Strengthening the climate resilience of small-scale farmers in the Central Highland and South-Central Coastal regions of Viet Nam (SACCR)

Sub-assessment report of
Climate information and agro-climate advisories

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List of acronyms

ACIS	Agro-Climatic Information Systems
AgM	Agricultural Meteorology
CCAFS	Climate Change, Agriculture and Food Security
CH	Central Highlands
CSA	Climate-smart agriculture
DARD	Department of Agriculture and Rural Development
ECMWF	European Centre for Medium-Range Weather Forecasts
NHMS	National Hydro-Meteorological Service
IMHEN	Vietnam Institute of Meteorology, Hydrology and Climate Change
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
NCHMF	National Centre for Hydro - Meteorological Forecasting
RCA	Research Center for Agrometeorology
RCP4.5	Low greenhouse gas emissions
RCP8.5	High greenhouse gas emissions
SC	South Central
SST	Sea Surface Temperature

Executive summary

This study analyzes the current state of supply and use of weather and climate information for agricultural production schemes in Vietnam and in the target area of the GCF project. The GCF project has identified several gaps in weather and climate information dissemination and has therefore various solutions to overcome these gaps. Research results show that:

Hydro-meteorological Forecasting in Vietnam is currently divided into three levels: National level, regional level and provincial level. The distribution between the three levels improves the roles and responsibilities of each unit in the connected hydro-meteorological system of Viet Nam to implement forecasting and warning of natural disasters, baseline investigations, effective exploitation of machines and hydro-meteorological services for the public and socio-economic development.

However, there are several shortcomings in meteorological activities and services:

- The network of surface observation stations is sparse. Though it is not the main cause of these shortcomings related to weather forecasting;
- Meteorological information has not been explained or translated in detail for local areas and for specialized fields and not sent directly to the users, especially farmers. Thus, the contents and terms used in forecasts are difficult for users to understand and to apply to their agricultural practice;
- Mechanisms and policies have not encouraged hydro-meteorological research for application in climate change related projects. They furthermore have not attracted highly qualified staff to work in the agricultural meteorology stations;
- Additionally, agricultural meteorology stations did not receive enough attention and awareness by policy makers.

Based on the experiences gathered in the study area, we propose three specific activities including: (1) Training for generating and interpreting down-scaled hydro-met forecasts for use in agricultural planning; (2) Co-development of these forecasts through Participatory Scenario Planning (PSP) for each seasonal crop; (3) Dissemination of advisories to farmers.

Introduction

Most of the people living in the South Central (SC) and Central Highland (CH) provinces highly depend on agricultural production as a main income source. Current agricultural practices in these regions are still not adapted to the severe effects of climate change. Farming practices need to adapt to fluctuations in climate change effects such as irregular droughts, floods and storms in order to ensure resilient livelihoods for rural communities.

In the Central Highlands and South Coastal regions, crop yields are highly affected by unpredictable climate phenomena. For example, the heavy drought in 2016 destroyed most of the rice fields and pepper trees. Additionally, unfavorable rainfall patterns damaged flowering in coffee plantations in the Central Highlands.

Agricultural meteorology (AgM) refers to a system where climate change data, seasonal forecasts and data on crops, animals and soils are combined and analyzed to support successful agricultural production. The role of agricultural meteorology for production as a component of climate change adaptation is highly important for this this area.

This report therefore assesses the current situation and gaps in agricultural meteorology in the target area and offers solutions that provide the scientific basis for activities within the context of a potential future Green Climate Fund (GCF) project.

Chapter 1 of this report looks at the current system for organizing agro-climate information services in Viet Nam, reviewing both systems for weather and climate change data information generation. Chapter 2 examines relevant past and on-going projects related to the use of climate information in agricultural production in potential target project areas. Chapter 3 looks more closely at gaps in agricultural meteorological activities, in data generation and in information dissemination. It then looks at the relevant policy and institutional frameworks and opportunities to strengthen capacity and knowledge management gaps. Finally, Chapter 4 provides specific recommended interventions to address identified gaps in the project, including options for creating down-scaled forecast information, means of increasing application of adaptation solutions to manage climate fluctuations, Participatory Scenario Planning (PSP), and the dissemination of advisories to farmers. Issues of costs, sustainability and exit strategies are also discussed.

1. Agro-climate information services in Vietnam

In 2002, the Ministry of Natural Resources and Environment (MONRE) was established. The National Hydro-meteorological Service (HMS) and the Vietnam Institute of Meteorology, Hydrology and Climate change (IHMEN) are under the control/supervision/monitoring of MONRE. The National Centre for Hydro-Meteorological Forecasting (NCHMF) is under the control/supervision/monitoring of HMS, the main task of NCHMF is weather forecasting, while IMHEN focusses more on seasonal climate forecasting (Fig. 1.).

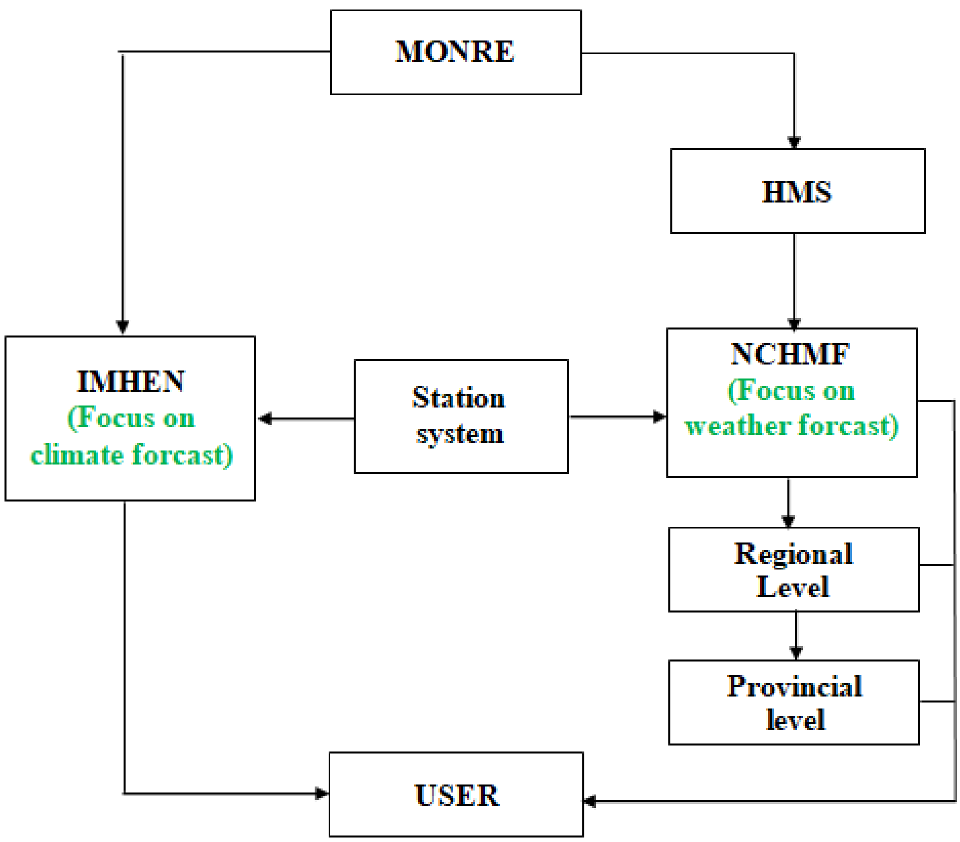

Figure 1. System of weather and climate information services in Vietnam

1.1. The national level

1.1.1. The National Center for Hydro-meteorological Forecasting

The National Centre for Hydro-Meteorological Forecasting (NCHMF) is a public-profitable organization which belongs to the National Hydro-Meteorological Service (HMS). The central function of NCHMF is the organization of weather-, climate-, hydrology- and hydrometeorology forecasting to prevent natural disasters, to strengthen/enhance socio-economic development and to ensure national security for the whole country.

The responsibilities of NCHMF include operational hydro-meteorological forecasting, advisories and preparedness for disaster prevention, socio-economic development, and national defense security. Furthermore, the NCHMF is in charge of directing and guiding professional operations, inspecting and monitoring hydro-meteorology and the performance assessment of hydro-meteorological forecasting for regional centers. The NCHMF is the lead organization for developing strategies, planning of programs for long-term, five-year and annual plans, schemes and projects on hydro-meteorological forecasting.

Besides the two functional Divisions (Administrative Division and Planning & Finance Division), the NCHMF consists of seven operational Divisions (Fig. 2).

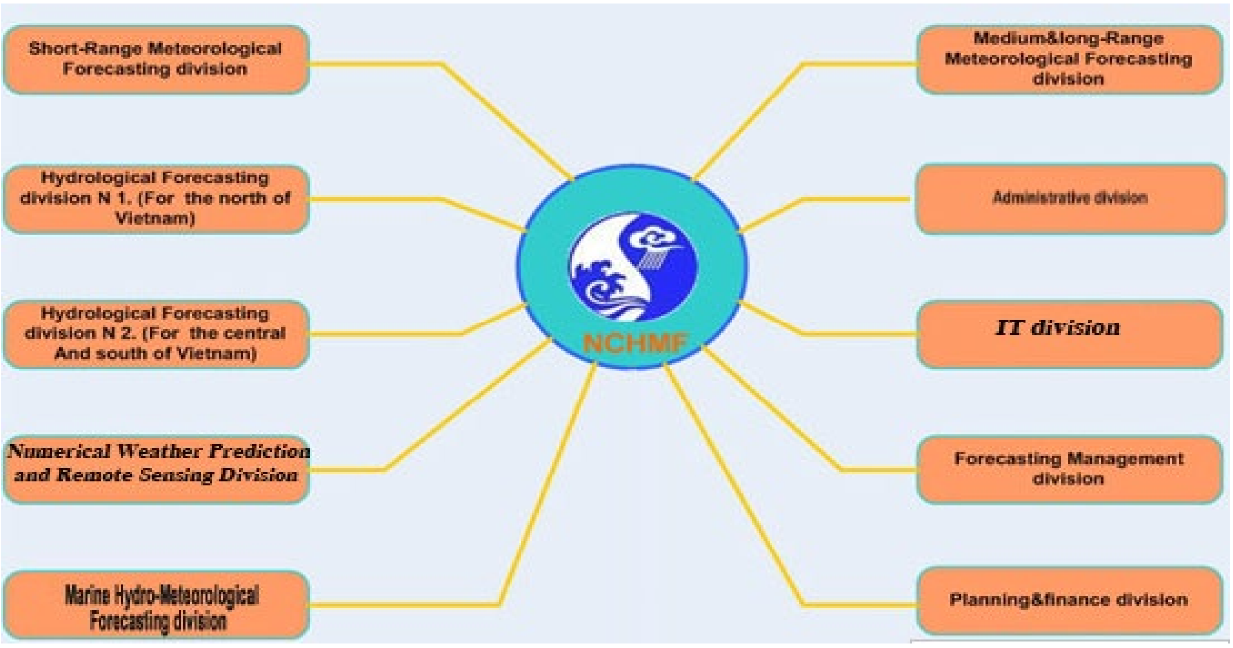

Figure 1. Structure of National Centre for Hydro-Meteorological Forecasting (NCHMF)

The NCHMF weather forecasting system is based on ~~and connected to the analytical basis of~~ synoptic maps, numerical modeling, satellite images and radar data. The NCHMF weather forecasting system also refers to the forecasting results of other meteorological centers in the region and in the world. Short-term forecasts for the mainland, several cities, the entire coast and rural areas are broadcasted on the mass media. In rural areas, regional radio and television channels in collaboration with weather forecasting centers provide daily weather forecasts for each province.

The NCHMF produces weather forecast bulletins. To create a weather forecast bulletin for small areas, the following steps are required:

Step 1: Analysis of forecast data

- Analysis of surrounding maps (Eurasia and East China Sea). Analysis of temperature maps at isobaric level (AT850, 700, 500, 300, 200). Comparison with maps from other forecast centers, in particular from countries such as Japan, Korea and Thailand. Using other supplementary tools such as remote sensing, satellite images, and weather radar images;
- Analysis of Numerical Weather Prediction (NWP) models at regional and global scales. These are used by NCHMF to obtain specific weather information. The main regional NWP models are: HRM (Germany, WRF (USA), MM5 (USA). The main global numeric weather forecasting models are: GSM (Japan), GFS (USA) and ECMWF (Europe). Additional weather forecast information is obtained from weather forecast websites such as the windy website and from different satellites such as HIMAWARI-8;
- In Viet Nam, in order to combine weather forecast information from different stations, the Inverse Distance Weighting (IDW) deterministic method is applied to integrate and disseminate regional weather forecast information.

Step 2: Data Analysis

- Analysis of weather patterns is then conducted with reference to the past based on synoptic maps. This helps determine current weather patterns, based on the results analyzed from the past to the present associated with analyzed results from radar, satellite images and NWP products;
- Analysis of weather patterns of the present time is also inducted;
- Weather forecast decisions are made based on individual expertise of each forecaster;
- Weather forecast information from NWP models is interpreted using quantitative techniques;
- The variables of weather forecast information for seven different regions of Viet Nam include temperature (min., max.), humidity, cloud density, solar radiation, rainfall and wind speed;
- Nowcasting techniques, such as with use of radar, are used to inform about thunderstorms and heavy rainfall incidents.

Step 3:Conclusion

- Depending on conclusions resulting from analysis of weather patterns, the forecaster will issue draft weather forecast bulletin for specific regions and stations;
- All bulletins are double-checked;
- After approvals, the weather forecast bulletins are disseminated to Regional and Provincial Centers for hydro-meteorological forecasting and related agencies and updated on the website of the National Center for Hydro-meteorological Forecasting. Finally, weather forecast bulletins are stored at the NHMS Archive Center for verification and quality control.

1.1.2. Vietnam Institute of Meteorology, Hydrology and Climate change

The Vietnam Institute of Meteorology, Hydrology and Climate change (IMHEN) is a public science and technology organization under the Ministry of Natural Resources and Environment, which has the function of basic research, technological development in meteorology and hydrology and climate change (see figure 3).

IMHEN has been involved in many studies covering both basic of Tropical monsoon, atmospheric physics, monsoons, ENSO (El Nino / La Nina and Southern Oscillation), tropical cyclones and storms, heavy rain, droughts and meteorological disasters and theoretical research, as well as scientific and technological applications.

IMHEN's climate change-related studies include climate change processes and modelling, the Southeast Asian Monsoon and its effect on the variability of monsoon rainfall in Southeast Asia, climate change and sea level rise scenarios, climate change impact assessments, climate risk reduction studies and mainstreaming climate change into policies and development. To meet the demand of for the country's socio-economic development, IMHEN has also participated in sustainable development activities with specifically designed programs, such as climate change impact assessments on agriculture, water resources, and coastal zones.

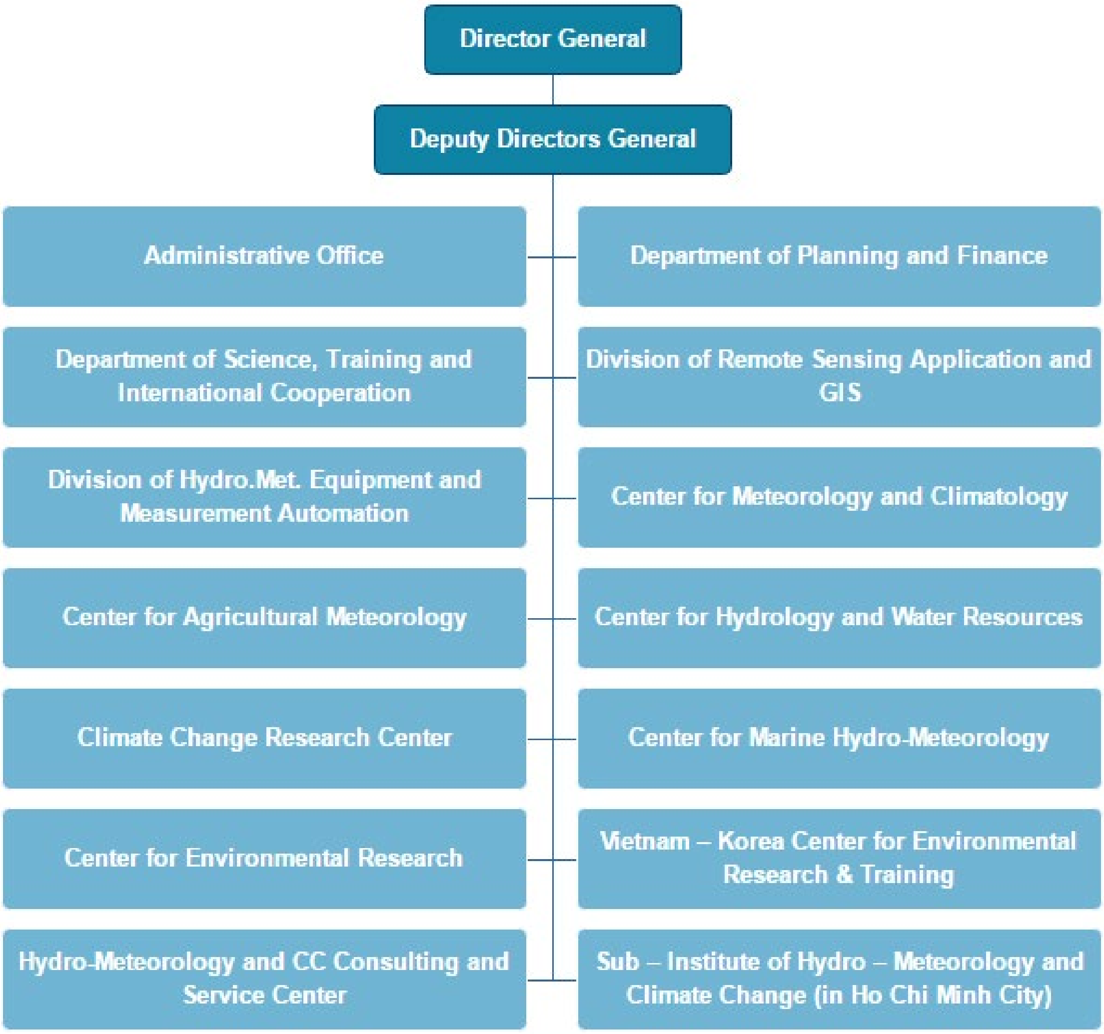

Figure 2. Structure of Vietnam Institute of Meteorology, Hydrology and Climate Change (IMHEN)

IMHEN was established in 1976 and is responsible for seasonal weather forecasts, because of its long tradition, experience, expertise and data sources related to this field. One of IMHEN's strengths is researching and forecasting climate. At present, the professional activities of IMHEN provide monthly news on climate information for the whole territory of Vietnam. The content of the newsletter has two parts. First, the assessment of climate variability over the previous three months and second forecasting of climate for the following three months, according to seven climatic zones of Vietnam. The newsletters are sent to agencies of MONRE and updated to the IMHEN website.

The climate forecast is mainly based on the statistical model of Analysis of Variances (ANOVA). By using ANOVA, information is downscaled for all stations in Viet Nam. All in all, seven staff members are qualified to run the ANOVA model and disseminate the information.

The input variables are sea surface temperature indicators (SST) for el NINO1.2, NINO3, NINO4, NINO3.4. ENSO forecasting products are also generated such as possibility of occurrence El Niño/La Niña events and global forecasts by international research organizations, such as the International Research Institute for Climate and

Society (IRI), the United States Climate Change Centre (CPC) and The European Centre for Medium-Range Weather Forecasts (ECMWF).

Forecasts for the following three months at the regional level include three probability levels (below normal, normal and above normal) for temperature and precipitation and estimates of extreme phenomenon such as numbers of hot days, performance of the monsoon, and the number of hurricanes and tropical depressions affecting the mainland of Vietnam. Forecast results of below normal and above normal probability for temperature and precipitation from different meteorological stations are shown in table 1:

Table 1. Seasonal climate forecast (temperature, precipitation) results from different stations in Vietnam

No.	*Station*	Temperature		Precipitation	
		Below *(%)*	Above *(%)*	Below *(%)*	Above *(%)*
The South Central					
1	*Đà Nẵng*	*20*	*25*	*5.6*	*66.7*
2	*Tam Kỳ*	*85.7*	*0*	*0*	*87.5*
3	*Trà My*	*0*	*95*	*0*	*85.7*
4	*Quảng Ngãi*	*92.9*	*0*	*75*	*0*
5	*Ba Tơ*	*80*	*0*	*0*	*86*
6	*Quy Nhơn*	*13.3*	*20*	*0*	*90*
7	*Tuy Hoà*	*90*	*0*	*0*	*78.6*
8	*Sơn Hoà*	*0*	*0*	*73*	*0*
9	*Nha Trang*	*0*	*66.7*	*86.7*	*0*
10	*Trường Sa*	*16.7*	*0*	*0*	*80*
Central Highlands					
1	*Kon Tum*	*81.8*	*0*	*0*	*88.9*
2	*Đắc Tô*	*85.7*	*0*	*0*	*92*
3	*Plâycu*	*29.4*	*17.6*	*10*	*70*
4	*Ayunpa*	*87.5*	*0*	*0*	*79*
5	*M'Drak*	*94*	*0*	*0*	*87.5*
6	*Đắc Nông*	*87*	*0*	*0*	*81*
7	*Đà Lạt*	*0*	*85.7*	*5.9*	*76.5*

8	*Liên Khương*	*90*	*0*	*8.3*	*33.3*
9	*Bảo Lộc*	*0*	*88.9*	*75*	*8.3*

Starting in 2018, IMHEN will begin to receive support from the International Research Institute for Climate and Society to improve its climate forecast capacity.

Through this cooperation, based on numerical prediction models, IMHEN will be able to provide detailed seasonal forecasts for small areas, with high spatial resolution (5 km) by using Regional Simulation Models (RSM) and Regional Climate Model Systems (RCMS).

In addition, IMHEN also is responsible for developing climate change scenarios for Vietnam. The Methodology for building climate change scenarios for Vietnam in 2016 is based on the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). The results are divided into two levels: Low greenhouse gas emissions (RCP4.5) and high greenhouse gas emissions (RCP8.5), with factors such as temperature and rainfall at provincial level and extreme weather phenomena at national level. Details of these results are presented in Figures 3 to 8 and Tables 6 to 13.

Climate adaptation in agriculture

- Currently, the Research Center for Agrometeorology (RCA) of the Vietnam Institute of Meteorology, Hydrology and Climate change (IMHEN) is the only agency specializing in research on agricultural meteorology. After more than 50 years of operation, RCA in collaboration with HMS and other organizations, has developed significant capacity in agrometeorology, however, further development of these systems is required. For example: agricultural climate zoning for development planning of agricultural production is needed to be able to rationally prepare for climate conditions for agricultural disaster mitigation.
- Crop productivity and sustainable development can be achieved by studying the crop seasonal calendars and adjusting the appropriate planting seasons to avoid unfavorable weather conditions and to minimize losses, these studies are very useful in cultivating annual crops such as rice, maize, and soybean in areas with extreme weather conditions. Climate information, such as the number of hot and cold days and heavy rainfall incidents, can be better used to manage the risks associated with crop production.

This analysis can inform decisions about how cropping systems should be changed to respond to both short and long-term climate signals. Action that can be considered include arranging cultivars according to the begin of the rainy season and dry season for each region to achieve high productivity, minimize damages, a diversify agricultural products and to produce some off-season crops. Climate information can also be useful in forecasting pests and disease probability with crops. These crop yield forecasts are central to ensuring national food security in a country like Viet Nam where the vast majority of the extreme poor are still employed in the agriculture sector.

Climatic factors that are of particularly relevance to agricultural production include:

Radiation and day length indicators

Solar radiation has an important role in agriculure. Radiation waves involved in photosynthesis (photosynthetic activity radiation) have significant impacts on crop yield and on the characteristics of the leaf shape. Therefore, the characteristics of these indicators are considered as important scientific criteria for the selection of crops that are suitable for the agro-climatic resources in each region.

Day length has an important role for selecting suitable crops. The day length for crops is divided into three main groups: (1) crops with short day lengths (12-14 hours); (2) crops with long day lengths (15-18 hours) and dayneutral cropping groups. Day length is changed by the same latitude but will be changed by time. Crop growing seasons depend on dry or wet climates. Therefore, when considering the role of light (short or long day length) for crops, it is very important as well to consider the length of the growing season of the crop.

Radiation and day length indicators are forecasted based on long-term data averages over many years. Additionally, radiation and day length indicators are used to advise farmers where and which crop varieties are most suitable under current circumstances. In northwest Viet Nam these indicators were used to provide information as to which rice varieties should be planted and where exactly. These indicators also give information on limitations of crop seasons (early or late start).

Indicators for winter crops

Indicators for winter crops such as yearly average minimum temperature, air temperature of the coldest month and possible first or last-frost dates have a great significance for crop production in low temperature areas. The indicators are analyzed using a cumulative probability method with 80% related to each day per year to give information on the growing season for short-term crops and the possibility of introducing long-term crop varieties.

Temperature indicators

Temperature is an important factor for the development of crops. In Vietnam, temperatures fluctuations in agricultural production are measured in reference to fluctuations outside a specific temperature range, specifically the period of temperature below 20°C in reference to winter crops and over 25°C - the latter is very important in regard to rice flowering, and the number of hot days is also positively correlated with rice yield).

Soil moisture indicators

Soil moisture is a key factor for the development of crops. The provision of information on humidity is essential for each region. A number of moisture indicators have been developed to support agricultural activities in each region of Vietnam. Indicators of precipitation accumulation at the beginning and end of each season are extremely important to ensure successful crop production, especially in areas where irrigation water is not available.

For such areas, three main points need to be addressed for successful cultivation:

1) Rainfall information to identify the right time for sowing
2) How long does it take for the rainfall to moisten the crops?
3) When does the wet rice season start/ Starting point of the wet rice season?
4) It is possible to schedule late times when the potential rain occurs (period to grow rice, maize, or soybean)

To address these four points, the information from the figure below is crucial. Figure 4 gives exact information on different precipitation probabilities for each month. Furthermore, it provides data for two types of dry period probabilities (2Tk=20 days and 3TK= 30 days with precipitation below 30mm) over the whole year.

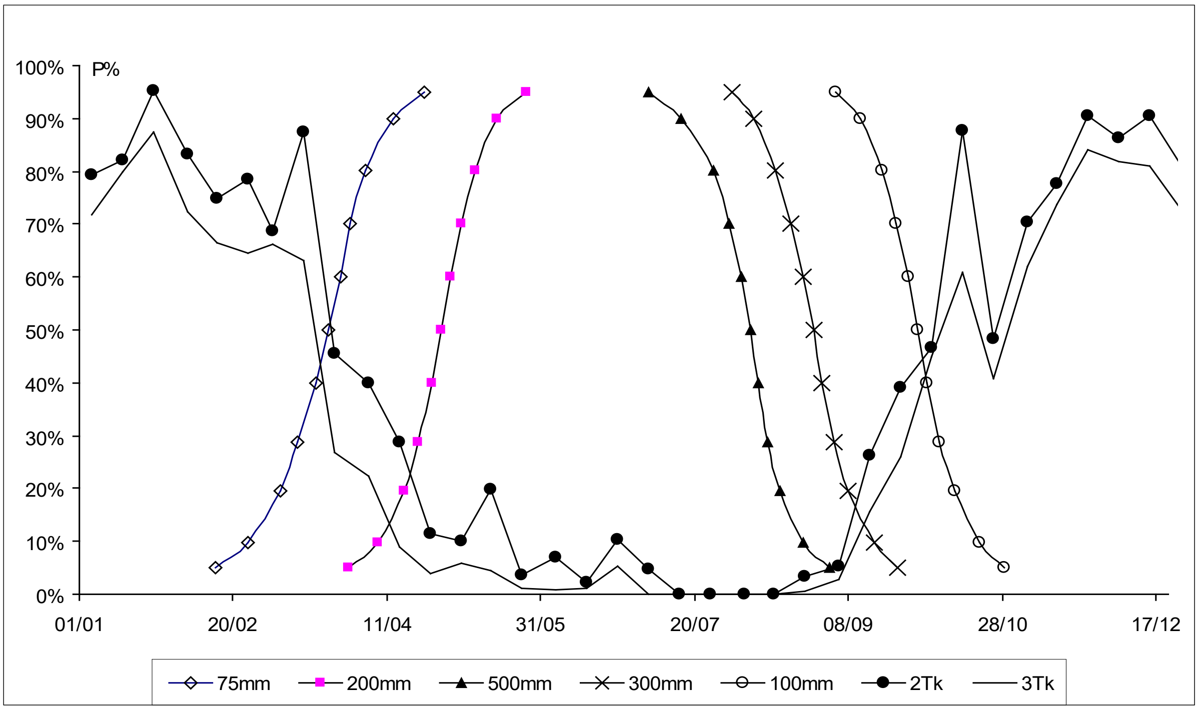

Figure 4. Different precipitation patterns and dry season probabilities of Northern Vietnam

Unfavourable weather phenomena

In the Central Highlands and South-Central Coast regions, unfavourable weather phenomena, such as drought and heavy rainfall have direct detrimental impacts on crop development. Rice, soybean, maize are mainly affected by drought in the South-Central Coast region. Rice, maize, rubber and pepper trees are mainly impacted by heavy rains in the Central Highlands.

Such climate extremes tend to be localised, and improved mapping to show disaster risk can be effective in preventing some damage.

1.2. Regional Level Forecasting within Viet Nam

In Viet Nam there are nine Regional Centers for Hydro-meteorological Forecasting. Each is responsible for:

- Baseline investigations of surface meteorology, agro-meteorology, hydro-meteorological forecasting; air and water quality monitoring for natural disasters, prevention and control, socio-economic development, national security
- Developing implementation plans for the national strategy for hydro-meteorological forecasting and warning, implementing hydro-meteorological forecasting, issuing bulletins about weather, typhoons, tropical depressions, floods and other weather extremes for natural disaster prevention and control, strengthening socio-economic development and national security in each province
- Developing, managing and storing hydro-meteorological data; providing and exploiting services related to hydro-meteorological data, providing information systems on baseline investigations and hydro-meteorological forecasting in the region; structure of Regional Centers in SC and CH are presented in Figure 4 and 5.

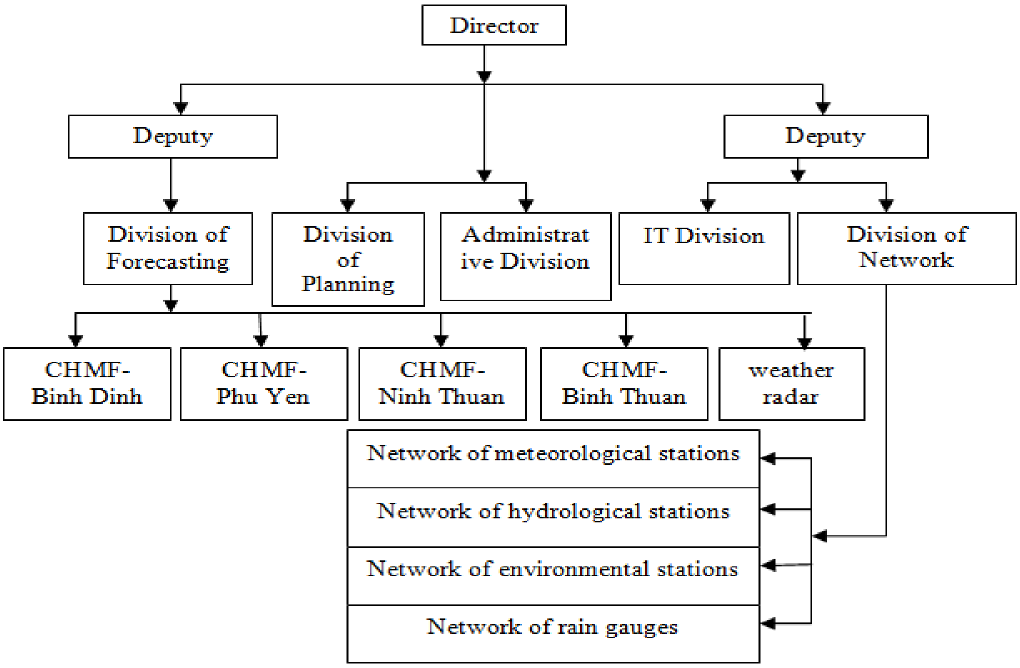

Figure 5. Structure of the Regional Centre for Hydro-Meteorological Forecasting in the South-Central Region of Viet Nam

The Regional Center for Hydro-meteorological Forecasting in the South-Central Coast region is responsible for five provinces including Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, and Binh Thuan.

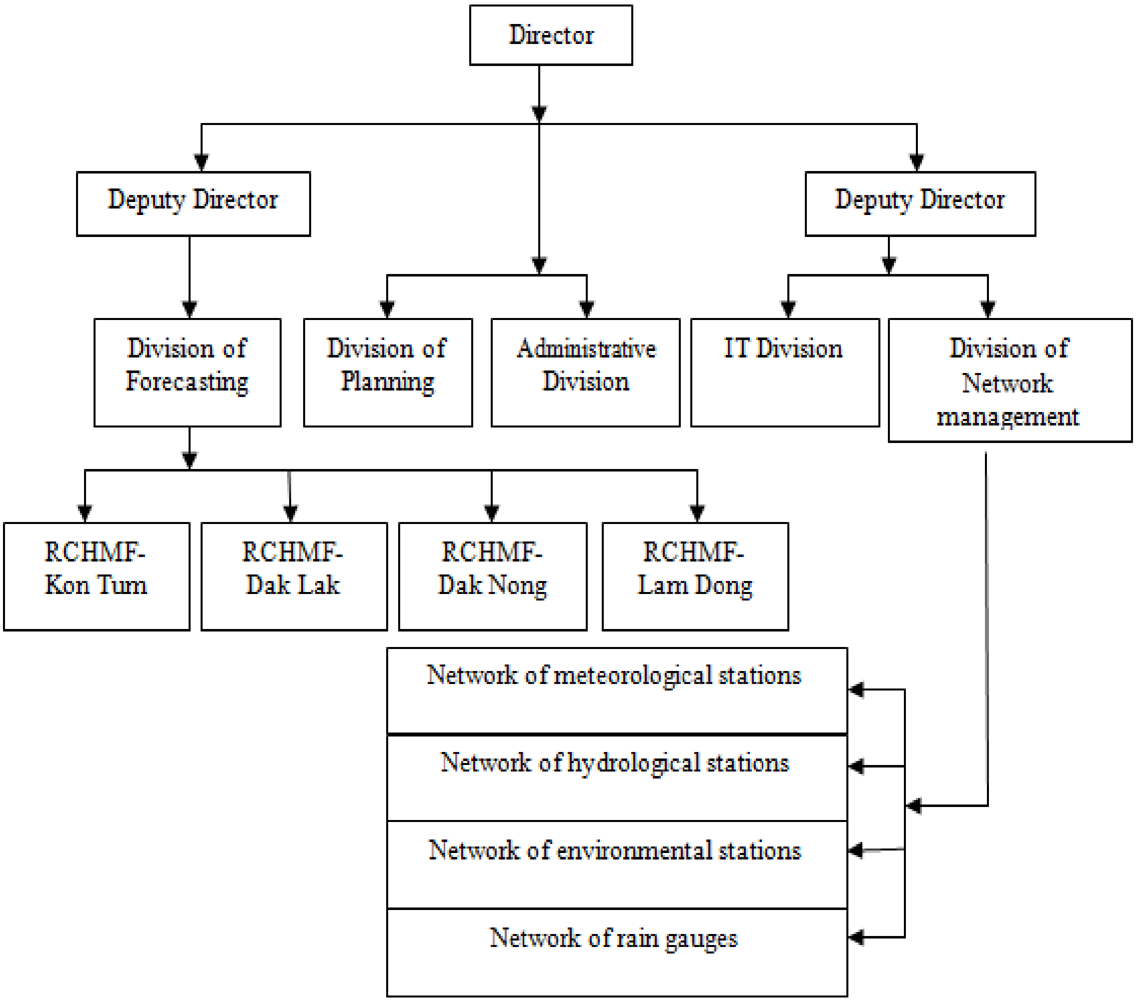

Figure 6. Structure of the Regional Centre for Hydro-Meteorological Forecasting in the Central Highlands

The Regional Centre for Hydro-Meteorological Forecasting in the Central Highlands is responsible for managing and coordinating the activities of the provincial Centers, including Kon Tum, Dak Lak, Dak Nong and Lam Dong provinces (Fig. 6). Regional level forecasts have several challenges including:

- Technological limitations of forecasting (they lack computers large enough to run numeric prediction models); lack of local capacity to analyse and communicate data; the sparse network of meteorological stations
- The connection between the Regional Center and the community is not close.
- The content of bulletins has not been adopted by the community in production planning, There are no recommendations in accordance with weather conditions.

1.3. The provincial level

The Provincial Centers for Hydro-meteorological Forecasting (PCHMF) are under the Regional Centers for Hydro-meteorological Forecasting and are responsible for management, baseline investigations and hydro-meteorological services for their provinces, as shown in figure 7.

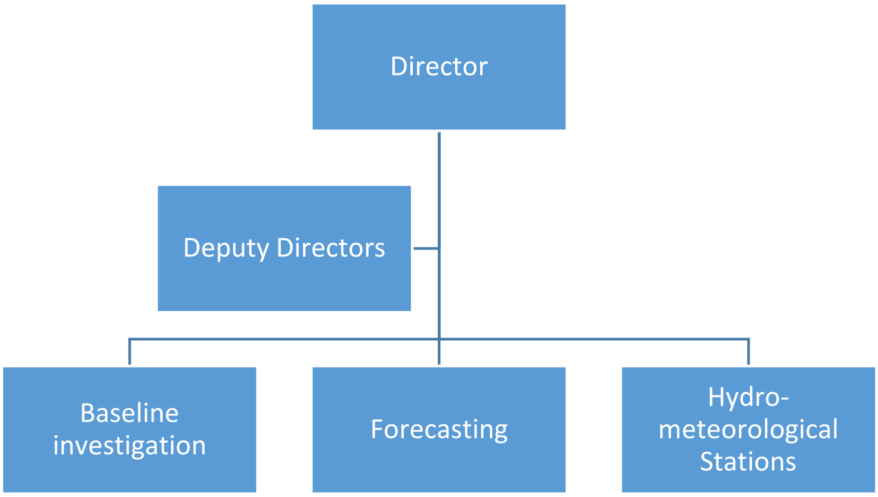

Figure 7. Structure of the Provincial Centre for Hydro-Meteorological Forecasting

1.3.1. Khanh Hoa Province

Khanh Hoa climate is dominated by tropical monsoons. The ocean climate is relatively moderate, there is no large difference in temperature between day and night and between seasons. The annual average temperature is 26°C, annual average rainfall is over 2,000 mm, divided into two different climatic seasons: the rainy season from September to December with 70- 80% of the total rainfall and the rest of the year characterized as dry season, with an annual average of 2,600 hours of sunshine.

Khanh Hoa province has two meteorological stations located in the coastal area and two rain gauges located in the northern part of the province. The meteorological stations are traditionally monitored by observers, running 4 times/day (1h, 7h, 13h and 19h), with rain gauges in automatic stations. It is able to store and update data hourly. The locations of these stations are presented in table 1 to 3 and figure 8.

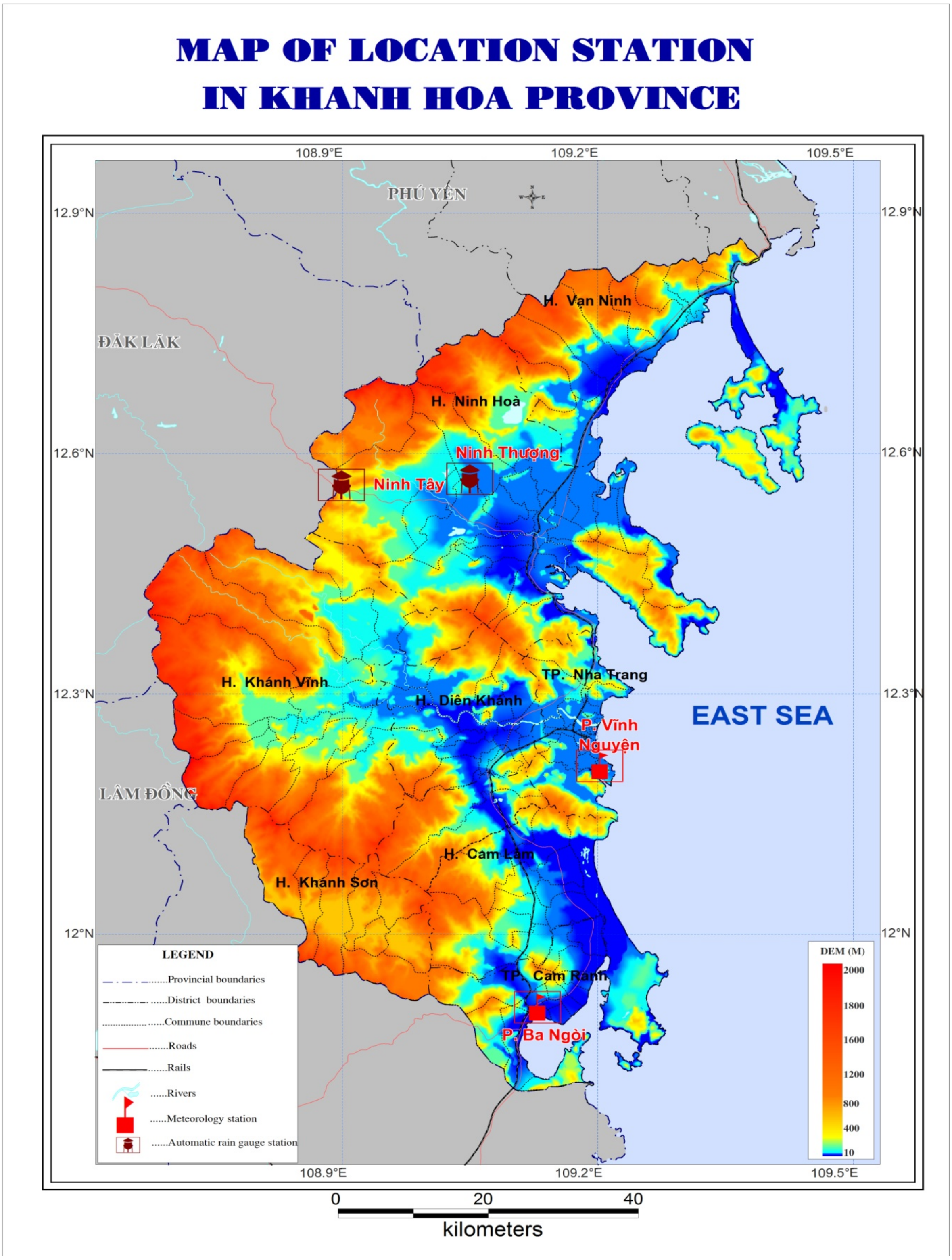

Figure 8. Typology of meteorological stations in Khanh Hoa

The meteorological stations are monitored by observers four times per day (1h, 7h, 13h and 19h). Rain gauges are in automatic stations. They are able to store and update data hourly. News weather forecasts of Khanh Hoa province are provided by the Regional Center for Hydro-meteorological Forecasting. The weather forecast bulletins are created based on the results of national and provincial forecasts and the experience of the forecasters for each area in each province.

These bulletins are then sent by email to the provincial departments. The information is received by the Provincial Party Committee, the Office of the Provincial People's Committee, the Department of Agriculture and Rural Development, the Department of Natural Resources and Environment and the Provincial Radio and Television Station Committee. The newsletters have various features such as:

- Daily weather report of the mainland, including Nha Trang City area, Northern provinces, Western provinces and Southern provinces.
- Weather forecast for following 10 days: The newsletter contains an overview of weather patterns and forecasts of general rainfall and temperature factors for the whole province, but not yet detailed for the areas of the province.
- Monthly weather forecasts: The content of this newsletter is similar to the 10-day weather forecast, but not yet detailed for the provinces.
- The weather and hydrology news for each season: The content of this newsletter includes an overview of the weather and hydrography of the previous seasons and the meteorological and hydrographical situation in the mountainous and coastal areas of the province.

In case of dangerous weather patterns, such as storms, tropical low pressure, heavy rains, additional bulletins are created. Their frequency depends on the level of danger of each specific weather hazard (for example in the case of typhoons, bulletins are issued hourly.)

1.3.2. Ninh Thuan province

Ninh Thuan has a tropical monsoon climate with typical characteristics of high evaporation rates due to hot and windy weather patterns during the dry season. The climate is divided into two distinct seasons: the rainy season from September to November and the dry season from December to August. The annual average temperature ranges between 26-27°C, with an average rainfall of about 700-800 mm in Phan Rang province, gradually increasing to over 1100 mm precipitation in the mountains. Air humidity varies from 75-77%.

Ninh Thuan province has one meteorological station located in the coastal area and five rain gauges located in the west of the province. The locations of these stations are presented in Figure 9 and Tables 1 to 3.

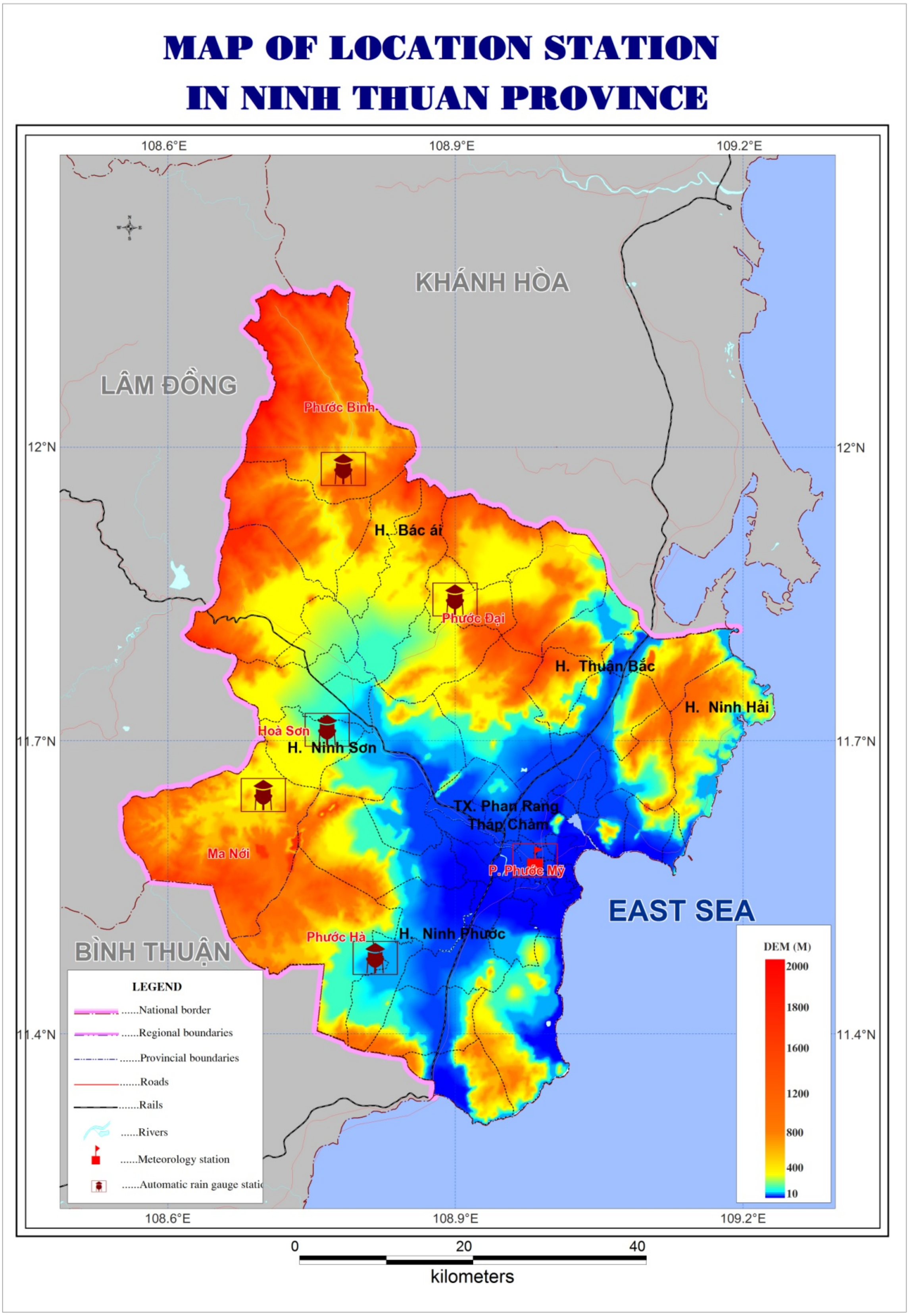

Figure 9. Typology of meteorological stations in Ninh Thuan

News weather forecasts from the Ninh Thuan Center for Hydro Meteorological Forecasting are provided by the Regional Center for Hydro-meteorological Forecasting in the South-Central region and by national forecasts. These newsletters are then sent via email to the provincial departments. The newsletters include daily forecasts for four areas: Ninh Hai - Thuan Bac; Phan Rang City - Thap Cham; Ninh Phuoc - Thuan Nam; Ninh Son - Bac Ai. Weather forecast for the next 10 days, month and seasons are done at provincial level.

1.3.3. Binh Thuan province

Binh Thuan province is located in a typical tropical monsoon climate region with two distinct seasons: the rainy season occurs from May to October and the dry season from November to April. The annual average temperature is 27°C with an annual average rainfall of 1,024 mm annual relative humidity of 79% and 2,459 hours of total sunshine.

Binh Thuan province has two meteorological stations located in the coastal area and two rain gauges located in the center of the province. The locations of these stations are presented in Figure 10 and Tables 1 to 3.

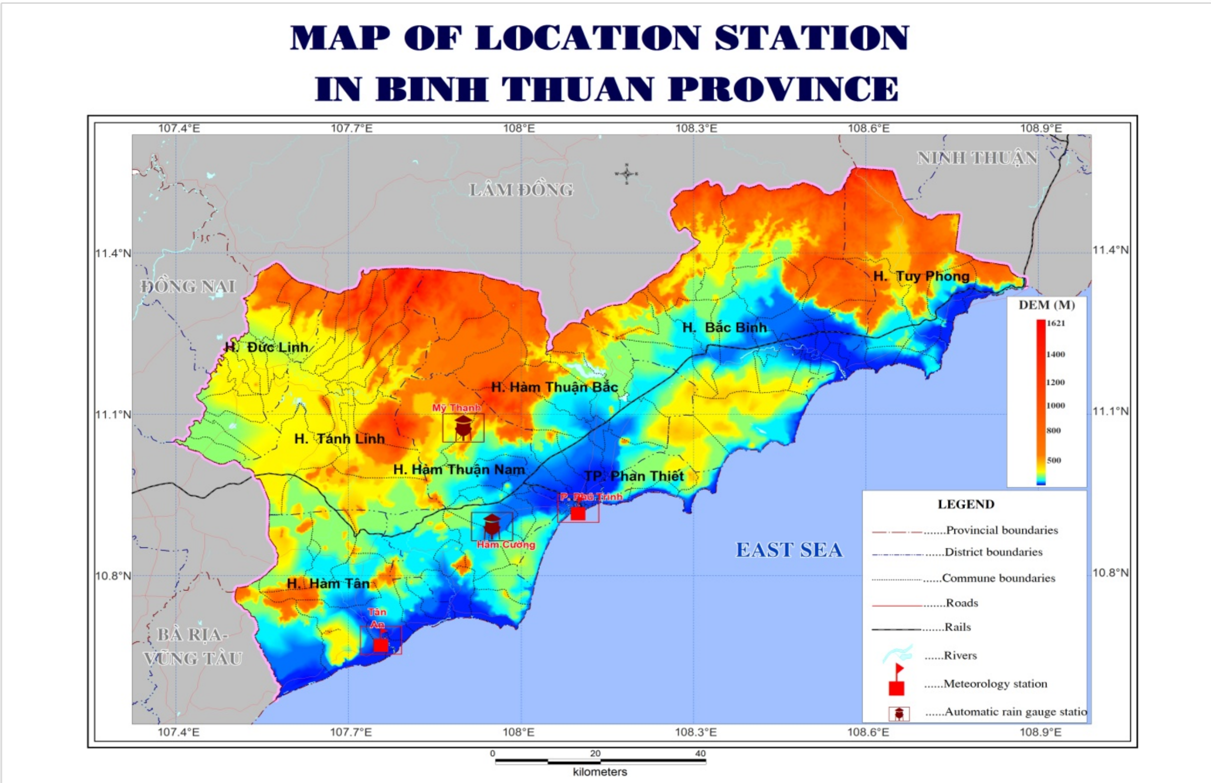

Figure 10. Typology of meteorological stations in Binh Thuan

News weather forecasts from Binh Thuan Center for Hydro Meteorological Forecasting are provided by the Regional Center for Hydro-meteorological Forecasting of the South-Central region and by national forecasts. These newsletters are then sent via email to the provincial departments. These newsletters include the daily forecasts on the mainland for three areas in the North, the Center, Phan Thiet City and the South and weather forecasts for the next 10 days, months and seasons (similar to Khanh Hoa province).

1.3.4. Dak Lak province

The province's climate is divided into two sub-climates. Hot and dry climates in the Northwest and cooler climates in the Eastern areas. The average annual temperature (Northwest and Eastern areas) is 24 °C, while the amplitude between the hottest monthly average temperature and coldest monthly temperature is approximately 5 °C.

In general, the region contains both tropical monsoon and plateau climate with moderate temperatures almost all year-round. This special climatic situation has created many different agro-ecological zones suitable for many types of high value crops, such as coffee, pepper, rubber, cashew and cotton. That makes the provision of downscaled weather and climate information particularly important for these areas.

Dac Lac province has one meteorological station, two climate stations and 16 rain gauges. The operation of these meteorological stations is similar to the stations in Khanh Hoa province.

In 2017, Multimedia Agriculture Communications Joint Stock Company (AgriMedia) set up an automatic weather station for Agriculture only (iMetos). This consists of eight stations, one in each district of Dak Lak. The government has regular access to weather forecast information of the iMetos stations and assesses as well the sensor preformance of these stations. In general, these stations are evenly distributed throughout the province. The weather forecast information of AgriMedia is always shared on the following website: http://daklak.thoittietnhanong.vn/. The locations of these stations are presented in Figure 11 and Tables 1 to 4.

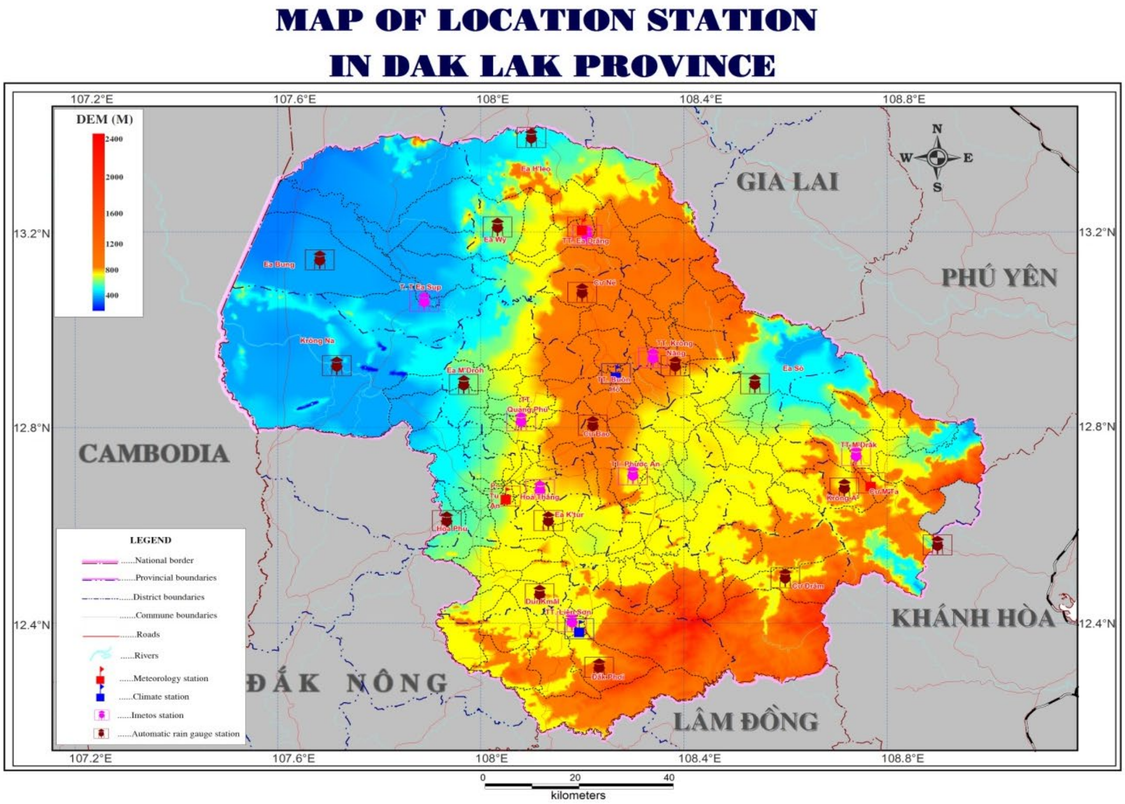

Figure 11. Typology of meteorological stations in Dac Lac

News weather forecast of Dak Lak Center for Hydro Meteorological Forecasting is provided by the Regional Center for Hydro-meteorological Forecasting of the Central Highlands and by national forecasts,

The newsletter forecasts are then sent via email to the different provincial departments. In contrast to the newsletter weather forecasts of the South-Central provinces, the Dak Lak newsletter focuses more on towns.

<u>The newsletters consist of:</u>

Daily forecasts that are predicted for areas and points: East Province (M'Drak district, Ea Kar, Krong Bong), Central region provinces (Buon Ma Thuot, CuM'gar district, Cu Kuin, Krong Pak), regional northwest provinces (Ea Sup District, Buon Don District), region northwest provinces (EaH'leo, Krong Buk, Krong Nang and Buon Ho districts) and the southern part of the province (Lak district, Krong Ana district, Krong Bong district) and point forecasting including the cities of M'Drak, Lien Son, Buon Ma Thuot, Ea Sup and Buon Ho (Fig. 12)

Weather forecast night 24 days 25 May 2018 in Dak Lak province

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	REGIONAL PROJECTION	FORECASTING POINTS
first	**The eastern part of the province** *(M'Drak district, Ea Kar, part of Krong Bong district):* Clouds change, there are rain showers and some thunderstorms, sunny days. - Gentle. - lowest temperature: 21 - 23 o C. - Maximum temperature: 31- 33 o C. - Average humidity: 75 - 80%.	***In M'Drak Town*** **:** Clouds change, with rain showers and thunderstorms, sunny days. - Gentle. - lowest temperature: 22 - 24 o C. - The highest temperature: 31-33 o C. - Average humidity: 75 - 80%.
2	**North East** (*EaH'leo, Krong Buk, Krong Nang):* Clouds change, dark with showers and scattered thunder, sunny day. - Gentle. - lowest temperature: 21-23 o C. - Highest temperature range: 30- 32 o C. - Average humidity: 80 - 85%.	***In Buon Ho town :*** Clouds change, with rain showers and thunderstorms, sunny days. - Gentle. - lowest temperature: 21-23 o C. - Maximum temperature: 30- 32 o C. - Average humidity: 80 - 85%.

Figure 12. Example of weather forecast newsletter for Dak Lak province

Weather forecasts for the next 10 days, months and seasons are carried out for different areas in the province. In case of dangerous weather patterns, the frequency of news broadcasting is increased.

1.3.5. Dak Nong province

The climate of Dak Nong Province is characterized by tropical humid highland conditions and influenced by the hot and dry southwest monsoon.

The climate comprises a rainy and a dry season. The rainy season starts in April and ends in October with 90% of annual rainfall. The Dry season takes place from November to April. The average annual temperature is 22-23°C, with highest temperature being 35°C and average annual rainfall of 2,200 - 2,400mm. The rainy season is heaviest in August and lowest in January. Average humidity is about 84%.

Dak Nong province has one meteorological station, one climate station and 14 rain gauges These stations are evenly distributed at elevations below 1000m and operated like the meteorological stations in Khanh Hoa province. The locations of these stations are presented in Figure 13 and Tables 1 to 3.

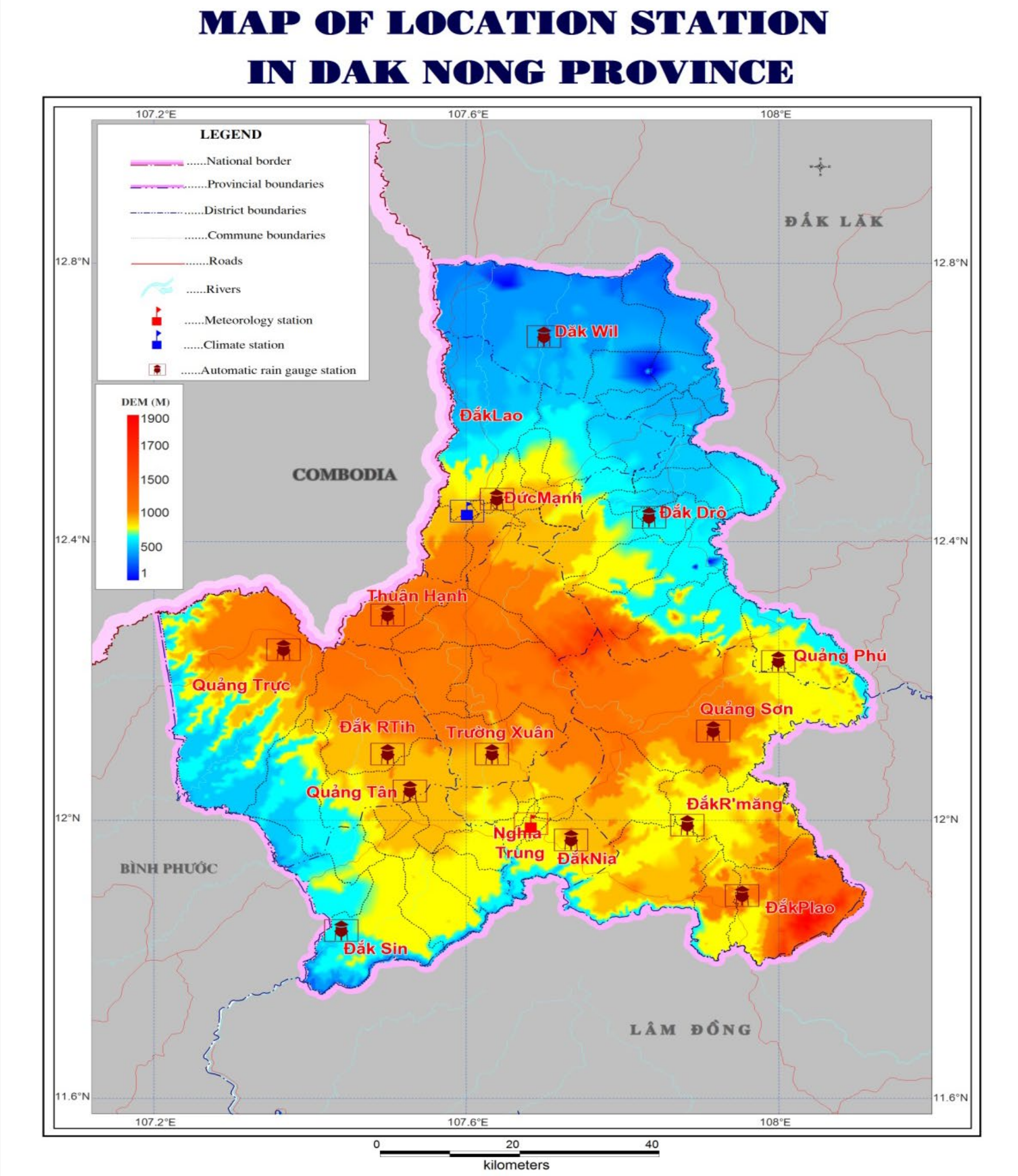


Figure 13. Typology of meteorological stations in Dac Nong

Similar to Dak Lak province, News weather forecasts from Dac Nong Center for Hydrometeorological Forecasting are provided by the Regional Center for Hydro-meteorological Forecasting of the Central Highlands and by national forecasts. These newsletters are then sent via email to the provincial departments.

Daily forecasts are predicted for three areas, including the Northern Region provinces (bridge 14, Dak drong, Dak Mam), the central area provinces (Dak Mil, Nam N'Jang, Duc Xuyen, Quang Son, Dac Rmang), and the southern part of the provinces (Gia Nghia, Quang Khe, Kien Duc, Dak Ngo, Dak Buk So); three points that are forecasted are Eatlinh, Dak Mil and Gia Nghia Town. The lead time is 24 hours and the weather forecast bulletin is similar to the bulletin of Dak Nong province.

Similar to Dak Lak, weather forecasts for the 10-day periods, months and seasons are also carried out for different areas in the province.

Summary of Daily Forecasting capacity in the five potential target provinces:

The daily forecasts of the five provinces under the GCF project have been provided down to district level. Weather forecasts for the 10-day periods and months in the Central Highlands provinces are detailed down to district level. The weather forecasts for the South-Central provinces are only available for provincial level, see table 2 below.

Table 2. Time series of weather forecast in the different provinces

Province	**Daily Forecast**	**10 days forecast**	**Monthly forecast**	**Seasonal forecast**
Khanh Hoa	Regions and cities	Province level	Province level	Province level
Ninh Thuan	Regions	Province level	Province level	Province level
Binh Thuan	Regions and cities	Province level	Province level	Province level
Dak Lac	Regions cities and towns	Regions	Regions	Regions
Dak Nong	Regions cities and town	Regions	Regions	Regions

Seasonal weather forecasts for South Central and Central Highlands provinces are realized at provincial scale and not detailed for district or commune level.

2. Past and on-going projects related to the use of climate information in agricultural production

Target provinces have benefited from a number of previous projects related to improving climate and weather information. Lessons learned and experience from these previous projects can be used to help inform project design. They are shown in Table 3.

Table 3. Overview of past and on-going projects related to the use of climate information in agricultural production

Project/Programme	Description	Key results	Lessons learnt
Building Drought maps for Vietnam Project MONRE (2013-2014)	Evaluation of causes, status, development and trends of three kinds of droughts: meteorological drought, agricultural drought and hydrological drought in eight ecological zones of Vietnam. Developing database, mapping technology and real time and static thematic maps of drought under information technology in Vietnam. Enhancing capacity in monitoring drought, in water resource management and proposing preventive measures for drought in	• Analyze drought and soil moisture. • Identify remote sensing targets and form relationships between remote sensing targets with hydro meteorological factors and drought indicators. • Develop database of hydro meteorological indicators, soil moisture parameters; develop drought maps with remote sensing (real time) in eight ecological regions. • Develop thematic maps of drought for eight ecological regions by information technology systems with 1:250,000 ratio for each region.	Normally, meteorological drought occurs first, secondly hydrological drought, then agricultural drought. Serious droughts usually occur in el Nino years, which causes deficit of rainfall. The life of people is significantly impaired and food security threatened when drought occurs, especially in the SC and CH. In addition, water shortage and salinity intrusion has occurred on

	ecological zones of the country.		a large scale causing severe damage to rice and upland crops, HC: cracked rice fields, exhausted ponds, dried up coffee and pepper trees, lack of water.
Research, evaluation, selection and testing of drought-resistant rice varieties adapted to the Central Coast Region and its typical climate conditions Project MONRE (2012-2013)	Zoning atlas of maps relating the severity of droughts with drought-resistant rice lines. The maps have been developed according to the climate change scenarios of 2030 and 2050 with four levels: no drought, mild drought, moderate drought and severe drought	• Collect and systematize data of the current state of agricultural production, create map to complete the baseline data. • Research and assess the level of drought in the central coastal provinces due to the effects of climate change. • Assess the level of adaptation of drought-resistant rice varieties which have been selected for the Central Coast. • Develop zoning atlas for the severity of droughts and adapted to drought-resistant rice varieties.	- Approving the change of temperature and rainfall based on the climate change scenario, the situation of drought will be become more severe in the future. - Dry season rice varieties can save a lot of water, mainly spraying water when fertilizing the first three times, and when the rice starts flowering, spraying water into the field for the last time, then waiting for the field to become dry until harvest. This not only saves water but also reduces greenhouse gas (CH4) emissions.
Application of remote sensing and GIS technology to determine agro-climatic regions for restructuring the current crop availability in Thua Thien Hue. Project of the Department of Science and Technology of Thua Thien Hue province (2012-2013)	Assess agro-climatic conditions and their impacts on agricultural production of Thua Thien Hue province based on remote sensing and GIS technology. Develop atlas of agro-climatic regions for baseline GIS of Hue. Propose solutions to restructure cropping systems.	• Research remote sensing targets and build relationships between remote sensing targets and agro-meteorological factors mainly on inspected indicators serving for data interpolate of agriculture climate.to create a database of agricultural climate indicators in space • Research and apply agricultural climate softwares to calculate agricultural climate norms. • Research and assess the Agrometshell software to calculate water balance for major crops. • Research and assess the agro-climatic conditions and its	- Using remote sensing technology can resolve the data deficit problem at region level without relying just on weather station. - Although the output of our research is highly applied, but deprived of training content, lack of the training course that directions for use the results of the project. Therefore, it will not produce the desired effect, the research results have not been applied to production. - The research results can be improved and applied for the South-

		impacts on agricultural production in Thua Thien Hue province. • Develop 39 digital maps specialized on agro-climatic characteristics and agro-climatic zoning, rate 1/50.000 GIS base of Hue.	Central Coast and Central Highland Regions in Vietnam.
Research of the ARIMA model to forecast rainfall for spring crop production in the Northern Delta provinces. Project MONRE (2012-2013)	Application of ARIMA model to forecast spring crop production in the northern delta provinces. Evaluate ability to meet natural rainwater harvesting for spring crop production with the aim of rational irrigation in the northern delta provinces.	• Develop algorithms to predict rainfall for winter spring crop production with the ARIMA dynamic model for 10 provinces. • Process and interpret remote sensing images for the studied region to support the assessment of the status and classification of coating serves for assessment the needs of water of crops. Integrated rainfall forecast information and crop map, calculate the amount of water needed to irrigate Use Cropwat software to calculate potential evaporation and (PET) to assess water needs. • Use Agrometshell software to calculate the water needs.	- This approach can support the creation of specific tools for analyzing water spraying - Increasing crop season forecasting. - Currently, the ACIS project (CARE and ICRAF) has used this model to enhance the capacity to provide forecasting information for two Provinces, (Dien Bien and Ha Tinh provinces.)
Setting up a map of drought and domestic water shortage for the South Central and Central Highlands, Project MONRE (2008-2010)	Assess level of drought and lack of domestic water in 4 provinces in the Southern Central region and 5 provinces in the Central Highlands Setup of two thematic maps of drought and domestic water shortage using information technology in the South-Central region and Highlands	Collect data, calculate indicators of drought and lack of domestic water in the regions. Calculate 33 hydro meteorological characteristics of 25 years (1981-2005), groundwater (1990-2005) to map drought and lack of water. Assess characteristics and indicators of drought and lack of water for setup of indicators and scenario mapping of the project. Set up calculation software and characteristics of 33 hydro-meteorological factors, indicators of drought and lack of water level, setup software and drawn boundary maps of drought and lack of domestic water for 2	- Project results will contribute to the GCF program - This project surveyed 84 soil profiles related to agro-hydrological research areas.

		regions, the South-Central region and Highlands.	
Building drought early forecasting technology in Vietnam Project MONRE (2006-2008)	Assessing scale of drought for different climate zones Building early drought forecasting and warning procedures for climatic zones in Vietnam with hydro meteorological data and remote sensing	Determine the criteria for all drought types. Research the relationship between drought indicators targets selected for each climate region in regard to the global climate (SST at NINO12, NINO3, NINO4, SOI…. using remote sensing and GIS technology for early warning of droughts in the Central Highlands. Develop methods of forecasting and early warning of droughts for 7 climate zones in Vietnam.	Some results of this project are applied in monthly report news, climate forecast at IMHEN such as using result forecasting and early warning of droughts for seven climate zones in Vietnam
Inventory, assess, zone and guide to use Vietnam agro-climatic natural resources Project MONRE (2006-2008)	Inventory and access agricultural climate resources of Vietnam to zone agricultural climate. Create manuals on climate information for agricultural production planning to ensure national food security.	• Determine the structure of seasonal plants for each province corresponding to the type of soil, climatic conditions and natural disasters in order to achieve high economic efficiency. • Zoning of Vietnams agricultural climate system including maps of agro-climatic factors Compiling manuals of agro-climatic information for zoning, production planning and restructuring agricultural crops.	The main knowledge of agro-meteorology were brought out such as Indicators of temperature, radiation rainfall, heat season, wet season are made clear in each agro-climatic zone

Agricultural climate zoning and agro-meteorological advisory bulletins in Ba Thuoc district - Thanh Hoa province, Cho Moi and Ba be districts – Bac Can province ProjectCARE (2012-2015)	Agro-climatic zoning for Ba Thuoc district; Develop monthly agro-meteorology newsletter	• Identify climatic characteristics of Ba Thuoc district • Evaluation of agro-climatic conditions of Ba Thuoc district • Agro-climatic zoning for Ba Thuoc district • Develop crop planning for each micro-agro climate regions • Develop monthly agro-meteorology advisory bulletins	This is the first agro-consultant at district scale. The project results were shared with the local farmers This project demonstrates that farmers' understanding of the application of climate information technology in agriculture is very low, so training and capacity building is very important.
Enhancing adaptive capacity of women and ethnic minority smallholder farmers through improved agro-climate information in South East Asia CCAFS- Flagship2-project (2014-2018)	This initiative will enhance the adaptive capacity of women and ethnic minority (W&EM) farmers to better anticipate and respond to risks and opportunities from climatic variability.	Country-specific participatory Agro-Climatic Information Systems(ACIS) established through an approach that integrate farmer-generated observations with downscaled agro-climatic information detailed to the commune level specific weather forecasts with agriculture management options. Based on climate information, climate forecasts and discussion of farmers, agro-meteorological advisory bulletins were established	The agro-meteorological program was carried out on three levels: provincial, district and commune level. Farmers felt excited because they could build the production plan based on climate forecast's informations.

3. Gaps in agricultural meteorological activities

Due to a number of reasons including organizational structures, state management mechanisms and technical knowledge, activities in the agricultural meteorology field are still limited. These specific gaps for the Central Highlands and South-Central Coast are shown below.

3.1 Gaps in data generation

The meteorological observation network in the South-Central region and Central Highlands areas is too thin, with an average of only 3200 km^2/station. This is significantly less than the national average of 400 km^2/station (according to HMS).

In addition, the current technology is based on traditional observation with a very low frequency (eight or four times per day depending on station type). Within 10 minutes the data is shared directly with the NCHMF, who will disseminate the information to national, provincial and district level.

The supply and sharing of data also is very limited. Many key production areas do not have any data; forecasts of rainfall at the time of seasonal change (rainy and dry seasons) are not accurate, and forecasts are not yet available at the district level.

Important factors such as radiation, soil moisture and evapotranspiration are severely lacking due to a lack of an adequate monitoring network. In crop production these factors are especially needed for the calculation of irrigation water (crop water balance).

3.2 Gaps in information dissemination

Climate information is also not disseminated sufficiently to local communities and farmers. The role of climate resources, land, water resources, crops and animals in development of agricultural production, and food security is not properly recognized. The state management agencies and industrial agriculture enterprises need to select and use climate information especially as it relates to crop yields, however, to date this issue has not received sufficient attention or investment. In addition, to improve the current use of climate data for crop yield purposes, trainings on climate information are needed.

3.3 Gaps in applying information

Although some pilot projects have aimed to provide information on agricultural meteorology such as weather and climate information, local level understanding of how to apply that knowledge remains problematic. Almost all farmers are unable to properly answer the question: “If a drought occurs, how should we proactively react and modify our current farming practices?”

Many farmers do not distinguish between weather and climate. They are also unclear about how specific weather events might affect their crops. Other important issues that still need to be managed by farmers include options for changing planting and harvest times, and how changing crop types or mixes can help reduce the impact of extreme weather phenomena on their livelihoods. These are very difficult topics for farmers at present, especially for ethnic minorities and less formally educated people with limited access to scientific and technical knowledge. Pilot projects have shown that there is significant experience available in Viet Nam to help farmers in making these decisions and to use climate data more effectively. However, this experience has not yet been replicated and scaled up in target areas. Such efforts also need to be targeted to ensure that poorer and less educated farmers (including women who generally have lower literacy rates in a number of these provinces) are also able to receive information in a format they can well understand.

Accordingly, there is a great need to develop better ways of communicating climate information to farmers. Climate information should be presented in a more graphically simplified format. At the same time farmers need to be trained to use climate information and more importantly how to plan their crop cycle accordingly.

3.4 Policy and institutional gaps

Present agricultural techniques need to be better coordinated with available meteorological products. Although the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Agriculture and Rural Development (MARD) have long been exchanging information, cooperation related to climate risk information needs to be extended.

The lack of binding mechanisms of institutional arrangements has resulted in less coordination between researchers and policymakers. To promote and improve the interaction and collaboration between researchers and policymakers in regard to climate information services, regular meetings need to be implemented to enhance information exchange. Additionally, researchers need to modify and simplify scientific results on climate information into a more understandable way for policymakers. It is important to strengthen the focus on climate information for agricultural production. Apart from long-term climate forecast (seasonal, yearly) the NHMS has to focus more on short-term climate information dissemination (10 days, daily) in order to help farmers plan and manage their cropping systems.

In each district the Department of Agriculture and Rural Development (DARD) is responsible for teaching farmers how to correctly use climate information effectively for their crop production schemes. Unfortunately, until now there has not been agricultural meteorology application in this process has been limited.

Communes also lack staff who are specialized for agricultural meteorological information generation for agricultural production. Currently, just one staff member is responsible for an entire district comprising many different communes. Increasing the number of staff responsible for information and dissemination, and ideally designating a dedicated staff member at local level would greatly improve current systems. To make useful recommendations on agricultural activities that are appropriate for current climatic conditions, extension officers are required to in-depth experience with agricultural production.

There are also issues of staff turn-over at local level in particular; the positions of the extension officers, who are responsible for agro-climate information advisories are constantly changing. Accordingly, new officers have a lengthy learning curve in order to make appropriate recommendations.

Recommendations

To be effective, district extension officers need to have a degree in agriculture. Project districts should also set up special working groups on climate information for agricultural production. These working groups should consist of one extension officer, one staff member from NHMS and one project own staff. The NHMS staff would receive climate information from provincial level and share it within the working group to come to sustainable and useful decisions for each district.

3.5 Capacity and knowledge management gaps

The supervision, quality and dissemination of agricultural meteorological forecasting from the hydro-meteorological centers at regional and provincial levels is still very poor and does not match the significant demand for agricultural development in the region.

The DARD provincial offices in charge of applying agricultural meteorological information are no sufficiently trained and educated to exploit and use the agro-climatic resources rationally, even though this could reduce damage caused by climate extreme events considerably. For each season one staff member is responsible for planning the agricultural crop calendar based on climate information. Unfortunately, these crop calendars are very general and not detailed, and therefore not useful for farmers at district level.

The central and local hydrological and meteorological agencies have not yet created the necessary coordination between the meteorology and agricultural sectors. They also have not yet paid attention to the actual situation and requirements of local agricultural production. Key questions such as if the rainy season is coming sooner or later, if a drought is expected or not are insufficiently prioritized in advisories. There are also opportunities to ensure more effective collaboration on data generation and analysis between Government ministries, especially those responsible for agriculture (MARD) and meteorology (MONRE), which would yield highly positive benefits for farmers.

4. Recommended interventions to address identified gaps in the project

4.1. Solutions for creating down-scaled forecast Information

In general, there are two approaches to climate forecasting: numerical/statistical method and the dynamic/ modeling method. The advantage of the numerical/statistical method is that the calculation process does not require large computers, it can process and store large data quickly. It is simple and easy to apply. The results are objective, according to a certain rule through regression equations between dependent variables and independent variables.

However, numerical forecasting has disadvantages as well. Analysis is based on linear relationships and forecast results depend on the length of the monitoring data series. Also, only those areas with monitoring stations have reliable forecast results.

In contrast, the dynamic modeling method calculates climate forecasts by climate simulations. The main advantage of the dynamics model is that it can be very detailed, especially for small areas, even when there is no meteorological observation station. However, digital modelling has many disadvantages such as the complexity of numerical modeling, the need for large-scale computer tools, massive investment in data assimilation and the need to have the most up to date information technology and data processing skills. WMO's recommendation is to use both methods.

Within Viet Nam, successful pilots can be replicated for the purpose of generating and interpreting down-scaled forecasts for use in agricultural planning at the commune level in the GCF project target area. Specifically, we recommend using the Climate Predictability Tool (CPT) for seasonal climate downscaling.

The Climate Predictability Tool (CPT) is a software package for constructing a seasonal climate forecast model, performing model validation and producing forecasts with given updated data. Its design has been tailored for producing seasonal climate forecasts using model output statistic (MOS) corrections for climate predictions from general circulation models (GCM) or for producing forecasts using fields of sea-surface temperatures or similar predictors such as indicators of sea surface temperature (SST) in the NINO1.2, NINO3, NINO4, NINO3.4 regions. Although the software is specifically tailored for these applications, it can be used in more general settings to perform canonical correlation analysis (CCA), principal components regression (PCR), or multiple linear regression (MLR) on any data, and for any application.

Currently weather forecasts rely on many different sources, mainly on internet websites, where detailed climate information for small areas is available. Currently, the forecast officers at provincial level are not able to operate and manage the CPT model. They need to be trained in using the CPT model for seasonal climate data downscaling.

This CPT tool has been developed by the International Research Institute for Climate and Society (IRI), which has already facilitated an initial training for the center of hydro meteorological forecasting Khanh Hoa, Ninh Thuan, Binh Thuan, Dac Lac, Dac Nong provinces, the target areas of the project.

4.2. Adaptation solutions for climate extremes

4.2.1. *Participatory Scenario Planning (PSP)*

Participatory Scenario Planning (PSP) is a multi-stakeholder approach to enable access to seasonal climate forecasts, understanding and interpretation of the forecasts and associated uncertainty into locally relevant information that is useful in decision making and planning (interpretation of seasonal forecast into actionable advisories for community level). It is particularly effective in sharing climate information from both local level and combining it with scientific knowledge.

This approach is being applied effectively by CARE and ICRAF through the Agro-climate Information Services (ACIS) for Women and Ethnic Minority farmers in South-East Asia project. The PSP is an effective smart climate change adaptation tool that could be well applied to the target project areas. The implementation of PSP in the ACIS project is described below:

1. **<u>When does it happen and how long does it take?</u>**

The PSP process occurs as soon as a seasonal (long-term) and daily to 10 days (short-term) climate forecast is available from meteorological stations. The PSP process has five steps (Fig. 14). Step 1 is Seasonal, step 2 takes 1-2 weeks; Step 3: 1-2 days; Step 4 takes about 10 days, while Step 5 which focuses on feedback monitoring and evaluation is an on-going or cross-cutting process across the whole PSP

- **<u>Five steps of PSP</u>**

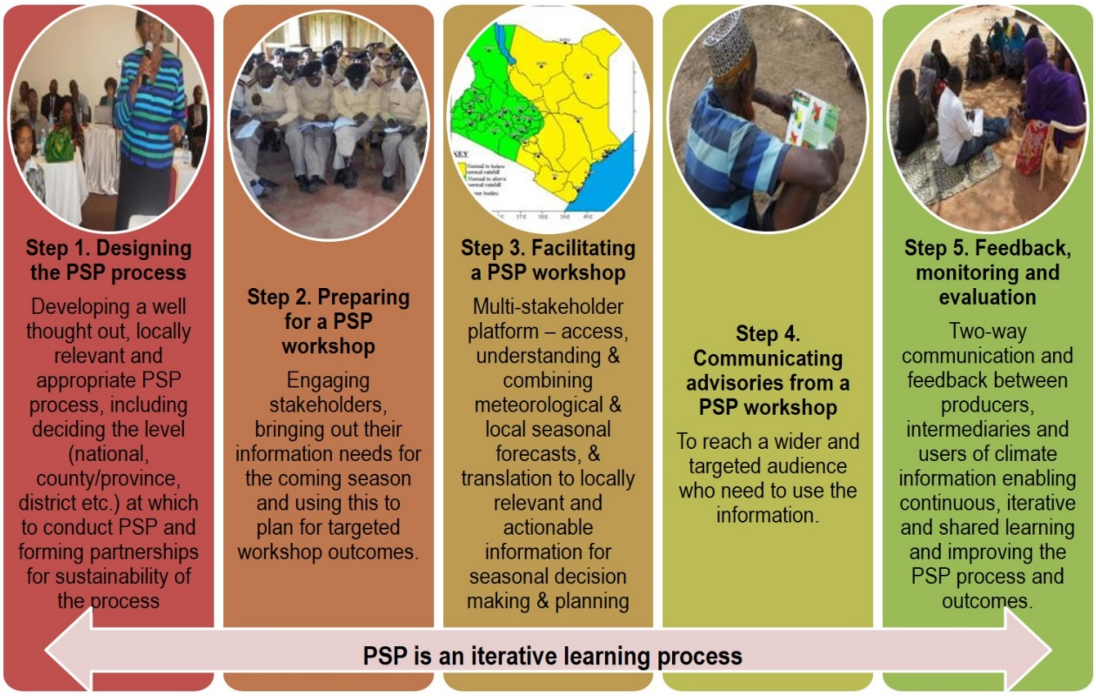


Figure 14. Diagram of the different steps of PSP

2. **<u>Who is involved?</u>**
    - IMHEN, staff from provincial, district Met-station, community representatives from different zones, Provincial and District DARD, including agricultural extension center, Women Union, District and Commune People Committee, CCD, Ha Tinh FU, ICRAF, CARE and potential private sector

3. **<u>Why PSP?</u>**
    - Uncertain future climate: incomplete scientific understanding of the climate
    - Limited predictability of future climate
    - Uncertain future information is more than no information at all
    - Scenarios developed by using the PSP approaches enable the interpretation and management of uncertainty
    - Based on the spread of probabilities, scenarios can enable
    - Anticipation and planning for strategies which integrate both investment and risk management.
    - Farmers to make better decisions on which mixture of crops to plant (e.g. early maturing and drought tolerant varieties), when to plant them and how much to plant to avoid total crop loss due to climate related hazards.

- Pastoralists and livestock keepers to engage in risk management livelihood and income generating strategies such as rearing different types of livestock, mixing improved and local breeds, integrating management of water and pasture/grazing resources, integrating economic trees which also provide protection against strong winds and involvement in other non-farm income generating activities in addition to livestock farming. This prompts livelihood diversification and environmental management as effective climate adaptation strategies.
- Agro-dealers to invest in stocking different volumes of certain inputs and products in anticipation of market in relation to the coming season.
- Government service providers in agriculture and related sectors to tailor their plans and actions to reflect different potential needs in the season

4. **<u>What are outcomes of PSP?</u>**
    - Actors' capacity to access and use downscaled and interpreted seasonal climate forecasts, and associated uncertainty, in climate responsive decision making and planning is strengthened.
    - Climate uncertainty, risks and opportunities are managed through actors making forward-looking and flexible decisions and plans, and developing innovative solutions.
    - Local climate resilience is enhanced by integration of adaptation, early warning-early action and disaster risk management into plans and actions for livelihoods, agriculture and other climate sensitive sectors, and development.
    - Multi-stakeholder collaboration in development of climate information services that is responsive to diverse and changing needs and demands of actors.
    -
5. **<u>What are linkages between PSP and adaptive capacity?</u>**
    - Variability in temperature, rainfall from one year to the next and climate continues to change now and over the long term. Seasonal forecasts, and their interpretation into locally relevant information, are therefore an essential resource for managing risks and uncertainties =>Potential pathways for strengthening stakeholders' adaptive capacities to manage climate change in the long term
    - Climate information to climate knowledge
    - Forward looking and flexible decision-making and planning

<u>Step 1: How to design the PSP process</u>

- Local context analysis: Defining local area (agro-climate zone), local climate, identifying climate sensitive sectors, livelihoods
- Stakeholder analysis: map key SH (cross-sectorial and multi-stakeholder) in decision making and planning
- Developing a convincing case for PSP: Showing the case applying PSP in another place
- Introducing PSP in a local area – presenting the convincing case for PSP
- Forming partnerships
- Planning for the entire PSP process: What activities, When, Who, Where, What

<u>Step 2: Preparing for PSP workshop as a participatory process</u>

- Engaging local actors: understand the local seasonal climate, climate risks and impacts and actors' climate information needs
    - Local seasonal climate and impacts
    - Climate information access and communication
    - Relevance of climate information to local decision making and planning
- Coordinating information and participation in a PSP workshop: significant amount of information => making sense
    - Analysis of discussions from actor engagement
    - Preparation of representatives from different actor groups
    - Preparation by meteorological services
    - Preparing local forecasters

- Facilitators' planning for a PSP Workshop
    - Develop a detailed agenda and agree on facilitation
    - Logistics

Step 3. Facilitating a PSP workshop

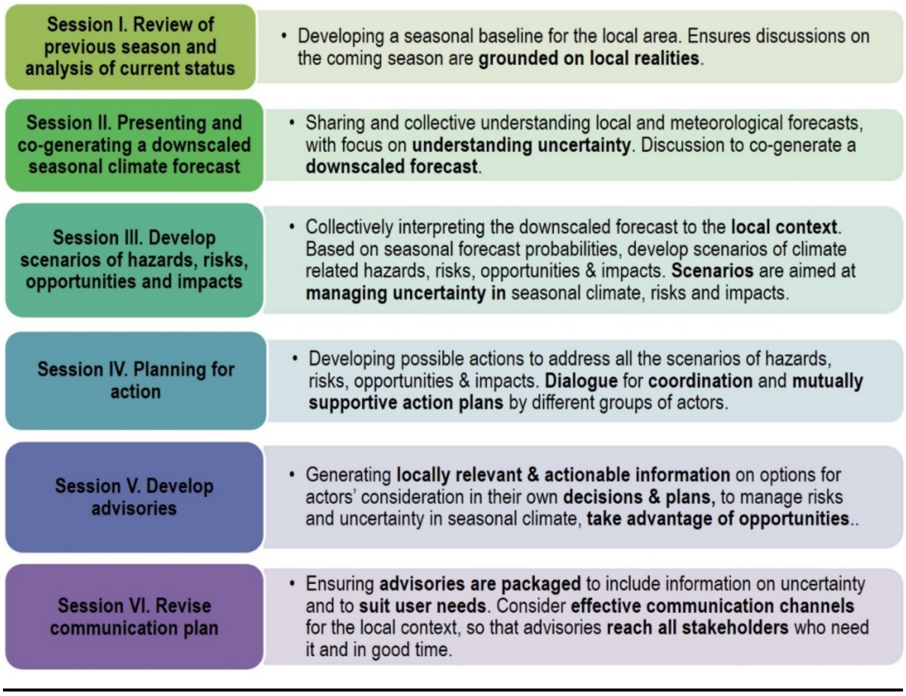


Figure 15. Preparation plan for a multi stake holder PSP workshop

The PSP process develops a hazard scenario for a particular area and crop, such as the one below. The advisory committee then determines a set of potential actions which can be taken by Government and farmers to provide an integrated approach to reduce the impact of climate extremes (Fig. 15). Advisories are then developed for dissemination which can provide information on specific risks and actions. These advisories can prompt local level action. For example:

- Pests and diseases may emerge as a key risk at a specific period in the season, therefore farmers need to choose the appropriate time for planting certain types of crops to avoid adverse effects by pests and diseases;
- Suppliers need to have sufficient stocks of different types of seeds and other inputs at certain times in the season;
- Sub-county officers for agriculture need to provide capacity building on particular pest management techniques.

Step 4. Communicating advisories from a PSP workshop

- Relevant stakeholders need to be involved in the whole communication process to make it more effectively, including meteorological forecast staff, agriculture and fishery officers, and local people (village chiefs, farmers);
- Meteorological forecast staff, agriculture and fishery officers teach and guide farmers on how to use climate information to cope with natural disasters;
- Discussions and knowledge exchange on how to use weather forecast information, talk about difficulties in the coming season and find solutions together;
- Agro-climate information will be communicated before sowing and planting.

Proposed enhancements of the ACIS model for consideration in this project.

The agro-climate zone in the ACIS project only considers agricultural climatic conditions for crops and does not consider conditions such as topography, soil condition, and water resources, so it is limited in recommending the change of suitable cropping systems.

In this project, we propose enhancement of the system through the development of an agro-ecological zonation (AEZ) for the key crops in the study area. This will be the scientific basis for recommending intercropping models in accordance with natural occurrence in each sub-region.

Agro-ecological zonation will be implemented according to an FAO method, which has been developed as part of the Land Use Evaluation Tool (LUSET), The structure of the LUSET is shown in the figure 16:

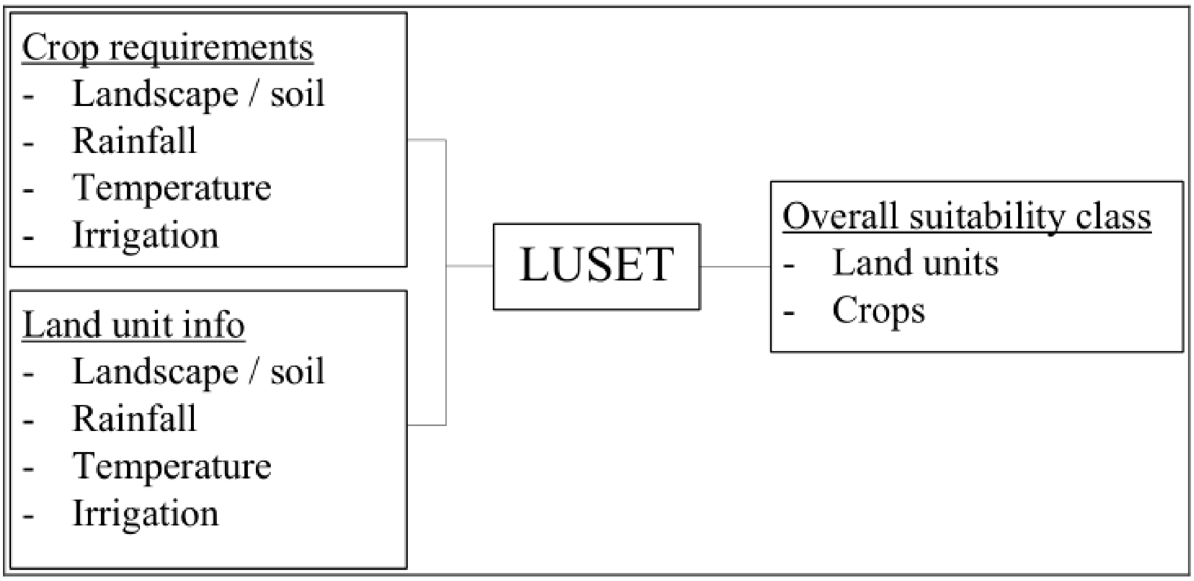


Figure 16. The structure of LUSET

This graphic (Fig. 16) was designed to illustrate the interlinkages of different factors of crop requirements and land unit information to provide overall guidance for the suitability of these areas according to land unit and crops. The LUSET results can then be communicated via PSP models to the local communities to improve their understanding of the interactions of weather variabilities and agricultural production.

4.2.2. Selected methods to be implemented in project activities (listed below in Table 4)

- Training of trainers on PSP for participants from each province, including provincial and district officials
- Training of leading farmers on PSP
- Print the documents, PSP newsletters, AEZ map and Climate chart to hang up at the village cultural house.
- Create videos and copy DVD discs about the process done by PSP in the commune,
- Use SMS to advise farmers on production activities;
- Coordination with provincial radio and television in transmitting information for agricultural purpose / to advise farmers

5. Cost and budget estimatations

Table 4. Overview of cost and budget estimations

Activities	Unit	Quantity	Unit cost in USD	Total cost in USD
Activity 2.3 Co-development and use of localized agro-climate advisories by smallholders to enhance climate-resilient agricultural production				**1,586,000**
2.3.1 Train 50 hydromet and DARD staff on generating and interpreting down-scaled forecasts for use in agricultural planning (eight training over four years for 50 participants)				***112,000***
Training of provincial hydromet (2 courses/year x 4 years); 5 provinces in one course, one week/course, 10 staff/course; costs including meals for participants, traveling of participants from province to province (training location), accommodation, meeting room.	course	8	4,000	32,000
Consultancy costs for training, costs including consultancy fee/day, software, equipment, accommodation, travels and preparation of trainings, handouts for participants, will be conducted by research organization (Research Institute)	Lump sum			80,000
2.3.3 Co-develop, through Participatory, Scenario Planning (PSP) of seasonal and 10-day/15-day agro-climate advisories with smallholder farmers (20 provincial level trainings for 30 staff and 56 district level trainings for 60 participants over four years)				***1,274,000***
- Developing agro-ecological zones (AEZ/provinces * 5 provinces)	AEZ	5	10,000	50,000
-Development of PSP training documents including: Characteristics of agricultural climate, disasters and their impacts on agricultural production for each province (training documents/provinces * 5 provinces)	documents	5	5,000	25,000
Training of trainers on PSP package (one course/province 5 provinces); 30 staff/course from DARD in the first year, one weeks/course; costs including meals for participants, traveling of participants from province, commune to district (training location)	course	5	3,800	19,000
Training of lead farmers on PSP package by trainers (60 courses (communes, 30 persons/course) x 2 courses/season x 2 season/year x 5 years); two days/course; costs including meals for participants, traveling of participants)	course	1200	900	1,080,000
Consultancy costs for trainers in teaching the course on training of trainers and coaching the trained trainers in delivering the course to lead farmers, costs included consultancy fee/day, accommodation, travels and preparation of trainings, handouts for participants, will be conducted by resource organization (NGO)	Lump sum			100,000
2.3.4-3 Disseminate advisories to 139,416 households in the 60 communes.				**200,000**

- Print the documents, PSP newsletters, AEZ map and Climate chart to hang upat the village cultural house	Lump sum			100,000
- Video and Copy Disc DVD about processing done PSP in the commune, SMS, TV, Radio...	Lump sum			100,000

6. Sustainability and exit strategy

Currently, agricultural production in the project area is highly affected by adverse weather conditions. To cope with climate variability and change and avoid natural disasters and reduce the damage caused by weather conditions, it is necessary to have appropriate production strategies. Choosing planting seasons, cultivars and rational farming techniques is the most feasible way to ensure a stable crop yield and minimize damage to agricultural production. Producers need to be supported by science to adjust their crop calendars and change cropping systems to avoid losses based on seasonal climate forecast information and early seasonal advisories.

During the implementation of the project, the consultants will train provincial meteorological forecasters and provide detailed climate forecast information to the commune level for PSP activities. The long-term outcome of the project is to increase and improve the linkages and information transfer between meteorologists and farmers. This will be assured by training of trainer sessions.

After the project finishes, local communities will have the need to get more and frequent agro-climate information. Therefore, they will support MET to extend the meteorological-hydro climate forecast to obtain more and frequent agro-climate information on commune level via different communication ways (television, SMS, loudspeakers).

After completing the project, the provincial weather forecasters (MET) will have the information and skills (e.g. hydromet) to downscale agro-climate information to commune level. To continue collaboration, communication and knowledge transfer between provincial weather forecasters (MET), local farmers and Agriculture and fishery officers (DARD), PSP workshops will be held twice a year before each cropping season.

APPENDIX

List of Meteorology station (Synoptic stations)

No.	Station	Region	Province	District	Commune	Longitude	Latitude
1	Nha Trang	South Central	Khanh Hoa	TP. Nha Trang	Vinh Nguyen	109.2	12.21667
2	Cam Ranh	South Central	Khanh Hoa	Cam Ranh	Ba Ngoi	109.15	11.91667
3	Phan Rang	South Central	Ninh Thuan	TX Phan Rang	Phuoc My	108.9833	11.58333
4	Phan Thiet	South Central	Ninh Thuan	TX Phan Thiet	Phu Trinh	108.1	10.93333
5	Ham Tan	South Central	Binh Thuan	Ham Tan	Tan An	107.7667	10.68333
6	Phu Quy	South Central	Binh Thuan	Phu Quy	Ngu Phung	108.9333	10.51667
7	Buon Me thuot	Central Highlands	Dak Lak	Buon Me Thuot	Tu An	108.05	12.66667
8	M'DRak	Central Highlands	Dak Lak	M’ Drak	Cu M’ Ta	108.7667	12.73333
9	EaHleo	Central Highlands	Dak Lak	Ea Hleo	Ea Drang	108.2	13.21667
10	Dac Nong	Central Highlands	Dac Nong	Dac Nong	Gia Nghia	107.6833	12

List of climate stations

No.	Station	Region	Province	District	Commune	Longitude	Latitude
1	Buon Ho	Central Highlands	Dak Lak	Krong Buk	Buon Ho	108.2667	12.91667
2	Lak	Central Highlands	Dak Lak	Lak	Lien Son	108.2	12.36667
3	Dak Mil	Central Highlands	Dak Nong	Dak Mil	Dak Lao	107.6167	12.45

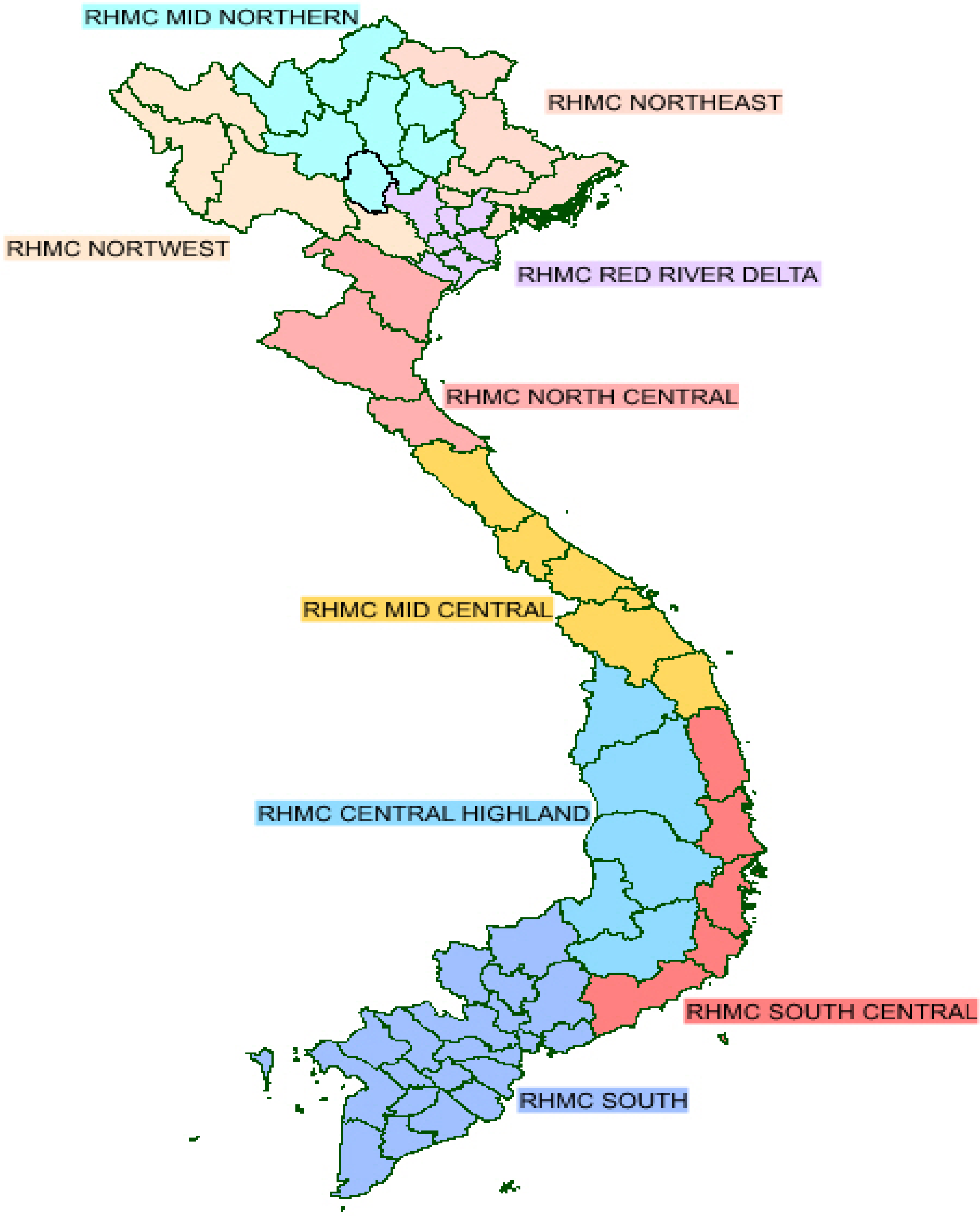
List of rain gauge automatic stations

No.	Station	Region	Province	District	Commune	Longitude	Latitude
1	Ninh Thuong	South Central	Khanh Hoa	Ninh Hoa	Ninh Thuong	109.05	12.56667
2	Ninh Tay	South Central		Ninh Hoa	Ninh Tay	108.9	12.56667
3	Phuoc Ha	South Central	Ninh Thuan	Ninh Phuoc	Nhi Ha	108.8167	11.48333
4	Ma Noi	South Central		Ninh Son	Ma Moi	108.7	11.65
5	Phuoc Dai	South Central		Bac Ai	Phuoc Dai	108.9	11.85
6	Hoa Son	South Central		Ninh Son	Hoa Son	108.7667	11.71667

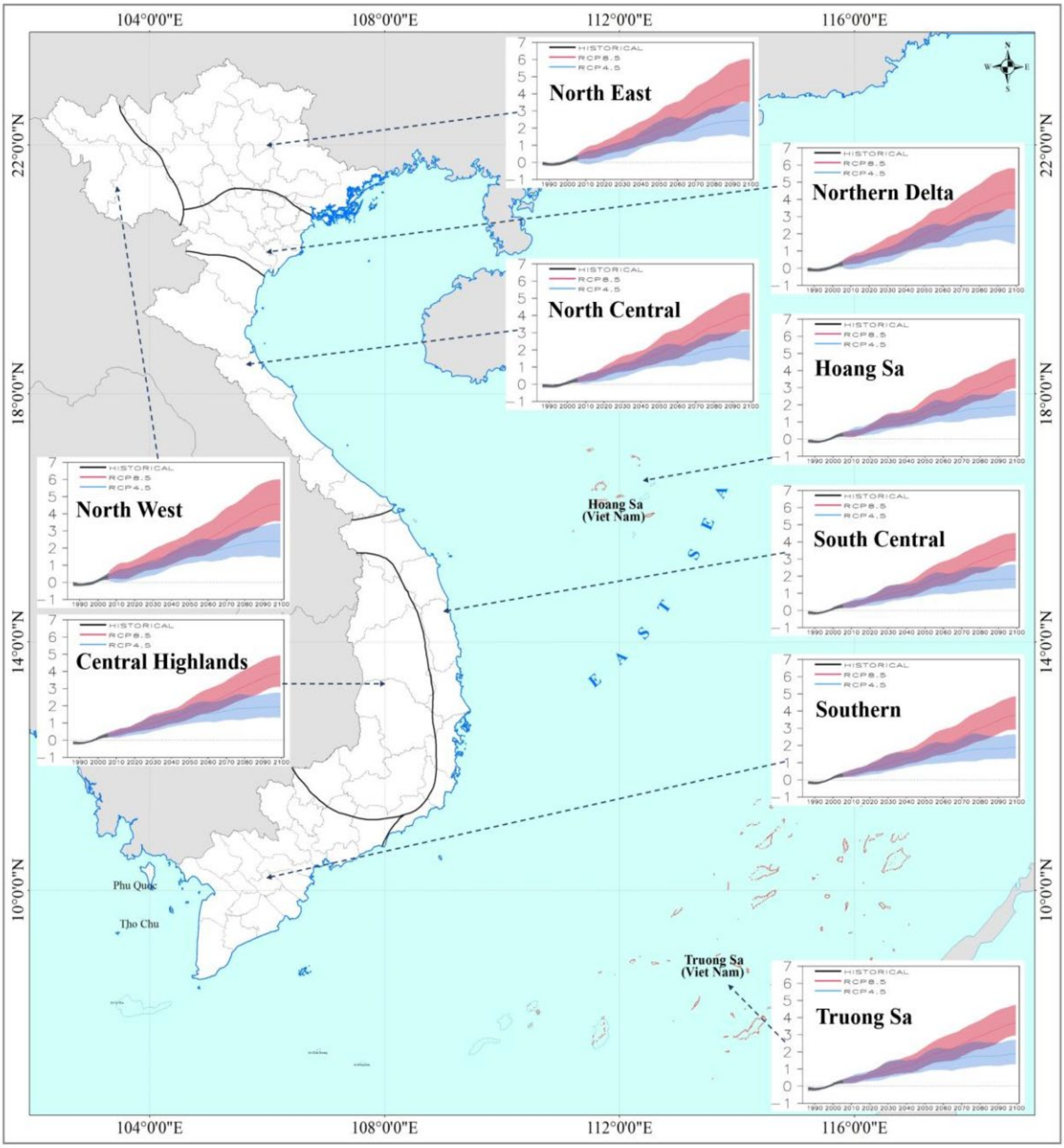
7	Phuoc Binh	South Central		Bac Ai	Phuoc Binh	108.7833	11.98333
8	Eabung	Central Highlands	Dak Lak	Easup	Eabung	107.6833	13.15
9	Krong Nang	Central Highlands		Krong Nang	Krong Nang	108.3833	12.93333
10	Cu Dram	Central Highlands		Krong Bong	Cudram	108.6	12.5
11	Ea H'Leo	Central Highlands		Eahleo	Eahleo	108.1	13.4
12	Dur Kmal	Central Highlands		Krongana	Dur Kmal	108.1167	12.46667
13	Dak Phoi	Central Highlands		Lak	Dak Phoi	108.2333	12.31667
14	Hoa Phu	Central Highlands		Buon Ma Thuot	Hoa Phu	107.9333	12.61667
15	Krong Na	Central Highlands		Buon Don	Krong Na	107.7167	12.93333
16	Cu Bao	Central Highlands		Buon Ho	Cu Bao	108.1833	13
17	Ea M'Droh	Central Highlands	Dak Lak	Cu Mnga	Eamdrol	107.9667	12.86667
18	Krong A	Central Highlands		Madrak	Krong A	108.7167	12.68333
19	Ea Ktur	Central Highlands		Cukuin	Eaktur	108.1333	12.61667
20	Eawy	Central Highlands		Ea Hleo	Eawy	108.0333	13.21667
21	Cu Ne	Central Highlands		Brongbuk	Cu Ne	108.2	13.08333
22	Ea So	Central Highlands		Ea Kar	Ea So	108.5403	12.89667
23	Quang Tan	Central Highlands	Dak Nong	Tuy Duc	Quang Tan	107.5333	11.96667
24	Dak Dro	Central Highlands		Krong No	Dak Ro	107.8333	12.46667
25	Dak Nia	Central Highlands		Gia Nghia	Dak Nia	107.6333	12.1
26	Dak R'mang	Central Highlands		Dak Glong	Dak R'mang	107.8667	12
27	Quang Phu	Central Highlands		Krong No	Quang Phu	108	12.23333
28	Truong Xuan	Central Highlands		Dak Song	Truong Xuan	107.6333	12.1
29	Dak Wil	Central Highlands		Cu Jut	Dak Wil	107.7	12.7
30	Quang Son	Central Highlands		Dak Glong	Quang Son	107.9167	12.13333
31	Dak P'lao	Central Highlands		Dak Glong	Dak P'lao	107.9	11.9
32	Quang Truc	Central Highlands		Tuy Duc	Quang Truc	107.3667	12.25
33	Dak R'Tih	Central Highlands		Tuy Duc	Dak R'Tih	107.5	12.1
34	Thuan Hanh	Central Highlands		Dak Song	Thuan Hanh	107.5	12.3
35	Duc Manh	Central Highlands		Dak Mil	Duc Manh	107.6333	12.46667
36	Dak Sin	Central Highlands		Dak Rlap	DakSin	107.4333	11.91667

List of Imetos stations (AgriMedia)

No.	Region	Station	Province	District	Commune	Longitude	Latitude
1	Central Highlands	Ea Sup	Dak Lak	TT Ea Sup	Ea Sup	107.89	13.7
2	Central Highlands	Ea Hleo	Dak Lak	Ea Hleo	Ea Drang	108.21	13.2
3	Central Highlands	Krong Nang	Dak Lak	Krong Nang	Krong Nang	108.34	12.95
4	Central Highlands	Krong Pak	Dak Lak	Krong Pak	Phuoc An	108.3	12.71
5	Central Highlands	Cu M'gar	Dak Lak	Cu M'gar	Quang Phu	108.08	12.82
6	Central Highlands	Buon Ma Thuọt	Dak Lak	Buon Ma Thuọt	Hoa Thang	108.1169	12.68
7	Central Highlands	M'Drak	Dak Lak	M'Drak	M'Drak	108.74	12.75
8	Central Highlands	Lak	Dak Lak	Lak	Lien Son	108.18	12.41



Regional Centers for Hydro-meteorological Forecasting and their jurisdiction



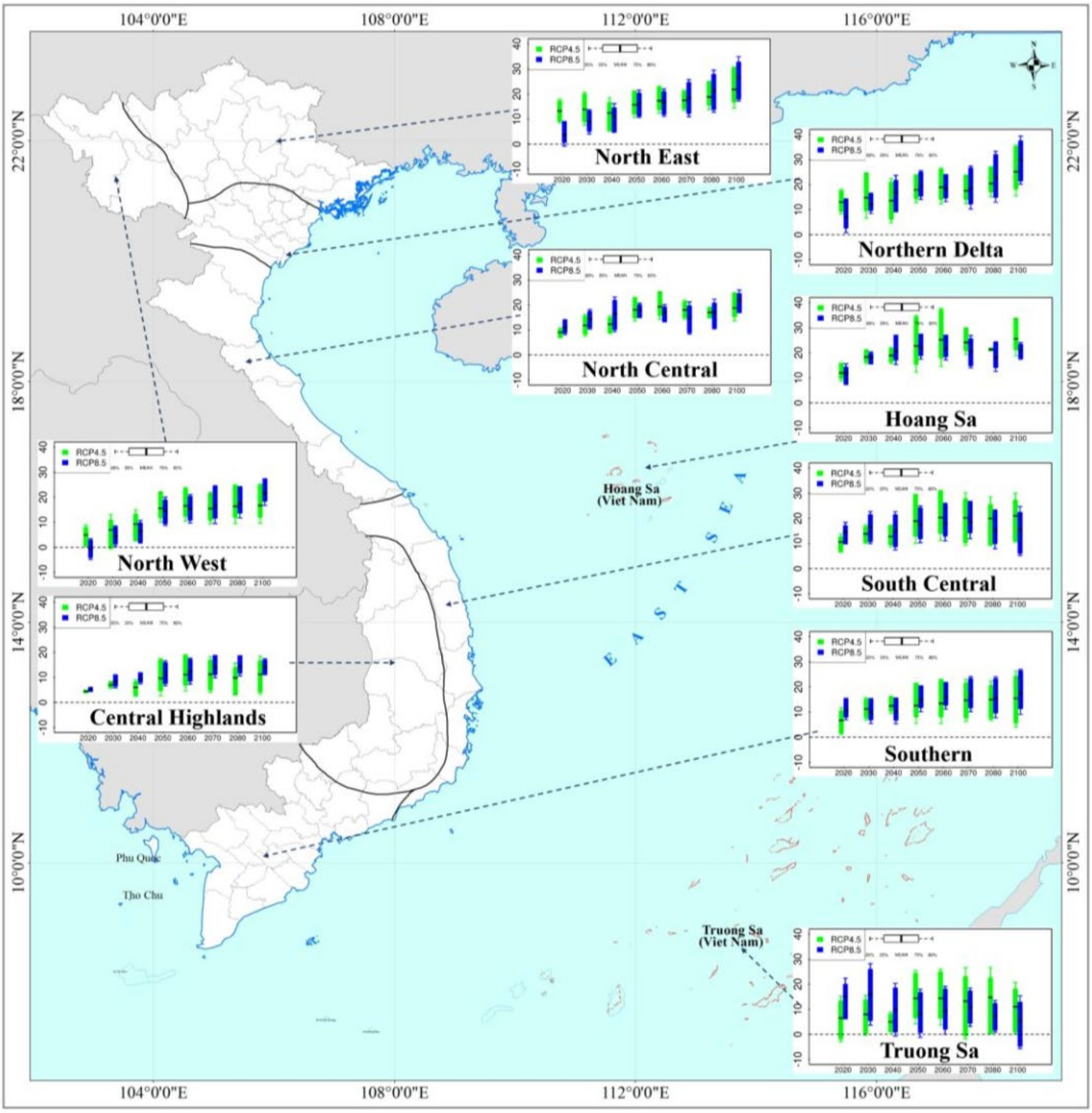
Projection temperature change in 7 climatic zones of Vietnam at the end of 21st century (RCP4.5 and RCP8.5)

Note:

Reference period (1986-2005)

RCP4.5: Surface temperatures would increase by 1.9÷2.4^{o}C in the North and 1.7÷1.9^{o}C in the South.

RCP8.5: Temperature would increase by 3.3÷4.0^{o}C in the North and 3.0÷3.5^{o}C in the South



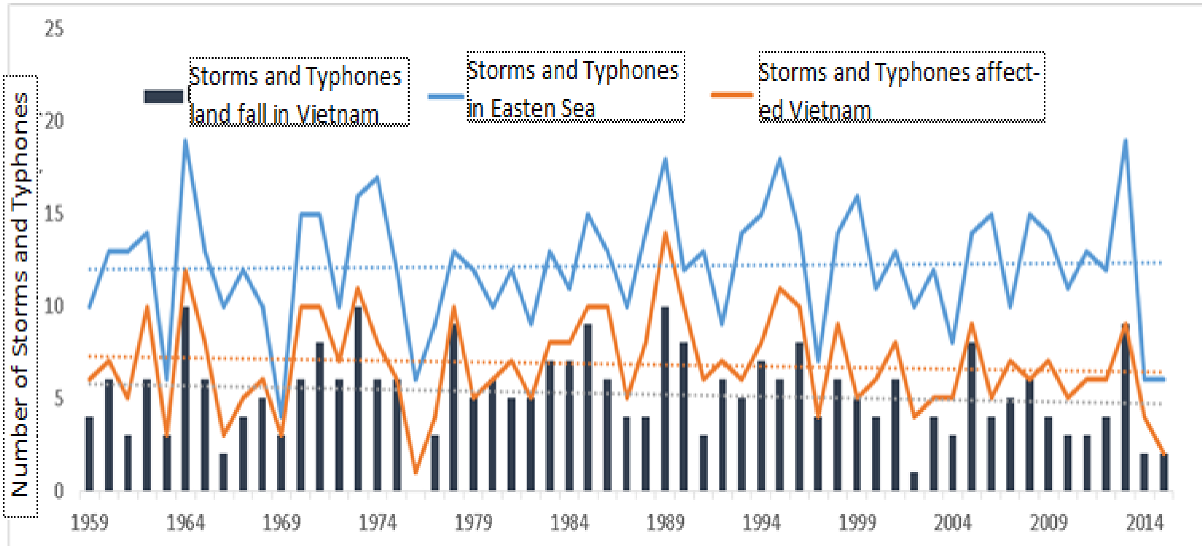
Projection temperature change in 7 climatic zones of Vietnam at the end of 21st century (RCP4.5 and RCP8.5)

Note:

Reference period (1986-2005)

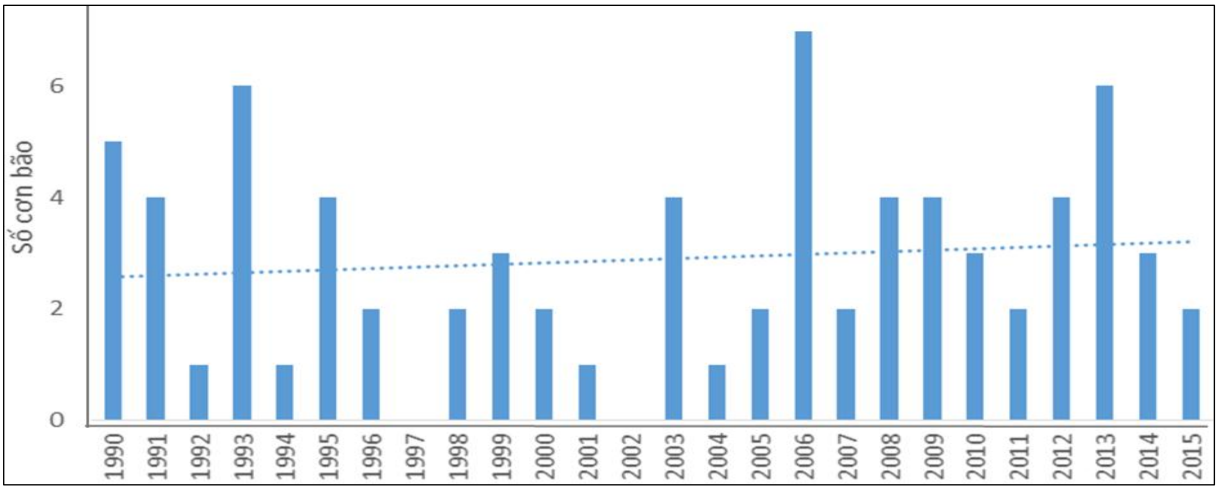
RCP4.5: Annual rainfall would generally increase in a range of 5÷15%.

RCP8.5: The greatest increase could reach over 20% in most of the North, Central Coast, a part of the South and Central Highlands.



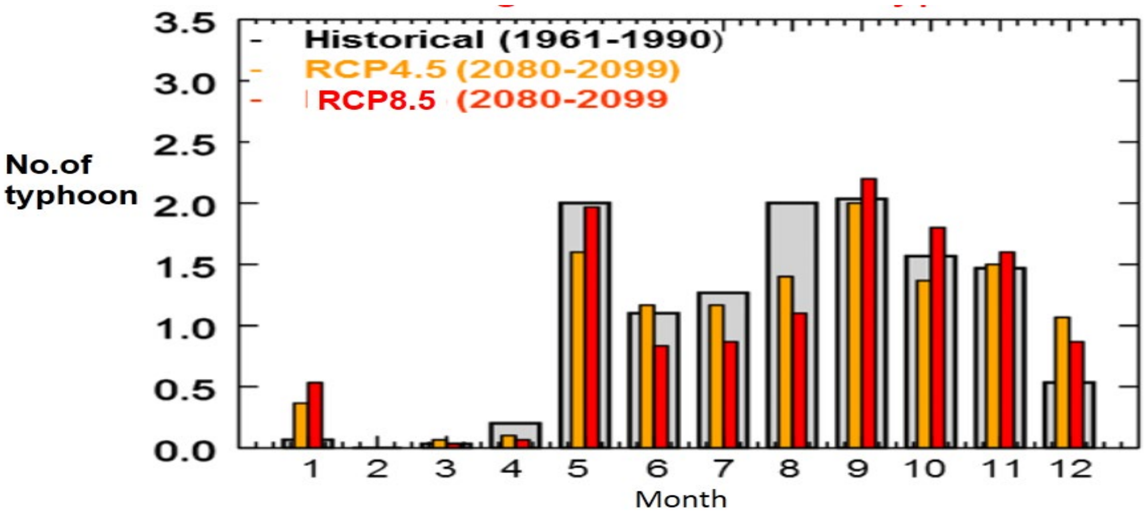
Change in the number of tropical depressions and typhoons in East Sea from 1959-2015

Note:
According to the data from 1959-2015, the change in the number of tropical depressions and typhoons in East Sea was quite low. the number of storms and typhoons landfall to Viet Nam was slight change. However, the inter-annual variation of number of tropical depressions and typhoons was substantial, sometimes up to 18÷19 storms (in 1964, 1989, 1995 and 2013), sometimes 4÷6 storms (1963, 1969, 1976, 2014, 2015)



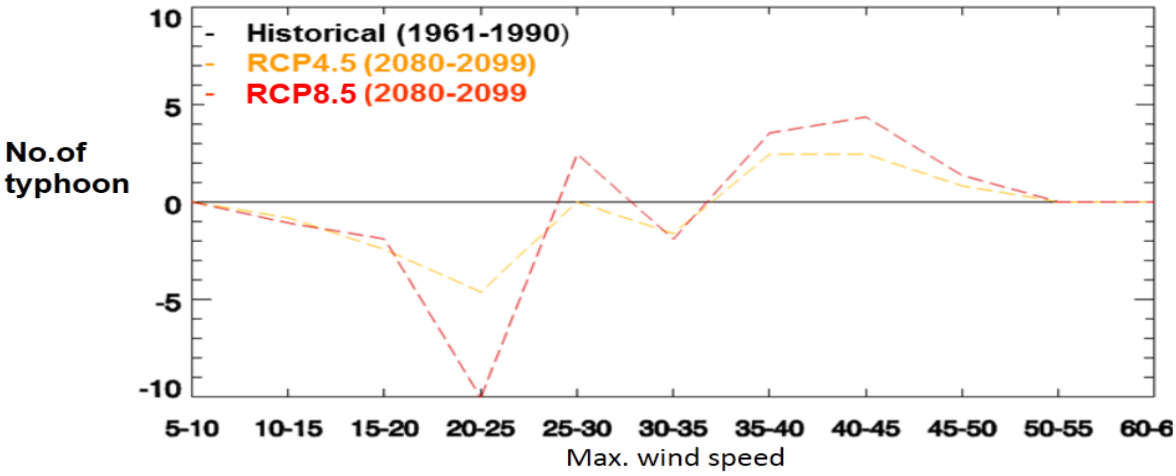
Number of typhoons with maximum wind speed exceeding category 12 (Beafort scale) for the Viet Nam East Sea (1990-2015)

Note:
No. of strong and very strong typhoons increase.
Typhoon season tend to last longer and typhoon tracks had a southward trend.



Projected numbers of tropical depressions and typhoons in the East Sea at the end of 21st century

Note:
Based on the PRECIS model, the projected numbers of tropical depressions and typhoons in the East Sea will decrease at the beginning of the typhoon season (June - August) for both scenarios, RCP4.5 and RCP8.5. Thus, tropical depressions and typhoons will likely occur at the end of the typhoon season mainly occurring in the South.



Fluctuations of number of tropical depressions and typhoons in the East Sea at the end of 21st century

Note:
The number of weak and moderate typhoons will likely decrease, while the number of strong typhoons will likely increase when compared to the baseline period.

Projected winter mean temperature change (oC) compared to the reference period (1986-2005)

NO.	Province	RCP4.5			RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	*Khanh Hoa*	0,7 (0,4÷1,2)	1,3 (0,9÷1,8)	1,5 (1,1÷2,1)	0,8 (0,5÷1,1)	1,7 (1,3÷2,2)	2,9 (2,3÷3,5)
2	*Ninh Thuan*	0,7 (0,4÷1,2)	1,3 (1,0÷1,9)	1,6 (1,2÷2,2)	0,8 (0,5÷1,1)	1,7 (1,3÷2,3)	3,0 (2,4÷3,8)
3	*Binh Thuan*	0,8 (0,4÷1,3)	1,3 (0,9÷1,9)	1,6 (1,1÷2,2)	0,8 (0,5÷1,3)	1,8 (1,3÷2,4)	3,1 (2,5÷3,7)
4	*Dak Lak*	0,8 (0,4÷1,2)	1,3 (1,0÷1,8)	1,6 (1,2÷2,2)	0,9 (0,6÷1,2)	1,8 (1,3÷2,2)	3,0 (2,5÷3,7)
5	*Dak Nong*	0,8 (0,4÷1,3)	1,4 (1,1÷2,1)	1,7 (1,2÷2,4)	0,9 (0,6÷1,2)	1,9 (1,5÷2,5)	3,3 (2,8÷4,1)

Projected spring mean temperature change (oC) compared to the reference period (1986-2005)

NO.	Province	RCP4.5			RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	*Khanh Hoa*	0,7 (0,4÷1,2)	1,3 (0,8÷2,0)	1,8 (1,2÷2,6)	0,8 (0,6÷1,0)	1,8 (1,2÷2,7)	3,2 (2,4÷4,1)
2	*Ninh Thuan*	0,7 (0,4÷1,1)	1,3 (0,9÷2,0)	1,8 (1,2÷2,6)	0,8 (0,6÷1,0)	1,8 (1,2÷2,6)	3,3 (2,5÷4,1)
3	*Binh Thuan*	0,7 (0,4÷1,3)	1,3 (0,8÷2,0)	1,8 (1,2÷2,6)	0,8 (0,5÷1,1)	1,8 (1,2÷2,6)	3,2 (2,5÷4,0)
4	*Dak Lak*	0,7 (0,3÷1,2)	1,4 (0,9÷2,0)	2,0 (1,3÷2,8)	0,9 (0,6÷1,2)	1,9 (1,2÷2,7)	3,3 (2,4÷4,5)
5	*Dak Nong*	0,7 (0,4÷1,2)	1,5 (0,9÷2,0)	2,0 (1,4÷2,8)	0,9 (0,6÷1,2)	2,0 (1,3÷2,7)	3,4 (2,6÷4,5)

Projected summer mean temperature change (oC) compared to the reference period (1986-2005)

NO.	Province	Script RCP4.5			Script RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	*Khanh Hoa*	0,7 (0,3÷1,2)	1,5 (0,9÷2,3)	2,0 (1,3÷2,8)	0,8 (0,5÷1,3)	2,0 (1,3÷2,9)	3,5 (2,7÷4,6)
2	*Ninh Thuan*	0,7 (0,3÷1,1)	1,5 (0,9÷2,2)	2,0 (1,3÷2,8)	0,8 (0,5÷1,2)	1,9 (1,3÷2,7)	3,4 (2,8÷4,6)
3	*Binh Thuan*	0,7 (0,4÷1,2)	1,4 (0,9÷2,1)	1,8 (1,2÷2,5)	0,8 (0,5÷1,3)	1,8 (1,3÷2,6)	3,2 (2,7÷4,2)
4	*Dak Lak*	0,7 (0,4÷1,2)	1,5 (1,0÷2,2)	2,0 (1,4÷3,0)	0,9 (0,6÷1,4)	2,0 (1,3÷3,0)	3,6 (2,8÷5,0)
5	*Dak Nong*	0,7 (0,4÷1,2)	1,5 (1,0÷2,2)	2,0 (1,3÷2,8)	0,9 (0,6÷1,4)	2,0 (1,4÷2,8)	3,5 (2,8÷4,8)

Projected autumn mean temperature change (oC) compared to the reference period (1986-2005)

NO.	Province	Script RCP4.5			Script RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	*Khanh Hoa*	0,7 (0,3÷1,1)	1,4 (0,9÷2,0)	1,8 (1,2÷2,5)	0,7 (0,5÷1,1)	1,9 (1,3÷2,6)	3,3 (2,6÷4,3)
2	*Ninh Thuan*	0,7 (0,4÷1,3)	1,3 (0,9÷1,9)	1,8 (1,1÷2,4)	0,8 (0,5÷1,2)	1,8 (1,3÷2,6)	3,2 (2,7÷4,1)
3	*Binh Thuan*	0,7 (0,4÷1,1)	1,4 (1,0÷2,2)	1,8 (1,2÷2,7)	0,8 (0,5÷1,3)	1,9 (1,3÷2,8)	3,5 (2,8÷4,5)
4	*Dak Lak*	0,6 (0,4÷1,2)	1,3 (0,9÷2,1)	1,8 (1,1÷2,7)	0,8 (0,5÷1,2)	1,8 (1,2÷2,8)	3,3 (2,5÷4,5)
5	*Dak Nong*	0,7 (0,4÷1,1)	1,4 (0,9÷2,1)	1,8 (1,2÷2,7)	0,8 (0,5÷1,2)	1,9 (1,3÷2,7)	3,4 (2,6÷4,5)

Projected winter rainfall change (oC) compared to the reference period (1986-2005)

NO.	Province	Script RCP4.5			Script RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	***Khanh Hoa***	7,1 (-6,2÷19,8)	23,2 (-8,0÷52,0)	26,4 (5,0÷47,3)	-11,2 (-18,1÷-4,4)	43,1 (5,8÷83,4)	7,7 (-19,8÷38,0)
2	***Ninh Thuan***	5,9 (-15,1÷27,3)	16,5 (-23,5÷54,8)	17,8 (-21,1÷51,4)	-10,3 (-27,5÷ 4,9)	40,8 (-9,4÷92,6)	-17,5 (-41,9÷ 9,6)
3	***Binh Thuan***	42,0 (4,5÷77,2)	2,7 (-19,5÷23,8)	36,8 (-1,9÷74,2)	-5,0 (-27,5÷15,9)	44,6 (1,9÷87,7)	-8,6 (-36,9÷19,1)
4	***Dak Lak***	3,2 (-19,4÷23,7)	2,0 (-15,9÷19,2)	18,0 (-23,2÷55,3)	-26,1 (-34,0÷18,7)	28,8 (-1,8÷59,2)	13,4 (-24,6÷52,8)
5	***Dak Nong***	13,4 (-10,2÷36,3)	20,9 (-3,5÷42,6)	22,2 (-13,1÷54,8)	25,0 (-14,8÷58,2)	46,1 (8,1÷81,7)	2,6 (-20,6÷28,2)

Projected spring rainfall change (oC) compared to the reference period (1986-2005)

NO.	Province	Script RCP4.5			Script RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	***Khanh Hoa***	22,3 (-18,5÷58,6)	4,3 (-16,0÷22,2)	13,3 (-2,5÷29,0)	24,5 (-9,3÷55,0)	-3,5 (-22,4÷14,0)	6,6 (-17,5÷28,2)
2	***Ninh Thuan***	7,4 (-16,0÷28,6)	-5,1 (-16,6÷ 5,5)	1,9 (-19,2÷22,7)	19,0 (-15,3÷52,3)	-15,4 (-24,5÷-6,0)	2,7 (-20,2÷22,2)
3	***Binh Thuan***	14,2 (-0,8÷28,4)	1,2 (-18,2÷19,6)	9,8 (-13,6÷30,5)	2,6 (-13,6÷17,9)	3,8 (-5,1÷12,4)	1,2 (-12,9÷14,9)
4	***Dak Lak***	4,5 (-3,6÷12,8)	1,1 (-6,8÷8,4)	5,5 (-5,0÷15,8)	-1,2 (-9,8÷6,9)	1,0 (-3,8÷5,8)	8,4 (1,4÷15,7)
5	***Dak Nong***	13,5 (6,7÷18,8)	4,6 (-6,8÷15,7)	9,6 (1,4÷17,7)	-5,3 (-11,8÷1,3)	19,3 (-3,5÷39,7)	14,8 (10,1÷19,6)

Projected summer rainfall change (oC) compared to the reference period (1986-2005)

NO.	Province	Script RCP4.5			Script RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	***Khanh Hoa***	11,9 (-0,4÷23,5)	1,9 (-8,5÷12,8)	6,3 (-5,3÷17,8)	19,8 (8,1÷31,1)	9,8 (-0,7÷19,8)	4,7 (-8,2÷16,7)
2	***Ninh Thuan***	12,2 (0,2÷23,5)	9,6 (-2,8÷21,9)	10,9 (-6,0÷27,1)	21,8 (10,3÷32,4)	17,4 (-0,8÷34,5)	6,9 (-11,0÷23,9)
3	***Binh Thuan***	9,5 (-1,8÷19,7)	10,1 (0,0÷21,3)	12,4 (4,0÷20,5)	12,3 (3,9÷20,9)	12,4 (6,1÷18,9)	12,1 (3,0÷20,6)
4	***Dak Lak***	1,3 (-6,4÷9,1)	-5,1 (-11,9÷2,2)	-2,2 (-8,7÷4,7)	2,8 (-4,6÷9,9)	0,4 (-4,8÷5,7)	-1,6 (-10,2÷7,7)
5	***Dak Nong***	4,9 (-0,3÷10,1)	12,1 (2,0÷23,5)	9,6 (2,3÷17,2)	7,8 (1,3÷14,9)	16,2 (10,6÷21,8)	15,5 (12,6÷18,6)

Projected autumn rainfall change (oC) compared to the reference period (1986-2005)

NO.	Province	Script RCP4.5			Script RCP8.5		
		2016-2035	2046-2065	2080-2099	2016-2035	2046-2065	2080-2099
1	***Khanh Hoa***	5,9 (-3,2÷13,9)	15,8 (4,8÷26,0)	8,5 (-3,2÷19,4)	17,2 (4,6÷30,2)	0,1 (-10,9÷10,9)	6,7 (-7,6÷19,5)
2	***Ninh Thuan***	4,5 (-1,5÷ 9,9)	4,7 (2,6÷26,3)	12,7 (-5,6÷28,9)	19,3 (5,7÷33,2)	4,3 (-7,5÷15,0)	9,5 (-5,2÷23,3)
3	***Binh Thuan***	18,4 (8,3÷28,0)	21,5(13,5÷30,1)	23,2 (13,4÷33,2)	16,0 (6,6÷25,8)	17,8 (6,2÷28,9)	21,5 (11,8÷31,2)
4	***Dak Lak***	10,2 (3,3÷16,7)	16,3 (4,6÷28,5)	17,4 (0,6÷32,9)	9,3 (0,4÷18,1)	11,5 (-0,6÷23,8)	21,1 (1,8÷39,2)
5	***Dak Nong***	2,9 (-1,9÷7,7)	12,5 (0,8÷25,5)	11,9 (-2,6÷26,3)	5,9 (-0,9÷13,3)	14,2 (0,3÷29,2)	29,7 (15,7÷42,7)