

REVIEW OF ASSESSMENT OF AGRICULTURAL METEOROLOGY IN VIET NAM CROPS 2020

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Abstract: Assessment of the agricultural meteorology has a critical role in agriculture production, especially in Viet Nam, where the agricultural products play a majority part in its economy. In addition to that, more frequent and intense changes in climate patterns as a result of the global warming have been recently increasing. This study therefore attempts to provide an assessment as an input for sustainable solutions to cultivation, improvement and protection of climate resources that facilitate the crop production.

The climatic impacts on each cropping pattern vary by the growth cycles of different crops. In this study, the authors generally review agricultural meteorology in Viet Nam by applying the comprehensive methodology of the seasonal characteristics of climate factors, based on the meteorological and statistical data of the General Department of Meteorology and Hydrology of Viet Nam (MONRE), in order to determine the changes and characteristics. The characteristics of climate factors according to each season throughout the territory of Viet Nam in 2020, are the basis for assessing the agro-climate for the next production crops.

Keywords: Agricultural meteorology, Viet Nam crops 2020, crops season, climate factors.

1. Introduction

Agriculture is an important sector of the Viet Nam economy [6, 10, 13]. The share of agriculture, forestry, and fishery sector in 2020 GDP preliminarily reached 14.85% [10]. Generally, in 2016 - 2020, the production of cereals reached 240.7 million tons. The gross output per hectare of arable land witnessed 102.8 million VND per hectare in 2020 [10]. Agriculture, forestry, and fishery production in 2020 faced many difficulties due to the impact of drought, saline intrusion, and floods; the complicated and unpredictable developments of the COVID-19 pandemic that caused effecting to the export, import actives of agricultural products [10]. Agricultural production depends greatly on climate conditions, so the direct and long-term challenge to agricultural production is the impact of climate change - Viet Nam is

considered as one of the countries most affected by climate change [3, 7]. Climate change has created challenges for the agricultural sector - and will continue to do so. Climate change-induced increases in temperatures, rainfall variation, and the frequency and intensity of extreme weather events are adding to pressures on global agricultural and food systems. Climate change is expected to negatively affect crop and livestock production systems in most regions, although some countries may benefit from the changing conditions. The changing climate is also adding to resource problems, such as water scarcity, pollution, and soil degradation [1, 5, 13]. Therefore, studying the characteristics of agro-climate is necessary to develop agriculture in harmony with the specific natural conditions of each region and adapt to abnormal changes due to the impact of climate change [1, 4, 5].

In 2020, The effects of climate change had appeared in most of Viet Nam, most often in the Central Coast zone with the weather and climate

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extremes events such as heavy rains, floods, flash floods, landslides and tornadoes, hail. The Northern in Viet Nam, was the record-breaking heat-wave in the past 27 years and rare hailstorms. According to Viet Nam Disaster Management Authority, Ministry of Agriculture and Rural Development in 2020 and General Statistics Office of Viet Nam, natural disasters consecutively and complicated occurred including 14 storms; 265 thunderstorms, whirlwinds, heavy rains; 120 floods, flash floods, landslides and droughts, saltwater intrusion caused 379 deaths and missing, 1,060 injuries; 4.3 thousand houses collapsed and swept away; 594.9 thousand houses were damaged; nearly 269 thousand hectares of rice and 134.9 thousand hectares of arable crop were damaged; 38.6 thousand cattle and 4.1 million poultry died. Total property loss was estimated at 39.1 trillion VND, of which damage caused by the storms and flood was 32.3 trillion VND (accounting for 82.8% of total loss) [8, 10]. In the socio-economic situation in the fourth quarter and the whole year 2020 by Viet Nam General Statistics Office[9], rice production was estimated at 42.69 million tons, down 806.6 thousand tons over the previous year. In comparison with the crop of 2019, the country's winter-spring paddy production reached 19.9 million tons, a drop of 593.5 thousand tons; the cultivated area this year was at 3,024.1 thousand hectares, a decrease of 100.3 thousand hectares; the summer-autumn paddy crop yield in 2020 reached higher results, but due to the effects of drought, salinity, and change of use purposes on rice land, the area of cultivation decreased, resulting in total output reduced. This year, the country cultivated 1,945.1 thousand hectares of summer-autumn paddy, a decrease of 64.5 thousand hectares compared to 2019; the yield reached 55.2 quintal/hectare, an increase of 0.7 quintal/hectare; the total production reached 10.74 million tons, a drop of 205.4 thousand tons. Of which, production of the Mekong River Delta reached 8.46 million tons, a fall of 219.1 thousand tons; The results of winter rice production in 2020 increased in yield, but due to the cultivated decreased, the

total output of whole crop declined. The whole country's winter rice cultivated area reached 1,584.6 thousand hectares, a fall of 27 thousand hectares compared to the crop in 2019; the yield reached 51 quintal/ha, increased by 0.7 quintal/ha; the production reached 8.08 million tons, down 20.7 thousand tons; Results of production of crops and some annual crops: maize output reached 4.59 million tons, a decrease of 140.3 thousand tons compared to 2019; sweet potato reached 1.37 million tons, down 57.5 thousand tons; sugarcane reached 11.88 million tons, down 3.44 million tons; cassava reached 10.49 million tons, an increase of 313 thousand tons; groundnut reached 425.5 thousand tons, down 17.1 thousand tons; soybean reached 65.7 thousand tons, down 11.6 thousand tons; the output of vegetables of all kinds reached 18.33 million tons, an increase of 339.1 thousand tons [9, 10].

The influence of weather and climate on the growth, development, and yield of crops is very obvious. According to the list of agro-climate and agro-ecological indicators developed by FAO for the tropical monsoon climate area of Southeast Asia, a specific example. Rice in the sprouting stage, with a suitable temperature from 22 - 18°C, a suitable temperature from 14 - 18°C, an unsuitable temperature below 7°C. For the growth stage, the most suitable temperature for rice to develop is 32 - 30°C; at the harvest stage, it is 33°C. Rainfall is suitable from 200 - 400 mm. The humidity in the germination stage is from 60 - 75°C, in the development stage from 37 - 65%. With the characteristics of climate factors outside this threshold, rice plants may be slow to grow, yield low, or die.

In general, agricultural production recommendations in Viet Nam are based on agro-climatic information on a large scale, such as regional or provincial levels [11, 12]. At this scale, the recommendations provide specific climatic factors both in time and space. In terms of time, advice on planting season is often based on multi-year average meteorological data. Therefore, recommendations are being built based on short-term (weather) and medium

-term (month, season, crop) forecast information. In terms of space, recommending agricultural production based on administrative boundaries is a method that is easily accessible to farmers because of the habits in receiving information in Viet Nam. In this article, the authors have synthesized, evaluated, and analyzed the agricultural climate conditions of Viet Nam in 2020 for crops. The data and methods of analysis are presented in section 2. The analysis by month and production season is presented in section 3 of this paper.

2. Data and Methods

2.1. Data

To assess meteorological conditions, monthly and yearly meteorological data at Viet Nam's meteorological stations were collected from 1961 to 2020, including mean temperature (Tmean), maximum temperature (Tmax), minimum temperature (Tmin), average air humidity (Umean), number of hours of sunshine (SH), precipitation (P). Data was provided by the Ministry of Natural Resources and Environment by 150 measuring stations [2] (Figure 1).

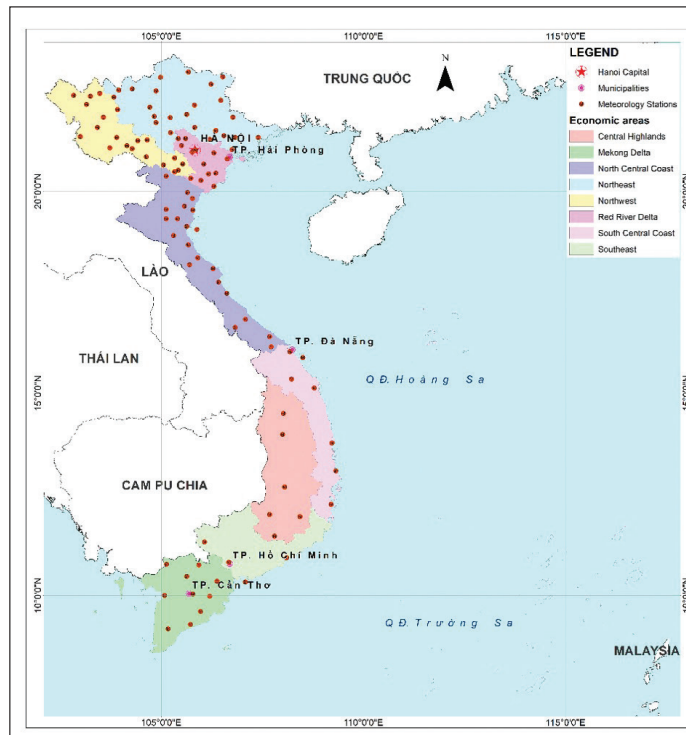


Figure 1. Meteorological Stations in Viet Nam

2.2. Method for assessment

The authors use basic formulas used in hydrometeorology to assess climate conditions, including:

- The average value for many years:

$$\bar{x} = a_1 = \frac{1}{n} \sum_{t=1}^n x_t \quad (1)$$

- The differences in meteorological characteristics (temperature, precipitation,...) compared to the average of many years:

$$v_a = \frac{1}{n} \sum_{t=1}^n |x_t - \bar{x}| \quad (2)$$

- Maximum value (Max):

$$Maxx_t = Max (x_1, x_2, \dots, x_n) \quad (3)$$

- Minimum value (Min):

$$Minx_t = Min (x_1, x_2, \dots, x_n) \quad (4)$$

In which:

x_t is the the time series value (actual data) at period t .

t is time series ($t= 1, 2, \dots, n-1, n$);

- The linear regression method is used to determine the trend and degree of variation of climate extremes:

$$X = a_0 + a_1 t \quad (5)$$

In which:

x is the the time series value (actual data) at period t .

t is time ($t= 1, 2, \dots, n-1, n$);

The slope of the line is a_1 , and a_0 is the intercept. If $a_1 > 0$ then the series tends to increase, if $a_1 < 0$ then the series tends to decrease.

To assess climate conditions base on 7 different regions, namely the Northwest (B1), Northeast (B2), North Delta (B3), North Central (B4), South Central (N1), Central Highlands (N2), and the South and Mekong Delta (N3) (Figure 1) and divided by 2 seasons of crops are the winter-spring cropping season and Main season (summer-autumn cropping season) in 2020.

3. Results and Discussions

In response to Viet Nam's tropical climate zone characteristics, the crops are produced

in two main seasons called winter-spring and main cropping (summer-autumn season). Rice is the major crop grown in both Red River (RRD) and Mekong Deltas (MKD) of Viet Nam, which occupies two-thirds of the total field area and presents up to 70 percent of the rice production nationwide.

3.1. Assessment of agrometeorological conditions in winter-spring 2020

3.1.1. Detailed evolution of meteorological conditions

The winter-spring season is the most important cropping among others around the year (starting from November to April of the following year), responsible for more than 40% of the whole year's growing area, giving the highest yield in all cropping seasons and presenting roughly 45% - 47% of the total yearly production output [10]. For the above reasons, it is critical to assess the detailed evolution of meteorological conditions in the winter-spring crop and provide practical information for proper production management and implementation of the annual agricultural produce in general and rice yield in particular.

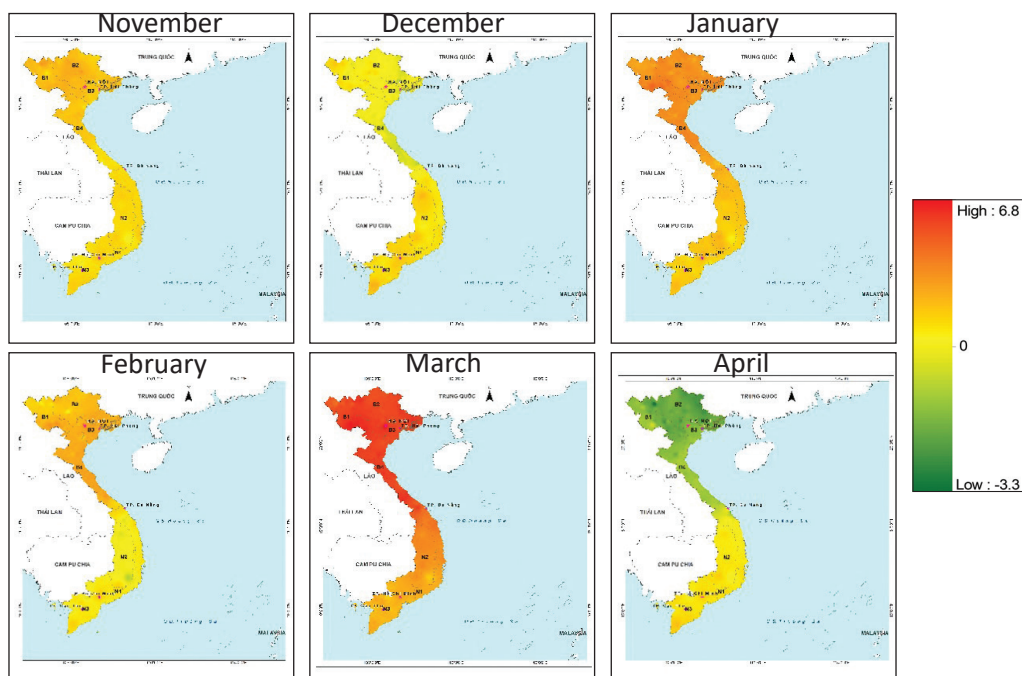


Figure 2. Temperature mapping relative to the average temperatures over many years in the winter-spring season 2020

Figure 2 shows the Temperature difference in the winter-spring season months in 2020 with an average of many years. The average temperature observed during the first month of the crop (from December 2019 to January 2020) was always (approximately between 0.2°C and 4.8°C) higher than the average temperatures recorded over recent years. Starting February 2020, the overall surface temperature across the country continued fluctuating around the average temperatures recorded over many recent years between -0.9°C and 3.3°C. In the middle and late periods of the crop, the temperature continued to increase and is higher than the average temperatures recorded over many recent years

(from 0.2°C to 5.7°C).

Figure 3 illustrates the difference in precipitation in winter-spring season months in 2020 with an average of many years. In some mountainous regions and Northern midlands, the high daily rainfall often varies between 3 mm and 25 mm; the highest of 39 mm occurs on February 3 in Bac Can. The number of rainy days of one month is commonly from 3 to 21 days. The number of consecutive rainy days happens from 1 to 14 days. The number of consecutive days without rain is common from 3 to 18 days. In some Southern regions, monthly rainfall ranges from 6 mm to roughly 51 mm, while there is no rain in some provinces such as Phan Thiet and Phan Rang.

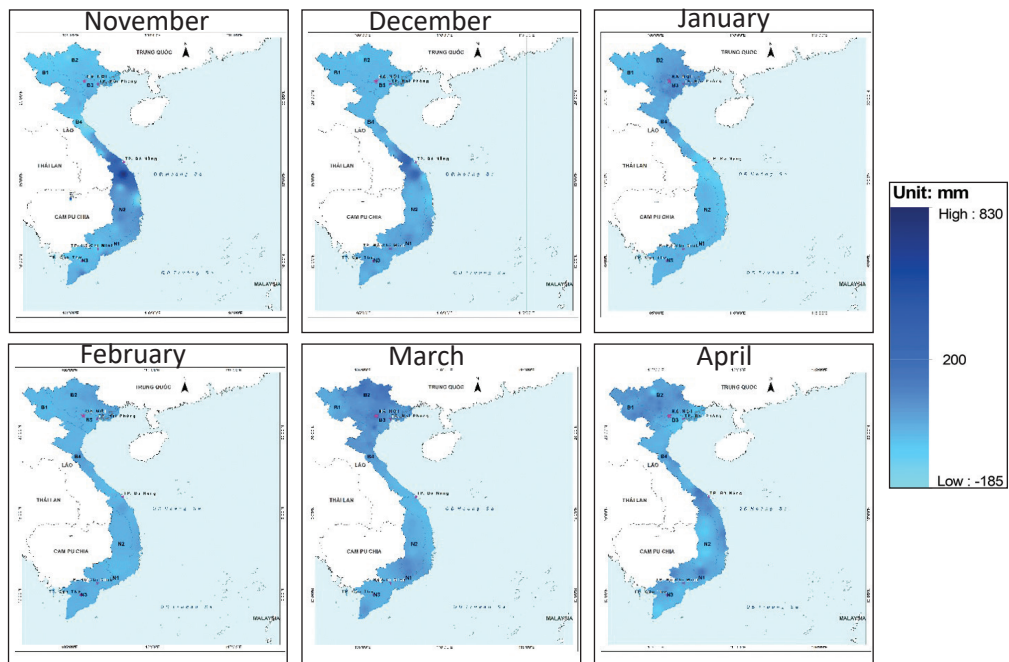


Figure 3. The difference of precipitation in winter-spring season months in 2020 with the average of many years

Most of the regions in Viet Nam normally get the total number of sunshine hours in the early months of the cropping season relative to the sunshine duration averages recorded over many recent years (from -77.9 hours to 77.3 hours) (in figure 4). The average monthly air humidity in most localities in the country has a common value that is approximately or fluctuates around

the average value (from -16% to 9%). In the mid-crop period and at the end of the season, the total monthly sunshine hours fluctuated around the average value (from -55.2 hours to 110.5 hours). The average monthly atmospheric humidity in most of the regions around the annual averages recorded over recent years (ranging from -15% to 10%).

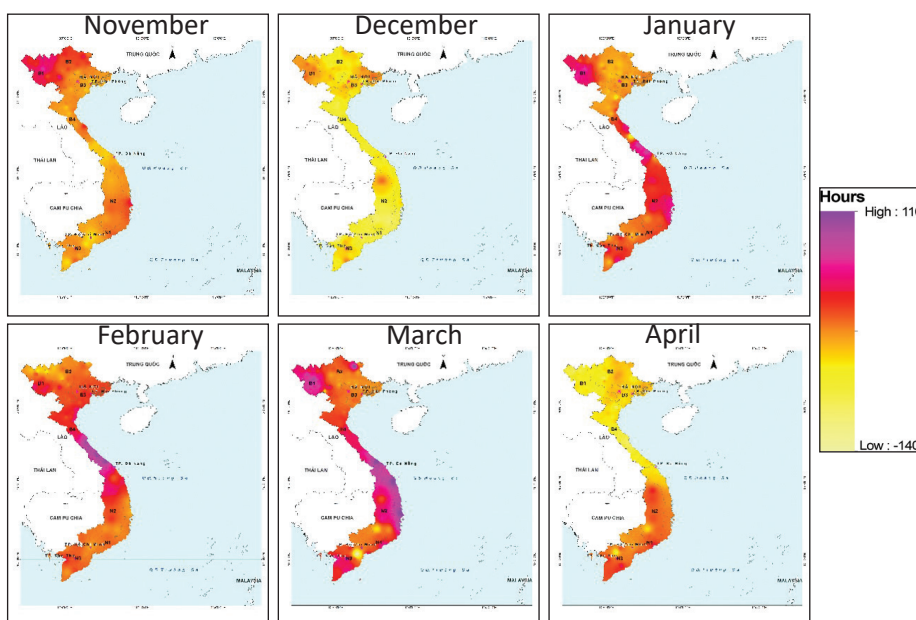


Figure 4. The difference of sunshine of the winter-spring crop season 2020 with the the average of many years

Extreme weather events [8, 10]:

During the early months of the season, the Northern midlands and mountains often experience thunderstorms for 1 to 3 days. In the central and Southern regions, thunderstorms usually last longer, from 1 to 10 days. Drizzle also occurs earlier than usual in the Central region, and later also in February in the Northern midlands and mountains.

In the mid-crop months, hot and dry westerly winds from Laos are becoming more common, especially more extreme in the southern region. This kind of wind occurs from 3 to 27 days, of which six days, typically intense in Dong Phu, other places also Ayunpa and Kon Tum. Thunderstorms also appear more than they used to during this period, primarily in the Central Highlands for a duration of 1 - 12 days.

At the end of the season, thunderstorms appear in most areas from 4 to 16 days in the South. Hot and dry weather occurs in the Southeast region (Bien Hoa, Xuan Loc, Tan Son Nhat, Dong Phu, and Phuoc Long), lasting from 9 to 27 days where it intensifies for 3 - 11 days. This weather pattern is also seen in the Southwest region including Soc Trang, Can Tho, and Cang Long lasting for 16 - 21 days while other regions experience a shorter occurrence between 2 - 7

days at a mild intensity.

3.1.2. Observed meteorological conditions influencing agricultural productivity in the winter-spring season

At the beginning months of crop growth period (December 2019 to January 2020), agricultural, forestry and fishery production activities at the end of 2019 face multiple stresses, in particular prolonged droughts and severe heat affect crop yields and productivities. Besides, African swine fever spreads across the country causing serious losses to the livestock industry and also consumers. In January 2020 the unfavourable weather conditions interrupted agricultural production in most provinces. The surface monthly average temperature of these regions was primarily higher than the annual averages recorded over many recent years, but cold air waves in the beginning and middle of the month and the number of hours of sunshine decreases much lower than the the annual averages recorded over many recent years, which affected the harvest activities of winter crops and preparing land field for next winter-spring rice production.

Mid-season period:

Natural disasters happened in February,

mainly hail, heavy rain, landslides and salinity intrusion in some areas, damaging an extensive amount of roughly 15,000 hectares of rice and 878 hectares of crops. Some provinces suffered significant losses, for instance the hail and thunderstorms in Lao Cai affect 17.1 hectares of agricultural production area, and more than 1,000 poultries. In Yen Bai, there were more than 5 hectares of crops, ruining forestry trees and harm to 58 fish cages in Yen Binh district.

In March 2020, the main natural disasters such as hail, heavy rain, thunderstorms, salinity intrusion and land subsidence ruined nearly 24.3 thousand hectares of rice paddies and more than 6 thousand hectares of vegetable crops. In the South Central region and the Highlands, the prolonged drought also greatly affected agricultural production. Rainfall in the South Central provinces and the Highlands has decreased significantly due to the lower rainfall than the average recorded over many years. Therefore, water reserves in irrigation reservoirs are currently very low. At the end of February 2020, the amount of water in reservoirs in the South Central region only reached around 31 - 87% of the design capacity, 22% lower than the same period in 2019; in the Highlands, only reached 59 - 73%, it means 6% lower than the same period in 2019. In the South Central Coast and Highlands a total of approximately 1,392 hectares of agricultural production (1,157 hectares of rice paddies and 235 hectares of coffee) are suffering from water shortages.

End-season period:

During this time, the most common natural disasters were hail, heavy rain, landslides and salinity intrusion in some areas causing a failure of 29.4 thousand hectares of rice paddies and 9.2 thousand hectares of crops. Total economic loss caused by such natural disasters is VND 1,577.4 billion. Currently, the drought event still intensifies in the Central and Highland provinces.

Agro-meteorological conditions in May 2020 in most Northern regions are relatively favorable for crop planting and growth. During this time there was an increase in the number of days with thunderstorms and heavy thunderstorms in some areas. In particular, hot and dry westerly winds appeared in places while hot

and dry weather waves with strong intensity occurred in Northwest, North Central, South Central, Highlands, and the South, which had strong impacts on agricultural production. Natural disasters in May were mainly hail, heavy rain, landslides and salinity intrusion in some areas, damaging 32.2 thousand hectares of rice paddies and 10.3 thousand hectares of vegetable crops. Particularly, drought and salinity intrusion occurred in 6 provinces: Kon Tum, Gia Lai, Tien Giang, Ben Tre, Tra Vinh, Soc Trang, which caused damage to more than 8.7 thousand hectares of rice paddies and 917 hectares of vegetable crops.

3.2. Assessment of agrometeorological conditions in main season in 2020

3.2.1. Detailed changes of meteorological conditions

The 2020 crop started from May to November. The average atmospheric temperature in the early months of the season in 2020 across all parts of the country was generally higher than the annual averages recorded over many recent years (between 0.1°C and 3.2°C higher) (Figure 5).

Other areas, including Son La, Hoa Binh, Phu Tho, Lang Son, North and Central North regions, Northwest part of the Mekong Delta, experienced the lower temperature than the annual averages recorded over many recent years (0°C - 2.6°C). The absolute highest temperature of 35.3°C occurred on October 1, 2020 in Song Ma and the absolute lowest temperature of 7°C occurred on October 11, 2020 in SaPa. During the last months of the season, the monthly atmospheric temperature was commonly (0.1°C to 3.2°C) higher than the averages recorded over recent years. The absolute highest temperature of 35.3°C occurred on November 17, 2020 in Bien Hoa, and the absolute lowest temperature of 7.3°C occurred on November 11, 2020 in Sin Ho.

The monthly rainfall in most of the areas was higher than the annual averages recorded over many recent years (from 0 to 2450 mm). The exception occurred in some areas of the Northwest and Northeast, Tay Ninh, where the rainfall was 0mm -167 mm lower than the averages recorded over many recent years. The

highest total rainfall per month was 3449 mm in A Luoi, and the lowest is 21 mm in Tuan Giao.

The highest rainfall per day of 756 mm occurred on October 19, 2020 in Ba Don (Figure 6).

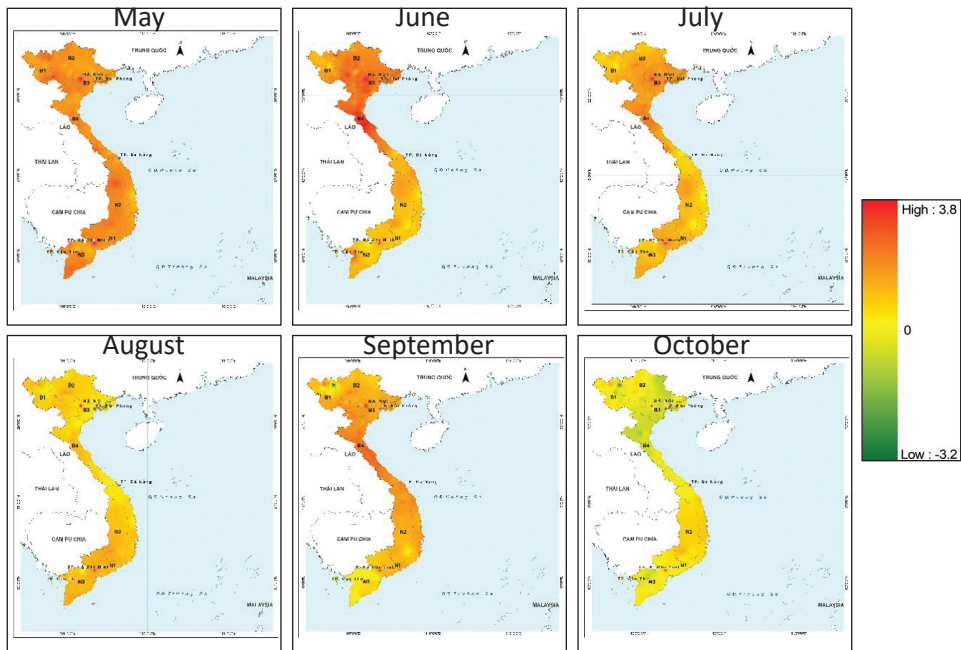


Figure 5. Temperature mapping relative to the average temperatures over many years in the main season 2020

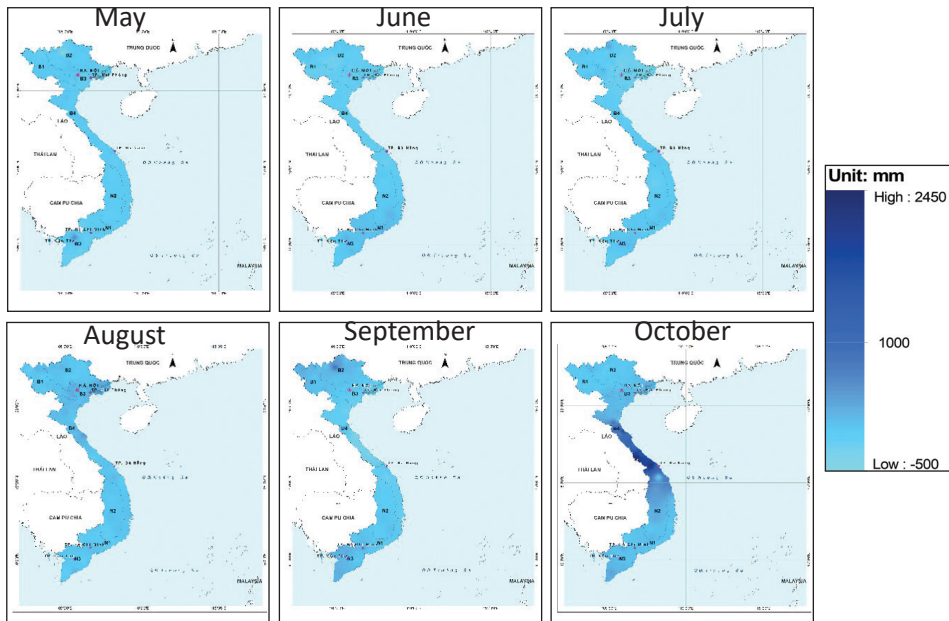


Figure 6. The difference of precipitation in main season months in 2020 with the average of many years

The monthly rainfall in most region was lower than the annual averages recorded over many recent years (from 0 to 181.7 mm), except for some areas of Quang Binh and Quang Ngai, the Central Highlands it was recorded higher than

the averages recorded over many recent years from 0mm to 830.5 mm. The highest total rainfall per month was 1746 mm in Tra My, the lowest was 1 mm in That Khe. The highest daily rainfall of 463 mm occurred on 11/11/2020 in A Luoi.

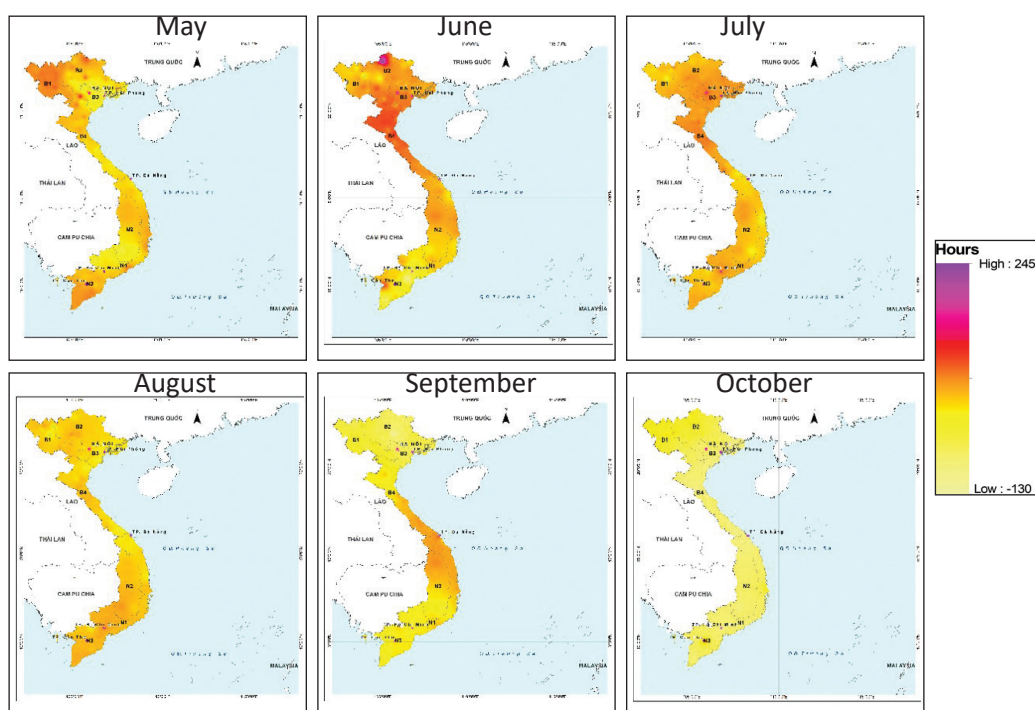


Figure 7. The difference of sunshine of the main crop season 2020 with the the average of many years

The total number of monthly sunshine hours in most of regions was (from 0 to 111 hours) lower than the averages recorded over many recent years, other areas such as Lai Chau, Quynh Nhai and Ha Giang experienced from 0 to 54 hours higher than the averages recorded over many recent years. The average atmospheric humidity per month in most parts of the country was 0 - 7% higher than the averages recorded over many recent years, except for the Northern Midlands and Mountains, the Northern Delta, and the Northern Midlands. Thanh Hoa and Nghe An which experienced 0% to 12% lower than the averages recorded over many recent years.

Extreme weather events:

The situation was recorded relatively similar to those of the winter-spring season, during the early months there were often thunderstorms, dry and hot weather events in the Northern mountain and midland areas. In the Northern and Northern-central and southern regions, the hot and dry phenomenon happened with stronger intensity for 18 days. During the middle and late months, there was mild drought in the Northern mountainous and midland areas. No extreme

weather event occurred in the Central and Southern regions.

3.2.2. Observed meteorological conditions influencing agricultural productivity in the main crop season 2020

Early season period

Agro-meteorological conditions observed in July 2020 in most parts of the North were relatively favorable for crop planting and growth. However, there was hot dry westerly wind in the Central region resulting in hot, more evaporation than rainfall, leading to a shortage of water for agricultural production. Natural disasters in July were mainly hail, heavy rain, landslides and salinity intrusion in some areas, causing damage of 11.9 thousand hectares of rice paddies and 24.7 thousand hectares of vegetable crops. In July, agricultural production activities primarily included starting new rice paddies, cultivating summer-autumn cropping and harvesting summer-autumn rice early, ensuring planting and harvesting in the best practices. However, the prolonged heat caused drought in some areas, and affected the progress of rice cultivation.

As effects of the tropical storm No. 2, excessive rainfall was generated in the provinces

of the Northern Delta, the North Central Coast, and some other places of the Northern Midlands and Mountains, causing significant loss in people and economy. Further than that, the hot and dry westerly wind remained strongly active in the Central region, resulting in low local water shortage for agricultural production. In the Mekong Delta, floods and high tides also affected agricultural production. Natural disasters mostly storms, heavy rains, landslides, tornadoes occurred in July 2020, that ruined 7 thousand hectares of rice paddies and 2.9 thousand hectares of vegetable crops.

Mid season period

In August 2020, such weather events as significant rainfall, several rainy days occurring in different times of a month, and good temperature and sunshine hours, sharply decrease in extreme hot and dry winds days compared to previous months supported crop growth and development.

Similar weather conditions remained till September with significant rainfall, more frequent rainy days together with good sunshine hours, less hot dry westerly wind compared to the previous months. These contributed to the proper growth and development of crops. However, there was a storm No. 5 at the beginning of the month and heavy rain in the central provinces, causing loss in human and economy. In addition, the hot dry westerly wind remained strongly active in the Central region, it resulted in shortage of water for agricultural production in some locations. In the Mekong Delta, floods and high tides also affected cropping activities. Some natural disasters in September including mainly storms, floods, heavy rains, cyclones and landslides ruined 4.4 thousand hectares of rice paddies and 3.7 thousand hectares of crops.

End-season period

Natural disasters occurring in October were mainly storms, heavy rains, landslides, tornadoes, particularly consecutive storms No. 6 (Oct 12), No. 7 (Oct 14), No. 8 (Oct 25), No. 9 (Oct 29) hit in the Central region, causing heavy rain, significant losses to agricultural production in some provinces of Northern Midlands and Highlands, where thousand cattles and 600.5

thousand poultrys died; 45 thousand hectares of rice and 22.3 thousand hectares of crops were ruined.

In November 2020, natural disasters primarily included storms, floods and landslides, causing excessive losses of 5.6 thousand cattles and 1.5 million poultrys; 66.7 thousand hectares of rice and 35.4 thousand hectares of crops. In particular, the damage caused by storm No. 11 in Nghe An, as a result of heavy rain and flood after the storm, the water level in the fields of some deltas increased, thus 100% of the remaining rice area and all winter crops were completely damaged.

4. Conclusion

This study aims to review agro-meteorological conditions in Viet Nam 2020. Based on such information, they can make better decisions on agricultural production activities which help improve yield and productivity in following years, and adapt to expected adverse weather events. The initial assessment shows that in 2020, natural disasters occurred continuously and had complicated developments. It greatly affects agricultural production activities in Viet Nam, especially rice and crop production.

The assessment of agro-meteorological conditions in the winter-spring crop of 2020 shows that the temperature in the first and last months of the crop is higher than the average value of many years from 0.2 to 5.7°C. The change in rainfall tends to increase more in the central region in the starting months of the crop. In the last months of the crop, rainfall changes tend to be more in the North and North Central. As for the change of sunshine hours, there is a strong change and an increasing trend in the mid-crop months (January, February and March). Extremely weather such as heavy rain, hail; drought and hot weather have greatly affected rice and crop production; Thunderstorms are quite frequent in the winter-spring crop, however, reports indicate no damage to crops;

The assessment of agro-meteorological conditions in the main crop of 2020 shows that the temperature in 2020 will be 0.1 - 3.6°C higher than the average value of many years. Monthly rainfall in most areas is lower than the average

value of many years (from 0 to 181.7 mm), except for some areas from Quang Binh to Quang Ngai, the Central Highlands is higher than the average for many years from 0mm to 830.5 mm. The total number of monthly sunshine hours in most areas is lower than the average number of years from 0 to 111

hours; Lai Chau, Quynh Nhai and Ha Giang areas are higher than the average for many years from 0 to 54 hours. The crop of 2020 agricultural production is strongly affected by storms, heavy rains, landslides, floods, landslides and cyclones, especially in the central coastal provinces.

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