer Field Schools

FFS is an approach to agricultural extension education based on the concept and principles of people-centred learning. This approach is developed as an alternative to the conventional, top-down, extension approaches. The FFS uses innovative and participatory methods to create a learning environment, including learning networks, in which farmers have an opportunity to solve their production problems through observation, discussion and learning-by-doing.

About 20 to 25 farmers with similar problems organize their weekly sessions to observe and analyse the dynamics of specific farm problems such as insect pests, diseases, moisture stress and other weather stresses, and plan for potential promising solutions for on-farm trials. Trained facilitators support farmers to follow the process of observation, analysis, planning and trials to solve problems. Master trainers provide training to the facilitators using detailed curriculum and training modules before the start of the FFS sessions. The FFS sessions start before the planting season and run for the entire season from seed to seed.

Principles of FFS

The curriculum of the field schools includes team-building and organization skills, and special topics chosen by individual field school members on the basis of locally-faced problems.

Field schools are designed to encourage local innovations for sustainable agriculture and to empower farmers by educating farming communities on planning and implementing decision. The concepts and principles of the FFS approach are presented in Box 6.

Box 6: Concept and principles of the FFS approach:

(a) **Farmers are experts:** Farmers in groups learn by carrying out the field studies and comparing particular farming practices they feel they need to know about (learning by doing).

(b) **Field-based education:** Real-life examples in the field (farmer domain) are the primary learning material. Farmers interact in small sub-groups (5 to 7 farmers) to collect and analyse data, make decisions and act.

a) **Farmer-driven:** The trials should be a response to field needs as part of the research network and supporting educational programmes.

(c) **Decisions based on farmer analyses:** Farmers in each sub-group share their observations with the group for further discussion, questioning and refinement.

(d) **Extension workers are facilitators, not teachers:** Extension workers offer guidance to farmers' activities only.

(e) **Problem-Posing and Problem-Solving:** Problems and challenges confronted in the field during the crop season are tackled in real-time using numerous analytical methods within farmers' groups.

(f) **Holistic approach:** The FFS integrates all technical, ecological, socio-economical and educative aspects in the farmers' field and their decisions are more realistic.

(g) **Group dynamics:** They are built within farmers' groups to improve communication skills, problem solving and leadership towards a higher quality of farm management skills.

Source: FAO, 2019

FFS Facilitators

FFS facilitators may come from a wide variety of domains such as extension workers, NGO workers, farmer organization staff, or previously trained farmers. They are prepared by rigorous, season-long training conducted by master trainers and follow the same learning-by-doing approach as the farmers they will teach in FFS.

The main role of the facilitators is to inspire farmers to test technologies and better understand farming systems. They familiarise new ideas through exercises and discussion. But they do not teach the farmers. They guide the farmers, help them decide what they need to learn and how to find possible solutions, and answer any queries they may have (Box 7). The farmers draw on their own experience and observations to make decisions on how to manage their crops (FAO 2019).

Box 7: Characteristics of a typical FFS:

a) A group of 30 farmers, assisted by a trained facilitator, prepares two training plots of around 1000 m^2 total. The FFS group spends roughly one-half day per week setting up experiments, making observations and jointly managing the two plots, one using local, conventional farming methods and a second plot testing new practices appropriate to the crop and location.

b) Exercises are explicitly designed to introduce topics in synchrony with the specific growth stages of the crop over a cropping season.

c) Farmers in subgroups are asked to summarize their observations by depicting the status of the observed plots, including plants, insects, water levels, weeds, etc. Drawings are used as an effort to engage less literate farmers.

d) Additional special topics are introduced throughout the season to introduce or reinforce key concepts, e.g. demonstrations of pesticide toxicity, soil water-holding capacities, composting methods, etc.

e) Exercises include agronomic techniques for planting, soil fertility management and integrated pest management (IPM), varietal comparisons and marketing.

f) At the end of the FFS season an "open house day" is generally held. Other farmers from the community and adjacent communities are invited, along with local government personnel and civil society and non-government organizations, to see the FFS farmers' presentations and discuss their outcomes from the season.

g) The land used is either donated by the community, rented from a local farmer, or seeds, inputs and labour are provided, and proceeds from harvest go to the landowner.

Source: http://www.fao.org/farmer-field-schools/en/

Climate Field Schools

The climate field schools (CFS) is an approach to transform climate risks in agriculture into resilience. The CFS is based on the FFS model to disseminate knowledge about climate change, its causes, potential impacts on livelihoods, agrometeorological services and local coping strategies. The CFS aims to enhance the capacity of extension workers and farmers to understand and apply climate information to reduce agriculture risks.

The CFS offers in-depth training and skills development to help farmers to enhance the resilience of their livelihood. The farmers learn climate and weather information by measuring rainfall and applying forecast products. Farmers learn to observe and record plant growth, humidity and rainfall, and adjust crop cultivation practices to fit to climate and weather information, to adapt to climate change and transform climate risk into climate resilience. The primary objectives of the CFS are presented in Box 8.

Box 8: Objectives of the CFS:

a) Enable extension staff and farmers to understand climate-related risks in agriculture and the crop management system;
b) Show the importance of climate in plant growth and development, as well as its relationship with plant pests and diseases;
c) Familiarize the participants on forecast implementation, climate parameters and instruments;
d) Help farmers learn to integrate weather and climate information with disaster management and agricultural planning;
e) Create awareness of participants on disaster risk reduction and climate change adaptation.

Source: FAO 2019

Curriculum of CFS

The CFS curriculum should fit the local conditions such as specific climate change-related knowledge and skills. The CFS assists farmers to adapt to climate change and develop better climate resilience. It also helps farmers to enhance their ability to handle natural disasters and other environmental challenges. Key modules for CFS are presented in Box 9.

Box 9: Key modules for CFS

a) Knowing about elements of weather and climate
- To introduce elements of weather and climate;
- To build the ability to differentiate between weather and climate.

b) Process of rainfall formation
- To study the process of rainfall formation;
- To develop a better understanding of specific crops' need for water during different crop stages and how to conserve rainwater in upland agriculture.

c) Developing an understanding of terminologies used in Seasonal Climate Forecast
- To develop an understanding of the meaning of normal, below normal and above normal;
- To develop the capacity to translate the seasonal climate forecast to local conditions (in their farm) taking into consideration of the trend in rainfall data measured by the farmers.

d) Developing an understanding of probability concept of forecast (forecast contains errors)
- To develop a better understanding of the probability concept of weather forecast;
- To relate weather forecasts to farm level day-to-day decision making.
- Introduction to measuring tool**s for weather data collection**
- To introduce field-level weather observation instruments used for measuring the major weather parameters;
- To learn what weather information is available from station data collected through standard method;
- To learn what factors can affect the accuracy of data measured by non-standard instruments;
- To learn how to calibrate data which is not measured using standard methods.

e) How to use climate forecast information for setting up planting strategies?
- To develop a better understanding of how extreme weather events can affect the crops, and the relationship between cropping rotation and planting time on damage level;
- To develop a better capacity to use seasonal climate forecasts for setting up cropping strategies to avoid or minimize the effects of floods and drought.

f) Learning about the water balance concept and its use to assess crop water requirements and flood risk
- To develop a better understanding of the meaning of rainfall deficit from evapotranspiration;
- To develop a better capacity to estimate irrigation water requirements based on simple water balance;
- To assess the risk of floods from water balance analysis.

g) Assessing the benefits of climate forecast information to the farmers
- To develop a better capacity to quantify the benefits of using climate forecast information.

Source: Adapted from Boer et al., 2010

The weather forecasts and early warning information supplied by the DMH can be used in the CFS in a simple and accessible way, indicating whether there will be rainfall, dry spells, storms, high winds, or risk of floods, bush fires, or heatwaves. This information helps the farmers plan their activities and assess the best times to plant, maintain, and harvest their crops, significantly reducing risk of losses from unpredictable weather patterns. The major differences between FFS and CFS are presented in Table 7.

Table 7. Difference between FFS and CFS

Components	FFS	CFS
1 Participants	Farmers facing any problem like disease, pest, disaster and other environmental problems	Farmers facing problems of climate change
2. Objectives	Solving nature-based problems faced by the farmers	Field-based learning for farmers and their communities to adapt to a new normal and transform climate risk into climate resilience
3. Curriculum	Cover problems faced by the farmers	Climate and weather, measurement of rainfall, forecast products Integration of cultivation techniques with climate and weather information
4. Observations	Disease, pest, water and their effects on plant growth	Temperature, rainfall, humidity affecting plant growths and disease pests

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Differentiate the purpose of FFS and CFS.

Activity 2: Identify major topics that need to be included in CFS curriculum in the Lao context.

Activity 3: Identify indigenous knowledge that can be incorporated into CFS curriculum.

Lesson B2: Development of CFS Curriculum for the rice crop

Learning objectives

The trainees will be able to:

a. describe the major components of CFS curriculum; and
b. design CFS curricula for the rice crop.

Materials required

- Flip Chart Paper
- Markers
- Projector

Structure of CFS

The structure of the CFS curriculum for agrometeorology (as in the case of FFS) consists of four parts that the facilitator needs to understand clearly:

- Pre-CFS preparation (baseline data collection, identify the needs and potential farmers' group, curriculum development, set up monitoring system).
- CFS implementation.
- Agrometeorology implementation.
- Special topics.

The CFS teaching programme takes 19 days during 19 weeks of the rice crop season (Table 8). The main activities are allocated according to the crop growing stages, but the special topics and agrometeorology will be based on baseline surveys or need assessments for CFS curriculum development.

Table 8. Curriculum of CFS for agrometeorology and its linkages with the rice crop vegetative phase

Week	DAS	Growing stage	Main activities	Agrometeorology topics	Special topic	Tools needed
0	0	Pre-FFS	- Initial meeting and farmer selection - Present the overview, objective, goal and concept of CFS on agrometeorology	What is agrometeorology? How important is it for rice growing?	Soil: pH, soil nutrient, drainage, water-holding capacity	Register, pH meter
0	0	Pre-FFS	- Baseline survey: identify problem and needs - Choose suitable land preparation time based on seasonal forecasts - Design CFS study plot and farmers' plot	What is a climate information service? Linkages to land preparation. - Seasonal forecast (Monthly bulletin)? - Weekly forecast and weekly bulletin? - LaCSA?	Compost making	Questionnaire, seasonal forecast, weekly bulletins, Measuring tape, Rope, Pegs
1	0	Prepare seed	- Seed selection matching with seasonal forecast (amount and distribution of rain). - Germination test - Installation of weather measurement device	Overview on climate information service, their linkages to crop variety selection. - Seasonal forecast and their linkages to crop variety selection. -LaCSA?	Pre-Test for knowledge.	Pluviometer, Thermometer, Soil thermometer, Hygrometer, Evaporimeter. Seed, Weekly bulletin.

Week	DAS	Growing stage	Main activities	Agrometeorology topics	Special topic	Tools needed
2	7	Seedling	- Survey nursery and discuss management practices - Field measurement of weather parameters - Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and its linkages to rice seed-ling stage - Temperature - Rainfall and water control. - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA.w	Cost benefit analysis	Format for cost benefit analysis, Weekly bulletin, Disease and pest al-bum
3	14	Seedling	- Agro-ecosystem analysis (AESA) in nursery - Field measurement of weather parameters - Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to rice seed-ling stage - Temperature - Rainfall and water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	Soil fertility im-provement	Soil testing kit, Measuring scale, Reg-ister for sub-groups, Weekly bulletin, Dis-ease and pest album
4	21	Transplanting	- Identify data collection plot - Field measurement of weather parameters - Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to rice transplanting stage - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	IPM: classification, role of enemy insect and management.	Weekly bulletin, Disease and pest album
5	28	Stem elongation	-1st Biodiversity survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to stem elongation - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LACSA Analysis of season forecasts – temperature and rainfall.	- Climate change and pest - Pest life cycle and management	Weekly bulletin, Seasonal forecast, Disease and pest album, Pest lifecycle charts
6	35	Tillering	2nd Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to tillering stage. - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	- Consumption of aquatic plant and fish survey - Rice fish and other	- Weekly bulletin, Disease and pest album
7	42	Tillering	3rd Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of rainfall and air temperature. -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to tillering stage - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	- Bio-pesticides - Top dress urea fertilizer	- Weekly bulletin Disease and pest album - Biopesticides - Urea - Leaf colour chart

Week	DAS	Growing stage	Main activities	Agrometeorology topics	Special topic	Tools needed
8	49	Tillering	4th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to tillering stage - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA.	Topic depends on the situation	Weekly bulletin, Disease and pest album
9	56	Tillering	5th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to tillering stages - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	Topic depends on the situation	Weekly bulletin, Disease and pest album
10	63	Highest tillering	6th Agro-ecology survey in association with Weekly forecast & LaCSA. - Field measurement of weather parameters. -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk. - Insect-pest risk - LaCSA Analysis of season forecasts – temperature and rainfall	Topic depends on the situation	- Weekly bulletin, - Seasonal forecast, Disease and pest album
11	70	Highest tillering	7th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	Topic depends on the situation	Weekly bulletin, Disease and pest album
12	77	Panicle initiation	8th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to panicle initiation stage - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk. - Insect-pest risk - LaCSA	Topic depends on the situation	- Weekly bulletin, Disease and pest album
13	84	Panicle initiation	9th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to panicle initiation stage - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	Topic depends on the situation.	- Weekly bulletin, Disease and pest album

Week	DAS	Growing stage	Main activities	Agrometeorology topics	Special topic	Tools needed
14	91	Heading to flower	10th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linkages to flowering stage - Temperature - Rainfall - Water control - Extreme weather risk. - Disease risk - Insect-pest risk - LaCSA - Analysis of season forecasts – temperature and rainfall	Topic depends on the situation	- Weekly bulletin, - Seasonal forecast, Disease and pest album
15	98	Soft dough	11th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and linking to dough stage - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	- Potential pest and insect for rice, during soft dough stage	- Weekly bulletin, Disease and pest album
16	106	Milky	12th Agro-ecology survey in association with Weekly forecast & LaCSA - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	- Good post-harvest handling - Climate requirement for harvesting	- Weekly bulletin, Disease and pest album
17	113	Doughy	-Biodiversity survey in association with Weekly forecast & LaCSA. - Field measurement of weather parameters -Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin - Temperature - Rainfall - Water control - Extreme weather risk - Disease risk - Insect-pest risk - LaCSA	- Topic Depend on the situation	- Weekly bulletin, Disease and pest album
18	120	Grain	- Harvesting of the rice - Measurement of grain moisture - Field measurement of weather parameters - Interpretation of the observed weather parameters	Analysis of recent weekly weather bulletin and avoid risk during harvesting stage - Extreme weather risk - Economic assessment - Post-testing	- Topic Depend on the situation	- Moisture meter, Weighing balance, Weekly bulletin, Disease and pest album
19	127	Closing	Field day	Field day		

DAS= Days after sowing

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Identify critical stages of irrigation on the rice crop.

Activity 2: Identify critical stages for night temperature on the rice crop.

Lesson B3: Preparation for Climate Field Schools

Learning objectives

The trainees will be able to:

a. list implementation requirements of CFS; and
b. describe pre-test for the participants of CFS.

Materials required

- Flip Chart Paper
- Markers
- Projector

FFS pre-implementation meeting with local authorities

A village consultation meeting is held with local authorities to identify current issues faced by the village and implementation arrangements such as:

- purposes of CFS;
- expected benefit of CFS to the participant farmers and other farmers in the locality;
- problems to be addressed by the CFS;
- whether there are suitable facilitators available in the village;
- agrometeorological station available in the village or location of the most nearby one;
- time to be invested for the CFS, for example, covering the entire season; and
- resources needed for the CFS and their probable sources.

Identification of needs and farmers' groups

This is the first step of pre-CFS preparation. A two-day meeting will be organized with farmers in the target village for the CFS. The first day is to select 30 farmers who will participate in the CFS and the second day is for the needs identification for the CFS curriculum development (Table 9).

What is the need for a CFS for agrometeorology? How can the farmers receive agrometeorological information? What is the specific need?

Table 9. Needs assessment

	Needs identification	How can agrometeorological information address the needs?
1	Access, receive agrometeorological information from LaCSA.	Providing knowledge about communication equipment such as tablets and smartphones Develop capacity to access agrometeorological forecasts
2	Assessment of water supply, water requirement calculation, date of onset, rainfall intensity, water balance and locally available meteorological stations	Simple agrometeorological measurement devices like a rain gauge and thermometers for air, soil temperature measurement Skills to handle these instruments A visit to the local agrometeorological station, if available, to understand the status and operation of the instruments and availability of data.

The facilitator needs to prepare the documents for setting up an introductory meeting in the village. The trainer needs to prepare project documents: project overview, objective of CFS, goals and concept of agrometeorology (these documents should be prepared in brochures for distribution).

Selection of farmers' group

The facilitator needs to provide information about the objectives, benefits and working process of the CFS and the amount of time the farmers should devote to the school during the season. They should also be informed that they need to work in the field every week. After providing sufficient information, the facilitator should ask for the farmers' agreement to participate in the CFS for the entire season.

About 30 participant farmers should then be selected for the CFS based on the following criteria:

a) interest and willingness to participate;
b) commitment to participate for the entire season (19 weeks);
c) resident in the same village or at walking distance;
d) readiness to take responsibility for conducting demonstrations and other activities of CFS;
e) the farmers should have background in rice farming;
f) gender balance in the CFS;
g) age between 20-65 years;
h) at least half of the farmers can read and write and use smartphones for communication by Facebook or WhatsApp; and
i) their main occupation should be agriculture, mainly rice farming.

After selecting the farmers for CFS, the facilitator should collect the information as given in the following form (Table 10).

Table 10. FFS farmer selection forms

Name of the farmer	Gender	Age	Household size	Main occupation	Land for paddy (ha)			Total rice production (ton)	Rice yield (ton/ha)
					Irrigated	Rainfed	Upland		
1.									
2.									
3.									

Identification of needs

After the CFS participants are identified, the facilitator needs to collect the baseline information and analyse the context of the rice cultivation in selected village. The facilitator can conduct the study by a focus group discussion as follows in Table 11:

Table 11. Major decision problems in rice farming and CFS

Crop stage	Decision problems	Use of agrometeorological information in CFS
Crops and cropping system	Matching crops and cropping systems - rice varieties - mono-cropping, - mixed- cropping - relay- cropping - intercropping	Seasonal forecast, rainfall above normal, normal or below normal
Selection of rice variety	How to select the variety (short, medium, long), seed preparation	Seasonal forecast, rainfall above normal, normal or below normal
Nursery raising	Dry method or wet method	Weekly weather forecast, LaCSA
Land preparation	Timing of tillage and irrigation Soil fertility and fertilizer doses	Weekly weather forecast, LaCSA, Soil analysis information
Transplanting	Seedling age, planting space, number of seedlings per hill Type and amount of fertilizers for basal dose	Seasonal forecast, weekly forecast, LaCSA
Irrigation management	Frequency and timing of irrigation for different crop stages (e.g. wet and dry during tillering stage and continuous irrigation during flowering and dough stage) Drainage management	Weekly weather forecast, LaCSA
Farming practices	Amount of fertilizer topdressing, Weeding Insect and disease control	Weekly weather forecast, LaCSA Disease and insect forecasts
Harvesting	Time harvesting, harvesting handling	Weekly weather forecast
Production	Total production, yield	

(See Appendix III: Example of baseline survey)

Curriculum development

After the facilitator receives the baseline information, they need to design the training curriculum and demonstration plan that can increase rice production in the village context by applying agrometeorological information. The process of CFS curriculum development is demonstrated in Figure 21 below.

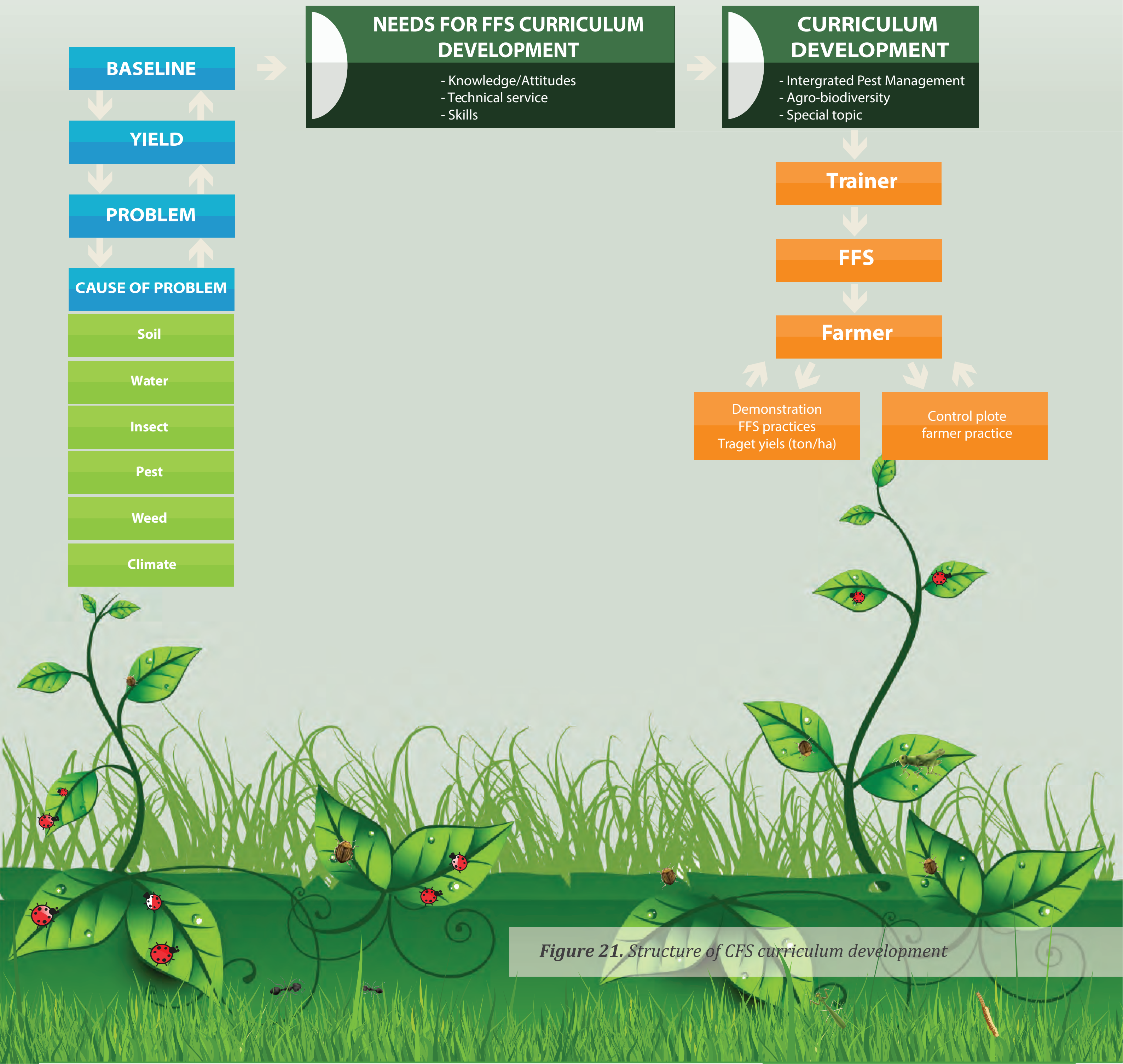


Figure 21. Structure of CFS curriculum development

For the demonstration of CFS practices the facilitator needs to clearly identify seedling age, planting space, number of seedlings, type and amount of fertilizer and pest and insect control methods for comparison with the farmer practices.

Pre-evaluation of the CFS

Pre-evaluation of the CFS is usually taken in the first week of the CFS. The facilitator needs to prepare a questionnaire for pre-testing of all farmers attended in the CFS. The primary questions for testing can be adjusted based on the curriculum development as follows:

- Have you heard the term "agrometeorology"?
- Can you name any agrometeorological service, or information?
- How can we benefit from a seasonal weather forecast?
- How can we benefit from a weekly weather forecast?
- Have you heard about the Lao Climate Service for Agriculture, or LaCSA?
- Do weather conditions affect insect pests in rice crops?
- Do weather conditions affect rice diseases?
- Which of the following rainfall pattern is suitable for land preparation?
- Which of the following is a suitable time for transplanting?
- Which of the following is a suitable planting space for transplanting?
- Which of the following is a suitable number of seedlings for transplanting?
- Which of the following is a suitable time for applying the manure or compost?
- Which of the following is a suitable type of fertilizers?
- Which of these is urea?
- Which among these is a pest?
- Which among these is a natural enemy?
- Which among these is a farmer's friend?
- Which among these is a farmer's enemy?
- Which of these causes rice yield decline?
- Which of these causes rice yield increase?
- Which of these causes low quality rice?
- Which of these causes good quality rice?

The format of the questions should formulate into a multiple-choice question with three choices for each question. The total of 20 questions is enough. Each question should indicate the maximum score of 5, making a total score of 100. After the assessment, the facilitator has to summarise each farmer's score into the ballot box in the attendance sheet (Appendix IV).

Agro-Ecosystem Zone (AEZ) and action before the start of CFS

Agro-ecosystem zoning is a way to understand the different land use patterns and climate at the local level. The AEZ can be implemented at the provincial, district or village level. Land Resources Information Management System (LRMIS) has developed National Agro-Ecological Zoning (NAEZ) in Lao PDR and contain maps of present AEZ that could be used for an initial assessment. The AEZ at the CFS needs to be integrated with climate information and soil profile data to formulate the CFS training curriculum for rice.

The facilitator needs to formulate the climate data, especially rainfall, temperature and soil, into the CFS curriculum to adapt the agriculture technique for the farmers in the area.

The LaCSA provides climate information to the CFS facilitators directly. The CFS facilitator can access soil data on the location of each CFS school and demonstration site from the LRIMS app to make a good recommendation for suitable fertilizer application of each zone. The soil profile data are presented in the soil map. There are 12 common classes of the soil as presented in Appendix V. Acrisols are predominant in Laos. This type of soil was formed on old landscapes with undulating topography and a humid tropical climate. The natural vegetation is woodland, which in some areas have given way to tree savannah maintained by seasonal burning. The age, mineralogy, and extensive leaching of these soils have led to low levels of plant nutrients, excess aluminium, and high erodibility, all of which make agriculture problematic. Nevertheless, traditional shifting cultivation of acid-tolerant crops has adapted well to the conditions found in Acrisols.

After checking the selected village's agriculture land use zone, the facilitator has to identify the study plot, or demonstration experiment site. The demonstration has to adopt the recommendations of rice cultivation according to the developed CFS curriculum in the selected village as given in Table 12.

Table 12. Recommended practices for rice crop CFS

Description	CFS demonstration	How can this practice be supported by seasonal forecast?	How can this practice be supported by weekly forecast?
Variety	Selected/certified variety	Variety depends on seasonal forecast, the amount of rainfall per season (seasonal forecast analysis)	
Time of seedling nursery	Should match rainfall distribution	Preparing seedling nursery on time	Type of nursery rising – dry or wet
Seedling age	15-20 days	-	Amount of daily rainfall and temperature, pest and diseases from weekly bulletin
Planting time	Should match rainfall amount	Seasonal forecast (rainfall amount and distribution)	Analysis of rainfall pattern and distribution
Planting space	30 x 30 or 35 x 35 cm	Depends on soil fertility and variety	
No. seedlings	2-3 seedlings	Depends on soil fertility and variety	
Fertilizer basal dose	Depends on soil fertility of the area	Reduce the basal dose if season forecast of rainfall is below normal	Amount of daily rainfall and temperature
Fertilizer top dressing	Leaf colour chart	_	Amount of daily rainfall
Weeding	Depends on area	_	
Water level	Depends on water supply	Preparedness for water control on time based on seasonal forecast	Preparedness for water control on time
Pest and disease control	Depends on the incidence and economic damage	_	Prediction of outbreak of pest and diseases

Materials required

Materials required for demonstration and crop management are as follows:

- Rain gauge
- Thermometer
- Open pan evaporimeter (locally made)
- Leaf colour chart for rice
- Equipment for clearing of land, land preparation
- Field measuring tape and pegs
- Seeds – determine varieties and sowing density
- Tools for maintenance of plots
- Fertilizers
- Bio-pesticides for demonstration (according to cropping calendar) and IPM (based on AESA recommendations)
- Equipment for application of bio-pesticides

Materials for conduct of AESA

- Notebooks and pens/pencils for each person.
- Ruler or measuring tape (4) -one per group.
- Magnifying lens (8) – two per group.
- Collection materials.
- Sweep nets.
- Containers for storing samples of fauna found in the plots.
- Vials, or jars, and plastic bags for sample collection.

Materials for presentation of AESA

- Plain sheets 100cmx50cm e.g. newsprint or flip chart paper.
- Drawing materials.
- Markers of varying colours (one set per group).

Materials for presentation of AESA

- Plain sheets 100cmx50cm e.g. newsprint or flip chart paper.
- Drawing materials.
- Markers of varying colours (one set per group).
- Coloured pencils or crayons.
- Eraser and ruler.
- Board for displaying drawings or flip chart board.
- Weekly bulletin.
- Mobile phone.
- Tablets.

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Identify the technology that can be compared with the farmers' practices.

Activity 2: Identify agrometeorological services required in the CFS.

Lesson B4: Implementation of Climate Field Schools for rice crops

Learning objectives

The participants will be able to:

a. describe steps for implementation of CFS; and
b. collect data from CFS for analysis.

Materials required

- Flip Chart Paper
- Markers
- Projector

Group organization

The group organization is part of the CFS activities that help strengthen group knowledge sharing and enhance cooperation. The CFS farmers have different levels of farming skills and knowledge so they can help each other to support the learning process.

Implementation of Agro-ecosystem analysis (AESA)

The AESA is a learning method to develop CFS farmers' skills and knowledge on ecosystems and integrated pest management (IPM). The farmers work in groups to observe the field ecosystems and make notes on: water stress on the crop, water availability, temperature stress, nutrient deficiency symptoms, harmful and useful insects, diseases, weeds, aquatic plants and animals, etc. The AESA is conducted in different crop phenological stages.

Agenda for work and activities (including AESA) to be implemented in each week (once per week, for half a day) (Table 13).

Table 13. Weekly agenda of CFS

No of daily agenda: ...., Date........ Month.........., Year.........

No:	Time	Training/ activity agenda	Responsible person
1	8.00-8.10 AM	Share the objectives	Head of the CFS
2	8.10-8.30AM	Overview of activities done in the last week	Head of the sub-group
3	8.30-9.00AM	AESA field survey (by sub-groups)	Each subgroup
4	9.00-10.00 AM	Analysis of AESA	All
5	10.00-10.30 AM	Group presentations	Head of the subgroup
6	10.30-11.00 AM	Summarise AESA results	Head of the subgroup
7	11.00-11.30 AM	Special topic based on field problems	All
8	11.30-12.00 Noon	Evaluation and planning for next week's activities	All

Facilitating the AESA

a. Explain the implications of the seasonal forecasts and weekly forecasts. Discuss with the farmers and let them choose a suitable rice variety for the season, based on the seasonal forecasts.
b. Set out measurement plans, such as paddy water control, extreme weather, pest and diseases outbreaks to reduce risk.
c. Discuss observations of agroclimatic factors affecting the growth of paddy rice, such as rainfall and temperature.
d. Explain how to measure the rainfall. The rainfall data are essential to determine an appropriate climate change adaptation strategy. If they do not measure the rainfall, how could they know which rains are good for the paddy rice? Which rains could lead to drought, or flood?
e. Discuss how water loss to the atmosphere (evaporation) contributes to the evaporation and what factor that minimises the evaporation rate.
f. Discuss how the field observations will be recorded in the diary.
g. Explain how each group will analyse the data.
h. Explain how each group can present their observations and analysis in the plenary group.

There are three main components of an AESA: observation, analysis and recommendation/s.

i. Observation

- Form four CFS farmers' groups (including some who can read and write in each group) and names each group for easy identification.
- Assign each group to a specific study area in the CFS plot, and farmers practice plot. For example, two groups are assigned to do AESA in the CFS plot and the other two groups on the farmers' practice plot. The groups can be rotated on a weekly basis.
- Plants for observation in the plot are randomly selected and marked by each group (sample plants). They are used as observation plants for each AESA unless they are damaged, in which case the nearest plant is used as a substitute.
- Record observations on the form such as Plant height, No. of tillers, No. of leaves, Pests/hill, NE/hill (Table 14).
- Biotic life counting includes insects, other arthropods and other living organisms on, or around, the observation plants.
- Observe for disease symptoms noting the shape, colour, markings, extent of symptoms and location of the plants on which they are found.
- Collect samples for display to other participants, or further investigations.
- Assess reasons for the damage, e.g. insect type, mechanical disease, vigour and health of plants, soil conditions, type and amount of weeds, weather conditions and drainage.
- Some groups may need to sweep to catch flying insects by using insect nets.

ii. Analysis

The groups return to the meeting place and prepare presentations based on observations and discussions among the group members. Observations are depicted in drawings as seen by the participants in the plot. The analysis aims to record the crop situation at specific stages and communicate by the group to the plenary. Relate the field observations on weather information to weekly forecast bulletins. Analyse relationships between climatic conditions to the pests and disease outbreak in the plots such as gall midges (*Orseolia oryzae*), stem borers (*Chilo suppressalis*), planthoppers (*Nilaparvata lugens, Sogatella furcifera)* and blasts (*Magnaporthe oryzae*).

iii. Recommendations

Each group presents its proposed actions as part of the presentations. Other groups discuss the proposed actions. The facilitator should encourage the CFS farmers to freely share opinions, giving reasons based on their observations and guiding the group for proper recommendations. The CFS farmers then decide on a list of actions they will undertake.

Table 14. AESA observation form

Week……..	Date	Crop Growth Stage
	Name of the plot	**CFS or farmers' practice plot**
	Name of the group	
AESA	**Observations**	
	Plant height	
	No. of tillers	
	No. of leaves	
	Pests/hill	
	NE/hill	
	TMax: Tmin: Rainfall (mm):	
	Recommendations:	
	Problems encountered:	
	Suggestions for improvement:	

Note: this form can be modified upon the CFS curriculum development

Monitoring system[16]

Monitoring is necessary to compare different practices in the CFS plot with the farmers' practice plot, including fertilizer application, seed application, labour application, pesticides control, water management and seed management to determine if there is any difference. The facilitator needs to use the form that allows the CFS participants to complete the tables as follows (Tables 15 to 20).

Table 15. Monitoring of temperature and rainfall

Parameter	Crop Phases in CFS plot (Fill only the relevant column)			Describe if any difference in farmers' practice plot
	Vegetative phase	Reproductive phase	Maturity phase	
Starting date of the phase				
Ending date of the phase				
Days under each phase				
Temperature (°C) Minimum				
Temperature (°C) Maximum				
Temperature Average				
Rainfall (mm)				
Rainy days (number)				
Water balance (mm)				
Flood days (number)				
% loss from flood				
Drought days (number)				
Insects				
% loss from insects				
Diseases				
% loss from disease				

Table 16. Seed application in rice nursery for CFS plot and farmers' practice plot

	CFS Plot	farmers' practice plot
Name of the variety		
Seed source		
Price (KIP/kg)		
Seed amount		
Seed selection method		
Seed treatment method		
Germination status		

[16]Monitoring of FFS is partially done in Lao People's Democratic Republic.

Table 17. Fertiliser application in CFS plot and farmers' practice plot

Time	Type	CFS Plot			Farmers' practice plot		
		Dosage (kg)	Application method	Costs (Kip)	Dosage (kg)	Application method	Costs (Kip)
Nursery	Area (sq m)						
	46.0.0						
	16.20.0						
	15.15.15						
	18.46.0						
Transplantation 1st: Basal dose	Manure						
	Compost						
	Organic						
	46.0.0						
	16.20.0						
	15.15.15						
	18.46.0						
2nd:____DAT	46.0.0						
3rd:____DAT	46.0.0						

Note: Converting to per ha will be done at the time of analysis.

Table 18. Labour application in CFS plot and farmers' practice plot

Timing/ Date	Description	Daily wage rate (KIP/Day)	*CFS plot*		*Farmers' practice plot*	
			# of labour	# of days	# of labour	# of days
	1. Land preparation for seedlings					
	2. Sowing					
	3. Land preparation for transplanting					
	4. Transplanting					
	5. Fertilizer application					
	6. Pesticide application					
	7. Weeding					
	8. Other crop protection methods					
	9. Water/Irrigation					
	10. Harvesting					
	11. Threshing					
	12. Hauling					
	13. Transporting					

[17] **Not generally performed in Lao People's Democratic Republic.**

Table 19. Water Management in FFS plot and farmers' practice plot

Timing /Date	Crop stage	Water level	Water source	Any difference between CFS plot and farmers' practice plot?
	Nursery raising			
	Transplanting			
	Vegetative phase			
	Reproductive phase			
	Maturity phase			

Table 20. Management of crop protection problems in FFS plot and farmers' practice plot

Field Problem	Pesticides applied (last year)				Other known management practices	Any difference between CFS plot and farmers' practice plot?
	Brand & active ingredient	Dosage (kg/plot)	No. of Applications/ Timing (DAT)	Costs Kip/ plot	Description	
For nursery						
1.						
2						
3						
For field crops						
1.						
2						
3						

DAT= Days after transplanting

Post Evaluation of the CFS

The post-CFS evaluation will be taken in the last days of CFS. The facilitator uses the same questionnaire of pre-FFS test to compare the knowledge learned from the CFS. Moreover, the facilitator also observes the CFS plot and farmers' practice plot regularly and discusses the lessons learned and recommendations for improvement during the class.

Stakeholders Workshop/Field Day[17]

A field day is organized by the CFS farmers and the facilitator to demonstrate the activities and success of the CFS and share lessons learnt to other farmers in the community who did not participate in the CFS. Field days provide an opportunity for interactions, sharing experiences and encouraging non-CFS farmers to participate, or adopt the CFS lessons on their farm. This activity is essential for scaling up of the technology and practices tested in the CFS.

The most appropriate time for conducting a field day would be during the crop in maturity stage before harvesting. The facilitator should invite the stakeholders, farmers in the community, policy makers, researchers, and community leaders to observe the plots and share in the CFS demonstrations' experiences and observations.

Objectives of the field day:

- Observe and compare the results in the CFS plot and the farmers' practice plot and other experiments, if any;
- Encourage other farmers to participate in future CFS, or adoption of the appropriate technology proven by the CFS;
- Share calculation of financial cost-benefit analysis of the two plots and compare; and
- Provide a forum for participants to show the skills developed and experiences learnt.

The following materials should be prepared for observation by field day attendees:

- display weekly weather forecast bulletins;
- display seasonal weather forecast bulletins;
- display information about how to access the LaCSA and share the LaCSA access code;
- display key AESA that represent changes in the crop during its growth;
- display of results of special experimentations;
- insect and/or disease zoos facilitate learning about natural enemies, life cycles, damages etc. and those of beneficial insects; and
- presentation of some of the team building and learning exercises.

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Identify agrometeorological parameters that can affect the rice crop.

Activity 2: List weather parameters that can be observed in the CFS plot.

Lesson B5: Special topics and discovery learning

Learning objectives

The trainees will be able to:

- identify and elaborate special topics necessary to solve problems faced in the CFS; and
- describe the method of discovery learning in CFS to solve problems.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Laptop

What is a special topic?

Identification of the special topics is based on problems that emerge in the crop. The special topic is linked to the stage of crop growth and specific local issues (Figure 22). This part of the curriculum cannot be standardised as the problem may be location-specific and situation-specific. Any new problem that emerges as the CFS progresses can be addressed through the special topics. The topic is selected from an extensive menu of potential topics CFS facilitators learn during their training.

Special topic activities can cover such issues as:

- financial cost-benefit analysis and comparison
- soil and water management
- insects collection and identification
- insect pest management
- seed selection
- any other topics.

Figure 22. Farmers discussed issues/special topics on rice field and finding how to manage it which leaded by DAFO staff in Champhone, Savannakhet province

a) Financial cost-benefit analysis and comparison (for plot size)

A participatory financial cost benefit analysis should be done separately for CSA plot and farmers practice plot to compare the costs and benefits of these two (Table 21).

Table 21. *Cost-benefit analysis*

No.	Parameters	CFS plot	Farmers' Practice Plot
	Plot area (sq. m.)		
	Revenues	XXX	XXX
	A) Farm gate price of rice at harvest (Kip/kg)		
	B) Production of rice (kg)		
	C) Farm gate price of straw (Kip/quintal)		
	D) Production of straw (quintals)		
	E) Gross income (Kip) (E = A*B + C*D)		
	Material costs	XXX	XXX
	F) Seed costs (kip)		
	G) Total Fertilisers costs (kip) (G= g1 + g2….+ g8)		
	g1) 46.0.0 (kip)		
	g2) 16.20.0 (kip)		
	g3) 15.15.15 (kip)		
	g4) 18.46.0 (kip)		
	g5) Organic fertiliser (kip)		
	g6) Compost (kip)		
	g7) Manure (kip)		
	g8) Other fertilizers (kip)		
	H) Pesticides costs (kip) (H = h1 + h2 + h3)		
	h1) Brand =		
	h2) Brand =		
	h3) Brand =		
	I) Other crop protection inputs costs (kip) (I= i1 + i2 + i3)		
	i1) Input =		
	i2) Input =		
	i3) Input =		
	J) Equipment (kip)		
	K) Water (kip)		
	L) Land rental (kip)		

No.	Parameters	CFS plot	Farmers' Practice Plot
M) **Total input costs (M= F + G + H + I + J + K + L)**			
Labour costs		XXX	XXX
N) Total person days (N=n1+n2+………+ n19)			
n1) Seedbed preparation (person days)			
n2) Sowing (person days)			
n3) Land preparation (person days)			
n4) Pulling of seedlings (person -days)			
n5) Transplanting (person days)			
n6) Fertiliser application (person days)			
n7) Pesticide application (person days)			
n8) Weeding (person days)			
n9) Other crop protection application (person days)			
n10) Watering & irrigation (person days)			
n11) Harvesting (person days)			
n12) Threshing (person days)			
n13) Hauling (person days)			
n14) Transport (person days)			
n15) Marketing (person days)			
n16) Others (person days)			
n17)………….. (person days)			
n18)………… (person days)			
n19)………… (person days)			
O) Wage rate (kip/person day)			
P) Total labour costs (kip) (P=N*O)			
Q) Bullock costs (Kip)			
R) Tractor costs (Kip)			
S) Total costs (S = M + N+O+P+Q+R)			
T) Net Income per plot (Kip) (T=E-S)			
U. Gross income (Kip/ha) (U=E/area*10000)			
V. Total costs (Kip/ha) (V=S/area*10000)			
W. Net income (Kip/ha) (W=T/area*10000)			
X. Return on Investment (ROI) (X= W / V)			

Note: XXX= Leave the cell vacant.

Return on Investment (ROI) is a performance measure used to evaluate the CFS plot's efficiency compared to farmers' practice plot. ROI directly measures the return on the investment in the CFS plot and farmers' practice plot relative to the respective investment cost. To calculate ROI, each plot's net benefit is divided by the cost of the investment in the plot. The result is expressed as a ratio.

b. Soil and water management

Soil nutrition and crop requirements

Proper fertilizers application should be used in two phases:

1. **Land preparation stage:** compost or manures are recommended to use at the rate of 1,500-2,000 kg/ha. Farmers can also use chemical fertilizers to make the soil to increase fertility. It is recommended to use 15:15:15 at 150 kg/ha. If the farmers integrate the organic fertilizer with 15:15:15 by 50-70 kg/ha will be enough. If the soil is acidic, it is necessary to apply 300-500 kg/ha of lime to make the soil better. Note: As urea may get easily leached or washed away, do not use this fertilizer during land preparation.
2. **The growing period:** 15 to 30 days after transplanting, apply fertilizers to increase the plant's growth and increase the rooting and stems. Urea fertilizer (46:00:00) or fertilizer (16:20:00) about 100 kg/ha are recommended, or apply the bio-extracted fertilizer to save money.

Water management

Rice is typically grown in the flooded area for weed control. Crop periods require a different level of water, such as:

a. Maintain water during the first 30 days of transplanting to kill emerging weeds.
b. 30 days after transplanting, let the land dry and wet alternately to increase tillering and activate stem extension (about 0.5 to 1 wrist measurement) for 3-5 days and then maintain the water level at 15 cm (2-3 times if possible).
c. During the reproduction period, the rice crop requires a lot of water; the farmer must maintain a sufficient water level (15 cm from the surface).
d. During maturity stage, less water is required.

c. Insect Collection and Identification

Insects are arthropods and come in many different sizes, from small thrips that are difficult to see to bigger mantises which are easy to see. Collecting and identifying insects will help the CFS participants understand the insects' biology and ecosystems in the rice field.

The concept of insect collection and identification will affect the pesticides used for rice because the CFS promotes biological control to reduce chemical use on rice. Beneficial insects will be identified and conserved.

Materials:

- Transparent plastic bag sweep net
- Discarded plastic bottle
- Alcohol
- Cotton fabric
- Guidelines for insects and pests in rice fields

Procedures:

- Each CFS farmer group enters the field and examines the ground for insects and spiders. These are collected and put into a plastic bag.
- Return to the classroom and put onto a large piece of paper.
- Separate and group of the collected specimens based on their similarity of physical characteristics.
- Identify the specimens based on their local name and their function in the field (ask an entomologist for unknown insects to have them correctly named and their functions correctly understood).
- Preserve the insects in vials and attach a label to each of them.
- Separate harmful insects and beneficial insects.
- Guided questions for CFS participants
- How many of them are categorized as plant feeder insects?
- How many of them are categorized as beneficial insects?
- How many spiders did you catch?
- What will happen if there are no beneficial insects and spiders in the field?
- Why is it important to conserve natural enemies?
- What will happen to them if pesticides are being used excessively?
- What lesson is learnt from this exercise?

d. Insect pest management

The CFS promotes and demonstrates the concept of biological control. The beneficial arthropods are called "predators" (insects or spiders that feed on other insects, particularly pests). Some of them are "parasitoids" (insects that lay eggs in, or on its host so that the host provides food for the young stages of the parasitoid). The hosts of the parasitoid may be harmful insects. Predators are easier to study because they are usually larger than parasitoids.

To enhance biological controls in the rice field, bio-pesticides are promoted in CFS's special topic. The facilitator makes a presentation on different types of plants that can be used to protect the rice crop and prevent pests and insects in the rice field.

e. Seed selection

Selection of quality seed results in an increase in rice yield. If the farmers use certified seed, there is no need for seed selection. It is recommended for the farmers to select their own seed for sowing as follows:

a. put water in a bucket or large bowl;
b. place an egg in the water;
c. add common salt to the water and go on adding until the egg floats. If the egg floats it means that the concentration of salt in the water is appropriate for rice seed selection;
d. then place a small amount of rice seeds at a time into the bucket or bowl (do not overload) for 2-3 minutes, then remove the floating seed grains that are not good for the seed;
e. the rice seed grains that sink are quality grains, and good for purpose; and
f. wash the quality grains 2-3 times to remove the salt, and soak in clean water for sowing.

f. Other possible special topics and their resources

Identification of special topics is based on field-level problems identified or emerged during the implementation of the CFS. If information related to agrometeorology is selected as a special topic, Module A of this manual may be helpful. If some agronomic problems need special topics, existing manuals being used by FAO in different countries can be used (Table 22).

Table 22. Other possible special topics and their sources of technical materials

	Special topics	Page number	Related Literature	Source of the document
1	Water management in crops	81-97	FAO 2013. Climate-Smart Agriculture Sourcebook	http://www.fao.org/3/i3325e/i3325e.pdf
2	Soil management practices	120-124		
3	Planning for resilience against multiple risks	417-424		
4	Sustainable intensification farming system practices	15-26	FAO, 2011. Save and grow: A policymaker's guide to the sustainable intensification of smallholder crop production	http://www.fao.org/3/i2215e/i2215e.pdf
5	Soil health management	27-37		
6	Selections of crops and varieties	38-49		
7	Water management	51-63		
8	Plant protection	65-76		
9	Insect collection and identification	18-27	FAO, 2006. Farmer Field School (FFS) Manual Special Framework of Assistance (SFA) 2006 | St. Lucia	http://www.fao.org/3/a-ap094e.pdf
10	Insecticides effect on insects	27-30		
11	Plant disease zoo	30-31		
12	Weed seed bank	31-32		

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Identify other special topics that could be dealt with in CFS.

Activity 2: List the benefits of each of the special topics you identified.

Module C: DISSEMINATION OF AGROMETEOROLOGICAL SERVICES

Module C includes the following lessons:

1. Designing agrometeorological communications for farmers
2. Village Loudspeaker System for agrometeorological communication to farmers
3. Magnetic School Poster programme for agrometeorological communication to the new generation

Lesson C1: Designing agrometeorological communications for farmers

Learning objectives

The trainees will be able to:

a. identify key challenges of agrometeorological communications; and
b. design a communication strategy for agrometeorological services to farmers.

Materials required

- Flip Chart Paper
- Markers
- Projector

Agrometeorological communication actors and channels

Agricultural extension workers are already sufficiently trained in communications of agricultural technology to farmers. They may need additional knowledge to communicate agrometeorological services to rural farmers.

- The District Office of Natural Resources and Environment (DONRE) collects data continuously (both meteorological and agriculture cycle data).
- The DMH/DALAM/PPC/NAFRI develop the LaCSA and provide weekly and monthly data.
- The NAFRI provides training on agrometeorology to the staff of DAFO, DONRE, PAFO, PONRE before the cropping season.
- DALAM and PPC are able to conduct agrometeorological training.
- Training at the local level is organized by DAFO and DONRE, and may have support from projects or NGOs. They are capable of organizing such training even without direct support of DMH, DALAM or NAFRI.
- Farmers receive agrometeorological information from farmers' groups managed by MAF extension service. The group may have FFS or not, depending on the project.
- Agrometeorological services are disseminated regularly through android apps, LaCSA website smartphone applications, Facebook, and Lao National Radio and Television.
- More organized communications are done through village loudspeaker systems and school poster programmes.

Dissemination challenges

Agriculture extension workers need to understand the challenges in providing agrometeorological information to farmers when it is needed. This can be done by:

- decentralizing the meteorological services to better address location-specific weather-related problems;
- designing communication of the agrometeorological information to capture local level farming environment;
- integrating the agrometeorological services with local knowledge systems;
- translating the information into local language; and
- minimising long lead-times in providing information to local people, particularly during emergencies.

Agrometeorological information can have a positive impact on farmers' livelihoods if the farmers see it as salient, credible and legitimate (Cash and Buizer, 2005). This challenge can be addressed by some recommendations (Table 23).

Table 23. Key challenges and recommendations for the best use of agrometeorological information

	Key Challenges	Recommendations
1	Salience or relevance: tailoring content, scale, format and lead-time to farm level decision-making	• Provide information that farmers need, in a form and at a time that they can best use it • Local downscaling, improved resolution of rainfall forecasts and value adding to ensure it is usable and relevant to local farmers' needs • The agrometeorological services should be simple so farmers can easily use it in their decision-making and planning
2	Credibility: perceived technical quality of information	• Provide information that is perceived by the farmers to be valid, accurate, tested
3	Access: providing timely access to remote rural communities with marginal infrastructure	• For easy access, the agrometeorological information should be integrated with farm advisory services to coincide with farm crop and livestock operations • Broadcast advisories over a loudspeaker in the village. • Display bulletins in strategic places in the village. • Presence of a local agrometeorological knowledge hub for improved access and usability of advisories • Diversity of communication channels (agricultural extension, presence at farmer fairs, local knowledge hubs, face-to-face village meetings and training by agricultural experts, SMS, apps, voice messages, etc.)
4	Legitimacy: ensuring that farmers own climate services, and shape their design and delivery	• Collaboration with local NGOs or projects to promote the use of advisories to increase the range and subsequent adoption by embedding into local practice. • Sustained interaction between farmers and agrometeorologists and agricultural scientists to encourage higher use of advisories. • Designated agrometeorological contact point at the village level to communicate with extension service staff and disseminate advisories to the village. • Farmers can share the information learned in their training with other farmers. • Appointment of local farmers from villages to manage and record data collected from manual weather stations in the village • Keep interests of the farmer in mind, not merely a vehicle for pushing other actors' agendas and interests.
5	Equity: ensuring that women, poor and socially marginalized groups are served	• Training and discussions in villages with agricultural experts are the preferred form of communication, ensuring that all farmers can attend • Broad community mobilization and inclusion of all farmers within the community • Fully engage women farmers to maximize the adoption and use of advisories. • Women's groups play a positive role in gathering agrometeorological information from agrometeorologists and agricultural scientists, and disseminating it via word of mouth • Special care should be taken to identify gender-specific preferences for communications channels for climate advisory services, taking daily schedules and tasks into account

Source: Adapted from Venkatasubramanian et al., 2014

Information needed to design a communication strategy for agrometeorological services

- What are the characteristics of the target audience farmers?
- Which farming systems do they operate?
- Which crops are being grown in this season?
- What agrometeorological information doe they need?
- What is the levels of their education or literacy?
- What language do they feel comfortable?
- What is the socio-economic status to access the information (having TV, radio or smartphone)?
- What are the gender considerations for communication?
- Which time is suitable for female farmers to receive the information?
- Which media or channel are appropriate to transmit the information?

Designing a communication strategy for agrometeorological services

Farmers can benefit from effective communication and dissemination of agrometeorological information through multiple channels. The major points that can help in designing effective communications of agrometeorological services to reach needy farmers are summarised in Figure 23.

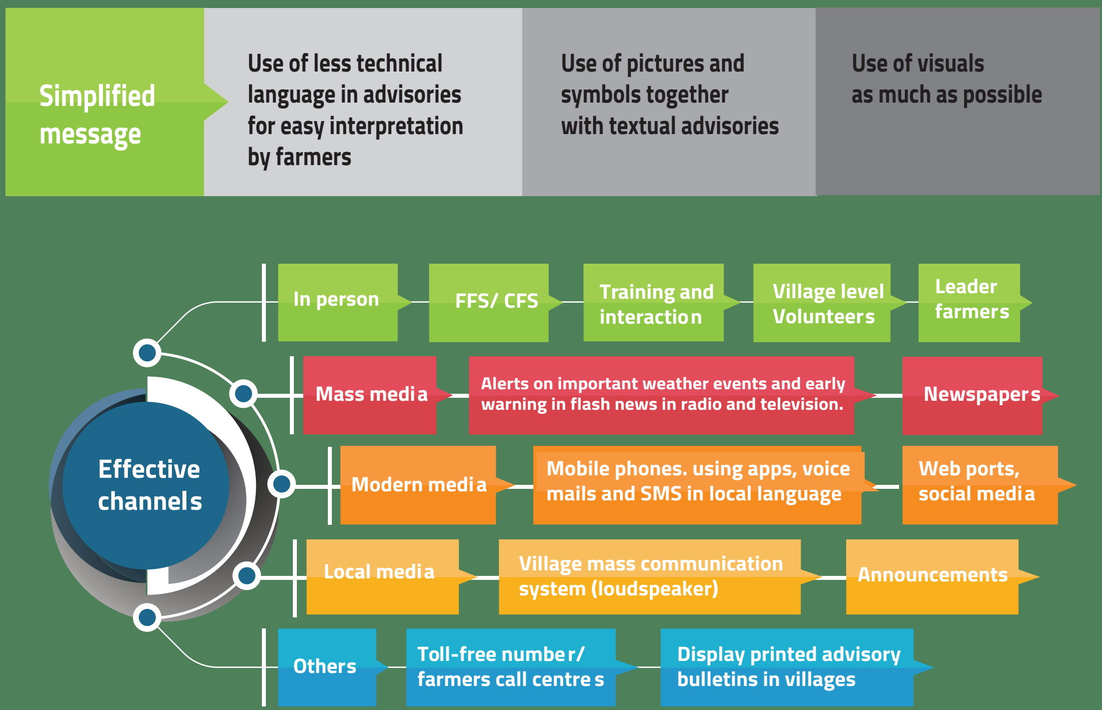


Figure 23. *Dimensions of effective communication Source: Authors, 2021*

Effectiveness of communication

Effectiveness of communication can be monitored by answering the following key questions (FAO, 2019):

- Has the information reached the user?
- Has the farmer used the information?
- How has the information helped the user to adapt their farm management?
- Has the information been helpful? How much?
- What feature did the user like, or dislike about the delivery system?
- What improvement/s would the users suggest?
- How can diverse types of agrometeorological data be integrated into useful information that responds to farming communities' often-dissimilar application needs?
- What type of information is needed by diverse groups of end-users, given their different farming socio-economic and cultural systems?
- Were the communication technologies appropriate for each social group?

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: List the dissemination channels used for agrometeorological information.

Activity 2: Rank the dissemination channels used in terms of their coverage.

Activity 3: Rank the channels in terms of their effectiveness.

Lesson C2: Village Loudspeaker System for agrometeorological communication to farmers

Learning objectives

The trainees will be able to:

a. elaborate on the methodology used for loudspeakers; and
b. design and operate a loudspeaker programme.

Materials required

- Flip Chart Paper
- Markers
- Projector
- Loudspeaker set
- The latest weekly and monthly bulletins.

The Village Loudspeaker System

More than 80 percent of the Lao PDR population live in rural areas, and they are mostly engaged in the agricultural sector. Crop and livestock production suffers from a lack of climatic information, especially agro-climatic information. The village loudspeaker system (Figure 24) is the most practical and useful way of providing information to farmers at the village level. Other transmission systems like TV, radio, and newspaper are not as effective due to the reduced number of local stations, unavailability of devices, or time to listen or read. The village loudspeaker system is adequate to reach farmers directly, as the farmers can listen to it or hear the information while working. This is a low-cost intervention and simple and easy for implementation as 60 percent of Lao villages have a loudspeaker system already installed and functioning. Based on an assessment undertaken in collaboration with CIAT (under publication), the SAMIS project recommends this system as the most cost-effective and appropriate for disseminating climatic information to farmers in rural areas in Lao PDR.

The village loudspeaker system aims to provide agro-climatic information (LaCSA) to farmers who could not access the LaCSA online or read the bulletins, especially the elderly and vulnerable people.

The loudspeaker programme's main objective is to encourage the flow of information from DMH to the village level without continued visits, while increasing regular access to agrometeorological information for decision-making. This improved decision-making has the potential to enhance local farmers' resilience through the inclusion of comprehensible climate and agrometeorological data in their farming plans.

The loudspeaker system aims to:

- encourage the flow of information from central to the local level and ultimately to farmers, particularly in those households that cannot read written bulletins or don't have time or resources to access it;
- raise awareness among villages about climate change, weather and the use the agrometeorological information; and
- have a financially sustainable system to distribute the LaCSA bulletin regularly.

Figure 24. *Champhone district, Savannakhet province. (left) Village news reader announces the weekly weather forecast to farmers at village level (right) Loudspeaker system*

Methodology and procedure of village loudspeaker programme

- Form a team composed of National Departments, PAFO, DAFO, DONRE, Lao National Radio and NGOs, depending on the availability of experts. In principle, at least one person in all decentralized offices of MAF and MONRE have been trained in the use of loudspeakers by NAFRI or by other departments.
- Organise a consultation village meeting with participation of team members. The meeting should cover project objectives, expected outcomes/ benefits, and role and responsibilities of village participants.
- Select village loudspeaker readers (at least two persons, male and female) assigned by village council or as volunteers.
- Train the village loudspeaker readers.
- Decide on the level of compensation to the village speakers.
- If possible, provide at least one LaCSA training for village farmers to understand the message given by the village loudspeaker system.
- If necessary, upgrade or install the village loudspeaker system.
- Test the operation of the system.
- Caution: Avoid unnecessary noise in the village; be very specific about the message to be communicated.

Role of the stakeholders

PAFO and DAFO officials are the facilitators. Their role is to:

- monitor and support the village council to implement the village loudspeaker system and village speakers' operation;
- monitor the appropriate reading of the agrometeorological information and ensure the regularity of the announcements;
- solve any problems or constraints in the operationalization of the system, through advice or technical assistance in solving issues in the operationalization of the LaCSA (technical aspect) for farmers; and
- coordinate with the village council in case of any emergency.
- The village council are the implementers. Their role is to:
- compensate the village speakers; and
- ensure regular operation of the system including repair and maintenance of the devices and replacement of any device if necessary.

Village speakers are the operators of the system. They are responsible for:

- the regular flow of agrometeorological information to the farmers through reading the LaCSA bulletin; and
- the repair and maintenance of the system, informing the village council if they cannot solve the problem.

Farmers in the village are the actual beneficiaries of the village loudspeaker system but they also have a role to play in ensuring the effectiveness of the system. They are responsible for paying attention to the announcements. In case of any emergency in the village such as fire, flood, wild animals, contagious diseases, theft, etc., the farmers should inform the village speakers' readers as soon as possible for an announcement so that other farmers can save their lives and properties. This is an additional benefit of the village loudspeaker system.

Tools and equipment for the village loudspeaker system

- laptop or tablet (1 unit) to receive the LaCSA bulletin for operating and receiving climatic information online; One smartphone is also suitable, but it might be less comfortable;
- internet connection to receive the bulletin;
- studio room (1 room) in a calm and quiet place;
- portable speaker (1 unit) for the village consultation meeting;
- loudspeakers (4 units) for transmitting climatic information to the whole village;
- amplifier of 2000W power (1 unit);
- wireless microphones (2 units)
- electric cable for connecting from studio room to set up loudspeakers (generally 5 units 1000 m long).

Training for using the LaCSA

The LNR experts or the NAFRI technical experts provide Agrometeorological News Training to DAFO, PAFO and DONRE, using a script for village authorities to read the weekly bulletins via the public announcement speakers. Every part of the bulletin is detailed in the script, making it easy for the villagers to convert the bulletins in a "radio-like" announcement. LaCSA use is related in lesson A5 to A9.

Training of Trainers (TOT) to train village speakers by MONRE or MAF

Since many villages in the country need setting up of the village loudspeaker system, DHM, DALAM and LNR staff cannot reach each village to train village heads, key farmers and village speakers. For this, multiple national entities (NAFRI, DHM, DALAM and LNR) can provide Training of Trainers (TOT) to PAFO and DAFO (or to PONRE and DONRE) staff to develop a pool of trainers so that they can conduct training in the villages.

The main topics to be covered in this TOT are:

- Technical basic knowledge about training village heads, key farmers and village speakers;
- Role of village heads, key farmers and village speakers;
- The LaCSA system and accessing information from the LaCSA;
- What is news and how many types of news are available (printed and electronic news in LaCSA, Facebook, or by WhatsApp);
- Mandate and responsibility of speakers on loudspeakers, radios and news;
- Characteristics of radios and loudspeakers;
- Advantages of loudspeakers compared to radio, TV, newspapers and others;
- Characteristics and properties of village speakers;
- Standardised characteristics of village speakers;
- What things should you do and not do with village loudspeakers;
- Language use through village speakers (writing and talking);
- Attention to be given for village speakers during the transmission;
- Setup and operation of the village loudspeaker system;
- Practical reading loudspeaker scripts.

Training village heads, key farmers and village speakers' readers on using the LaCSA

- Whether service is focused on 7-day weather forecast.
- Agromet service focused on weekly bulletin.
- Use and reading of weekly alerts and crop and livestock management urgent recommendations.
- Agromet service focused on monthly bulletin.
- Use and reading of monthly alerts and planning to follow up crop and livestock management recommendations
- Operation and maintenance of the loudspeaker system.

Training the village speakers on how to operate village loudspeaker system and how to read climatic information through the loudspeakers

- Installation and operation of the village loudspeaker system;
- Repair and maintenance of the system;
- What is news and how many types of news are available (printed and electronic news);
- Mandate and responsibility of loudspeakers, radios and news;
- Characteristics of radios and loudspeakers;
- Advantage of loudspeakers compared to radio, TV, newspaper and others;
- Accessing the bulletin updated on the LaCSA, including Facebook;
- Understanding the content of weekly and seasonal bulletins;
- What is news?
- How to be a newsreader?
- Characteristics and properties of village speakers.
- Standardised characteristics of village speakers.
- What things should you do, and not do, with village loudspeakers?
- Language used through village speakers (writing and talking);
- Attention for village speakers during the transmission;
- Practical reading loudspeaker script.

Practicing reading of LaCSA news using the script

After the village speakers receive the basic technical knowledge in reading climatic information and learn and understand how to read it, the trainers distribute loudspeaker scripts to village speakers for practice (Box 10 and 11). The trainer reads first, followed by the village speakers. After reading, the facilitators ask the audience for comments and how they feel about transcript reading. They discuss if the reading is clear in terms of voice, if it's understandable and applicable, and what might need to be improved. After approval by the audience, the village speakers read again in the studio room to transmit information through loudspeaker systems.

The script for the weekly bulletin, available in Box 10, is short and concise and should be read in rapidly and regularly, potentially every week at the same time. The bulletin is produced automatically and is ready for download every Monday morning. So, the reader could read the weekly bulletin early on Monday or Tuesday morning. The reading of the bulletin should not take more than five to ten minutes.

Box 10: Village Loudspeaker script for weekly bulletin

Greeting to the audience!

I am ……………………(Spokesperson's name)

This is the time for weather forecast and agro-advisory issued on …………. (Lao date and month). .

In the last week, rainfall was ………. mm

The maximum temperature was ……….degree centigrade.

The minimum temperature was ……… degree centigrade.

In the coming week, rainfall is expected/not expected on such and such days.

The maximum temperature will remain [normal/above normal/below normal].

The minimum temperature will remain [normal/above normal/below normal].

The coming week presents the following agro-meteorological stresses:

(select based on the forecast)

There is a [low / medium / high] risk of [drought]

There is a [low / medium / high] risk of [heat or cold stress]

There is a [low / medium / high] risk of [heavy rainfall]

[Such and such] insect pests are forecasted for [such and such] crops.

You are advised to do [such and such] farm practices (nursery raising, transplanting, fertilizer application, pesticide application, irrigation or harvesting of [such and such] crops.

These information are obtained from the LaCSA system weekly and seasonal bulletins produced by the DMH.

For more information please check Facebook.com at samisdmh or access to the LaCSA on http://147.46.250.219:8081/

Contrary to the previous one, the script for the monthly bulletin, available in Box 11, is long and contain advisories for a few months. Also, they allow for many more details for multiple crops. The monthly bulletin changes over the time of the years, and it is published around the sixth or eight day of each month. The reader should be reading regularly but it cannot be read fast. The bulletin is easy to read, as it contain simple phrases in pasalao. However, the reading of the bulletin could take more than twenty minutes during the cropping season.

Box 11: Village Loudspeaker script for monthly bulletin

Greeting to the audience!

Finally, today we have met again with weather forecast news service on Meteorological Weather Forecast throughout the village's loudspeaker.

This is regularly previewing on (time) day (………..).

Today, the presenter of this program is ……. (Spokesperson's name). I gonna take you to meet the meteorological – agro climate news which is predicting on (from month ... to month ...) which consistency to the Lao calendar year (from Lao month ... to Lao month…) (B.C.).

You are informed that our province (name of province) will experience

(select based on the forecast) [warmer than normal / normal / cooler than normal] years temperature, and

(select based on the forecast) [drier than normal / normal / wetter than normal] rainfall.

Based on this situation, the agro-climate advisory foreseen the following risks as follows:

(read the most evident risks and the month, one by one, such as:

There is a [low / medium / high] risk of drought for the month of [read the name of the month]

There is a [low / medium / high] risk of flooding for the month of [read the name of the month]

There is a [low / medium / high] risk of diseases for the month of [read the name of the month]

There is a [low / medium / high] risk of insect pests for the month of [read the name of the month]

There is a [low / medium / high] risk of heat stress for the month of [read the name of the month]

There is a [low / medium / high] risk of cold stress for the month of [read the name of the month]

The Department of Meteorology and Hydrology is giving the following climate smart recommendations for [name of the crop] [... read the details of the recommendations for each crop].

For more information please check the LaCSA system Facebook at samisdmh or access to the LaCSA on http://147.46.250.219:8081/

Loudspeaker monitoring system

There are two monitoring steps: regular monitoring by PAFO, DAFO and yearly monitoring on assessment and evaluation by DMH and DALAM. Appendix VI presents various questionnaires for monitoring results. The PAFO and DAFO monitor the loudspeaker activities implemented by villagers. Moreover, the DAFO can closely monitor the functioning, regularity and effectiveness of the village loudspeaker system from time to time.

The regular monitoring by PAFO and DAFO should cover at least the following points.

- Are the farmers receiving agrometeorological information regularly?
- Do the farmers give attention to the loudspeaker announcements? Can they tell in which day and at what time the announcement is made?
- Can the farmers tell what was announced in the recent announcement?
- Do the farmers understand the information received?
- Do the farmers apply the agrometeorological information received?
- Are the farmers satisfied with the information?
- Do they need any support?

Yearly monitoring system

A scientific evaluation of loudspeaker systems' effectiveness by using KOBO collect or similar software has been developed in collaboration with CIAT.

The result of the assessment will be published separately. However, the questionnaire is published as Appendix VI as other interested actors and users of the LaCSA can access it and adapt it to their needs. The assessment includes questionnaires for individual households, bulletin readers and NGO interviews.

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Install the village loudspeaker system. If already installed, explain how to install, upgrade, and explain each of the instruments' functions.

Activity 2: Identify what precautions are needed during the announcement, such as the distance of the microphone from the mouth, keeping the studio calm and quiet, speed of speaking, language to use, and script to be read.

[18]Government of Lao People's Democratic Republic, Food and Agriculture Organization (FAO) and World Food Programme piloted dissemination of agrometeorological services via school teachers and students using school posters.

Lesson C3: Magnetic School Poster programme for agrometeorological communication in schools

Learning objectives

The trainees will be able to:

a. describe the process of the school programme for agrometeorology; and
b. design a school programme for effective dissemination of agrometeorological services.

Materials required

- Flip Chart Paper, Markers, Projector
- The latest weekly weather bulletin
- The latest school poster.

Explanation of the School Poster programme

The school poster programme raises young people's awareness of climate change, weather and the use of agrometeorological information.

This approach is an effective way to reach illiterate farmers in the village, as teachers and students are likely to take the agrometeorological information back home to their families to implement in their farms. Through the use of this information, farmers may make better informed decisions regarding their rice crops and support the food security and nutrition of their communities.

This dissemination mode provides a new avenue to share innovative climate service system information within Lao rural schools and their communities. Also, it is conceivable that by choosing the right age group through appropriate awareness raising campaigns, distribution through schools may be a useful long-term approach as children grow older.

Objectives and purposes of the school poster programme[18]

The school poster programme objective is to disseminate agrometeorological services via school teachers and students. School teachers and local Government staff are trained in the interpretation of the LaCSA bulletins.

This programme's main objective is to improve the flow of information from children to their families, thereby increasing farmers' access to agrometeorological information for better decision-making. This improved decision-making has the potential to enhance the local farmers' resilience through the inclusion of comprehensible climate and agrometeorological data into their farming plans.

The school poster programme aims to:

- test the flow of information from teachers to children and ultimately to their farming families, particularly in those households that cannot read written bulletins;
- raise awareness among school children about climate change, weather and the use the agrometeorological information; and
- train school teachers in the LaCSA bulletin.

Methodology of the school programme

Teachers need to be trained the LaCSA products can be disseminated through schools. The scope of the training includes:

- accessing the weekly bulletins from the LaCSA;
- interpreting the weekly bulletins;
- summarising the information into an easy-to-understand poster; and
- using images to make the different meteorological conditions and advisories understandable and straightforward for the pupils.

The weekly bulletins are reproduced onto magnetic posters and placed in school premises. The magnetic posters are available for download and printing at: https://drive.google.com/file/d/1mQ3nFb1CRjiHYlLmtY-MnlbnUkd_dwn z/view?usp=sharing

The trained school teachers update the signboards weekly. Students are expected to be able to effectively communicate the information to their parents, with the aim of improving agricultural productions and climate-preparedness. The students understand the content of the poster and talk among themselves about it and carry the message to their parents at home

Equipment and tools for school posters:

- Sign board (downloadable from: http://www.fao.org/fileadmin/user_upload/samis/imgs/2_POSTER_AGROMETEO%20FORECAST_A1_594%20x%20841%20mm_10nov19.jpg
- Magnet stickers of agroclimatic symbols.
- Magnetic weekly posters.

LaCSA training for school teachers

The Provincial Education and Sports Bureau authorizes training teachers in the school poster programme. The training can be organized at the District Education and Sports Bureau. Two teachers are to be trained from each school. One single training session can include 20-25 teachers.

The curriculum of the training includes how to:

- access the climate and agrometeorological information via the LaCSA website;
- download and understand the LaCSA bulletins;
- interpret the weekly and seasonal forecast bulletins
    - selection of weather stations (automatic or manual)
    - weather forecast services
    - weekly weather forecast
    - monthly/ seasonal-weather forecast
    - agrometeorological services;
- update the signboards;
- explain the posters to the students in the language they can understand
    - interpretation of magnet sticker signs for school children
    - rainy day
    - sunny day
    - wind (gentle, medium, strong)
    - extreme events (storm, strong wind, heat stress, cold stress, drought, flood)
    - cloud
    - temperature (increasing, decreasing)
    - insect pests (planthoppers, bugs, etc.)
    - crop diseases (blast, leaf blight, etc.); and
- where to report the progress of the school poster programme.

Presentation of school magnetic posters to students

The presentation is conducted in the school courtyard (Figure 25) and should be interactive with the students. Teachers:

- put up the boards in front of a group of students;
- place magnetic pictures on the board according to the weekly bulletin;
- present the updated poster to students, starting by explaining the pictures in detail; and
- ask students what the weekly weather is likely to be (rainfall, temperature, cold stress, heat stress, extreme events, flood, drought and what pest and diseases), based on the information on the poster.

The students are invited to carry the messages home, because the ultimate goal is having the parents applying the information in their farming activities.

Figure 27. Magnetic poster and its sharing with students (Saravan province in collaboration with WFP)

Student Participation

After the teacher presents the poster (Figure 26), the students observe and explain or express their perceptions on what will happen this week, including:

- Will the temperature increase or decrease or remain the same as the last week?
- Will the rainfall occur this week?
- Will the rainfall be increased or decreased or remain the same as the last week?
- Will there be any extreme events (storm, flood, drought, hot stress, cold stress) this week?
- What is the stage of rice growth this week (vegetative, reproductive, maturity)?
- What types of insect pests and diseases might occur in their parents' rice fields (planthoppers, gall midge, etc.) this week?
- Will you pass the information home to your parents?
- Do your parents accept what you tell them?

School poster monitoring system

Regular monitoring is available for the teachers, the pupils, and the farmers to follow up the implementation of School Poster Programme. The questionnaire is available in Appendix VII.

Typical questions include:

- Are the school teachers receiving the weekly bulletin regularly?
- How do they understand the information?
- Do they update poster sign board regularly?
- How often do they present the sign board to their students (how many times per week, and at what time they do the presentation)?
- How interested are the students?
- Do the students understand the messages?
- Do the student carry the messages to their parents?
- Do their parents accept the messages given by their children?
- Do the farmers apply the information in their day-to-day decision making?

Yearly monitoring in collaboration with WFP

A scientific evaluation of the loudspeaker systems' effectiveness by using KOBO collect or similar software has been developed in collaboration with CIAT. The result of the assessment will be published separately. However, the questionnaire is published as Appendix VI so NGOs, and other interested actors can access it and adapt it to their needs.

The assessment includes interviews with teachers, focus groups or individual discussions with students, and focus groups or individual discussions with the students' parents

Challenges of the school poster programme

Information transmission gaps from school children to their parents may be the greatest challenge of this programme. The information gaps can be reduced with some improvements in the village school poster programme (Table 24).

Table 24. Challenges and possible solutions for the school poster programme

	Challenges	Possible improvements
1	The key information for farming, such as pest and disease spread, may not reach their farming parents	The trained teachers orient the parents and explain the poster to parents on parents' day Display the poster in front of the school continuously so that whenever any parent visits the school, he or she can see the poster and ask students and teachers about it
2	The students may be too young to communicate the information to their parents effectively	Use the poster programme to the students of higher class
3	The students seem to be lacking confidence in their ability to pass on the information to their parents accurately	Hand over printed individual climatic symbols to the schools. The teachers distribute the specific symbol to the students on the basis of the forecasts. The students can show the symbol to their parents and talk with them more confidently

ACTIVITIES TO BE COMPLETED BY THE TRAINEES

Activity 1: Draw agro-climatic symbols to represent light rainfall, heavy rainfall, flood, drought, low temperature, high temperature, heat waves, cold waves, spread of insect pests, spread of plant diseases and clear weather.

Activity 2: Identify actions the farming parents can take for each of the symbols drawn.

CONCLUSIONS

This manual is prepared for training of agriculture extension staff on agrometeorological service delivery to farmers. It can also be used to train other staff including agrometeorologists and agrometeorology-related policy makers to better understand the needs of the farmers.

This manual will help government staff, staff in projects and the development sector to understand and explore agrometeorological information, apply agrometeorological services in agriculture, and improve crop yields and reduce losses.

The manual is based on learning from the SAMIS project to enable it to be replicated in other parts of Lao PDR. The manual includes basic theory on field climate services for farmers, as well as details of the technological innovations introduced by the SAMIS. Some other technologies not yet implemented by SAMIS are also added for future endeavour to adopt agrometeorology in agriculture or other projects.

By involving local experts, the training can offer the chance for participants to become better informed and engaged with this innovative methodology, new and useful information and techniques. Farmers and experts across Lao PDR have easier access to more and better agrometeorological weather forecasts and related information on the implications for crops than ever before, thanks to the Laos Climate Service for Agriculture (LaCSA). The LaCSA system is an initiative of the Department of Meteorology and Hydrology in MONRE with the support of many entities in MAF.

The LACSA system provides farmers with rainfall and temperature seasonal forecasts as well as crop calendar and pest and disease in near-real-time (once per week) during the crop season.

The training manual comprises three modul*es:*

- agrometeorology and weather forecasts;
- climate farmers' field schools; and
- disseminating agrometeorological services to farmers.

The first module is the largest one comprising 11 lessons. The second and third modules consist of five and three lessons, respectively. The first module can be used independently, whereas training of the second and third modules depends on having completed the first module.

Though the manual provides most of the information needed for the training of agricultural extension staff in agrometeorology, resource persons should check for updates at the time of training to be abreast of the most recent information.

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Accumulated Rainfall: is a measure of rainfall accumulation for a defined period to predict plant and pest development effects. Comparing with the accumulated rainfall last year informs farmers about crop water stress levels (either from shortage of or excess of water) and potential build-up of diseases and insect pests affected by rainfall during the present cropping season.

Actinometer: is a device to measure the intensity of solar radiation by measuring the rate of change of photo-induced responses in a chemical system.

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm, or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).

Adaptive Capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014).

Adaptation to climate change: Refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects, or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.

Agroclimatology: Refers to applied climatology to understand effect of climate on crops, including length of the growing season, relation of growth rate to crop yield to various climatic factors.

Agro-ecosystem analysis (AESA): Farmers in FFS divided into sub-groups closely observe and analyse production system and growth and other behaviour of the crop under study every week and compare the observations with those observed the previous week. The AESA help farmers to understand the inter-relationships between the crop, soil, water, weeds, insect pests, and weather patterns.

Agricultural meteorology (or agrometeorology): Refers to the interactions between meteorological and hydrological factors, on the one hand, and to agriculture in the widest sense including horticulture and animal husbandry and forestry on the other. Agricultural meteorology deals with the meteorological, hydrological, pedological and biological factors that affect agricultural production as well as the interaction between agriculture and the environment.

Aquifer: Underground layers of permeable rock, sediment or soil filled with water and interconnected, so the water stays within or flows through them. The two major types of aquifers are confined and unconfined.

Aridity: Characteristic of a climate relating to insufficiency or inadequacy of precipitation to maintain vegetation (WMO, 1992). Aridity is measured by comparing long-term average water supply (precipitation) to long-term average water demand (evapotranspiration). If demand is greater than supply, on average, then the climate is arid.

Available groundwater resource: Volume of water stored in an aquifer which is available for development and use (WMO-UNESCO). It is calculated as the difference between the long-term annual average rate of overall recharge of the body of groundwater and the long-term annual rate of flow required to achieve the ecological quality objectives for associated surface waters (surface waters that are recharged by groundwater) (WMO/UNESCO, 2012)

Basin (catchment or watershed): An area having a common outlet for its surface runoff (WMO/UNESCO, 2012).

Biology: is the study of living organisms (plants, animals and microorganisms), their morphology, physiology, anatomy, behaviour, origin, and distribution.

Climate: represents the integrated composite of the long-term prevailing weather and can be represented by a long-term average (30 years) of specific elements, together with their variation or the frequency of occurrence of extreme weather conditions.

Climate change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014).

Climate data: Historical and real-time climate data, together with direct model outputs covering historical and future periods. Information about how these observations and model outputs were generated ("metadata") should accompany all climate data.

Climate information: Refers to the different types of weather forecasts, climate data, climate products, climate knowledge and agrometeorology products.

Climate service: Providing climate information in a way that assists decision-making by individuals and organizations. A service requires appropriate engagement together with an effective access mechanism and must respond to user needs.

Climate forecast (prediction): A climate forecast (prediction) is a probabilistic statement about future climate conditions on timescales ranging from seasons to decades. It is based on conditions that are known at present and assumptions about the physical processes that will determine future changes.

Climate product: A derived synthesis of climate data. A product combines climate data with climate knowledge to addvalue.

Climatology: is the study of the behaviour of the atmosphere and changes in temperature, pressure, and other atmospheric factors over a period of time. It is a branch of atmospheric science, but the study of climate can be related to every other aspect of the earth system including the geosphere (solid earth) and hydrosphere (terrestrial water reserves) because climate affects all of Earth's surface.

Competency: An observable behaviour supported by specific knowledge, skills, and attitudes. Each competency has a specific result or output.

Competency model: A set of competencies for a specific role. Shows optimum behaviours with supporting knowledge, skills, and attitudes for a specific role, such as needs assessor or training plan developer.

Content Analysis: A procedure for organizing narrative and qualitative data into emerging themes and concepts. Usually associated with a quantitative form of analysis in which the themes are counted or measured.

Contextual analysis: Takes information from other analyses and answers how, when, and where training will be delivered. It compares different delivery media and addresses scheduling issues and other logistics.

Cost/benefit analysis: An estimate of the cost of the training weighed against the possible benefits of training.

Course designer: A person who designs a training program based on a needs assessment and a training plan and includes writing learning objectives, creating learning activities, lesson plans, and audio-visuals.

Crop calendar: Contains information on planting as well as sowing and harvesting periods of locally adapted cropsin specific agro-ecological zones. It also provides information on the sowing rates of seeds, planting material and the main agricultural practices and furthermore, it helps farmers and extension staff to make the appropriate decisions on crops and their sowing period with respect to agroecology.

Crop failure: Abnormal reductions in crop yield such that is insufficient to meet the nutritional or economic needs of the community.

Deficiency: A performance that does not meet the current standard. It means that there is a prescribed or best way of doing a task and that variance from it is creating a problem.

Desertification: Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UNCCD, 2019).

Deterministic forecast (prediction): Forecasts (predictions) of an event of a specific magnitude at a specific time and place.

Development plan: suggests ways to correct a deficiency to meet a goal.

Disaster: A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts (UNISDR, 2017).

Disease Index: indicates a potential risk of disease epidemic during a defined rice cropping period, calculated with complex effects of temperature, relative humidity, and rainfall on infection development for two different disease groups. Group A diseases include rice blast, sheath rot; Group B diseases include bakanae, brown spot, sheath blight, bacterial blight, and tungro. Farmers are recommended to do frequent surveillance for disease symptoms when there are medium or high risk warnings.

Disaster Risk: The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity (UNISDR, 2017).

Disaster Risk Management: DRM is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses (UNISDR, 2017).

Disaster Risk Reduction: DRR is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development (UNISDR, 2017).

Drosometer: is an instrument used to measure the amount of dew formed on a given surface. It consists ofa hemispheric glass vacuum cup exposed to the atmosphere. Dew forming on the glass surface automatically collectsin the bottom of the cup and is weighed at the end of the exposure period. Another form of drosometer, the Duvdevani dew gauge, consists of a block of wood with its surface treated in such a manner that dew forms in characteristic patterns. Photographs are supplied with each instrument to enable the observer to match the dew formation with a set of standards corresponding to a dew fall of from 0.01 to 0.45 mm.

Drainage: Removal of surface water or groundwater from a given area by natural or artificial mean (WMO/UNESCO, 2012).

Drought: (1) Prolonged absence or marked deficiency of precipitation. (2) Period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance (WMO, 1992).

Drought assessment: Assessment reviewing drought conditions and indicating potential impacts for various economic sectors, such as agriculture and forestry (NOAA/NWS, 2017).

Drought forecast: The statistical estimate of the probability of occurrence of a future drought event (GWP/CEE, 2015).

Drought impact: A specific effect of drought on the economy, society, and/or environment, which is a symptom of vulnerability (GWP/CEE, 2015).

Drought impact assessment: The process of assessing the magnitude and distribution of the effects of a drought (GWP/CEE, 2015).

Drought index: Computed numerical representations of drought severity, assessed using climatic or hydrometeorological inputs, including precipitation, temperature, streamflow, groundwater and reservoir levels, soil moisture and snowpack. They aim to measure the qualitative status of drought on the landscape for a given time period. Indices are technically indicators as well (WMO/GWP, 2016). The drought index is calculated from the Effective Drought Index (EDI) that considers weighted contribution of daily rainfall over the past 60 days.

Drought indicator: Variables or parameters used to describe drought conditions. Examples include precipitation, temperature, streamflow, groundwater and reservoir levels, soil moisture and snowpack (WMO/GWP, 2016).

Drought Management Plan: It is a planning tool that can be applied to the basin scale or to other scales. It aims to define mechanisms and a methodology for detecting and predicting droughts, establish thresholds for different stages of drought as it intensifies and recedes, define measures to achieve specific objectives in each drought stage, ensure transparency and public participation in the development of drought strategies. The main objective of drought management plans is to minimize the adverse impacts on the economy, social life and environment when drought appears (GWP/CEE, 2015).

Drought vulnerability assessment: It is a drought vulnerability quantification and description that consistin identifying the relevant factors influencing it, from the point of view of exposure, sensitivity and adaptive capacity. The final aim of a drought vulnerability assessment is to identify the underlying sources of drought impact (Urquijo et al., 2015).

Dry spell: Period of abnormally dry weather. Use of the term should be confined to conditions less severe than those of a drought (WMO, 1992).

Early Warning (EW): The provision of timely and effective information, through identified institutions, that allows stakeholders at risk of a disaster to take action to avoid or reduce their risk and prepare for effective response (GWP / CEE, 2015).

Early Warning System: EWS is a set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss (IPCC, 2014).

El Niño: refers to the large-scale ocean-atmosphere climate phenomenon linked to a periodic warming in sea-surface temperatures across the central and east-central equatorial Pacific (between approximately the date line and 120W). El Nino represents the warm phase of the El Nino/Southern Oscillation (ENSO) cycle, and is sometimes referred to as a Pacific warm episode. El Nino originally referred to an annual warming of sea-surface temperatures along the west coast of tropical South America (CPC, 2018).

El Niño Southern Oscillation (ENSO): The ENSO cycle refers to the coherent and sometimes very strong year-to-year variations in sea- surface temperatures, convective rainfall, surface air pressure, and atmospheric circulation that occur across the equatorial Pacific Ocean. El Nino and La Nina represent opposite extremes in the ENSO cycle (CPC, 2018).

Erosion: Wearing away and transport of soil and rock by running water, glaciers, wind or waves (WMO/UNESCO, 2012).

Evaluation criteria: A list of behaviours that are met in order to describe achievement or success.

Evapotranspiration: The combined processes by which water is transferred from the Earth's surface to the atmosphere by evaporation from the land and ocean surfaces and by transpiration from vegetation (WMO, 1992).

Exposure: The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas (UNISDR, 2017).

Famine: Famine exists in areas where at least one in five households has an extreme lack of food and other basic needs. Extreme hunger and destitution is evident. Significant mortality, directly attributable to outright starvation or to the interaction of malnutrition and disease is occurring (IPC, 2018).

Feasibility Analysis: A cost-benefit analysis completed prior to conducting training. It is an estimate of the cost of the training weighed against the possible benefits that could be achieved if training were conducted. A feasibility analysis identifies whether conducting the training costs less than doing nothing.

Feedback meeting/debrief meeting: A meeting where the needs assessor tells decision makers what information or data have been collected. Data are interpreted and recommendations created and become part of the training plan.

Food security: Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability. The nutritional dimension is integral to the concept of food security (FAO, 2009).

Gale: is a very strong wind. There are conflicting definitions of how strong a wind must be to be considered a gale (63-87 km/h or 17.5-24.2 m/s of sustained surface winds) (NOAA/NWS, 2017).

Gap Analysis/performance analysis: identifies the difference between current performance and the desired performance.

Goal analysis: A consensus process to make a vague desire more specific and measurable.

Gridded climate data: satellite-based information to obtain a regular grid of weather parameters whichallow estimates of climate parameters at locations far from the vicinity of meteorological stations, thereby allowing studies of local climate in data-sparse regions.

Groundwater: Water within the earth that supplies wells and springs; water in the zone of saturation where all openings in rocks and soil are filled, the upper surface of which forms the water table (NOAA/NWS, 2017).

Growing Degree Days: GDD is a measure of heat accumulation used by farmers to predict crop and insect pest development rates, such as how long it takes for a flower to bloom, a crop to reach maturity, or an insect pest to complete its life cycle. Higher (lower) GDD accumulation than last year indicates earlier (later) development of crops and insect pests during the present cropping season.

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, proper ty damage, social and economic disruption or environmental degradation. Hazards may be natural, anthropogenic or socio-natural in origin. Natural hazards are predominantly associated with natural processes and phenomena. Anthropogenic hazards, or human-induced hazards, are induced entirely or predominantly by human activities and choices. Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity or magnitude, frequency and probability (UNISDR, 2017).

Hydrology: is the science dealing with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere.

Integrated Water Resources Management: IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2000).

Insect Pest Index: indicates a potential risk of insect pest infestation during a defined rice cropping period, calculated with heat accumulation (growing degree days) and rainfall effect on insect population build up. Farmers are recommended to do frequent insect pest surveillance when there are medium or high risks warnings.

Interview: The process of asking questions to experts or performers to identify training needs.

Job Analysis: The process of identifying all the parts of a specific job; conducted before a task analysis.

Land degradation: Reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns such as: soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation (UNCCD, 2019).

Land use: Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction and conservation) (IPCC, 2014).

La Niña: refers to the periodic cooling of ocean surface temperatures in the central and east-central equatorial Pacific that occurs every 3 to 5 years or so. La Nina represents the cool phase of the El Nino/Southern Oscillation (ENSO) cycle, and is sometimes referred to as a Pacific cold episode. La Nina originally referred to an annual cooling of ocean waters off the west coast of Peru and Ecuador (CPC, 2018).

Learning objective: describes specific behaviour, conditions, level of achievement and is written from the learner's point of view.

Lysimeters: define a specific boundary to contain soil water and permit measurement of either the soil- water balance or the volume of water percolating vertically and/or its quality.

Meteorology refers to a science dealing with the atmosphere and its phenomena.

Mitigation (of disaster risk and disaster): The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability.

Mitigation (of climate change): A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2012).

Monsoon: Seasonal change of wind direction, from sea to land or vice versa, associated with widespread changes in temperature and rainfall in subtropical regions (WMO/UNESCO, 2012).

Need: A desire to improve current performance or to correct a deficiency.

Need Assessment: Process of collecting information about an expressed or implied need that could be met by conducting training. Gathering of information about a specific work need that can be resolved by training. The types of needs assessment include performance analysis, target population analysis, sorting training needs and wants, job analysis, and task analysis.

Needs versus Wants Analysis: Discovers training needs that are related to the organization's work. Training is linked to the outcome and providing appropriate training will benefit the individual as well as the organization.

Participant learning hour (PLH): Calculated by multiplying the number of participants by class hours. The PLH is later divided into the total cost to get the cost per participant and cost per learning hour. The cost per learning hour, similar to a person hour figure, can be used to compare the cost of one training program to another.

Pedology, or soil science: is the study of formation, characteristics, and distribution of soils.

Percolation lysimeters: may be installed to determine vertical soil-water flux (drainage) or the chemical movement within the soil at a defined boundary. Its accuracy of the evaporative water balance is directly related to the precision of the soil-water measurement and its integration through the vegetation root zone.

Performance Analysis/gap analysis: Looks at an official's current performance and identifies whether the official is performing as desired.

Performance Deficiency: A difference with a negative connotation, implying that the official is not meeting a known standard for performance.

Point climate data: station data that are more representative of the site alone and not of a wider area. Guidelines on where to install a weather station are defined by the World Meteorological Organization (WMO, 2017).

Post-training analysis: Occurs after training has been completed and attempts to identify the cause of continuing deficient performance.

Preparedness: The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters (UNISDR, 2017).

Prevention: Activities and measures to avoid existing and new disaster risks. Prevention (i.e., disaster prevention) expresses the concept and intention to completely avoid potential adverse impacts of hazardous events. While certain disaster risks cannot be eliminated, prevention aims at reducing vulnerability and exposure in such contexts where, as a result, the risk of disaster is removed (UNISDR, 2017).

Proactive approach to drought management: A proactive approach to drought risk management includes appropriate measures being designed in advance, with related planning tools and stakeholder participation. The proactive approach is based on both short-term and long-term measures and includes monitoring systems for a timely warning of drought conditions, the identification of the most vulnerable part of the population and tailored measures to mitigate drought risk and improve preparedness. The proactive approach entails the planning of necessary measures to prevent or minimize drought impacts in advance. This approach is reflected in the three pillars of integrated drought management (Vogt et al., 2018).

Probabilistic forecast (prediction): Forecasts (predictions) of the probability of an event of a certain (range of) magnitude(s) may occur in a specific region in a particular time period.

Psychrometer: measures the relative humidity (RH) in the atmosphere through the use of difference in temperature readings in two thermometers: a dry bulb thermometer that measures the temperature by being exposed to the air and a wet bulb thermometer which measures temperature with moist bulb. Water evaporation, which is negatively related with RH, cools the moist bulb.

Pyranometer: a type of actinometer used for measuring solar irradiance on a planar surface and it is designed to measure the solar radiation flux density (W/m2) from the hemisphere above within a wavelength range 0.3 μm to 3 μm.

Raster data represent the landscape as a rectangular matrix of square cells, composed of rectangular arrays of regularly spaced square grid cells. Each cell has a value representing a property or attribute of interest. Eg., gridded data of land usage and elevation.

Reactive approach to drought management: A reactive approach to drought management is based on crisis management: it includes measures and actions after a drought event has started and is perceived. This approach is taken in emergency situations and often results in inefficient technical and economic solutions, because actions are taken with little time to evaluate best options and stakeholder participation is very limited. This approach has often been uncoordinated and untimely. In addition, crisis management places little attention on trying to reduce drought impacts caused by future drought events (Vogt et al., 2018).

Recovery: The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risk (UNISDR, 2017).

Reservoir: Body of water, either natural or man-made, used for storage, regulation and control of water resources (WMO/UNESCO, 2012).

Resilience: The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management (UNISDR, 2017).

Response: Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. Disaster response is predominantly focused on immediate and short-term needs and is sometimes called disaster relief (UNISDR, 2017).

Runoff: That part of the precipitation which flows towards a river on the ground surface (surface runoff) or within the soil (subsurface runoff or interflow) (WMO/UNESCO, 2012).

Seasonal climate outlook: provides the probabilities of rainfall and temperature over a three-month period (FAO, 2019).

Skill deficiency: When a task is not being done correctly due to a lack of skill by the performer.

Skill hierarchy: An arrangement of skills that shows dependence of one skill on another. A graphic representation of the skills any learner must possess in order to meet the learning objective. It looks like an organization chart because it shows the relationship between skills. The hierarchy is not specific to a learner; it is specific to the task.

Special topic: Some topics are included in discovery learning process of FFS to solve local problem faced by the farmers and identified by them or sometimes advised by facilitators based on observation of local problems.

Soil degradation: The decline in soil quality caused by natural processes or, more commonly, improper use by humans, resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries (FAO, 2017).

Soil moisture: Moisture contained in that portion of the soil which lies above the water table, including the water vapour contained in the soil pores. Sometimes it refers strictly to the humidity contained in the root zone of the plants (WMO, 1992).

Spatial interpolation: is the process of using points with known values to estimate values at other unknown points to estimate value of rainfall, temperature, or any other climatic parameter at a given site based on the observations at neighbouring locations. Operational climatology and agrometeorology are regularly confronted with problems, such as when estimating missing data.

Squall: is universally used to refer to a sudden wind-speed increase, both historically and in the present day. To be classified as a squall, the wind must increase at least 8 m/s and must attain a top speed of at least 11 m/s, lasting at least one minute in duration (WMO, 1962). Usually, this sudden violent wind is associated with briefly heavy precipitation.

Target Population: The individual or group involved in a need assessment or training programme.

Target population analysis: Collects information about who will attend the training. The results of a target population analysis yield two types of information: first, it helps you decide who needs training and how a specific course mustbe customized to meet the participants' needs, and second, what class groupings are appropriate.

Task Analysis: Finds the best method and sequence of steps to complete a specific task.

Teleconnection: A linkage between weather changes occurring in widely separated regions of the globe. Most commonly applied to variability on monthly and longer timescales, the name refers to the fact that such correlations suggest that information is propagating between the distant points through the atmosphere.

Trainer: This person presents information and directs structured learning experiences, so individuals increase their knowledge and skills. This person can also act as a performance coach and facilitator.

Training Needs Assessment: The method of determining if a training need exists and, if it does, what training is required to fill the gap. It is the process of collecting information about an expressed or implied organizational need that could be met by conducting training.

Training of Trainers: TOT is a high-level professional learning process for qualified trainers who will be providing training and capacity-building assistance for field level staff for implementation of agrometeorological services in climate farmers field schools.

Training plan: Based on a needs assessment, a training plan identifies training issues, recommends results and objectives, and suggests how they can be reached. The plan states the causes of a deficiency, what performance standards are not being met, and who is the target population. The plan further recommends a means to evaluate suggested strategies, how to partner with management, and when interventions are to be scheduled.

Training programme: A training course or event to improve the knowledge, skills and attitudes of employees to meet a business need.

Vector data represent features as discrete points, lines, and polygons. Spatial interpolation uses vector points with known values to estimate values at unknown locations in order to create a raster surface covering an entire area, for example political or administrative boundaries, streets and parcels.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (UNFCCC, 2014).

Water banking: A water management strategy that temporarily transfers water from those who are willing to lease it to those who are willing to pay to use it (NDMC, 2017).

Water consumption: Water abstracted which is no longer available for use because it has evaporated, transpired, been incorporated into products and crops, consumed by man or livestock, ejected directly into sea, or otherwise removed from freshwater resources. Water losses during transport of water between the point or points of abstractions and point or points of use are excluded (EEA, 2017).

Water demand: Quantities of water scheduled for delivery to consumers during specified periods for identified uses at given prices (WMO/UNESCO, 2012).

Water governance: The political, administrative, economic and social systems that exist to manage water resources and services and is essential in order to manage water resources sustainably and provide access to water services for domestic or productive purposes (GWP, 2017).

Water scarcity: An imbalance between supply and demand of freshwater in a specified domain (country, region, catchment, river basin, etc.) as a result of a high rate of demand compared with available supply, under prevailing institutional arrangements (including price) and infrastructural conditions (FAO, 2012).

Water security: The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies (GWP, 2017).

Water shortage: A shortage of water supply of an acceptable quality; low levels of water supply, at a given place and a given time, relative to design supply levels. The shortage may arise from climatic factors, or other causes of insufficient water resources, a lack of, or poorly maintained, infrastructure; or a range of other hydrological or hydro-geological factors (FAQ, 2012).

Water stress: The symptoms of water scarcity or shortage, e.g. widespread, frequent and serious restrictions on use, growing conflict between users and competition for water, declining standards of reliability and service, harvest failures and food insecurity (FAQ, 2012).

Water supply: The share of water abstraction which is supplied to users (excluding losses in storage, conveyance and distribution) (GWP, 2017).

Water withdrawal: Extraction of water from a surface reservoir or an aquifer (WMQ U ESCQ, 2012).

Weather: is the state or condition of the atmosphere at a specific place and time (as represented by weather elements such as air temperature, pressure, humidity, precipitation, wind, solar radiation) over a short period of time. State of the atmosphere at a particular time, as defined by the various meteorological elements (WMQ, 1992).

Weather forecasts: are prediction of the future weather and supplied in real-time one or more times per day.

Weighing lysimeters can determine the net infiltration from rainfall or irrigation and the amount of evaporation between wetting events. It measures the drainage rate as well as the evaporation rate. It can be been used to quantify precipitation (rain, snow, dew, fog and frost) and to determine actual evapotranspiration.

APPENDICES
Appendix I: Psychrometric table to determine the relative humidity

Source: www.pharmaguideline.com

RELATIVE HUMINDITY CONVERSION TABLE

Dry-bulb temperature	Dry-bulb temperature minus wet-bulb temperature, °C									
	1	2	3	4	5	6	7	8	9	10
10 °C	88	77	66	55	44	34	24	15	6	
11 °C	89	78	67	56	46	36	27	18	9	
12 °C	89	78	68	58	48	39	29	21	12	
13 °C	89	79	69	59	50	41	32	22	15	7
14 °C	90	79	70	60	51	42	34	26	18	10
15 °C	90	80	71	61	53	44	36	27	20	13
16 °C	90	81	71	63	54	46	38	30	23	15
17 °C	90	81	72	64	55	47	40	32	25	18
18 °C	91	82	73	65	57	49	41	34	27	20
19 °C	91	82	74	65	58	40	43	36	29	22
20 °C	91	83	74	66	59	51	44	37	31	24
21 °C	91	83	75	67	60	53	46	39	32	26
22 °C	92	83	76	68	61	54	47	40	34	28
23 °C	92	84	76	69	62	55	48	42	36	30
24 °C	92	84	77	69	62	56	49	43	37	31
25 °C	92	84	77	70	63	57	50	44	39	33
26 °C	92	85	78	71	64	58	51	46	40	34
27 °C	92	85	78	71	65	58	52	47	41	36
28 °C	93	85	78	72	65	59	53	48	42	37
29 °C	93	86	79	72	66	60	54	49	43	38
30 °C	93	86	79	73	67	61	55	50	44	39

Appendix II: Example of baseline survey questionnaire for farmer field school

Socio-economic data:

Average household size:_________________________

Average no. of people working on farm:_________ Men and _________Women

Educational background: Secondary School _____%, Primary _____%, None _____%

Reading skills: Good _____%, Average _____%, Minimal _____%, None _____%

Writing skills: Good _____%, Average _____%, Minimal _____%, None _____%

Training on crop production attended: ______________________________________

Off-farm sources of income: ____

Source of agricultural information: ____

Source of water: Rain fed: _____%, Irrigation:_____%

Average Farm area:______________Ha Landowner ____%, Tenant _____%

Major crops grown:

Main crop:_______________, Variety: ________________, Source of seed: __________

2nd crop:_________________, Variety: ________________, Source of seed: ___________

3rd crop:_________________, Variety: ________________, Source of seed: ___________

Other crops:_____________, Variety: _________________, Source of seed: _________

Yield data:

Average yield main crop: ________Ton/Ha, Average yield 2nd crop: ________Ton/Ha

Average yield third crop: ________Ton/Ha, Average yearly income: __________kip

Cropping pattern:

Dates (months) Crop

1st ____

2nd ____

3rd ________________________________ __________________________

Rice Paddy Production data:

Method used for cultivation:

Transplanting: _____%, Direct seeded _____%, Broadcasting _____%

Amount of seeds used for each method:

Transplanting: _____Kg/Ha, Direct seeded _____Kg/Ha, Broadcasting _____Kg/Ha

Varieties: Local variety...........%, Improved/Inbred variety ....%, Hybrid ....%,

Seed source:

From certified supplier: _____%, Farmers keep their own seed _____%

Age of seedlings used for transplanting by farmers:

Less than 15 days: _____%, 15-20 days: _____%, 21-25 days: _____% ,

26-30 days: _____%, 31-40 days: _____%, 40-45 days:_____%

Spacing (cm x cm) used by farmers:

10x10: _____%, 10x15: _____%, 15x15 _____%, 15x20: _____%, 20x20 _____%, 20x25 _____%, 25x25 _____% 25x30: _____%, 30x30: _____%

Yield data for each method:

Average yield for wet season for:

Transplanting: _____Ton/Ha, Direct seeded: _____Ton/Ha, Broadcasting : ______Ton/Ha

Management of crop protection problems

Problem	Pesticides applied (last year)					Other known management practices
Priority: 1-highest, 5-lowest	**Season**	**Brand & Active Ingredient**	**Dosage (in kg or L per hectare)**	**No. of Applications/ Timing (DAT)**	**Costs per Hectare**	Description

Fertilizer history

Type	Dosage (kg/Ha)	Timing (DAS/DAT)	Application method	Costs (Kip/bag @50 kg)
46.0.0				
16.20.0				
15.15.15				
18.46.0				
Organic ( )				

General farm problems encountered

Description	Management strategy used

Appendix III: Farmer field school attendance sheet

Name	Ballot Box		Week																			
	Pre test	Post test	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Date ->																						
1																						
2																						
3																						
...																						
...																						
N																						
Total no. of farmers																						

Remarks:

Appendix IV: Soil classificatio n

Soil types	Characteristics
Arenosols	Arenosols are sandy-textured soils that lack any significant soil profile development. They exhibit only a partially formed surface horizon (uppermost layer) that is low in humus, and they lack subsurface clay accumulation. Given their excessive permeability and low nutrient content, agricultural use of these soils requires careful management.
Fluvisols	Fluvisols are found typically on level topography that is flooded periodically by surface waters or rising groundwater, as in river floodplains and deltas and in coastal lowlands. They are cultivated for dryland crops, or rice, and are used for grazing in the dry season.
Gleysols	Gleysols are formed under waterlogged conditions produced by rising groundwater. In the tropics and subtropics they are cultivated for rice or, after drainage, for field crops and trees.
Leptosols	Leptosols are soils with a very shallow profile depth (indicating little influence of soil-forming processes), and they often contain large amounts of gravel. They typically remain under natural vegetation, being especially susceptible to erosion, desiccation, or waterlogging, depending on climate and topography. Leptosols are approximately equally distributed among high mountain areas, deserts, and boreal or polar regions, where soil formation is limited by severe climatic conditions.

Soil types	Characteristics
Regosols	Regosols are characterized by shallow, medium- to fine-textured, unconsolidated parent material that may be of alluvial origin, and by the lack of a significant soil horizon (layer) formation because of dry or cold climatic conditions.
Nitisols	Nitisols are soils characterized by a "nitic horizon". The nitic horizon has a number of specific properties, viz. 30% or more clay, a lowwater-dispersible clay/total clay ratio, a low silt/clay ratio, moderate to strong nutty structures with shiny pedfaces, and a relatively high percentage of "active" and "free" iron, the ratio of which should be 0.05 or more.
Alisols	Alisols are highly acidic, poorly drained soils prone to aluminium toxicity and water erosion. Liming and fertilization are essential to their agricultural use—primarily for growing oil palm, corn (maize), and cotton.
Acrisols	Acrisols form on old landscapes that have an undulating topography and a humid tropical climate. Their natural vegetation is woodland, which in some areas has given way to tree savanna maintained by seasonal burning. The age, mineralogy, and extensive leaching of these soils have led to low levels of plant nutrients, excess aluminium, and high erodibility, all of which make agriculture problematic. Nevertheless, traditional shifting cultivation of acid-tolerant crops has adapted well to the conditions found in Acrisols.
Lixisols	Lixisols develop on old landscapes in a tropical climate with a pronounced dry season. Their age and mineralogy have led to low levels of plant nutrients and a high erodibility, making agriculture possible only with frequent fertilizer applications, minimum tillage, and careful erosion control. Perennial crops are thus more suitable for these soils than root, or tuber crops.
Solonchaks	Solonchaks are defined by high soluble salt accumulation within 30 cm (1 foot) of the land surface and by the absence of distinct subsurface horizonation (layering), except possibly for accumulations of gypsum, sodium, or calcium carbonate or layers showing the effects of waterlogging. Solonchaks are formed from saline parent material under conditions of high evaporation—conditions encountered in closed basins under warm to hot climates with a well-defined dry season, as in arid, Mediterranean, or subtropical zones
Solonetz	Solonetz soils are defined by an accumulation of sodium salts and readily displaceable sodium ions bound to soil particles in a layer below the surface horizon (uppermost layer). This subsurface layer also contains a significant amount of accumulated clay. Because of the high sodium content and dense, clay-rich subsoil, irrigated agriculture of these soils requires extensive reclamation—through leaching with fresh water and the construction of engineered drainage systems.
Luvisols	The mixed mineralogy, high nutrient content, and good drainage of these soils make them suitable for a wide range of agriculture, from grains to orchards to vineyards. Luvisols form on flat, or gently sloping, landscapes under climatic regimes that range from cool temperate to warm Mediterranean.
Ferralsols	Ferralsols are red and yellow weathered soils whose colours result from an accumulation of metal oxides, particularly iron and aluminum (from which the name of the soil group is derived). They are formed on geologically old parent materials in humid tropical climates, with rainforest vegetation growing in the natural state. Because of the residual metal oxides and the leaching of mineral nutrients, they have low fertility and require additions of lime and fertilizer if they are to be used for agriculture. Tree crops such as oil palm, rubber, or coffee are suitable, but pasture is often their main agricultural use after the original forest is cleared.
Fluvisols	Fluvisols are found typically on level topography that is flooded periodically by surface waters or rising groundwater, as in river floodplains and deltas and in coastal lowlands. They are cultivated for dryland crops or rice and are used for grazing in the dry season.

Appendix V: Questionnaires for loudspeaker assessment

Individual Interview - users

I. General information about respondent

1. Village: ……………………………
2. Respondent Name: ………………………………………….
3. Gender: ◯ M ◯ F
4. Spouse name (if any): ………………………………………………………..,
5. Ethnicity: ………………………
6. Religion: …………………………………..
7. Language spoken (3 max): (1 main) ……………………….., (2)………………………….., (3)…………………………………
8. Mobile number: ……………………………….

9. **Household Population** – number of family members ____________ people

	Household members									
Person number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Relation to household head, Starting with household head as #1										
Gender (M/F)										
Age										
Marriage status (1 = married) (2 = unmarried) (3 = widow) (4 = divorced) (5 = other, specify.........)										
How many years have you lived in this village?										
Highest completed level of education 1. Non formal 2. Primary 3. Secondary 4. Upper secondary 5. Vocational 6. College/uni 7. Postgraduate 8. Other										
What is your occupation? E.g. things you get paid for 1. Farmer 2. Shop owner 3. Student 4. Govt. official 5. Labourer 6. Disabled 7. Other______										

10. Do you hold any leadership position/s in the village?
   - ◯ Yes (next to 11)
   - ◯ No (jump to 12)

11. If yes, what is it ____

II. Weather news from the loudspeakers

12. Have you heard about weather news from the loudspeakers?
   - ◯ Yes (next to 13)
   - ◯ No (jump to 27)

A. For farmers have heard the weather news

13. How often heard about this? When? Should provide the frequency (once, twice per week or per month, etc.)
    Single choice
    - More than once a week
    - Every week

- More than twice a month
- Once a month
- Others

14. At what time did you usually hear the bulletin from the speaker?
    ________________ (time slot 1)
    ________________ (time slot 2)
    ________________ (time slot 3)
15. Which ones of those forecast are important for you?
    Multiple choice
    - Seasonal forecast
    - Weather forecast
    - Crop calendar
    - Water level forecast
    - Pest and disease forecast
    - Extreme event forecast
16. Which forecasts are useful for your farm?
    Multiple choice
    - Seasonal forecast
    - Weather forecast
    - Crop calendar
    - Water level forecast
    - Pest and disease forecast
    - Extreme event forecast
17. Did you use the forecast to adjust your farming practices?
    Yes -> next to 18 **(Group 1: receive the bulletins and use for any purpose)**
    No -> jump to 21 **(Group 2: receive the bulletins but not apply any change)**
18. How did you adjust your farming practices based on the forecast?
    Multiple choices
    - Use other variety
    - Change water management practice
    - Shift the planting date
    - Protect or cover the crop/farm
    - Change how to apply the pesticide
    - Change how to apply fertilizer
19. Did you discuss/share that information/forecast with other farmers?
    Yes -> next to 20
    No -> jump to 21
20. How many other farmers did you discuss/share the forecast?
    ____________ (insert number)
21. Which forecast is not useful for your farm? Multiple choice
    Weather forecast
    Energy efficiency forecast
    Pest and disease forecast
22. Why are they not useful?
    Multiple choices
    - I don't understand the information
    - They are not accurate
    - They are not specific
    - I don't know what to do with this forecast
23. From whom you seek for help?
    Multiple choices
    - Family members
    - Neighbours
    - Relatives
    - Local agriculture staff/worker
    - NGO staff
    - Village chief
    - Others:________________
24. How many time did you ask for help?
    _________________ (insert number)

25. Which kind of help did you ask?
    Multiple choices
    - Technical information (explanation of the information, practices needed to adopt, etc.)
    - Financial support (money for
    - Input material
26. Are there any suggestion for improvement?
    Multiple choices
    - Frequency: more frequent, less frequent (could be specified)
    - Time frame: specific time slot for the broadcasting
    - Specific: more locally tailored to the community
    - Agro-advisories: provide advice what to do with the crop, livestock to reduce the risk
    - Others: ___________________

B. For farmers have not heard the weather news

27. What might be the reason why you have not heard the weather news from the loudspeaker?
    Multiple choice
    - The loudspeaker cannot reach our house as I'm living in a remote area
    - I might go to work far away from the area when they broadcast the news
    - I might miss the broadcasting as listening to the local loudspeaker is not my habit
    - I don't like the loudspeaker
    - Others:_________________________________
28. If we broadcast the weather, extreme event, pest and disease forecast on the loudspeaker, would you like to listen to it?
    - Yes -> next with 29 **(Group 3: Have not receive climate info, but willing to)**
    - No -> move to 30
29. Are there any suggestion for improvement so you can hear the news/forecast?
    Multiple choices
    - Frequency: more frequent, less frequent (could be specified)
    - Time frame: specific time slot for the broadcasting
    - Specific: more locally tailored to the community
    - Agro-advisories: provide advice what to do with the crop, livestock to reduce the risk
    - Others:_________________________________
30. What other channels you would like to receive the news/forecast from?
    Multiple choices
    - Through internet/phone
    - Extension staff to share
    - Through TV/radio
    - Through printed bulletins with infographic
    - Others:_____________________________

    (Group 3b: Have not receive climate info, but willing to receive that in different approach rather than the loudspeaker)
    - None (I don't need the forecast) (Group 4: Have no interest in climate information)

II. Weather news from the internet

31. Do you have access to internet?
    Yes -> next to 32
    No -> end the interview
32. Have you ever had access to weather forecast from internet?
    Yes -> next to 33
    No -> end the interview
33. Have you accessed any of the following products through internet?
    Multiple choices
    - Forecast bulletins sent by Whatsapp
    - LaCSA
    - DMH Facebook
    - Others:_________________
34. Which of them are useful to you?
    Multiple choices
    - Forecast bulletins sent by Whatsapp
    - LaCSA
    - DMH Facebook
    - Others:_________________

35. Which one did you use more often?
    Multiple choices
    - Forecast bulletins sent by Whatsapp
    - LaCSA
    - DMH Facebook
    - Others:________________

Individual Interview - Reader

Page I. General information about respondent

1. Village: ………………………………
2. Respondent Name: ………………………………………………
3. Gender: ◯ M ◯ F
4. Ethnicity: ………………………
5. Religion: ……………………………………..
6. Language spoken (3 max): (1 main) …………………………, (2)……………………………, (3)…………………………………
7. Mobile number: ……………………………….
8. Do you hold any leadership position/s in the village?
   ◯ Yes ◯ No
   If yes, what it is ____
9. Do you have access to internet?

Move to Page II

Page II. Knowledge

10. How many times have you been trained to read the bulletins?
- Bulletin, seasonal forecast and LaCSA training (in the village training)
- Bulletin, seasonal forecast and LaCSA training (in team training)
- Specialized training (for village head, Women's Union, Farmers' Union, etc.)
- Journalist training

11. Do you understand the bulletins well?
- Yes
- No

Move to Page III

III. Attitude

12. Do you think the bulletins are useful?
- Yes -> to practices (part IV)
- No -> next to 13

13. Why do you think the bulletins are not useful?
    _______________________________ (open question)

Move to Page IV

IV. Practices

14. Do you receive the bulletins?
- Yes -> next to 15
- **No -> end the interview (they were trained but somehow did not receive the bulletins for reading - Group 4)**

15. Did you receive the bulletins regularly on Tuesday?
- Yes -> next to 16
- No -> jump to 17

16. When did you usually receive the bulletins?
    _________________________________ (insert date)

17. Did you read the bulletins?
- Yes -> Next to 18
- No -> Jump to 23 (Difficulties: part V) **(they received the bulletins but did not read the bulletins for some reasons – Group 3)**

18. Did you read the bulletins regularly at 7:00 in the morning?
    Yes -> Jump to 20
    No -> Next to 19

19. What time did you usually read the bulletins?

20. How frequently you missed/forgot to read the bulletins?
- Never
- Rarely
- Sometimes
- Frequently

VI. Farmers' practices

21. Do you know if farmers use the climate forecast bulletins?
- Yes -> next to 22 **(they read the bulletins and know the farmers are using them – Group 1)**
- No -> skip to 24 **(they read the bulletins but don't know if the farmers are using them – Group 2)**

22. Did farmers change their farming activity according to the forecast?
- Yes -> next to 23
- No -> skip to 24

23. What were the changes?

    ______________________________ (open question)

24. Which type of feedback have people given you about the information?
- None
- Format
- Frequency
- Time
- Language
- Content

V. Difficulties

25. How did you trust the quality of the bulletins?
- No trust at all
- A little
- Mostly
- Totally

26. How confident are you to read the bulletins?
- No confidence at all
- A little
- Mostly
- Totally

27. Were you familiar with the script from LNR?

    Are you happy /satisfied to be a reader?
- Yes
- No

28. Were you assigned with your consent?
- Yes
- No

29. Is your family happy if you are a speaker reader?
- Yes
- No

30. Was there any technical issue with the loudspeaker system?
- Yes
- No

31. Any suggestion to improve the bulletins?
- Format
- Time slot
- Frequency
- Language
- Content

Individual Interview: NGO or GOL experts

I. General information about respondent

1. Respondent Name: ………………………………………………Gender:◯ M ◯ F
2. Current position: …………………………………………………………
3. Name of current institution: …………………………………………………
4. Email: ……………………………………………………………………………
5. Mobile number: ……………………………………………………………
6. Type of organization: NGO/State agencies/Government/Private sector
7. Domain of the organization: sector and/or field of work (agriculture, climate change, development, poverty reduction)
8. Scope of work: community level, provincial level, national level
9. Any task or function related to climate information: ……………………………………………………………………………………
   ……
   ……

………

II. Knowledge

This questionnaire will be applied for all NGOs who already or have not yet participated, and for development projects currently ongoing at grass-root level like CAWA

10. Have you heard about the LaCSA?
    Yes -> next to 11;
    No -> jump to 33 (Introduction about the LaCSA and ask for willingness: part VI)
11. When was the first time you heard of the LaCSA?
    _____________ (insert date/ or month/year)
12. Who informed you about the LaCSA?
- SAMIS project officers
- DMH/DONRE officers
- DAFO/DALAM
- Colleagues at work
- Others:
13. Which type of training did your organization participate in?
- Master training
- Farmer training
- Local level office training

Knowledge

14. Do you understand the climate forecast/information?
15. What are the benefits that climate information can bring to your project?
- Higher/better deliverable productivity
- Cost efficiency
- None
16. What are the benefits that climate information can bring to your beneficiaries/farmers?
- Higher productivity
- Higher adaptive capacity (disaster risk reduction)
- None

III. Attitudes

17. Do you think is important/useful for farmers? Why?
    ______________________________ (open question)
18. Do you think is important for extension services? Why?
    ______________________________ (open question)
19. Do you think is important for researchers? Why?
    ______________________________ (open question)
20. Do you think is important for decision makers? Why?
    ______________________________ (open question)

IV. Practices

21. Did you have access to the bulletins regularly on Tuesday?
    Yes -> next to 22
    No -> jump to 23
22. When did you usually receive the bulletins?
    _________________ (insert date)
23. Did you use the LaCSA to disseminate the information/advisories to farmers over this season?
- Yes -> next to 24
- No -> jump to 28 (difficulties: part V) **(Group 3: They have heard about the bulletins but not yet used for farmers)**
24. Do you know whether the farmer group utilized the information/advisories over this season?
- Yes -> next to 25 **(Group 1: They used the bulletins and know the farmers also utilized the bulletins as well)**
- No -> jump to 28 (difficulties: part V) (Group 2: They used the bulletins but do not know if farmers utilized them or not)
25. How many people use the LaCSA?
    _________________ (insert number)
26. And how many villages?
    _________________ (insert number)
27. What are the challenges/barriers affecting the uptake of the LaCSA by farmers?
    __________________________(open question)

V. Difficulties

28. Was the system clear to you?
    No -> next to 29
    Yes -> jump to 30
29. If not, what was not clear?
- Seasonal forecast
- Weather forecast
- Crop calendar
- Water level forecast
- Pest and disease forecast
- Extreme event forecast
30. What are the major difficulties for you in using the LaCSA?
- Too narrow/focus on only one crop (rice)
- The information is too scientific
- Time limitation
- Not precise/specific
- Too broad
- Others:
31. Are there any suggestion for improvement?
    ________________________ (open question)
32. What technical assistance do you need to better utilize the LaCSA?
    ________________________ (open question)

- Thank you for your participation. SAMIS-DeRISK Project team -

VI. Willingness (only applicable for interviewees answered No in question 10)

Insert a quick introduction about the LaCSA and start the session for willingness

33. Thank you for giving us the chance to introduce the LaCSA. With the given information, would you like to receive more from us about the LaCSA.
- Yes -> jump to 34 **(Group 4: They have not heard of the LaCSA but willing to receive the bulletins in the future)**
- No -> next to 35 and end the interview. **(Group 5: They have not heard of the LaCSA and don't have interest in the LaCSA)**
34. Could you please share why you do not want to receive LaCSA information? Thank you for your participation.
35. Which type of information you would like to receive?
- LaCSA project document
- Seasonal forecast provincial bulletins
- Others (SAMIS to help with the information here)
36. How would you like to receive the information and technical assistance?
- Through technical training course
- Through workshop/conference
- Through email and other social media platforms
37. If the information/forecast/bulletin is good, would you disseminate to your targeted farmers?
- Yes -> next to 38
- No -> end the interview.
38. Do you have the estimation of how many farmers you can reach with the LaCSA and the seasonal forecast bulletins?
    ___________________ (insert estimated number)

Appendix VI: Questionnaires for school poster assessment

For school teachers:

1. Is the training provided by SAMIS sufficient to effectively relay the climate information to the students?
   a. Strongly agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree
2. How do you access the LaCSA bulletin?
   a. WhatsApp Group
   b. Facebook
   c. Website
   d. Other

3. How often do you update the LaCSA signboard?
    a. Weekly
    b. Bi-monthly
    c. Monthly
    d. Never
4. How often do you discuss the content of the bulletin to the students?
    a. Weekly
    b. Bi-monthly
    c. Monthly
    d. Never
5. What means do you use in transferring the information to students?
    a. Present in the school yard
    b. Present in the class room
    c. Other
6. Are the students interested in the information on the signboard?
    a. Yes, very interested
    b. Somewhat interested
    c. Not interested

For students:

1. Are you interested in the information on the signboard?
    a. Yes, very interested
    b. Somewhat interested
    c. Not interested
2. Are you aware that the information from the weekly bulletins were produced by PONRE and DAFO?
    a. Yes
    b. No
3. Is the information easy to read and understand?
    a. Yes
    b. No
4. Is the information useful?
    a. Yes
    b. No
    c. Why?
5. Do you share the information to your family?
    a. Yes, to whom?
    b. No
6. Can your parents read the bulletin?
    a. Yes
    b. No
7. What are the means of relaying the information to your parents?
    a. Casual conversation at meal time
    b. Casual conversation in the field
    c. Casual conversation during weekends
8. After seeing the poster, do you understand

Climate Change Information	Not at all	Not really	Neutral	Somewhat	Very much
Importance of weather forecast					
How weather affects farming activities					
How weather forecast can help in farming					
When extreme weather events occur (flood, drought, extreme cold/heat, etc.)					
When pests or diseases occur					

For parents:

1. Have you received any LaCSA information from your children?
    a. Yes
    b. No
    c. If yes, how often? Weekly/monthly?
2. Are you aware that the information from the weekly bulletins were produced by PONRE and DAFO?
    a. Yes
    b. No
3. Have you received information on weekly bulletins from other sources?
    a. Loudspeaker
    b. WhatsApp Group
    c. Facebook
    d. Website
    e. Other
4. Is the information useful for you?
    a. Yes
    b. No
    c. Why
5. If you have been receiving the information has this helped you make decisions for crops?
    a. Yes
    b. No
    c. If yes, how?
6. The information from the bulletins are applicable to your farming activities
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly Disagree
7. How useful is the information from the bulletins in managing your farm?

Climate Information	Not at all	Not really	Neutral	Somewhat	Very much
Water level forecast					
Pest and disease forecast					
Extreme event forecast (flood, drought, extreme heat/cold)					
Next day weather forecast					
Next 3 days weather forecast					
Next 7 days weather forecast					
Storm advisories					
Recommended planting dates					
Fertilizer recommendations					
Pesticides and fungicide recommendations					
Soil management recommendations					
Irrigation recommendations					

General observations by trainer:

1. Is the board up to date on the date (correct week/month)?
    a. Yes, correct week
    b. No, but correct month
    c. Not up to date at all
2. Are all the magnets for the LaCSA board accounted for? None lost.
    a. Yes
    b. No
3. Has the school garden improved as the result of the activity?
    a. Yes
    b. No
    c. Can't see a change
    d. If yes, how was it improved?

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