ASSESSING THE IMPACT OF DROUGHT ON AGRICULTURAL LAND USE BY INTEGRATING REMOTE SENSING TECHNOLOGY AND METEOROLOGICAL DATA: A CASE STUDY IN QUANG DIEN DISTRICT, THUA THIEN HUE PROVINCE, VIETNAM

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ABSTRACT

Nowadays there are many studies on drought with different methods, which have their own advantages and disadvantages. Specifically, the drought indexes calculated from meteorological data indicated detailed information on the level of drought in a particular location where the meteorological station are. Nevertheless, the drawback of this method is that it does not provide the information on the spatial distribution of drought. Consequently, using remote sensing technology for mapping drought will specify the parameters related to the drought in remote areas where there exist no meteorological station, moreover it also shows a holistic view of the spatial distribution of droughts risk through maps. The research result has built a partition map drought affecting agricultural land use in Quang Dien district, Thua Thien Hue province by integrating remote sensing technology and meteorological data. The results revealed that 74.65 percent are under moderate drought and 23.35 percent is the area under severe drought. In which, Quang Loi and Quang Thai commune have the largest drought areas with 33.55 percent and 34.30 percent respectively under drought. The other communes have drought areas of around 14 percent of the total area under severe drought in entire district.

Keywords: *drought, meteorology, agriculture, remote sensing*

1. INTRODUCTION

Drought is considered a disaster for agricultural production, which seriously affected the growth and development of plants. Vietnam is an economy based primarily on agriculture. Rural proportion took more than 80%. One of the characteristics of the agricultural production in Vietnam is mostly depended on natural rain water, but precipitation is distributed unevenly, regular climate variability. Meanwhile the drought situation in recent years increasingly unpredictable and hard to overcome with more and more frequency especially in Tay Nguyen region, North Central region, South Central region. Drought in between 1997 and 1998 caused 3.1 million people lack of clean water, 236.000 ha fruit crops wilted, caused total damage to 5.000 billion VND. In 2014 - 2015, meteorological experts said, in North region, winter-spring crop, water sources of the Hong River's upstream system likely to be less than the average from 10 to 55%, the deficient time from 11/2014 - 2/2015. For coastal Central, in the dry season 2014 - 2015, water in the river system is also likely to be deficient than the average of the same period (Forecast Center for Hydrometeorology TW, 2014). In fact, many studies have different evaluation of drought index, however each index has its own advantages and disadvantages. Specifically, the drought index that is calculated from meteorological data have disadvantages: measuring stations around the local area, the density of observation with sparse density, non-continuous time. Therefore, the use of remote sensing images, combination of meteorological data to build a map of drought makes it easy to manage and assess the impact of the drought to agricultural land use of research is urgently required. This research was conducted to assess the limit, determine the agricultural areas that affected by drought. At the same time propose solutions in order to adapt the drought in agricultural production in Quang Dien district.

2. MATERIAL AND METHODOLOGY

2.1 Research site

Quang Dien, a lowland valley, granary of Thua Thien Hue province, with many advantages for the development of agricultural production and fishery, facilitate exchanges and trade with the surrounding areas but It is simultaneously affected by climate change, changing the structure of agricultural land use. Quang Dien district has two distinct seasons. Especially, in dry season combined with western wind through rising temperatures make drought which led to occur in many places in the locality. Heat occurs from March to August, the relative humidity in range of 40 - 470C. The rainfall in Fall - Winter increases dry situatuon in Summer - Fall crop. Therefore, prolonged drought conditions combined with high tides have reduced the acreage of arable land particularly for coastal communities, lagoons, causing losses for the agricultural production of the farmers.

2.2 Methodology

Data collection methods

Collecting data, documents on the natural conditions, the economic and social situation of agricultural land management, collecting measurement data, the information, the reports related to the use of agricultural land, the boundaries of the communes in the district and the documents related to the drought to serve the research process

Collect precipitation, temperature data from 1987 to the year 2017 at meteorological stations data in Hue to contrast with results interpretation from remote sensing images.

Collecting: Sentinel Image – 2A - 2017 with a resolution of 10 x 20 x 60m, field observations 290km. Photo is free download from websites: https://scihub.copernicus.eu/dhus. Landsat satellite image in research area in 2007, 2014. The image resolution of the average space (30 m x 30 m) are processed and increase the resolution to get along with the Sentinel-2A, the picture is free download from websites: https://earthexplorer.usgs.gov.

Precipitation data is collected from the rain sensing image TRMM: to increase precipitation stations points for interpolating the distribution of drought in geographical research. Precipitation data from remote sensing images TRMM in this research is free download from websites: http://waterdata.dhigroup.com.

Construction method of agricultural land status maps from remote sensing images

Agricultural soils from 2005 to 2017 are classified by the time series data of NDVI with resolutions of images collected by type.

Geographic information system method GIS

This research has used the spatial analysis tool on the ArcGIS software to build a map of agricultural land, calculate agricultural land area for each commune of Quang Dien district.

This method use SPI_SL_6 software to calculate SPI index for Spring-Summer and Autumn-Winter crop from 1997 to 2017 in Quang Dien district. Afterward, finding out the risk of drought through SPI index. SPI is negative which indicating the drought and on the contrary it point out excess moisture.

Construction method of drought maps from interpolation (Inverse Distance Weighted)

IDW method determine interpolation value by calculating the average value of sample points in the vicinity. Points as near as center point has more influence.

3. RESULT AND DISCUSSION

3.1 Changing trends of precipitation in the period 1987-2017 in the research area

According to statistics from the hydro-meteorologicxal center of Thua Thien Hue province rainfall through the year has a markedly change. The rainfall varies depending on many different factors include the dependent on temperature. The temperature change is also one of the reason that causes the precipitation change. The rainfall of the month is also increasingly have large disparities between the highest months (September-November) and lowest (December-August). It expressed clearer than in recent years from 2012-2017, the annual average rainfall tends to decrease, the total average rainfall of year 2012 (2369, 4 mm), 2013 (2732mm), 2014 (2368, 5 mm), 2015 (2793mm), whereas the previous year 2011 rainfall was 4480.8 mm. The complex distribution over time had caused the phenomenon of excess water in the rainy season and lack of water in the dry season caused the disadvantage for production and living of the inhabitant. The average rainfall in the Quang Dien was expressed in Figure 1.

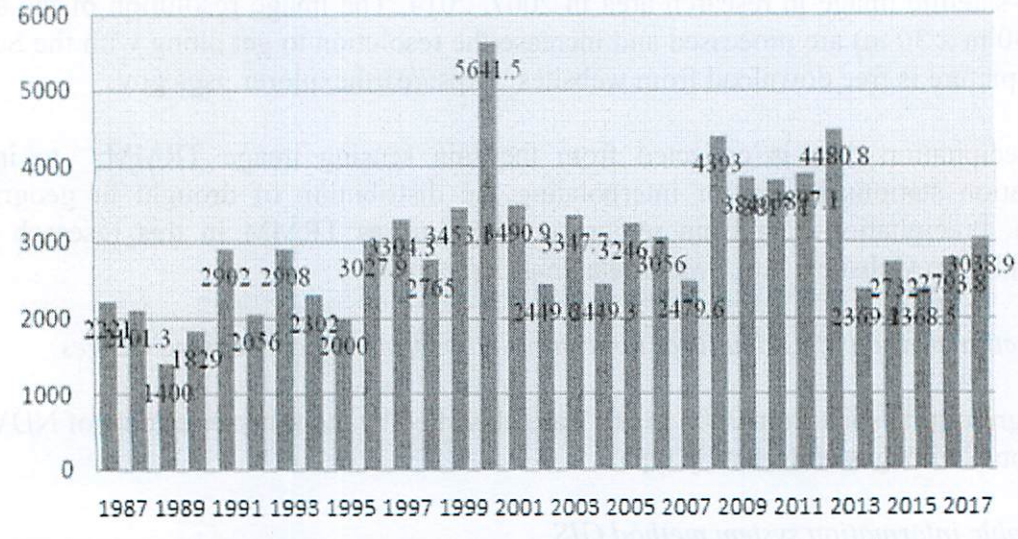

Figure 1. The chart demonstrates the total rainfall in the period 1987-2017

In the period of 1987-2017, There were some huge rainfall years such as in 1999 was *5641*, 5 mm, 2007 (4393mm), 2011 was 4480.8 mm, there are years of the flood that water level rose higher than the other years and especially the largest floods occurred in 1999 caused a lot of damage to people. However, in 2014 had relatively low rainfall, the highest month only reached 526.6 mm (November). March is usually very low rainfall, average *40, 3*

mm, but the year 2001 had up to 200.6 mm. So, we can clearly see on the characteristics of *rainfall in Quang Dien* which is through the period of time 2-3 years of floods (rainfall), there are 2-3 years prolonged drought (low rainfall). Years in which was drought was the year of El Nino phenomenon.

3.2 Drought situation in winter-spring crop and summer-autumn crop according to SPI index

In General, SPI index of the stations in winter-spring crop are the same (Figure 2). The period of 1999-2000, SPI index were very high corresponds to very moist. However, during the period of 2001-2005, SPI index falling down express relatively dry to severely dry. SPI index increased steadily from 2006-2009. The period of 2010-2014, SPI index declined particularly in 2014, rainfall reduced sharply which reached to severe drought. And increase again throught the following years until the present.

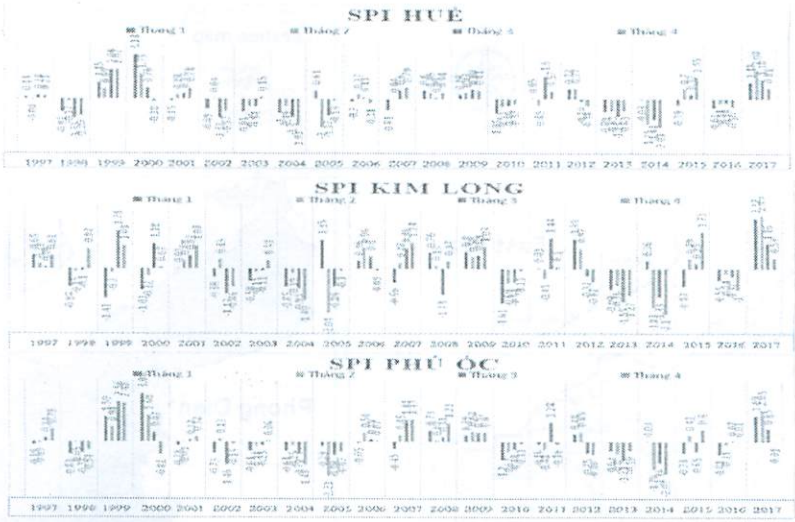

Figure 2. Performance index SPI in winter-spring crop 1997-2017

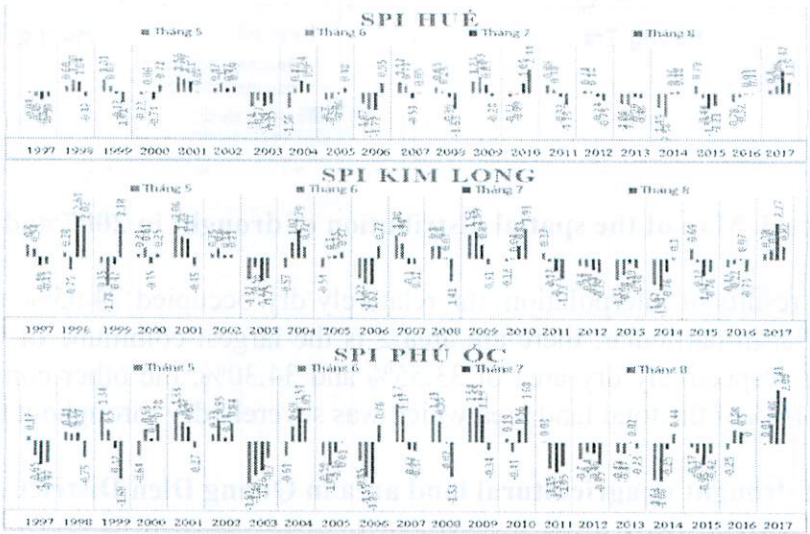

Figure 3. Performance index SPI in summer-fall crop 1997-2017

As can be seen from Figure 3, it showed the SPI index was very low in summer-fall crop. In 2003 and 2006, SPI index reached relatively dry to severely dry. The period of 2011-2015 SPI index reached relatively dry to severely dry, the lowest was in 2014 which mainly

occured in May and June in this period. By the year 2016, the index increase gradually and the highest in the year 2017 reached very moist. It can be judged from the winter-spring crop SPI index was relatively dry, so the summer-autumn crop-term have ability to occur drought on agricultural land.

3.3 Interpolation results of the spatial distribution of drought in Quang Dien

The research results have interpolation in two years 2007 and 2014 because this is the stage that have the shift when the land protection forests switch to land of production forests in Quang Cong, Quang Loi, Quang Thai, Quang Vinh, Quang Ngan commune and the shift when land of rice to land of annual plants. In addition to the year of 2014, agricultural landwas severely affected by drought. Therefore, authors focus only on assessing the impact of the drought to agricultural land use in 2007 and 2014, interpolation results of spatial analyze shown in Figure 4.

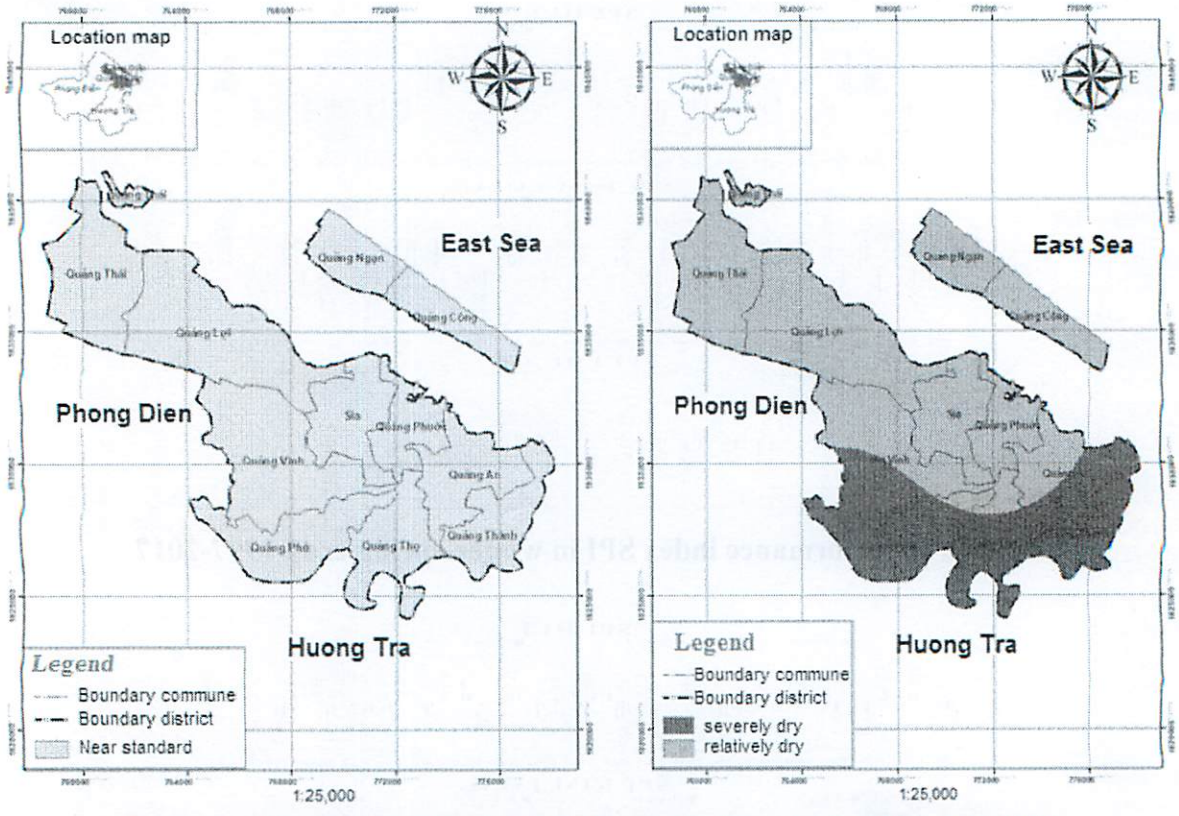

Figure 4. Map of the spatial distribution of drought in 2007 and 2014

Based on results of interpolation, the relatively dry occupied 74.65% and severely dry occupied 23.35%. In particular, there are area 2 is the largest commune of Quang Loi and Quang Thai has respectively dry area of 33.55% and 34.30%; the other commune occupied dry area about 14% of the total land area which was severely dry throughout the district.

3.4 Effects of drought to agricultural land area in Quang Dien District

Based on the established map, area of agricultural land in Quang Dien district, Thua Thien Hue province were calculated and presented in Table 1.

Table 1. Area of agricultural land were influenced by drought

Month: May				
Land use type	severely dry	relatively dry	near standard	relatively moist
Rice	318,39	4.078,41	0	0
Production forests	0	0	0	1.080,31
Protection forests	0	0	0	198,52
Annual plant land	199,97	933,97	0	0
Month: June	severely dry	relatively dry	near standard	relatively moist
Land use type				
Rice	670,01	3.726,79	0	0
Production forests	0	0	0	1.080,31
Protection forests	0	0	0	198,52
Annual plant land	330,47	803,47	0	0
Month: July	severely dry	relatively dry	near standard	relatively moist
Land use type				
Rice	0	0	4.396,80	0
Production forests	0	0	1.080,31	0
Protection forests	0	0	198,52	0
Annual plant land	0	0	1.133,94	0
Month: August	severely dry	relatively dry	near standard	relatively moist
Land use type				
Rice	0	0	4.396,80	0
Production forests	0	0	1.080,31	0
Protection forests	0	0	198,52	0
Annual plant land	0	0	1.133,94	0

It is shown that in term of May it begin to appear severely dry and relatively dry. Especially rice land and other annual plant land were of 4,078.41 ha and 933.97 ha. The reason are high temperature, high heat, extremely low rainfall in this term. Besides, the water are not saved enough for summer-fall crop. Results shown dry area in June is similar to May, in which the area of relatively dry land which mainly rice land occupied 3726.79 hectares and land other annual occupied 803.47 hectares, this month also appeared severely dry with the area were higher than the same period. For the protection forests and the production forests, it were in relatively moist. The reason is due to the rice land and annual land which mainly need a lot of water and low tolerance of dry so the relatively dry are mainly concentrated in this two kind of soils. In addition, because local is not active in irrigation (due to lack of water reservoirs), mainly dependent on rain. However, from July and August whole area of agricultural land are near standard, the reason cause this time in July and August, heat has dropped and become more comfortable than May and June.

4. CONCLUSION

Through researchs on climate change in period of 1987 - 2017 showed that the rainfall tends to decreases and appear later, however in recent years the total rainfall tends to increase, because of this change in rainfall it lead to disturb the cultivation and water storage resources in locality. Although rainfall has increased, temperature rises then water strongly

evaporates which is also one of the issues leading to drought. Through rainfall investigation at the monitoring stations and simulation stations, SPI index were calculated in period of 1997 - 2017 the results showed that severely drought occurred in 2014 however the following years to present SPI index increased which reached relatively moist and very moist. Besides, It can be seen that during period of 2007 - 2014, precipitation decreasing and temperatures increasing make difficulties for water shortage in irrigation and drought condition will be worse in May and June in the summer-fall crop. Therefore reserving water in the winter-spring crop and the construction of canals, pumping stations are necessary to ensure sufficient water in summer-fall crop.

5. REFERENCES

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