Applications of Remote Sensing and Geographic Information System to Identify Rice Planting Season During El Nino Years: Case Study in the Pringsewu District, Province of Lampung

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Abstract. Spatial Information about rice planting season (RPS) in a wide areas, particularly during periods of El Nino, is important to support an information about the availability of rice continuously. Application of remote sensing and geographic information system (GIS) technology can support it’s information continuously and accurate. In this study, we attempted to identify the rice planting season during El Nino years of 1997, 2006 and 2015 in the Pringsewu district, Lampung and we compared with meteorological drought index. Spatial information of the RPS obtained through Interpretation of multitemporal Landsat data aquired in 1997, 2006 and 2015 using normalized difference vegetation index (NDVI) and the humidity index. While standardized precipitation index (SPI) is used as a indicator of meteorological drought. This study has shown that the application of remote sensing and GIS could accurately monitor the rice planting season during the periods of El Nino in 1997, 2006 and 2015. The fallow land dominated during the El Nino years and there were no significant difference between years. While drought information based on SPI values showed different results between years of El Nino events. In this paper we also discussed the relationship between distribution of fallow land and meteorological drought in a spatial perspective.

Keywords: Rice planting season, Remote Sensing Application, Meteorological drought, Pringsewu, Lampung.

1. Introduction
Global warming is a problem faced today as the impact of long-term accumulation of atmospheric climate change pollution. Studies related to the impact of climate change on agriculture by the National Academy of Science / NAS (2007), showed that agriculture in Indonesia has been influenced significantly by the variations of the annual rainy and between years by Australia-Asia Monsoon and El Nino-Southern oscillation (ENSO). The strong influence of ENSO it can be proved by looking at the incidence of droughts and drought in various regions of Indonesia, which coincided with El Nino events [1].

The agricultural sector is the sector most vulnerable to the impacts of climate change because agriculture is very dependent on the climate in its activities [2]. Meteorological drought in this study to
determine the level of rainfall over a season in cultivated agricultural land, especially in paddy fields. Meteorological drought is the first indication of a drought [4].

Pringsewu is one district that has the potential of food crops, especially rice which is a priority in improving agricultural production in Lampung [3]. In connection with the remote sensing and Geographic Information System (GIS) can help in knowing the cropping patterns in years of El Nino, so the results are expected to help provide accurate information for the sustainability of agriculture and capable of supporting District Pringsewu in meeting the target of rice self-sufficiency. In knowing the indicators of drought when the El Nino years can be classified by the SPI (standardized precipitation index). Thus, in this study aims to analyze and classify the cropping pattern of rice paddy during a drought in El Nino years with the help of SPI through Landsat TM with the matriculation of NDVI and humidity index.

2. Method
The study was conducted in the District Pringsewu using Landsat time series when the occurrence of El Nino in 1997, 2006 and 2015 with the spatial approach. The variables used in this study is a meteorological drought and cropping of paddy. The data used is secondary data that is processed by several methods, namely:

2.1 SPI (Standardized Precipitation Index)
According to Hayes et al (1999) that the determination of drought criteria do with rainfall data processing for 30 years (1986-2015). The data is then calculated by the method of Standardized Precipitation Index (SPI) to determine the meteorological drought index is happening with SPI drought index. SPI uses software processing methods scopic with a choice of time of 1 month to determine the meteorological drought in 7 classification SPI. The drought classification based on SPI values are presented in table 1.

| Score     | Classification   |
|-----------|------------------|
| ≥2,00     | Really wet       |
| 1,50 ~ 1,99 | Wet            |
| 1,00 ~ 1,49 | Dampy          |
| 0,99 ~ 0,99 | Normal         |
| -1,00 ~ -1,49 | Bit dry    |
| 50 ~ -1,99 | Dry             |
| ≤-2,00    | Very dry        |

Source: Mc Kee, 1993 (treated by BMKG)

a. NDVI (Normalized Difference Vegetation Index)
Processing to obtain NDVI using ENVI 4.2 software by the equation:

\[ \text{NDVI} = \frac{\text{Band 4} - \text{Band 3}}{\text{Band 4} + \text{Band 3}} \]

Based on the research results Widagdo (2000), the vegetation index during the growth of rice plants from early planting to be harvested parabolic shape. NDVI value of the current rice plants aged 3–4 MST to 16 show the shape of the curve with a peak at the age when rice (phase) optimum vegetative - rice bunting (aged about 70-80 days after planting, or about 10-11 MST).

b. Image enhancement for moisture
Obtained from the processing of Landsat 5 and Landsat 8 with rasioning band 3 and 5 on the band math using ENVI 4.2. Bright image processing results indicate that the image has a high wetness. It can be used for paddy area experiencing drought during the dry season or below normal rainfall [5].
c. Overlay analysis using ArcGIS 10.3
The results of the processing of Landsat NDVI and humidity intersect using ArcGIS 10.3.2. to determine the activity of planting paddy rice by the following matrix:

| No | NDVI               | Indeks Kelembaban |
|----|--------------------|--------------------|
|    |                    | Sangat Kering | Kering  | Lembab | Sangat Lembab | Tergenang | Penggenangan Lahan |
| 1  | Tidak ada vegetasi |              |        |        |              |           |                |
| 2  | Kehijauan sangat rendah | Lahan Bera  |        |        |              |           |                |
| 3  | Kehijauan rendah |                  |        |        |              |           |                |
| 4  | Kehijauan sedang |                  |        |        |              |           |                |
| 5  | Kehijauan tinggi |                  |        |        |              |           |                |

Table 2. Matrix Determination Period Planting Rice

Source: Rizatus and Dwi, 2007 (Treated)

3. Results and Discussion
3.1. Pringsewu Climate
Meteorological drought that occurred in Pringsewu cause drought index different. Based on calculation of SPI, the meteorological drought occurred in the Kebupaten Pringsewu are presented in the following table.

Table 3. Drought meteorological District Pringsewu In El Nino years

| No | Rain Station | SPI (Standardized Precipitation Index) |
|----|--------------|----------------------------------------|
|    |              | July | August | September | October | November | December | 1994 | 1997 | 2006 | 2015 | 1994 | 1997 | 2006 | 2015 | 1994 | 1997 | 2006 | 2015 | 1994 | 1997 | 2006 | 2015 |
| 1  | Banyuwangi  | K    | K     | AK     | AK     | AK     | N     | K     | K     | K     | N     | AK     | K     | K     | AK     | N     | N     | N     | AK     | K     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     |
| 2  | Pameukan    | K    | N     | AK     | N     | N     | N     | N     | N     | N     | N     | AK     | N     | AK     | AK     | N     | N     | N     | AK     | K     | K     | N     | K     | N     | N     | N     | N     | N     | N     | N     | N     | N     |
| 3  | Gading Rejo | K    | AK    | N     | AK     | N     | N     | N     | N     | N     | N     | AK     | N     | K     | AK     | AK     | AK     | AK     | N     | AK     | K     | K     | N     | K     | N     | N     | N     | N     | N     | N     | N     | N     |
| 4  | Gadingjaya  | AK    | N     | N     | N     | N     | N     | N     | N     | N     | AK     | N     | N     | N     | N     | N     | N     | AK     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     |
| 5  | Kekra     | K    | N     | N     | N     | AK     | N     | N     | AK     | N     | AK     | N     | N     | AK     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     |
| 6  | Pameukan     | N    | N     | N     | N     | N     | N     | N     | N     | N     | AK     | N     | N     | AK     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     |
| 7  | Podomoro    | K    | AK    | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     | N     | AK     | AK     |
| 8  | Pringsewu   | SK    | N     | N     | N     | N     | N     | K     | AK     | AK     | AK     | AK     | K     | K     | N     | SK     | K     | SK     | AK     | SK     | SK     | N     | N     | N     | AB     | N     | N     | N     | N     | N     | N     | N     |
| 9  | Way Gatel    | K    | AK    | N     | N     | N     | N     | N     | N     | AK     | AK     | AK     | N     | N     | AK     | AK     | AK     | AK     | K     | K     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     |
| 10 | Way Harong   | N    | N     | N     | N     | AK     | AK     | N     | N     | N     | AK     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     | N     |
| 11 | Wonedukir   | AK    | AK    | N     | N     | N     | N     | N     | N     | N     | AK     | N     | N     | AK     | AK     | AK     | AK     | AK     | K     | K     | N     | N     | K     | N     | N     | N     | N     | N     | N     | N     | N     | N     |

Keterangan:
SK  : Very Dry
N : Normal
K : Dry
AK : Bit Dry
AB : Dampy
B : Wet

Source: Data processing, 2016

The years of El Nino in July to December each year it appears that the District Pringsewu have meteorological drought levels from normal to very dry. In July of meteorological drought occurred in the classification of normal to very dry. In a very strong El Nino, which in 1997 showed the level of dryness in July in the index rather dry to dry. In strong El Nino in 2015, drought in July was dominant by the normal index. Meteorological drought classification rather dry to very dry more dominant place in November. This shows the peak drought during El Nino in the District Pringsewu occurred in November.
Based on Figure 1, the El Nino of 1997 appears a strong influence in the district Pringsewu. El Nino was very strong in 1997 led to almost all areas affected by drought meteorological Pringsewu very dry in July. In the months that followed in Regency Pringsewu experiencing meteorological drought in the classification of normal to very dry to a peak in November. During the five-month drought continues, only in October just started to appear wet to very wet classification is in the region Adiluwih districts and parts of Ambarawa.
Figure 2. SPI Drought In July-November 2015 in the District Pringsewu

2015 El Nino going strong again, as shown in Figure 2. In 2015 drought meteorological in district Pringsewu very dry classification is seen only in a small area in the district of Pringsewu. Drought meteorological bit dry almost scattered throughout the region in August, just in Adiluwih visible in the wet classification. In 2015 the area suffered least of meteorological drought dry classification is Adiluwih and Ambarawa.

3.2. Rice Planting Pattern in District Pringsewu

The cropping pattern is influenced by rainfall, because rice production is dependent on water. Some farmers explained that the existing irrigation techniques is still inadequate in some areas. When the dry season paddy fields which are not traversed irrigation experience dryness. In addition to the presence of irrigation, irrigation for paddy can use the river water for rice fields, which are located not far from the river.

Based on interviews at the Department of Agriculture and Forestry District Pringsewu, explaining that the cropping pattern paddy rice in the District Pringsewu conducted three times in one year. The majority of wetland also contained two rice cropping pattern interspersed with crops. Wetland conditions in El Nino years compared with normal conditions can be demonstrated through the interpretation of Landsat imagery. The data processing of Landsat TM 5 and 8 using ENVI 4.2 software is made to calculate the value of vegetation index and moisture index.

In connection with the cropping pattern, imagery used to see in the area Pringsewu planting season is in March. As the wet months are used to compare the cropping patterns in a normal year with El Nino year. November is the beginning of the main cropping season paddy rice in Pringsewu. November is the month when the El Nino weather anomalies, which can be used to compare the current cropping patterns normal year with El Nino. In figure 3 is presented wetland conditions at planting time in the district Pringsewu in normal and El Nino year in March and November. It is apparent that the condition of El Nino (1997, 2006 and 2015) largely fallow rice field in a condition. The ratio of the condition of the fields during El Nino in 1997 and 2015 are presented in the following table.
Table 4. Size Wetland Condition In November At The El Nino of 1997 and 2015

|                  | November 1997 | November 2006 | November 2015 |
|------------------|---------------|---------------|---------------|
| Planting season  | Large (Ha)    | Large (Ha)    | Large (Ha)    |
| Fallow           | 17974         | 13794,8       | 13217         |
| Reproductive phase| 22            | 38            | -             |
| Total            | 17996         | 13742,8       | 13217         |

Source: Data processing, 2016

November in normal climate is the main cropping paddy fields in the district Pringsewu. Shown with the planting season in November in a normal year (2014 and 1996), rice paddy in the vegetative to reproductive phase. Conditions fallow in November in El Nino years showed the effect of El Nino impact on changes in the growing season. The absence of rain resulted in water supply for agricultural productivity is inadequate in several districts Pringsewu.

The drought that hit Pringsewu when El Nino caused a shift in the main planting season, which in November which is a transition month dry season to the wet season. Based on the results of the processing of Landsat 8 recording dated December 19, 2015 main paddy rice planting time become a retreat for 4-5 dasarian, is presented in Figure 4.

Shifting cropping patterns that starting from 1 November 2015 occurred between rice fields that exist in each district is different. Activities rice fields occur in December, there is still in a state of fallow land. Shifting planting season occurs faster in Sukoharjo districts, Banyumas, North Exhibition, and Adiluwih.
4. Conclusion
Drought occurred in 1997, 2006 and 2015 in the district Pringsewu generally covers the whole region. The impact of El Nino in 2015 is relatively weaker than in 1997 and 2006. Drought in El Nino effect on lowland rice cropping pattern in the district Pringsewu. The results of processing using Landsat imagery and GIS show in an El Nino paddy fields in the district of Pringsewu dominated by fallow. The pattern of planting paddy rice in El Nino years of 1997, 2006 and 2015 are always changing as a result of drought conditions paddy fields. It affects the withdrawal of the main planting season in November. Shifting the growing season can reach > 4 dasarian, so that in December became the main planting season in El Nino.

SPI drought index is based on spatially seen from Landsat imagery processing and GIS shows the areas most often experience faster fallow season El Nino is the dominant rice field located in the wetland units in the form of river terrace and the plains.

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