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

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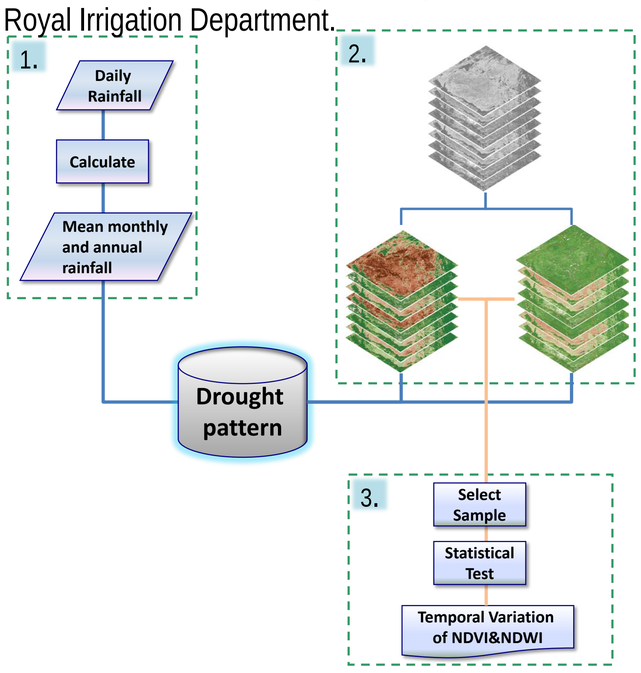
Abstract: MODIS data of the Terra Satellite with high temporal resolution is promising for drought analysis. The study aim is to determine the spatio-temporal patterns of drought in Northeastern Thailand. The Northeastern part of Thailand has increasingly been impacted by drought throughout many parts of the region. The use of Nomalized 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 comparing to those of the NDVI. No significant changes in the NDVI value 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 type of covers show similar to those of the NDVI. The field crop and paddy field are remarkably low in the NDWI values. Soil background and partially vegetated areas contributions to the NDWI are mostly negative, whereas fully vegetated areas contributions are positive.

Introduction: North-East Thailand is frequently subject to drought due to dry periods within the wet season. Traditionally, drought monitoring has been based on climatic data collected by weather stations, which often lack the continuous spatial coverage. Satellite data provide a synoptic view of land and repetitiveness for measuring drought conditions (Gu. Y et al 2007). NDVI has been used in many applications including drought forest and crop monitoring (Gao 1966). NDVI has several limitations including sensitivity to atmospheric aerosols and soil background and saturation in a multilayer closed canopy (Huete et al 2002). NDWI is less sensitive to atmospheric effect than NDVI and do not remove completely soil background reflectance effect (Gao, 1996).

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.

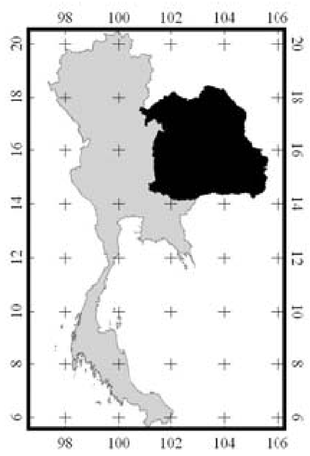
Method

1. Rainfall data over 300 stations of 7 years C2000-2006 records over NE Thailand collected the Meteorological Department and Royal Irrigation Department.



The Study Area

The study area encompassed most of North-East Thailand, with an approximate area of 170,000 km^2, between 14° 18´ N to 18° 15´ N and 102° 22´ E 104° 50´ E



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

NDVI = (ρNIR–ρred)/(ρNIR+ ρred)

NDWI = (ρNIR–ρSWIR)/(ρNIR+ ρSWIR)

Where ρNIR ρred and ρSWIR are the digital number of the reffectances at 0.857 μm. 0.645 μm. and 1.65 μm. respectively.

3.Random selection of land cover types in Phu Khieo Wildlife Sanctuary for statistical analysis. These included the statistical test of differences between NDVI/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-West Northeast 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.

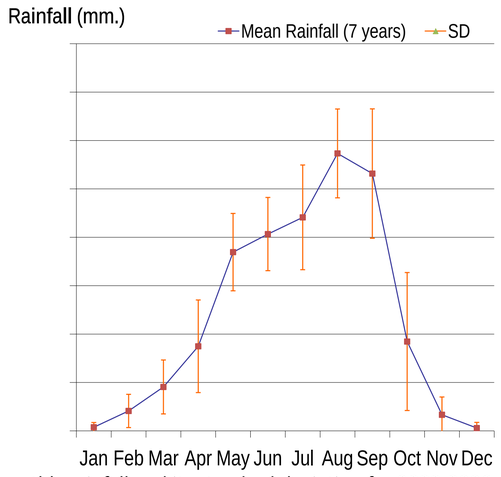


Fig.1 Mean monthly rainfall and its standard deviation for 2000-2006

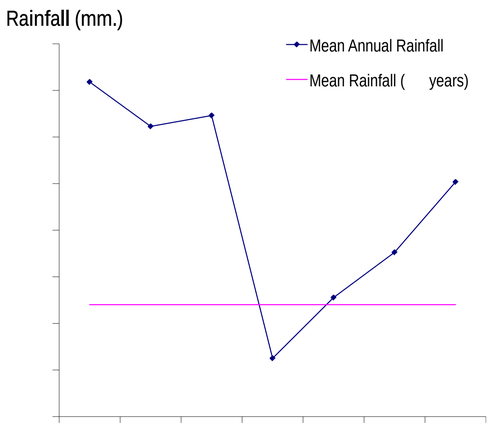


Fig.2 Mean annual rainfall for 2000-2006

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 period 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 (fig.3). The annual NDVI values range from 0.539 to 0.621 for the years 2000-2006 with its mean of 0.572.

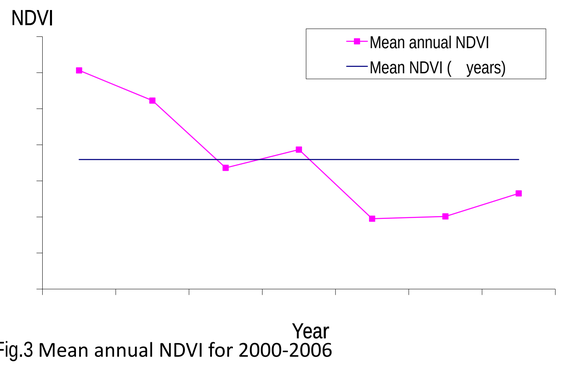


Fig.3 Mean annual NDVI for 2000-2006

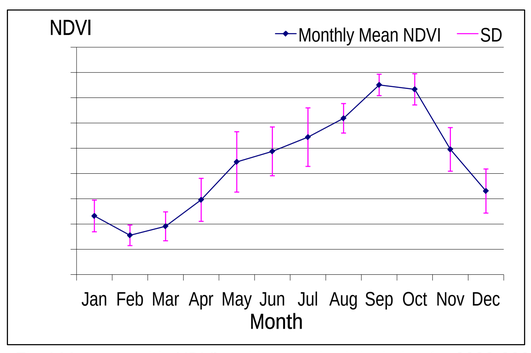


Fig.4 Mean monthly NDVI and its standard deviation for 2000-2006

It is observed that these values are strongly associated with the greenness of the area. The monthly mean NDVI and its deviation 6 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 NDVI occurred in the September-October with relatively low in standard deviation.

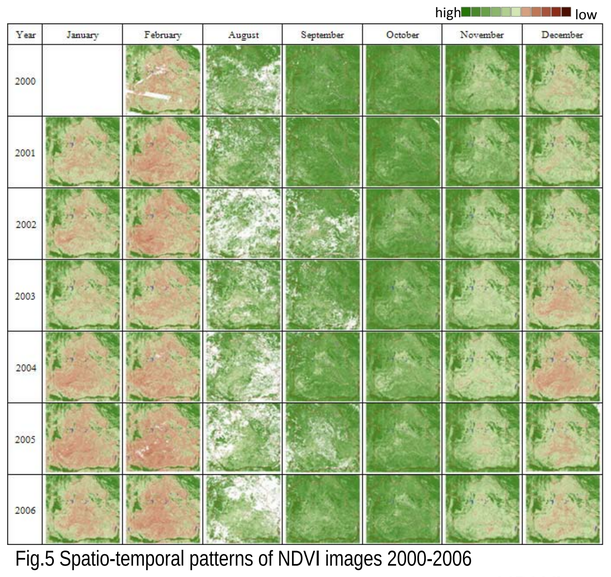


Fig.5 Spatio-temporal patterns of NDVI images 2000-2006

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).

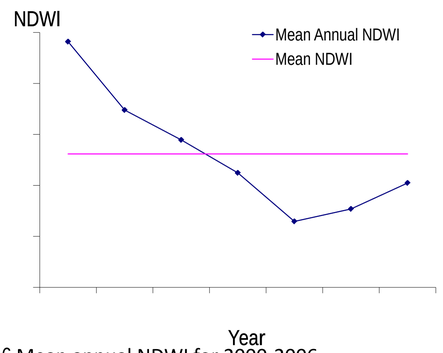


Fig.6 Mean annual NDWI for 2000-2006

NDWI pattern: The NDWI values for the monthly composite period varied from 0.326 to 0.396 (fig.6). The mean monthly NDWI values were substantially lower in the dry months (fig.7). The highest values of the mean monthly NDWI occurred in the August -September – October with lowest SD in the September.

The higher values of NDWI show a healthy vegetation or high bio-mass of which are forest cover, natural vegetation and annual crops. The paddy fields/ swidden land during the dry season are remarkably low in the NDWI values. Spatio-temporal patterns of NDWI for seven years (2000-2006) are presented in fig.8 to show the variability of drought during the wet and dry months.

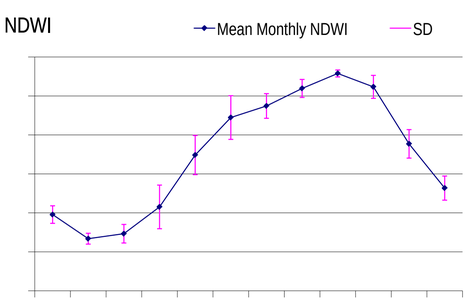


Fig.7 Mean monthly NDWI and its standard deviation for 2000-2006

We can separate the drought months from the non-drought (NDWI>0.35) months. The NDWI is more sensitive to changes in water content of vegetation in relation to the NDVI

Analysis of NDWI and NDVI values during the years 2002 and 2004 for different type of covers was performed(table1). No significant changes in the NDVI values within the forest covers under different climatic condition. 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 type of covers show similar patterns to those of the NDVI.

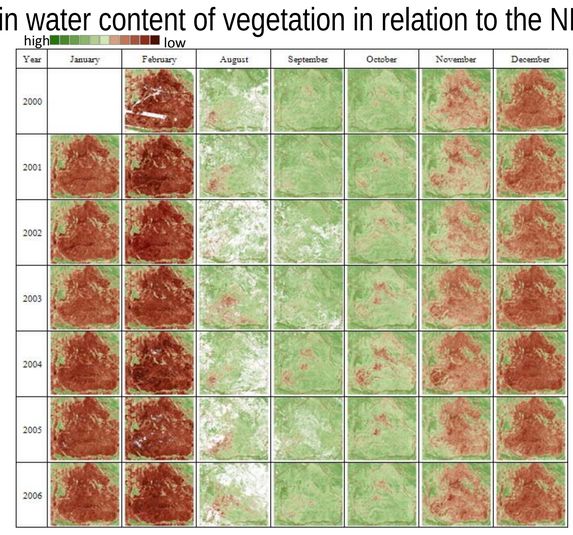


Fig.8 Spatio-temporal patterns of NDWI images 2000-2006

Table1 Temporal variation of NDVI and NDWI and major land cover types.

	NDVI										NDWI									
Month	January		February		October		November		December		January		February		October		November		December	
Type of forests	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004
Grassland	.720 b	.687 b	.660 b	.655 b	.771 a	.772 b	.779 b	.758 c	.754 b	.699 b	.500 b	.475 b	.415 b	.409 b	.589 b	.554 b	.588 b	.595 b	.556 c	.592 bc
Hill evergreen forest	.836 d	.824 d	.837 c	.825 d	.842 b	.840 c	.838 cd	.852 d	.858 d	.840 d	.685 d	.673 d	.691 d	.672 d	.708 e	.710 e	.692 d	.698 d	.710 e	.645 cd
Dry evergreen forest	.803 cd	.772 cd	.774 c	.748 cd	.827 b	.834 c	.844 d	.837 d	.830 cd	.786cd	.627 cd	.594 cd	.568 c	.555 cd	.687 de	.677 de	.694 d	.684 cd	.660 de	.656 d
Dry dipterocarp forest	.509 a	.414 a	.402 a	.404 a	.826 b	.789 b	.805 bc	.689 b	.720 b	.479 a	.244 a	.199 a	.121 a	.114 a	.646 c	.613 c	.617 c	.495 a	.496 b	.283 a
Bamboo forest	.798 cd	.784 cd	.768 c	.776 d	.842 b	.821 c	.812 cd	.828 d	.841 cd	.804 cd	.627 cd	.604 cd	.573 c	.583 d	.663 cd	.658 cd	.630 c	.652 c	.663 de	.626 bcd
Field crop	.494 a	.421 a	.407 a	.388 a	.737 a	.690 a	.706 a	.582 a	.631 a	.454 a	.205 a	.164 a	.102 a	.068 a	.551 a	.366 a	.515 a	.481 a	.381 a	.583 b
Plantation	.760 bc	.732 bc	.692 b	.672 bc	.818 b	.826 c	.822 cd	.813 d	.807 c	.745 bc	.565 bc	.539 bc	.459 b	.442 bc	.669 cd	.652 cd	.670 d	.675 cd	.637 d	.675 d
p-value	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*
C.V. (%)	10.056	10.674	11.93	14.005	5.525	3.971	3.946	5.840	5.753	9.206	19.212	19.261	17.992	32.080	4.035	9.060	5.020	5.908	8.485	10.893

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.

Reference

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Gu, Y., J. F. Brown, J. P. Verdin, and B. Wardlow (2007), A five-year analysis of MODIS NDVI and NDWI for grassland drought assessment over the central Great Plains of the United States, *Geophys. Res. Lett.*, 34

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