Effect of Emission Value for Land Surface Temperature on Landsat Image 7 ETM+

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Abstract. This research aims to know the impact of land surface temperature value with the use of emissions or not. Emission is essential because emissions become decisive as a result of land surface temperatures. The method used is processing Landsat 7 ETM+ imagery with radiometric and atmospheric correction and combining it with the maximum likelihood of getting land cover. The classification of land cover is essential because that reflects the emission value. The results showed that land surface temperature with emission has more near with conditions in the field than land surface temperature without emission. The most significant difference in land surface temperature in land cover is seven degrees Kelvin (7^oK), and the lowest is one degree Kelvin (1^oK). The analysis concluded that the use of emissions in Landsat 7 ETM+ imagery is necessary and must be done to get the land surface temperature value.

Keywords: Landsat 7 ETM+; LST; Emission

1 Introduction

The Land Surface Temperature (LST) has been used several variables in specific analyses such as; drought, urban heat island, and forest fires [1]–[4]. The acquisition of information related to surface temperature is made manually with temperature measurement, and it has a deficiency when the area to be monitored is extensive. Therefore, the utilization of remote sensing imagery in obtaining information related to surface temperature continues to increase for other research. Landsat image is one of the images that can provide information related to land surface temperature with its thermal bands [5]–[7].

Landsat development now on Landsat 8 OLI/TIRS and Landsat 7 ETM+, which are still used for land surface temperature information. Landsat 8 OLI/TIR developed split windows algorithm method that combines two thermal bands, band 10, and band 11 [8]–[12]. Different on Landsat 7 ETM+ has two similar thermal bands, but land surface temperature information uses band 6 high gain. The selection of the band 6 high gain was influenced by the use of emissions, which is the conversion value to determine the object's land surface temperature. The value of emissions has a difference to land cover so that it is based on the value of certain types of land cover that do not have a specific emission value and follow similar emission values [6], [13], [14]. Landsat 7 ETM+ requires identification related to emissions because the formulas and algorithms used based on the Handbook Landsat 7 ETM+ [7] differ from the algorithms that have been done by several studies [15]. In contrast, Landsat 8 OLI/TIRS has a more stable

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method of obtaining surface temperature information because it uses two thermal bands [16]–[20].

This research is fundamental because the land surface temperature has many applied for other analyses. Therefore, this research's objective is to know how much influence of emissions on land surface temperature processing in Landsat 7 ETM+ imagery. Besides, this research is expected to provide a role as a consideration for the acquisition of land surface temperature information.

2 Methodology

Study Area

Purworejo regency is one of the districts in Central Java Province, located between 109 o 47'28" to 110 o 8'20" East Longitude and between 7° 32" to 7° 54" South Latitude. The north of Purworejo regency borders Wonosobo and Magelang Regency, and the south borders the Indonesian Ocean. The west is bordered by Kebumen Regency, and the east borders the area of the Special Region of Yogyakarta, precisely Kulonprogo Regency. Purworejo regency is still much-having farmland that varies from plantations and rice fields with quite varied topographic conditions in the form of coastal areas, lowlands, to mountains so that it can have different levels of soil moisture – different as in areas of land where there are various kinds of land cover will provide different surface soil moisture [21], [22].

Remote Sensing Data

Landsat 7 ETM+ imagery can be obtained for free on the official website by USGS http://usgs.gov/. Landsat 7 ETM+ was processing with pre-processing such as; Correction Radiometric and Atmospheric, then cropping data for all band except band 8. The radiometric correction process is carried out by changing the pixel value to the radian and reflectance values. Meanwhile, the atmospheric correction process uses the Dark Pixel Subtraction (DOS) method developed by Chaves [23].

This research uses primary data, which is the leading data that is Landsat 7 ETM+ imagery. The research stage is shown in Figure 1.

Brightness Temperature

Landsat 7 ETM+ image processing using a band 6 high gain. The radiometric correction process used is radian correction developed by USGS [7] as in Equation (1).

$$L\lambda = \frac{L\,Max - L\,Min}{(QCAL\,Max - QCAL\,Min)} x\,(\mathrm{QCAL} - \mathrm{QCAL\ Min}) + \mathrm{L\ Min} \quad \text{.....(1)}$$

Where Lmax and Lmin can be obtained from Table 1; QcalMax is spectral value Landsat 7 ETM+; QcalMin is Zero (0). Brightness temperature band 6 data processing using Equation (2) developed by USGS (2010). The K1 and K2 values are calibration constants obtained from the Landsat 7 ETM+ image handbook; Lλ is the radiance value of Landsat 7 ETM+.

$$\mathrm{Trad} = K_2 / \ln[(K_1/L\lambda)+1] \quad \text{.....(2)}$$

Brightness temperature has a land surface temperature value, but it is not a temperature object because that value is not radiance temperature, just kinetic temperature [13]. Some research uses this algorithm to get land surface temperature value and uses it for its final temperature.

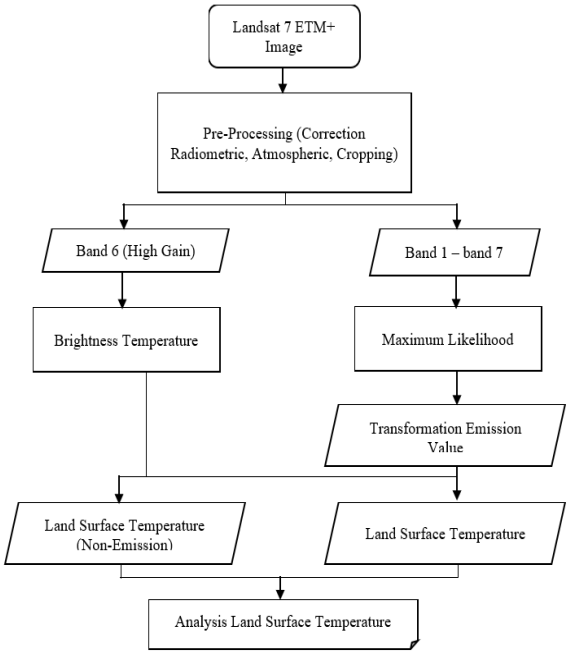

Fig. 1. Research Flowchart

Table 1. Spectrum Radiance ETM+

Number Band	LOW GAIN		HIGH GAIN	
	L MIN	L MAX	L MIN	L MAX
1	-6,2	293,7	-6,2	191,6
2	-6,4	300,9	-6,4	196,5
3	-5,0	234,4	-5,0	152,9
4	-5,1	241,1	-5,1	157,4
5	-1,0	47,57	-1,0	31,06
6	0,0	17,04	3,2	12,65
7	0,4	16,54	0,4	10,80
8	-4,7	243,1	-4,7	158,3

Source: [7]

Maximum Likelihood

Landsat 7 ETM+ image processing for image classification using the maximum likelihood method is a supervised category. This method has excellent accuracy to get the land cover classification [24]. Land-use is used for determining the emission value shown in Table 2. Meanwhile, the change land-use to emission value using ENVI application to have an emission image.

Table 2. Type of Land-Use with Emission

No	LandUse	Emission
1	Built-up	0.97
2	Built-up with Vegetation	0.96
3	High Vegetation	0.99
4	Moderate Vegetation	0.96
5	Low Vegetation	0.96
6	No Vegetation	0.92
7	Wet Soil	0.95
8	Dry Soil	0.92
9	Body of Water	0.98

Source: Processing Data (2011)

Land Surface Temperature (LST)

The processing surface temperature method uses the emission value developed by Curran [13] as in Equation (3). The value of ε is the emission value, and Tkin is the value of the brightness temperature Landsat 7 ETM+ band 6. The difference in the value of land surface temperature between kinetic temperature and radiance temperature is one degree (1^{o}) [25].

$$Trad = \epsilon^{1/4}. Tkin \quad (3)$$

4 Result and Discussion

Analysis of land surface temperature between brightness temperature and the land surface temperature has a significant difference value (Table 3). The difference value for land surface temperature is very high on seven degrees and very low on one degree. The brightness temperature always increases the value of temperature from land surface temperature and proves the theory about radiance temperature and kinetic temperature [13]. Cause the difference value of temperature from the processing of Landsat 7 ETM+ uses pixel as object analysis and uses the measurement of object reality such as; vegetation, soil, rooftop, and water. Also, the survey for measurement temperature must be the same time as the Landsat 7 ETM+ image take a record. This condition is essential because of the temperature changes with the sun's condition, especially weather and its application for all land surface temperature [12]. Land cover is not

affected by emission values because the high emission value and low emission value get the same difference temperature value is seven degrees (7°). Meanwhile, one class in land cover always has a different temperature that causes the field's condition.

Table 3. The difference in Surface Temperature to Emission Value

No		Land Cover	Emission Value	Land Surface Temperature (Kelvin)/ Emission	Brightness Temperature (Kelvin)Non-Emission	Difference
Class of Landcover	Sort					
1	1	Built-up	0.97	295	301	6
	2	Built-up	0.97	303	306	3
	3	Built-up	0.97	301	307	6
	4	Built-up	0.97	295	302	7
2	5	Built-up with Vegetation	0.96	299	301	2
	6	Built-up with Vegetation	0.96	296	300	4
	7	Built-up with Vegetation	0.96	298	301	3
	8	Built-up with Vegetation	0.96	298	300	2
	9	Built-up with Vegetation	0.96	299	302	3
3	10	Moderate Vegetation	0.96	297	299	2
	11	Moderate Vegetation	0.96	295	301	6
	12	Moderate Vegetation	0.96	297	300	3
4	13	Low Vegetation	0.96	302	305	3
	14	Low Vegetation	0.96	298	301	3
	15	Low Vegetation	0.96	298	301	3
5	16	No Vegetation	0.92	302	304	2
	17	No Vegetation	0.92	298	302	4
	18	No Vegetation	0.92	299	302	3
	19	No Vegetation	0.92	295	302	7
6	20	Wet Soil	0.95	295	301	6
	21	Wet Soil	0.95	296	300	4
	22	Wet Soil	0.95	299	300	1
7	23	Dry Soil	0.92	306	308	2
	24	Dry Soil	0.92	305	306	1
	25	Dry Soil	0.92	307	308	1

8	26	High Vegetation	0.99	298	301	3
	27	High Vegetation	0.99	297	300	3
	28	High Vegetation	0.99	293	299	6
9	29	Body of Water	0.98	298	300	2
	30	Body of Water	0.98	298	300	2

Source: Processing Data, 2015.

The result of land surface temperature is proving; one land cover has a different value of temperature. Built-up and no vegetation has a high temperature than another land cover. The built-up has a high temperature because density of settlement made land surface temperature increase, which could make urban heat island in the future [2]. While other land covers such as; vegetation make temperature decrease because the healthy vegetation with their density always reflects the sun's energy. This condition different from water. It absorbs the energy of the sun and cannot reflect directly. This condition can know the spread of land surface temperature on the field (Fig.2) influence of emission.

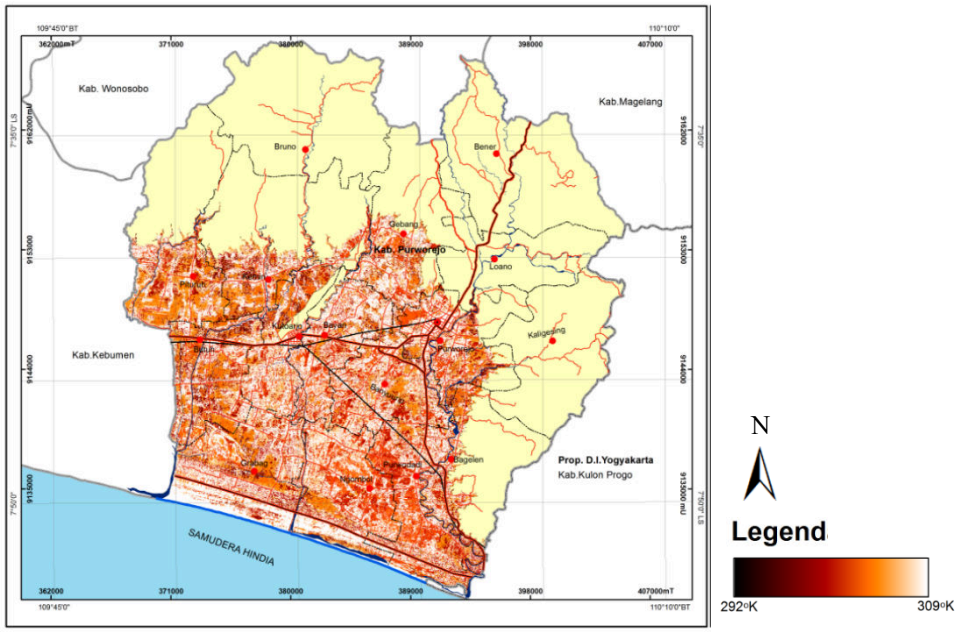

Fig. 2. The Result of Land Surface Temperature with Emission Value

Emission proof is essential to extraction information for land surface temperature, especially for Landsat image or other thermal band images. The calculated emission has several methods. Tursilowati et al. [15] using emission from vegetation index and give the result approaching the condition of the field for extraction land surface temperature. The method for calculating emission need more research to know the impact of land surface temperature. Therefore, land surface temperature without emission is not the real temperature object and cannot be used for anything analysis because increasing the temperature and anomaly.

5 Conclusion

Land Surface Temperature (LST) with emission and LST without emission has a high difference for one class in land cover. This class indicates that land surface temperature processing must use the emission value because it is near the field's land surface temperature. Emission proves LST needs this value to extraction temperature, although it can be obtained from land cover or another method. The difference of temperature values affected by comparing analysis where Landsat using pixel and measurement using a real object. Further study, especially on emissions extraction, to be compared with other methods for calculating emission. These impact value emissions are significant because studies on land surface temperatures always focus, and many applied to use.

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