# RECENT DROUGHT IN NE THAILAND: CASE STUDY USING MODIS TIME SERIES

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**ABSTRACT:** Drought is one of the most serious problems in Northeast Thailand with far-reaching environmental and socio-economic impacts on local as well as the whole country. It is important to improve knowledge of landscape temporal variations and inter-annual vegetation response to precipitation at local to regional scales for drought monitoring and planning. With continuous spatial and temporal coverage, MODIS-derived enhanced vegetation indices (EVI) 16-day composite time-series data were utilized to monitor the vegetation seasonal dynamics and phenology of major land cover types including rice, crops (sugar cane and cassava), deciduous forest, and evergreen forest. Also, rainfall and satellite data anomalies were analyzed. Overall, temporal profiles of rice, crops, and deciduous forest depicted dry-wet seasonal contrast strongly coupled with rainfall with a pronounced dry season from November to April and wet season from May to October. In contrast, the evergreen forest showed the lowest seasonal contrast and relationships with rainfall with green-up occurring during the dry season (Jan-Feb). Significant decreasing trends were found in the 6-year (2001-06) MODIS EVI anomaly time series profiles for the rice, crops, and deciduous forests. However, the dominant land cover type, dry paddy rice, exhibited seasonal profiles with large spatial variations due to land use management practices, which resulted in more complex rainfall- vegetation relationship. Therefore, it is suggested that land use practices be taken into account for drought assessment and that the use of other land cover types, i.e. dryland crops be considered.

## 1. INTRODUCTION

One of the major problems in Northeast Thailand is drought. Drought has the most profound effect on environmental and socio-economic at local, regional and the whole country as well (Mongkolsawat et. al, 2001). Drought has lowered the water resources for drinking and irrigation as well as stressed vegetation including rice and other crops. There are also serious issues of mental health due to prolonged dry and hot weather periods. For drought monitoring and planning, it is needed to improved knowledge of landscape temporal variations and inter-annual behavior at local to regional scales.

Satellite remote sensing provides systematic and consistent observations of terrestrial vegetation dynamics. Satellite observations have been found to be a powerful tool to measure photosynthetic activity and phenology of vegetation at local- and regional-scales. With very high temporal resolution (daily acquisitions) over large regional coverage, the Moderate Resolution Imaging Spectroradiometer (MODIS) has been reported as an excellent sensor for terrestrial vegetation monitoring for of the land surface and vegetation health status on a local and global basis (Field et al., 1995; Potter et al., 1993; Goward et al., 1994).

Vegetation indices (VIs) were designed to enhance and quantify the "green" photosynthetic signal. The VIs have been used successfully for studies of vegetation activity, seasonal and inter-annual behavior, land cover classification, change detection (Townshend et al. 1991), phenology events (Schwartz & Reed, 1999; Huete et al, 2006) and drought monitoring (Tucker & Choudhury 1987; Kogan 1997; Bell et al. 1999). Over past few decades, vegetation indices have been widely used in terrestrial monitoring and satellite-based biosphere modeling (Potter et al., 1993). Furthermore, satellite-derived VIs have been used to monitor causes and effects of drought. The Enhanced Vegetation Index (EVI) was developed to optimize the vegetation signal and reduce soil background noise and is more responsive to canopy architecture and structural variations (Huete et al. 2002). The EVI has been reported to be responsive to canopy structural variations, including plant physiognomy, canopy type, canopy architecture, and leaf area index (LAI) (Huete et al., 1997; 2002).

## 3. OBJECTIVE

Drought impacts have important environmental consequences with important economic consequences on local and regional. Therefore, improved knowledge of landscape seasonal variations at local and regional scales is needed for monitoring and planning drought events. It is hypothesized that various land cover types will be affected and respond differently to drought. Therefore, the objective of this study will be to investigate spatial and temporal characteristics and variations of satellite data in Northeast Thailand as a function of land cover types using MODIS data for the recent drought.

## 4. STUDY SITES AND METHODS

### 4.1 Study Sites

The Northeast of Thailand is located between latitude 14° 14′ to 18° 27′ and longitude 101° 15′ to 105° 35′, approximately one-third of the whole country (Figure 1). The annual rainfall of the region ranges from 1,000 to 2,000 mm/year, with higher average rainfall in the north and northeast parts. In this region, wet season is about 6 months long, May to October. Average temperature is ~26.9 ˚C with maximum temperatures in April. In this region, land surface heterogeneity is high in Northeast Thailand and includes agricultural areas, pastures, savanna and forests. Major land cover types are paddy filed, crops (i.e. sugar cane and cassava), and deciduous and evergreen forests. MODIS EVI temporal data were extracted over local sites including rice, sugar cane, and cassava, deciduous forest, and evergreen forest. These sites were known conditions (field visited), located at Mahasarakham, Burirum, Ubon Ratchathani, and Nakorn Ratchasima, Surin, and Loei Provinces.

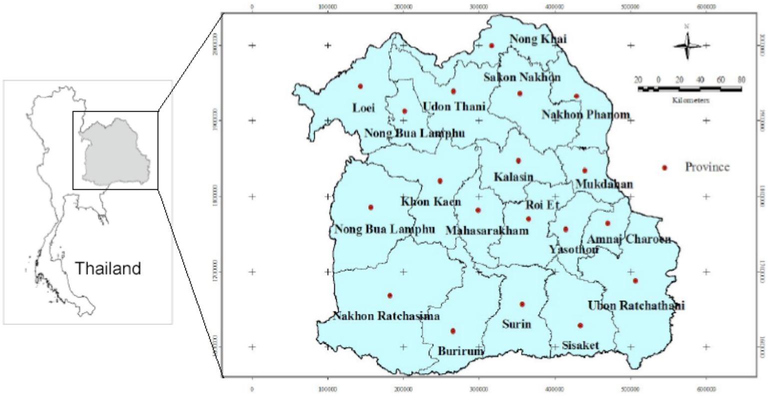


**Figure 1**. Northeast Thailand, Thailand

## 4.2 Data and Methods

For measuring temporal variations in "greenness" of different land cover types in Northeast Thailand, MODIS VIs time-series data were utilized over the local sites. The EVI optimizes the vegetation signal and reduced atmospheric and soil background noise,

$$EVI=2.5*[(\rho_{NIR}-\rho_{red})/(\rho_{NIR}+(6*\rho_{red})-(7.5*\rho_{blue})+1)] \qquad (1)$$

where $\rho_{NIR}$ is NIR reflectance , $\rho_{red}$ is red reflectance, $\rho_{blue}$ is blue reflectance, 6 and 7.5 are atmosphere resistance coefficients, 1 is a canopy background brightness correction factor, and the gain factor is 2.5 (Huete et al.,1997; 1994).

The MODIS EVI product is computed from atmosphere corrected and cloud filtered surface reflectances and is composited over 16-day time intervals. In this study, quality assurance (QA) metrics were utilized to further filter and reduce cloud contaminated pixels. Vegetation seasonality was analyzed with 6-years (2001-06) of 16-day composite EVI time series at 1km resolution (MOD13A2) over local sites, encompassing the rice fields, the sugar cane and cassava fields, and the deciduous and evergreen forests.

Point-based long-term rainfall data over the region were collected from the Thai Meteorological Department (http://www.tmd.go.th/). Monthly precipitation values for anomaly analyses were computed from 30-year stationary records.

Satellite and rainfall data anomalies were analyzed using long-term point-based monthly and annual rainfall records and year 2000-06 MODIS EVI data. Correlations of rainfall and EVI were analyzed using simple regression method.

# 5. RESULTS AND CONCLUSIONS

## 5.1 Results

The anomalies in precipitation for year 2001-06 were computed from 30-years point-based rainfall records. Negative anomaly from year 2001 to 2006 was found. As well, there were downward trends in 6-year EVI temporal profiles with negative anomalies in rice, crops, and deciduous forest (Figure 2). This suggested that the impact of drought on vegetation can be seen in MODIS EVI observation.

The seasonal dynamics across the major land cover types, rice, sugar cane, cassava, deciduous, and evergreen forest sites were plotted and analyzed with MODIS, 1km resolution 16-day composite VI profiles for years 2001-06. Overall, temporal profiles of rice, sugar cane, cassava, and deciduous forest depicted dry-wet seasonal contrast strongly coupled with rainfall with a pronounced dry season and wet seasons (Figure 2). During the rainy season, May through October, high vegetation activity can be seen. For the dry-down phase of the dry season, November through April, EVI values decreased. However, differences in EVI seasonal profiles were apparent among evergreen forest and other land cover types (Figure 3). The evergreen forest showed the lowest seasonal contrast with high EVI values throughout the year. The green-up occurred during the dry season (~ February) and reached the "green" peak of growing season in June-July.

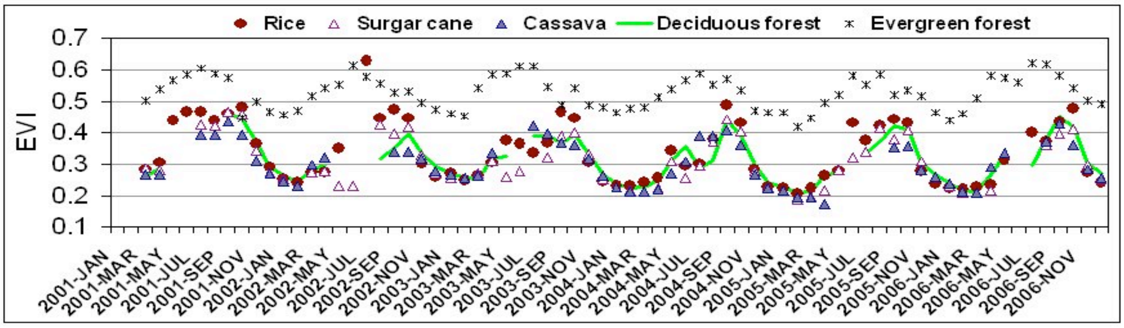


**Figure 2**. Six-years MODIS EVI temporal profiles over rice, sugar cane, cassava, deciduous forest, and evergreen forest sites.

The temporal profiles of all cover types showed distinct differences. Variations of vegetation seasonal behaviors (i.e. peak time and value and rate of increasing "greenness") of rice, crops and deciduous forest were observed. The rice seasonal profile in Figure 3 showed a decrease in EVI values at the onset of the dry season (November) as well as an increase in EVI following the initiation of rainy season (May) and with the time lag of 2 months of the sugar cane and cassava. The EVI peaks were found in September-October (~0.46), September (0.42), July (0.40), and September-October (~0.39) for rice, sugar cane, cassava and deciduous forest profiles respectively. However, the lowest EVI value of the rice was fairly similar to those of crops and deciduous forest (~0.22), which occurred in February. In addition, the rice profile depicted the highest rate in growing season (steeper slope, Figure 3).

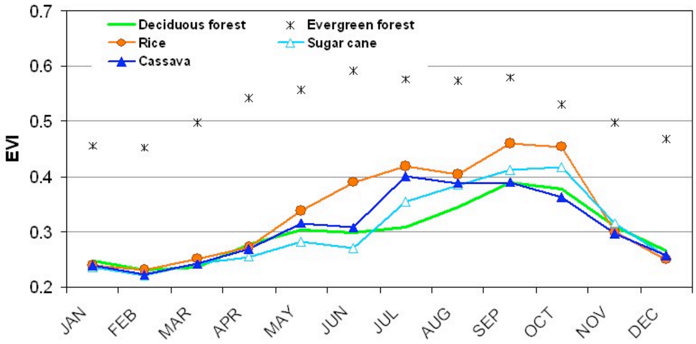


**Figure 3**. MODIS MOD13A2, 1km resolution, six-year monthly average land surface seasonal profiles over rice, sugar cane, cassava, deciduous forest, and evergreen forest sites.

From simple regression between rainfall and EVI, there were positively correlated between at the rice, sugar cane and cassava, and deciduous forest sites with fairly similar slopes. This suggests that water is an important controlling factor for vegetation in NE Thailand.

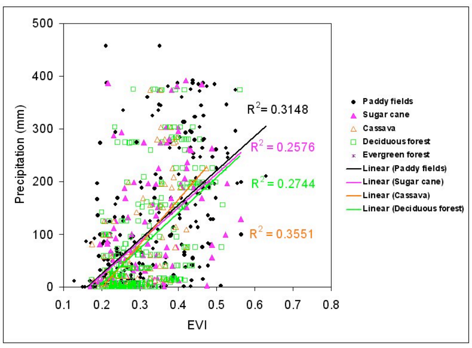


**Figure 4**. Relationships between EVI and rainfall at rice, sugar cane, cassava, deciduous forest sites.

## 5.2 Conclusions

MODIS time series dataset was able to monitor impact on drought. Drought-induced reduced in vegetation photosynthesis can be seen in the EVI temporal profiles. Decreasing trend of EVI values over 6-years data were found over major land cover types including rice, crops (sugar cane and cassava), and deciduous forest.

Strong pronounced dry-wet "greenness" values due to seasonal vegetation responses were found in this study. The rice, sugar cane, casava and deciduous forest seasonal profiles were driven by water. These agricultural and deciduous forest sites showed the highest wet-dry seasonal contrast with a pronounced dry season from November to April and an increase in wet season from May to October. The evergreen forest seasonal profile showed the least variations and least impact from drought.

However, the dominant land cover type, dry paddy rice, exhibited seasonal profiles with large spatial variations due to land use management practices (Figure 5), which resulted in more complex rainfall- vegetation relationship. Therefore, it is suggested that land use practices be taken into account for drought assessment and that the use of other land cover types, i.e. dryland crops be considered.

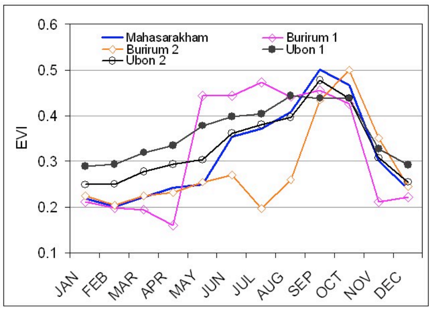


**Figure 5**. Monthly temporal profiles of 6-years average MODIS 16-days composite.

## 6. ACKNOWLEDGMENT

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