Land Surface Temperature Estimation After A Decade of Aceh Tsunami (Case Study of West Aceh District of 2013 Data)

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Abstract. Thermal images of Landsat satellite can be utilized by estimating the land surface temperature. Moreover, retrieving the temperature estimation before the current event can be done using temporal analysis. Land surface temperature estimation requires Land Surface Emissivity (LSE) value through the Normalized Difference Vegetation Index (NDVI) approach. The result showed that the average land surface temperature in West Aceh District in 2013 was 26.07 °C. The result also showed that the spatial distribution of temperature spread accordingly following the transect pattern. The temperature in the coastal areas was higher than the hinterland. This phenomenon is due to high built-up in the coastal regions, whereby vegetation is dominant in the hinterland areas.

1. Introduction

The land surface temperature is defined as an average temperature, which is described in units of pixels with various surface types. Land surface temperature (LST) is also one of the primary energy balance parameters and climatological variables. Thermal infrared is the most sensitive wavelength of the surface temperature. The function of the thermal infrared band is to find the surface temperature of an object on the ground surface. The amount of land surface temperature depends on the conditions of other surface parameters, such as albedo, surface humidity, and land cover and vegetation conditions.

West Aceh Regency is one of the districts in Aceh Province, which is part of the west and south coast of the Sumatra archipelago, which stretches from west to east. According to the West Aceh Regency Bappeda, geographically West Aceh Regency is located at the position of 04° 06’ - 04° 47’ N and 95° 52’ - 96° 30’ E with an area of 2,927.95 Km². Extreme climate change can occur drastically drought and high rainfall intensity. A significant expansion of oil palm plantations by clearance of the
peatland often leads to fire and smog [1]. The peatland is becoming build up areas that will increase the surface thermal. Cultivation will increase the area of developing land from vegetated land [2]. Replacement of soil surface is necessary to absorb and to reflect more heat from the Sun. The replacement makes the instability of land surface temperature.

Therefore, the studies of the estimation of land surface temperatures are mandatory. The process of estimating land surface temperature is carried out using remote sensing data. The use of remote sensing data in the identification of land surface temperature makes it easy to produce and to identify the surface temperature with a large area, relatively inexpensive and in a short time. Remote sensing technology is utilized imagery from Landsat 8, using channel 10, which is located on the Thermal Infrared Sensor (TIRS). Landsat 8 is used for indirect studies of land surface temperatures. The specific objective is to estimate land surface temperature of West Aceh Distric of 2013.

2. Research Method
This research was conducted in West Aceh Regency, geographically located at position 04° 06' - 04° 47' N and 95° 52' - 96° 30' E with an area of 2,927.95 km², spatially the location of the study can be seen in Figure 1. Image processing of this study was carried out at the GIS (Geographical Information System) and Remote Sensing Development Center, Syiah Kuala University.

![Figure 1. Map of Study Area](image)

The method used in this study is descriptive with a quantitative approach. The descriptive method means systematically facts of analyzing and presenting data for better understanding. Whereby, quantitative approach is used to examine an object with systematic or statistical calculations that are appropriate for the purpose with the aim of testing a predetermined hypothesis.

The NDVI approach is an alternative method to achieve surface emissivity or LSE (Land Surface Emissivity) [3] to estimate the surface temperature of the land accurately. From the NDVI values, the calculation was made by vegetation proportion and LSE. Whereas in the thermal band, the calculation
process in the form of conversion from Digital Number (DN) to Spectral Radiance value. Then, the conversion of brightness temperature using SCP (Semi-Automatic Classification Plugin), which set automatically during the radiometric correction process. Furthermore, to estimate land surface temperature, a thermal band calculation is performed using the LSE value obtained in NDVI calculations [4].

\[
\text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})}
\]  \hspace{1cm} (1)

where:
- NDVI : Normalized Difference Vegetation Index
- NIR : Band 5
- RED : Band 4

There are six classes of surface temperatures in the West Aceh District based on the distribution of surface temperatures produced from processing Landsat 8 images in 2013. Then, the classes use the following statistical formula [5].

\[
\text{Interval } T = \frac{(T_{\text{max}} - T_{\text{min}})}{6}
\]  \hspace{1cm} (2)

where:
- T : Surface Temperature (°C)
- T_{\text{max}} : Maximum Surface Temperature Value (°C)
- T_{\text{min}} : Minimum Surface Temperature Value (°C)

The results describe the surface temperature is straightforward interpretation using class interval and can be useful for land surface temperature classification in West Aceh District

Table 1. Classes of Land Surface Temperature

| Class | Land Surface Temperature |
|-------|--------------------------|
| 1     | < 16°C                   |
| 2     | 17 - 20°C                |
| 3     | 21 - 24°C                |
| 4     | 25 - 28°C                |
| 5     | 29 - 32°C                |
| 6     | > 33°C                   |
3. Results and Discussion
3.1. Land Surface Temperature
Land surface temperature in 2013 was obtained from the processing of Landsat 8 satellite imagery on 24 August 2013 and 30 June 2013. Classification of land surface temperature in the West Aceh Regency can be seen in Table 2.
The table above explains that in 2013 the lowest land surface temperature obtained, <16 °C, covered a small area and was concentrated in the eastern part of 85.75 Ha with a percentage of area coverage of 0.03%. The second-lowest land surface temperature is 17-20 °C in an area of 2,284.98 Ha with an area of 0.83%. The northern region is Sungai Mas District and Pantai Ceuremen District, with surface temperatures between 21-24 °C of 24.17%, covering 66,853.95 Ha. Most of the land cover is forest and is in the highlands. This area increases from the previous area with lower temperatures; this shows that there are many land conversions in the District of West Aceh. An increase in the land surface temperature of 25-28 °C affected an area of about 179,091.63 Ha found in all sub-districts in West Aceh District and covered 64.75% of the total area. The western region with a land surface temperature of 29 - 32 °C includes 8.74% spread over several districts, namely Johan Pahlawan Sub-District, Meureubo Sub-District, Samatiga Sub-District, Arongan Lambalek Sub-District, Woyla Sub-District, West Woyla Sub-District, East Woyla Sub-District, and Bubon Sub-District with an area of 24,161.57 Ha. Land surface temperature > 33% includes 1.48% with the concentration of the area in the Johan Pahlawan sub-district, which is the center of Meulaboh City, Saratoga District, Woyla District, and Arongan Lambalek District. Urban areas show surface temperatures that are hotter than industrial areas, vegetated areas, and cooler than irrigated agriculture [6].

### 3.2. Spread Land Surface Temperature Distribution Pattern

The results of land surface temperature estimation with a pink hue indicate the condition of land with an open area. Vegetation reduction causes the temperature of the land surface to become hotter. It reaches a maximum temperature of 38.13 °C. So the appearance of land use that shows a high level of land surface temperature is in areas with open land [7] with a combination of RGB bands 7-5-3 as shown in figure 3.
The average land surface temperature obtained is 26.07 °C with an air humidity of around 88.5%. The estimated land surface temperature in 2013 can be seen in figure 4.

**Figure 3.** Maximum Temperature of Baren Land

Landsat 8 imagery data used in June and August are included in the east monsoon climate period.
(May - October), which is a period of reduced rainfall so that it experiences drought. Landsat images acquired in the dry months have a cloud cover of less than 10%, making it easier to analyze. The visual results from the Google Earth search, which can be seen in Figure 5., show that the area of open land in 2013 was mostly prepared for oil palm plantations. The area of open land is estimated to be around 9,377.95 Ha.

![Google Earth Search Results](image)

**Figure 5. Google Earth Search Results**

Open land that has a high land surface temperature is caused by the absence of vegetation that covers the land. The transfer of land functions into mining land, oil palm plantations is one of the causes. The change from forests to oil palm is also driven by changes in forests to open areas [8]. The process of land degradation as a result of conversion to oil palm plantations, it will be vulnerable to fire disasters [9].

![Graph of percentage of land surface temperature distribution in 2013 of West Aceh District](image)

**Figure 6. Graph of percentage of land surface temperature distribution in 2013 of West Aceh District**
Distribution patterns of land surface temperature Distribution patterns of transects with areas that have vegetation in the form of forests are still in the Northern part of West Aceh District and still have lower temperatures, which is between (21-24)°C. The elongated pattern with a surface temperature between (25-28)°C still dominates most of the West Aceh Regency from the West to the North, which is from the coast to the areas with land cover. The elongated pattern consists of paddy fields and oil palm plantations. The specific pattern of distribution of surface soil temperature is closely related to the thermal characteristics of land cover classes [10].

4. Conclusion
This paper concluded that the dominant land surface temperature of 25-28 °C covered 179,091.63 Ha or 64.75% in 10 years after the tsunami in West Aceh District. The pattern of spread transect shows the average temperature obtained by 26.07° C.

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