An Application of NDVI and NDWI Indicies to Identifying Drought Pattern in Northeast Thailand

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Abstract: MODIS data of the Terra Satellite with high temporal resolution is promising for drought analysis. The study aim is to determine the spatio-temporal patterns of drought in Northeastern Thailand. The Northeastern part of Thailand has increasingly been impacted by drought throughout many parts of the region. The use of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index to detect stress conditions was conducted by using multitemporal Terra MODIS satellite images. The correlation between the rainfall and the indices was performed to identify drought. The analysis provided the spatio-temporal patterns of NDVI and NDWI of which the variability of drought during the wet and dry month was evident. The NDWI is more sensitive to changes in water content of vegetation when compared to those of the NDVI. No significant changes in the NDVI values within the forest covers under different climatic condition are found. Significant differences in the NDVI values between forest covers and annual crops (field crop, paddy fields) are evident, particularly during the dry season. The NDWI values for different types of covers show similar to those of the NDVI. The field crop and paddy field are remarkably low in the NDVI values. Soil background and partially vegetated areas contributions are positive. It is observed that these values are strongly associated with the greenness of the area. The monthly mean NDVI and its deviation provide the variation of the greenness of the area (fig.4). Both anomalous dry and wet months can be observed from NDVI values that deviate significantly from the means (>0.7) over the study period. The highest NDWI occurred in the September-October with relatively low in standard deviation.

The spatial pattern and intensity of drought from the NDVI values are shown in fig.5 Overall, the spatial patterns observed were similar in both the September-October results, although the dry areas were stronger in the November and December. The areas with lower NDVI values occurred in the agricultural region where most of crops were harvested. The forest areas remained unchanged or high NDVI values. NDVI and 4 months cumulative rainfall correlation for the study area were analyzed. The NDVI and the cumulative rainfall is highly correlated (r=0.7474).

The study area encompasses most of North-East Thailand, with an approximate area of 170,000 km², between 14° 18’ N to 18° 15’ N and 102° 22’ to 104° 50’ E. The vast extent of the Northeast acquired by the Terra(MODIS) satellite with its spectral features, high temporal resolution and synoptic view, the formation of NDVI and NDWI can be performed. The investigation aims to identify spatial and temporal patterns of drought and to compare the satellite-derived NDVI and NDWI temporal characteristics of major land cover types.

Method

1. Rainfall data over 300 stations of 7 years 2000-2006 records over NE Thailand collected the Meteorological Department and Royal Irrigation Department.

2. Multi-temporal MODIS 16-day composite images at 250 m. resolution were used in this study. The seven years (2000-2006) data were processed as follows:

\[\text{NDVI} = \frac{(\rho_{\text{NIR}} - \rho_{\text{red}})}{(\rho_{\text{NIR}} + \rho_{\text{red}})}\]

\[\text{NDWI} = \frac{(\rho_{\text{NIR}} - \rho_{\text{SWIR}})}{(\rho_{\text{NIR}} + \rho_{\text{SWIR}})}\]

Where \(\rho_{\text{NIR}}\), \(\rho_{\text{red}}\), and \(\rho_{\text{SWIR}}\) are the digital number of the reflectances at 0.857 µm, 0.65 µm, and 1.65 µm, respectively.


These included the statistical test of differences between NDVI and NDWI values for the major land used types and their coefficient of variation (C.V) several replications of the land cover types was sampled to produced a reliable result of the testing.

Result

Rainfall pattern: The rainfall period is from May through October and is controlled by the South-Western North East monsoon with two distinct rainfall periods, one from the southwest in the early wet season and the other from the northeast and east in the latter part. The mean monthly rainfall values varied from about less than 100 mm. during the dry season on the January-April and the October-December, to maximum of over 250 mm. on the August to September for most of the years.

Overall annual rainfall varied from 800 mm in the southwest parts of the region, to a maximum over 3,000 mm in the northern part for some year. Despite no significant trends in total annual rainfall amounts, the study area has been frequently subjected to drought. A cause of drought is evidently associated with an erratic distribution of rainfall. This results in critical dry spells for 2-4 weeks during the rainy season particularly from June to July, causing the failure of seedlings.

NDVI pattern: The mean annual NDVI values of the entire study area for the years 2000-2006 are presented to show its variation in terms of land cover composite pattern (fig.3). The mean annual NDVI values varied from 0.539 to 0.621 for the years 2000-2006 with its mean of 0.572.

Conclusion: Analysis provides the spatio-temporal patterns of NDVI and NDWI of which the variability of drought during the wet and dry periods are evident. The NDWI is more sensitive to changes in water content of vegetation than that of the NDVI. We investigated rainfall distribution, monthly and yearly NDVI and NDWI values, spatio-temporal patterns of NDVI and NDWI images which provide the drought patterns in the Northeast. The result obtained indicates that, in case of lacking full spatial coverage climatic data, the satellite data is useful to determine the characteristics and spatial distribution of drought and evaluate drought affected areas in the NE Thailand. The rainfall pattern is from May through October-December, to maximum of over 250 mm. on the August to September for most of the years.

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Table 1: Temporal variation of NDVI and NDWI and major land cover types. (Refer to the figure for details.)