Inventory of West Sumatera Province Area's Cropping Pattern Based on MODIS Image Data

E G Ekaputra¹, I Berd¹, F Arlius¹, D Yanti¹, and F Irsyad¹

¹Faculty of Agriculture, Andalas University, Campus Limau Manis, Padang, West Sumatera

Corresponding author’s email address: erigas@ae.unand.ac.id

Abstract. Paddy growth is influenced by natural factors such as climate and soil, the former being a factor that cannot be controlled. With global climate change, rainfall as one of the sources of water availability is the riskiest element affected, which is very influential in determining cropping patterns. This study aims to inventory the pattern of paddy cultivation in the province of West Sumatra by using the Enhanced Vegetation Index (EVI) of MODIS imagery. This study uses the MODIS EVI image (MOD13Q1, 16 composite days, 250m resolution, 2014 to 2018) in West Sumatra. During the course of this study the Province of West Sumatra experienced 3 paddy cropping seasons with 2 periods of harvest in one cropping calendar year.

Keywords: Cropping Patterns, MODIS, Paddy Fields, Rice, West Sumatra

1. Introduction

Paddy (Oryza sativa) is an important crop which is a staple food source for the world community, almost half of the world's population, especially in developing countries including Indonesia [1]. In Indonesia plants can be grown in almost all regions, but to be able to grow properly supporting factors are needed. Paddy growth is influenced by natural factors, i.e. climate and soil, while climate is a factor that cannot be controlled. With global climate change, rainfall as one of the sources of water availability is the riskiest element affected. Paddy will not be able to produce optimally if there is a lack of water, which will certainly affect aspects of food security.

Based on an analysis and field review conducted by the Minister of Agriculture (Andi Amran Sulaiman), the availability of irrigation water is a key factor in achieving the production targets [2]. While the Director-General of PSP, the Ministry of Agriculture (Pending Dadih), emphasized that “without water, agriculture will not run well and will not produce optimal results. Water is an absolute resource for farmers. Water is an absolute necessity if you want to increase rice production and achieve self-sufficiency in rice”.

Choosing the right cropping pattern can overcome the problem of increasingly limited water availability. At present, obtaining and monitoring data on cropping patterns and calendars of paddy cultivation can be done by applying remote sensing technology which detects the phenology (stages of growth) of paddy, for a wide area of coverage, fast time periods, and accurate results [3, 4]. The use of remote sensing satellites in addition to the time it takes to obtain information is fast and inexpensive [5]. Moreover, the scope of the survey area is broad and the information obtained is more sustainable.
While supporting the food security program, speed and accuracy of information is needed in the management of agricultural resources. This study aims to inventory the pattern of paddy cultivation in the province of West Sumatra by using the Enhanced Vegetation Index (EVI) of MODIS imagery.

2. Methods

2.1 Research Location
The study was conducted in the area of West Sumatra Province, which is geographically located at coordinates 3° 50' S - 1° 20' N 98° 10' - 102° 10' E, with a total area 42,297.30 km². The West Sumatra province region administratively consists of 19 cities / regencies.

2.2 Data
The data used in this study consisted of MODIS imagery data (EVI vegetation index values from 2014-2018), paddy field maps of West Sumatra Province, and administrative maps of districts / cities in West Sumatra Province.

2.3 Research Procedure
Data processing MODIS imagery (EVI vegetation index value) of inventory paddy cropping patterns is presented in Figure 1.
MODIS data that has been processed is used as a basis for EVI calculations. The EVI value for each MODIS image is obtained by applying the formula as in equation 1:

\[
EVI = 2.5 \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red} - 7.5 \times \rho_{blue} + 1}
\]

where \(\rho_{nir}\) = NIR canal surface reflectance; \(\rho_{red}\) = surface reflectance of the red canal; \(\rho_{blue}\) = blue channel surface reflectance; dan \(\rho_{swir}\) = SWIR canal surface reflectance.

Data processing procedures for MODIS Satellite Imagery with Vegetation Index EVI were carried out to see the cropping patterns of the West Sumatra Province as follows:

1. Download MODIS VI Satellite Imagery. The first stage is preparing satellite imagery data for the location of West Sumatra Province in 2014-2018.
2. MODIS VI Image Extract for EVI and Day of the Year Image (DOY) algorithms
3. Vector Map. The vector map used is a map containing data on paddy fields and administration areas per district of West Sumatra province.
4. Prepare Maps for Zonal Statistics (Corrected Vector Maps):
   a. Prepare paddy field digitization or Paddy vector map in the West Sumatra Province.
   b. Clipping of satellite imagery that has been extracted, using the Paddy vector map and West Sumatra Province Administration as a clipping reference.
   c. The clipping result is a Raster map of EVI MODIS products, which is then done by Poligonize to get a sample area map for EVI values.
   d. Geometry Correction
   e. Correction of map results
   The corrected Raster Map results are used for the Zonal Statistics process with the EVI Image and DOY Image.
   f. Do the Save As Map Correction Vector for zonal statistics on the image per year to reduce the PC process.
5. Zonal Statistics:
   a. Perform Zonal Statistics between the Correction Vector Map (Paddy field West Sumatra Province Map) with EVI Image and DOY Paddy field of West Sumatra Province 2014-2018.
   b. Zonal Statistics Stages:
      Raster \(\rightarrow\) Zonal Statistics \(\rightarrow\) Raster Layer (EVI Image and DOY Image), Polygon (Corrected Raster Map), Output Column Prefix (Id Attribute), Statistics to Calculate (Mean: EVI and DOY)
6. Attribute Data
   a. Copy-Paste Attribute Data
   b. Export Attribute Data
7. Interpolation of EVI Data to DOY Data to equalize the date of EVI value per pixel.

3. Results and Discussion

West Sumatra Province is located at 0°54'N - 3°30'S and 98°36'-101°53'E. The total area of West Sumatra Province is 42,200km², equal to 2.21% of the total area of Indonesia. The boundaries of the Province of West Sumatra are North Sumatra (north), Riau Province (East), Jambi Province (South), and the Indonesian Ocean (West). West Sumatra has a tropical climate with average temperatures ranging from 21.51°C to 31.52°C and has an average humidity of 87.03% [6].

The area of paddy fields in the West Sumatra Province in 2017 was 230,098.60ha, consisting of irrigated paddy fields covering an area of 186,550.20ha and non-irrigated areas covering 43,548.4ha. Paddy field area data by district / city is presented in Table 1.
Table 1 The area of paddy fields in West Sumatra Province in 2017 [7]

| Regency / City       | Irrigated Paddy Field (ha) | Non-Irrigated Paddy Field (ha) | Total (ha) |
|----------------------|-----------------------------|---------------------------------|------------|
| Regency              |                             |                                 |            |
| 1. Kep. Mentawai     | 158.0                       | 1938.0                          | 2096.0     |
| 2. Pesisir selatan   | 21890.0                     | 8526.0                          | 30416.0    |
| 3. Solok             | 22423.0                     | 1016.0                          | 23439.0    |
| 4. Sinjunjung        | 6136.0                      | 4084.0                          | 10220.0    |
| 5. Tanah datar       | 18033.0                     | 4911.0                          | 22944.0    |
| 6. Padang pariaman   | 17909.0                     | 4947.0                          | 22856.0    |
| 7. Agam              | 24266.0                     | 3011.0                          | 27277.0    |
| 8. Lima puluh kota   | 15826.0                     | 8012.0                          | 23838.0    |
| 9. Pasaman           | 21426.0                     | 155.0                           | 21581.0    |
| 10. Solok selatan    | 9994.0                      | 231.0                           | 10225.0    |
| 11. Dharmasraya      | 6023.4                      | 761.9                           | 6785.3     |
| 12. Pasaman barat    | 9275.0                      | 391.0                           | 13185.0    |
| City                 |                             |                                 |            |
| 1. Padang            | 6173.0                      | 245.0                           | 6418.0     |
| 2. Solok             | 684.2                       | 191.4                           | 875.6      |
| 3. Sawahlunto        | 762.0                       | 918.0                           | 1680.0     |
| 4. Padang panjang    | 630.0                       | -                               | 630.0      |
| 5. Bukittinggi       | 343.6                       | 45.1                            | 388.7      |
| 6. Payakumbuh        | 2602.0                      | 149.0                           | 2751.0     |
| 7. Pariaman          | 1996.0                      | 497.0                           | 2493.0     |
| Total                | 186550.2                    | 43548.4                         | 230098.6   |

In the pixel of paddy field in the city/regency of West Sumatra Province, there are three growing seasons with two harvesting seasons in one cropping calendar year. Beginning of the growing season in the city / district in the West Sumatra Province varies, with cropping season 1 in October-December, cropping season 2 in March-April, and cropping season 3 in July-August (Figure 2).
Figure 2 (b) EVI Time Profile Graph on Paddy Pixels in Solok Regency

Figure 2 (c) EVI Time Profile Graph on Paddy Pixels in Tanah Datar Regency
Figure 2 (d) EVI Time Profile Graph on Paddy Pixels in Padang Pariaman Regency

Figure 2 (e) EVI Time Profile Graph on Paddy Pixels in Agam Regency

Figure 2 (f) EVI Time Profile Graph on Paddy Pixels in Lima Puluh Kota Regency

Figure 2 (g) EVI Time Profile Graph on Paddy Pixels in Pasaman Regency
Each phase of the paddy growth has a ranging value of EVI. Based on the distribution of EVI vegetation index values, i.e. November, April, and August, it is more dominated by the vegetative phase, which is dominated by EVI vegetation index distribution values in the range 0.120 – 0.721, however in December, May, and September it was dominated by the generative phase which was dominated by the EVI vegetation index distribution range 0.718 – 0.153.

4. Conclusion
Based on the results of an inventory of cropping patterns based on MODIS EVI image data, in general the Province of West Sumatra experienced 3 periods of paddy cultivation season and 2 periods of harvesting season in one cropping calendar year. The beginning of the growing season in the city/district in the Province West Sumatra varies, with cropping season 1 being in October-December, cropping season 2 in March-April, and cropping season 3 in July-August.

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