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Application of remote sensing to assess the risk of drought in the Buon Ma Thuot city

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Abstract

Frequent drought led to water shortages in large areas, has caused disruption to agricultural production as well as affected the economy and society. Especially in the situation of current climate change, the drought is increasingly difficult to control. In recent years, droughts in our country is becoming more extreme due to global warming, combined with the El Nino phenomenon occurred more often have reduced rainfall. Besides, the impact of deforestation and the burning of forests for cultivation by humans has led to forest land become barren, affecting the lives of people. This study presents the current status of the drought has been going on in the Dak Lak province, where suffered the consequences of the drought from rampant deforestation. At the same time the paper also examined the risk of drought for Buon Ma Thuot city by remote sensing methods. The material used is a Landsat 8 image, based on the spectral characteristics of the reflectance bands to calculate the temperature vegetation dryness index (TVDI). Results showed that drought is a matter to be considered for Buon Ma Thuot city now, as they will impact on the risk of water shortage in the city in the future.

Keywords: climate change, deforestation, drought, LST, TVDI

1. Introduction

Drought is a phenomenon often appearing and occurring in most different areas of the world. However, the situation of the current climate change, with a trend of increasingly warm, has no less impact to the risk of drought. Drought causes enormous damage to people, property, economic and social, and environment. Drought is a natural disaster types characterized by its effects often accumulated a fairly sluggish for a long time and can last for years, so the timing of beginning and ending of the drought is difficult. There is no way to prevent this disaster. People only can avoid and minimize damage caused by its. With the progression of slow accumulation type, the impact of drought is often harder to recognize, and being aware, then the damage was considerable. Besides, with increasingly severe levels under the vagaries of the global climate and space range expanding even more, so the drought has caused many difficulties for the people, the most serious that is the power shortage, water shortage across the board, and causing poverty in many countries.

In recent years, droughts in our country is becoming increasingly tougher, due to the El Niño phenomenon occurs more frequently and reduces rainfall, along with the impact of illegal logging, slash to cultivation by humans, leading to thousands of hectares of crops were lost, causing many people living in poverty. On the world, the problem of drought has been going on very serious, increasing temperatures, less rainfall leading to

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desertification. Desertification threatens the habitat of humans and in coming years the situation will continue to increase disease, poverty and leads to reduced food production. Statistics at home and abroad shows that the damage caused by drought often ranks first or second among the common types of natural disasters.

Currently, the research on the phenomenon of drought, one of the big problems, has been attracting the attention of scientists around the world and in our country. But in the global warming trend, the transformation of drought also very complex and there will be a lot harder for the prevention and remediation of damage that it caused. Therefore, the study of drought in the context of climate change is a scientific problem and large practices.

2. Drought Situation in Dak Lak Province

Dak Lak Province is located in the central highlands, with a boundary on the west part adjoining Cambodia. It is mostly forest, evenly distributed throughout the districts in the province, especially in the border corridor of Dak Lak province bordering Cambodia.

In 2015 rainy season, rainfall was recorded in Dak Lak fewer than in previous years, only 60-80% of the rainfall and uneven distribution, where just over 40% compared to the same period last year. Dak Lak has announced disaster due to drought at the first level to seven districts, towns in the province, including: Buon Don, Cu M'gar, Ea H'leo, Ea Sup, Krong Buc, Krong Nang and Buon Ho town. Despite the rainy season, but in some districts has happened locally drought conditions. The two most affected districts were Ea Sup and Buon Don, with 11665.8 hectares of crops have been dried, in which more than 8410 hectares were lost, estimated losses of about 18.5 billion.

As of the date of 04.05.2015, Dak Lak province has more than 50,000 hectares of crops affected by drought, lack of irrigation water. According to statistics, some districts such as Krong Bong, Ea Kar ... had about 20,000 households lack of water for life. Damage caused by drought this time around 1,600 billion. Currently Dak Lak apply multiple solutions to combat drought, from structural measures such as dredging the inlet and canal systems, installation and commissioning of pumping stations quickly, digging ponds, wells, cover temporary dams to store water ... even the non-structural measures such as recommended farmers as planned, not planted in irrigated areas can not afford to avoid damage caused by the drought, including groundwater resources, apply the saving irrigation solutions. In particular, efforts to mobilize farmers to change crops, crop structure suitable to cope with prolonged drought (Hoang Gia, 2015).

3. Methodology

3.1. TVDI index calculation base

Chart of scattered pixels (Ts, NDVI) will provide useful information on plant conditions and surface moisture. The position of the pixel in this space is affected by many factors such as temperature, vegetation cover, humidity, evaporation and the contour of the main factors (humidity, evaporation) can drawn in the triangle defined so (Ts, NDVI) space. Based on (Ts, NDVI) space, built TVDI index to determine soil moisture (Sandholt et al., 2002). After observing the relationship between NDVI and LST, to quantify the relationships between them, people used temperature vegetation dryness index (TVDI) determined by the following formula:

$$\mathrm{TVDI} = \frac{T_s - T_{s_{min}}}{a + b\mathrm{NDVI} - T_{s_{min}}} \quad (1)$$

Where, Tsmin is the minimum surface temperature in the triangle defined "wet limit" temperature Ts is observed in image pixels to be calculated; Tsmax is the maximum temperature for each interval observed NDVI values. Parameters a and b of the "dry limit" line for each scene of Landsat image was determined by least squares regression of maximum value Ts for the range of NDVI values. Coefficients a and b are determined from the area is large enough to present a full range of surface moisture content (With Tsmin, a and b are defined constant for each Landsat, the value of TVDI for each pixel is calculated according to the above formula when instead the values of Ts and NDVI respectively). Since TVDI can be calculated for each pixel, the entire spatial resolution of the data is maintained. TVDI index is built on the assumption:

- Moisture is the main source for changes in Ts.
- TVDI related to the surface soil moisture because of changes in the thermal inertia and the evaporation control on radiation partition.

In (Ts, NDVI) space, TVDI is being represented as a straight line. The spatial form of TVDI can be compared with the simulation of moisture

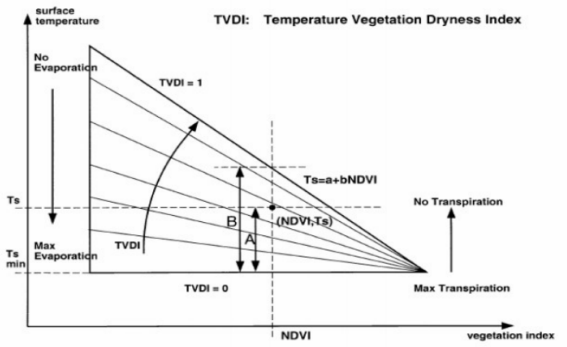

Figure 1. TVDI of a image pixel (Ts, NDVI) defined as a ratio between the A = (Ts - Tmin) and B = (Tsmax - Tsmin) (Sandholt *et al.,* 2002)

In (Ts, NDVI) space, the slope of the upper boundary related to the amount of surface evaporation, resistance to leaf and soil moisture averages. With the same climatic conditions, the surface temperature will be the smallest in places with maximum evaporation, due to water saturation, make up the bottom line " wet limit " (Ts, NDVI) triangle space, or in other words, it was modeled into horizontal lines, as opposed to "dry limit" slope. In places with minimum evaporation due to very dry surface (with or without plant cover), the surface temperature will increase the maximum - create boundary on "dry limit". Thus, the key to find TVDI is determined dry limit for studying image. Dry limit is modeled linearly form:

$$Tsmax= a + b*NDVI \quad (2)$$

From the division between NDVI values, we compute the pixel with the maximum surface temperature corresponds to determine parameters a and b. In other words, to determine the coefficient decision "dry limit", maximum temperature observed in the range of NDVI was extracted around in Ts – NDVI space. TVDI value is 1 in "dry limit" and 0 in “wet limit ". The general trend for TVDI that it went to peak during the dry season, and the low value in the rainy season, and usually change much during the dry season.

TVDI graph in (Ts, NDVI) space comes in two forms, triangles and trapezoids. The difference between the two is that, in the trapezoidal approach, higher NDVI value, the calculated TVDI value increasingly uncertain, and in the low TVDI value, can occur "transgressed” TVDI real value. The uncertainty in determining the coefficient of TVDI is most influential to TVDI at higher NDVI values. During the rainy season, the vegetation absorbs water reduces TVDI, but at the end of the rainy season, the TVDI value increased because of surface soil moisture is lower than the integrated value in the root zone (Sandholt et al., 2002)

TVDI is very sensitive to rainfall. In particular, the highest value of TVDI during track will correspond with little or no rain rainfall and this index decreased in those days there is heavy rainfall. In short, high TVDI synonymous with dry conditions and vice versa. Besides, the different types of land cover will form (Ts, NDVI) different, and different atmospheric conditions, surface humidity, the selection ratio also affects the shape of the scattered graph in (Ts, NDVI) space.

3.2. Criteria to classify drought regions

TVDI values are ranging from 0 to 1. According to the rating scale of Wang et al. (2004), the value TVDI be divided into five groups to decentralize drought level from low to high, including wet, normal, mild-term, medium-term and severe drought (Table 3.1). This study used criteria, to partition the city dry for Buon Ma Thuot, and established distribution map of drought through TVDI index. Accordingly, the value TVDI less than 0.2 corresponds to very wet areas, there is no risk of drought (surface water, lush vegetation, submerged farmland). If VDI from 0.2 to 0.4 in the corresponding areas at risk of drought (forest area); TVDI index of about 0.4 to 0.6 corresponding to mild drought area; in the range of 0.6 to 0.8 corresponding to areas with moderate drought condition. If the index is greater than 0.8 TVDI the region has severe drought.

Table 1. Drought levels based on TVDI (*Wang et al., 2004)*

TT	TVDI	Drought levels
1	0,0 – 0,2	very wet
2	0,2 – 0,4	wet
3	0,4 – 0,6	balance
4	0,6 – 0,8	dry
5	0,8 – 1,0	very dry

4. Results and Discussion

4.1. Data

The study area is the city of Buon Ma Thuot (Buon Me Thuot city) Dak Lak province, the image data Lansat 8, were collected on the day 04.25.2016

4.2. Calculating NDVI

NDVI in this study were calculated indirectly through bands 4 and 5 of Landsat 8 image. NDVI is calculated by the following formula: NDVI= (NIR-R)/ (NIR+R). Where, NIR, R - corresponding to the Landsat 8 spectral reflectance in band 4 and 5. NDVI is divided into intervals with step value 0.5 used to determine the TVDI below

4.3. Calculating T_s

Radiation value on Landsat 8 should be calculated converting pixel values from digital pixels (DN) to the reflectance values. This process is calculated for each pixel and spectral radiation standard value has been specified in the metadata of each scene. With Landsat 8, adjusting the radiation is done as follows: Lλ=ML*Qcal+AL. Where, Lλ - radiation values; ML - band coefficients for each specific image (the value of the data RADIANCE_MULT_BAND_x LANDSAT 8, where x is the image band); AL - band coefficients for each specific image (the value of the data RADIANCE_ADD_BAND_x LANDSAT 8, where x is the image band); Qcal - the value of the transmission band (Table 2). Then use ENVI software we calculated T_s

Table 2. ML, AL for thermal infrared image LANDSAT 8

Band	Satellite	ML	AL
10	LANDSAT8	3.3420x10-4	3.3420.10-4
11	LANDSAT8	0.10000	0.10000

4.4. Calculating TVDI

TVDI index is determined after taking into NDVI and Ts. Value Tsmin has been identified as Tsmin = 27.19˚ C. Write the linear regression equation of maximum temperature values at intervals NDVI values, we identified Tsmax = -27.706*NDVI + 44.671 (Figure 2). From here, we applied the formula (1) to work out for the whole city TVDI.

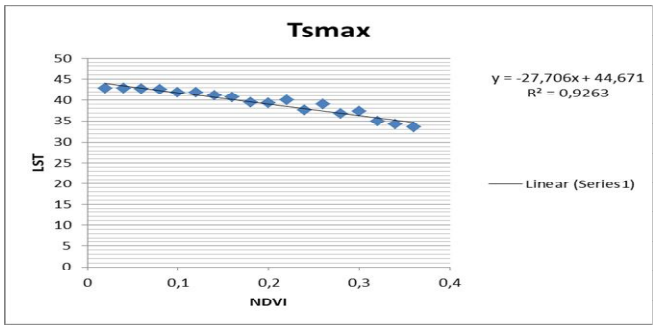

Table 2. Linear regression between Ts and NDVI

4.5. Map of TVDI for Buon Ma Thuot city

From image processing and computational software on ENVI, research has developed drought zoning map for the city of Buon Ma Thuot as in Figure 3. The results show that most of the region's index TVDI is in the range from 0.4 to 0.6 corresponds to the average level of drought. In Buon Ma Thuot city, the drought is focus at mild level, some areas reaching medium-level and heavy distribution in northeast and southwest areas of the city.

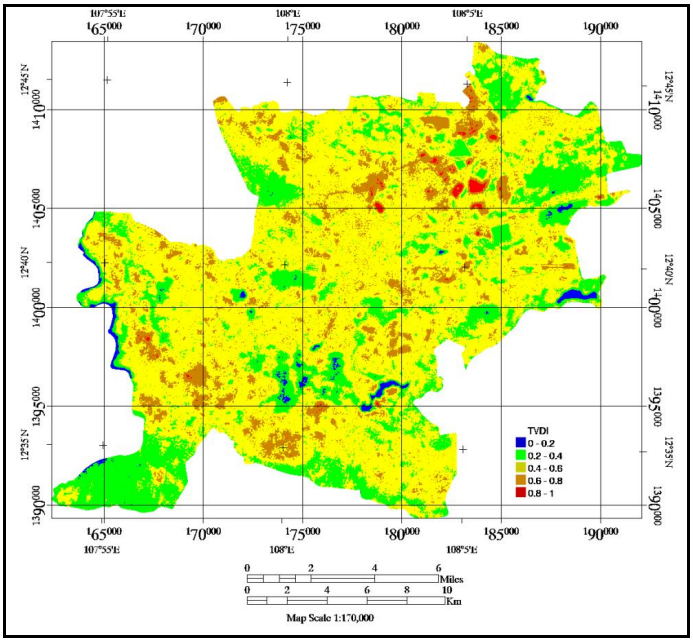

Fig. 3. Map of Drought for Buon Ma Thuot city

5. Conclusion

This paper presents the application of remote sensing to assess the drought situation for the city of Buon Ma Thuot, Dak Lak Province in the dry season in 2016 based on the characteristics of ground moisture, data from Landsat 8, in order to detection arid regions and is the basis for the authors to learn the cause of the drought here for the next study. The results showed that on TPBMT mostly medium term. Existing drought areas are negligible. However, in practice at other times, the drought situation has been going on in the region are complex. Therefore, there should be more research into the many different images time to properly assess the drought situation in the city.

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