STUDY OF LAND SURFACE TEMPERATURE USING REMOTE SENSING SATELLITE IMAGERY IN MAKASSAR, SOUTH SULAWESI

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Abstract

This research is aimed to know (1) Spatial pattern of land surface temperature, (2) Relationship between land surface temperature with cover terrain, and (3) Relationship between land surface temperature and the vegetation density of Makassar City in 1999, 2010 and 2015. This research using Landsat imagery data ETM+ and LDCM Landsat covered Makassar City. Variable of this research is land surface temperature from band thermal LWIR, land cover obtained by guidance classification use (maximum likelihood algorithm), and vegetation density that is obtained from result processing of Landsat band NIR and Visible Red in 1999, 2010 and 2015. Analysis results at this research show that (1) Spatial temperature land surface temperature of Makassar City be spread evenly but more dominant at the south part (2) Correlation of Land Surface Temperature and NDVI vegetation density indicate reverse relationship, which mean is the higher vegetation density so the lower surface temperature in Makassar City. (3) The highest surface temperature in Makassar City occurred on 2015 with 36,68°C in average tend to concentrate at central city with terrain cover is built areal.

Keywords : Land Surface Temperature, Land Cover, NDVI, Landsat Imagery, Makassar City

Preliminary

An increasing community in an urban or rural area can essentially be attributed to two things, namely the natural growth of the urban population and the increasing migration of permanent urban population (urbanization). The high land demand in urban and rural areas but the availability of land is limited enough to make land use available for high economic value. The demands for the fulfillment of the needs of urban population in number and increasingly diverse can also lead to increased activities of the community that is explorative and destructive (negative). These activities will result in reduced green open space in the area and decreased comfort of community (Triyanti, 2008). Reduced green open space in urban areas will impact on changes in land surface temperature.

Changes in surface air temperature in small or regional spatial scales show different characteristics. Earth's surface air temperature is determined by the amount of solar radiation that reaches the earth's surface. Solar radiation is transferred to the surface of the earth in the form of long waves. The amount of solar radiation that reaches the surface of the earth is affected by the cloud cover. Distribution of Earth's surface air temperature is strongly influenced by the location of latitude, the difference between land and sea, altitude and wind.

Land surface temperature is one of the key energetic equilibrium parameters on the surface and is a major climatological variable. Land surface temperature data are often required as input data in evapotranspiration calculation models, air humidity, soil moisture, and energy balance. The data can be obtained from the weather station but not all weather stations have a surface temperature gauge. (Inscription & et al, 2007). Data on the land surface temperature becomes a research data in the case study.

Studies on land surface temperature can be analyzed by Remote Sensing. The remote sensing satellite imagery facilitates the need for a study of terrestrial surface temperatures with thermal infrared channel technology capable of recording spectral values to identify temperatures. Satellite imagery that facilitate these needs Landsat. The land surface temperature can be defined as the mean surface temperature of a surface depicted in the scope of a pixel with different surface types (Faridah & Krisbiantoro, 2014).

Basically the estimated surface temperature using satellite imagery utilizes the concept of electro magnetic field wave emission that has uniqueness based on surface temperature. Objects with different temperatures will emit maximum electro magnetic waves in different wavelength ranges. However, in pixel scale in satellite imagery, the heterogeneity of the emitted wavelength of magnetic electrons, as well as due to variations in temperature, this heterogeneity is also due to surface moisture and vegetation land closure. The sources of data variations that can not be incorporated into the model caused by those things can be corrected by compiling the emission results obtained by using the NDVI (Normalized Difference Vegetation Index). The area to be estimated by surface temperature using satellite landsat imagery is Makassar City.

PROBLEMS

Based on the background, the problem in this research are as follows:

1. What is the spatial pattern of land surface temperature of Makassar in 1999, 2010 and 2015?
2. What is the relationship or correlation between the land surface temperature and land cover of Makassar City in 1999, 2010 and 2015?
3. What is the relationship or correlation between land surface temperature and vegetation density of Makassar in 1999, 2010 and 2015?

RESEARCH METHODS

The research was conducted in January-May 2016. The location of research observation that is Makassar City which is in South Sulawesi Indonesia. Determination of sample in this research by using purposive sampling technique. Determination of representative sample by considering the development of residential and industrial area, population growth, also construction of transportation facility and infrastructure, and also available data.

DATA PROCESSING

1. Radiometric Correction, Error or radiometric defects are errors in the form of shifting values or gray degree of image elements (pixels) in the imagery (Purwadhi, 2001).
2. Geometric correction, Satellite orbit is very high and field of view is small, geometric distortion occurs. Based on the source, distortion or geometric error can be grouped into two types of internal faults and external faults (Purwadhi, 2001).
3. Imagery data must be corrected geometrically to the coordinate system of the earth, so that all imagery data information has been in accordance with its existence on earth.
4. Land cover extraction from both Landsat 7 ETM + and Landsat 8 LDCM images done using classification method is supervised classification with maximum likelihood algorithm. The classification of land cover is divided into 5 (five) classes for Makassar City based on the Indonesian National Standard (SNI) classification in 2010. The verification by comparing the field survey results, and the higher resolution Geo Eye image and Google Earth.
5. NDVI processing generated from Landsat 7 ETM + satellite images using channel 3 and channel 4, while Landsat 8 LDCM using channels 4 and 5 with the formula:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

where:
NDVI = *Normalized difference vegetation index*
NIR = *Near infrared reflectance* (Band 4)
RED = *Red reflectance* (Band 3).

6. Surface temperature obtained from the calculation of satellite brightness (brightness value). In this method, the water content in the atmosphere is assumed to be constant for a small region. So that atmospheric conditions can be disrupted and can be modified (Chen et al 2005).

   a. Intake of surface temperature values from Landsat Imagery 7 (ETM +).
      Landsat 7 has 2 thermal bands namely band 6 low gain and band 6 high gain. Band 6 low gain is analyzed with reference to the formula set by Landsat 7 User's Handbook. First, the digital number (DN) band 6 is converted to Radian value (Lλ) with the following formula:

Radians (Lλ) = gain*DN + offset

Which can be expressed to be:

$$\textbf{Radians } (\mathbf{L\lambda}) = \frac{\text{LMAX - LMIN}}{\text{QCALMMAX - QCALMIN}} \text{X(QCAL - QCALMIN) + LMIN}$$

where:
QCALMIN = 1
QCALMAX = 255
QCAL = DN.

LMAX and LMIN are the spectral radiance of band 6 on digital number 1 up to 255 (obtained from header imagery file). Then the satellite brightness value can be taken from the above spectral radiance value by the following equation:

$$\mathrm{T} = \frac{K2}{(In(K1/L\lambda + 1}$$

where:
T = Surface temperature (oK)
K1 = The calibration constant of 1 (watt / m^3 μm) is 666,09
K2 = The calibration constant of 2 (watts / m^3 μm) is 1282,71
Lλ = Radiation or spectral radiance (watts / m^3 μm)

Temperature in units of degrees Kelvin is then converted into units of degrees Celsius with the formula:

Temperature Celcius = Kelvin Temperature - 273.15

b. The surface temperature rating of Landsat 8 (LDCM)
The initial stage is to perform radiometric calibration of the imagery of the band 10 and band 11. Surface temperature value is calculated from spectral radian image value, therefore imagery band 10 and band 11 must be calibrated into spectral radian with the following formula:

$$L\lambda = MP \times Qcal + AL$$

where:
MP = Factor scale
AL = Added Factor
Qcal = Digital Number.

The next step is to calculate the temperature value in Kelvin:

$$T = \frac{K2}{(In(K1/CV_{R2} + 1}$$

where:
T = Temperature (Kelvin)
CVR2 = Radiance value on thermal band
K1 and K2 = Calibration Constants (determination)

The next step is to convert a temperature value that is still in Kelvin units into Celsius units. The formula is as follows:

Temperatur Celcius = Temperatur Kelvin -272.15

Data analysis technique

The data will be analyzed by qualitatively and quantitatively. Qualitative analysis was performed with the spatial approach (spatial) and ecological approach. Spatial approaches are location differences about important properties or series of important properties, while the ecological approach is the interaction between human and environmental variables to be studied in relation (Bintarto and Hadisumarno, 1991). Analyzing the spatial pattern of surface temperature and the difference is used spatial approach. Analyze the relationship between surface temperature with land cover, and vegetation density. Quantitative analysis is also conducted in the form of statistical calculations. Statistical analysis is used to determine the strength and form of influence between variables tested.

Flowchart of Research

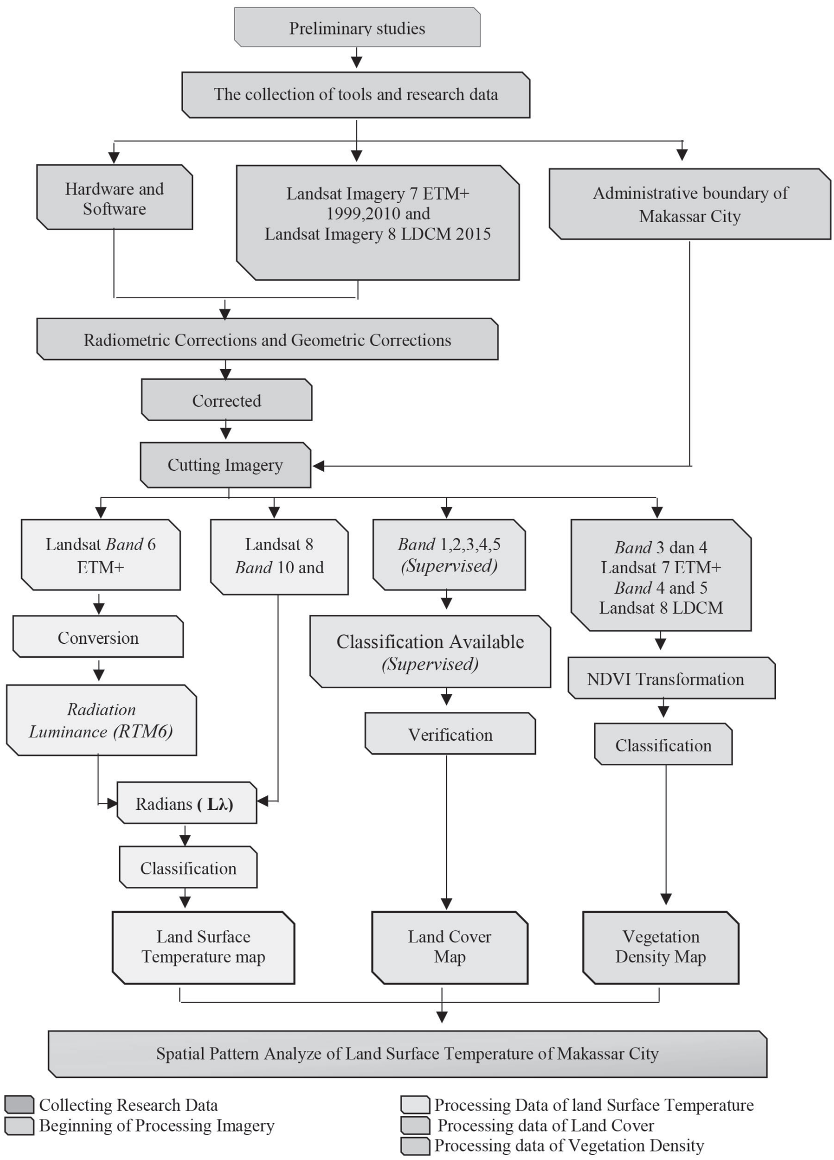


Figure 1. Flowchart of research

Land Cover of Makassar City in 1999, 2010 and 2015

Table 1. Land Cover of Makassar city in 1999, 2010, and 2015

Land Cover Area	Area (km2)		
	1999	2010	2015
Built Area	73,74	84,57	92,26
Shrubs	20,76	11,9	15,56
Rice field	28,45	17,13	20,88
Open Land	27,73	40,03	33,68
Inland Waters	23,85	20,89	12,14

Based on the results of the classification of land cover of Makassar City from Landsat imagery in 1999, 2010 and 2015, the division of land cover of Makassar city are built areas, shrubs, rice fields, open land, and inland waters. The most dominating land for Makassar City is the built area Which has been increasing every year. It is causing a reduction in land cover became a built area which was previously a shrub, rice fields, open land and inland waters. This is due to the increase in population and activity. The last 5 years recorded 2010 to 2015 song population growth reached 4.89%.

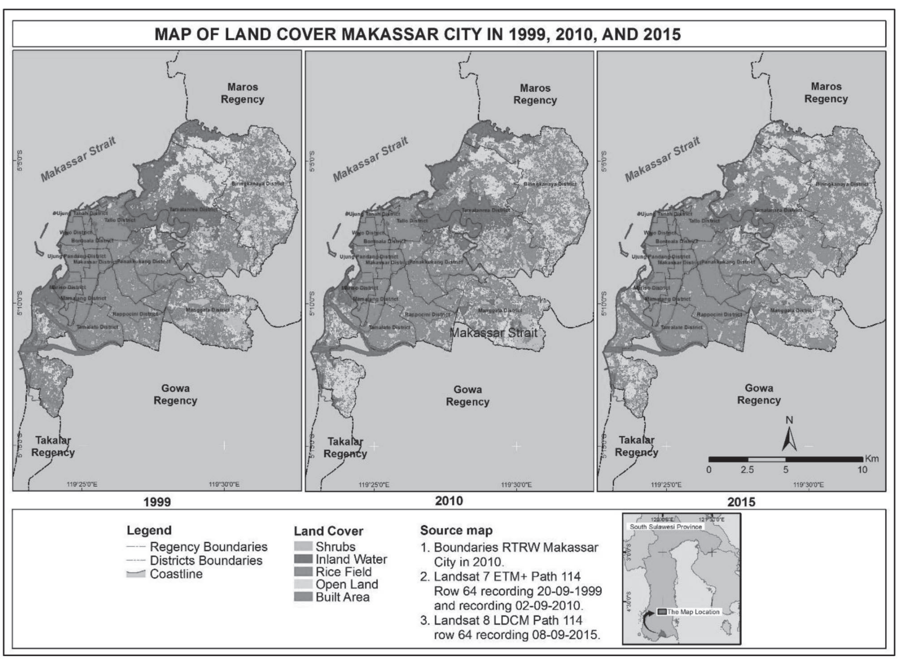


Figure 2. Map of Land Cover Makassar City in 1999, 2010, and 2015

Vegetation Density of Makassar City 1999, 2010 and 2015

Based on the calculations in the three years, the average value of NDVI indicates the minus (-) which indicates that Makassar City rarely found vegetation with high density. High vegetation density can be found in the central part of Panakukang Sub-district east of manggala sub-district. For example, in the middle of the area there are mangroves and swamps of the river tello on the east and also there are rice fields and shrubs on empty land. Low vegetation density of almost all Makassar and non-vegetation areas is located in the western part to the north of Makassar. For example, in urban centers dominated by buildings and the northern part is dominated by inland waters and ponds.

Table 2. Vegetation Density of Makassar City in 1999, 2010, and 2015

Vegetation Density	Area (km2)		
	1999	2010	2015
High Vegetation	24,57	23,53	18,63
Medium Vegetation	55,35	53,74	49,42
Low Vegetation	63,6	69,51	64,53
Non Vegetation	31,02	27,73	41,93

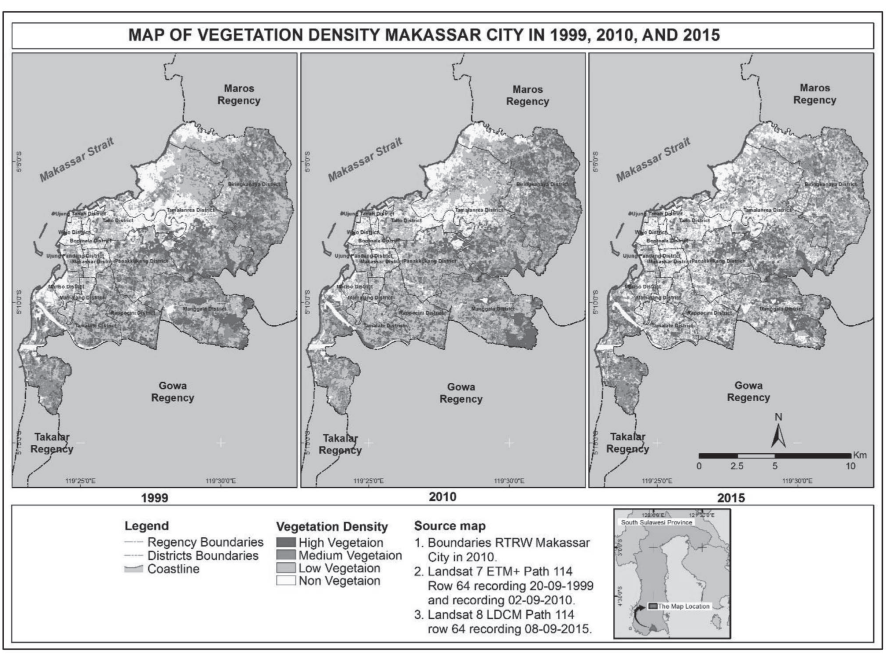


Figure 3. Map of Vegetation Density Makassar City in 1999, 2010, and 2015

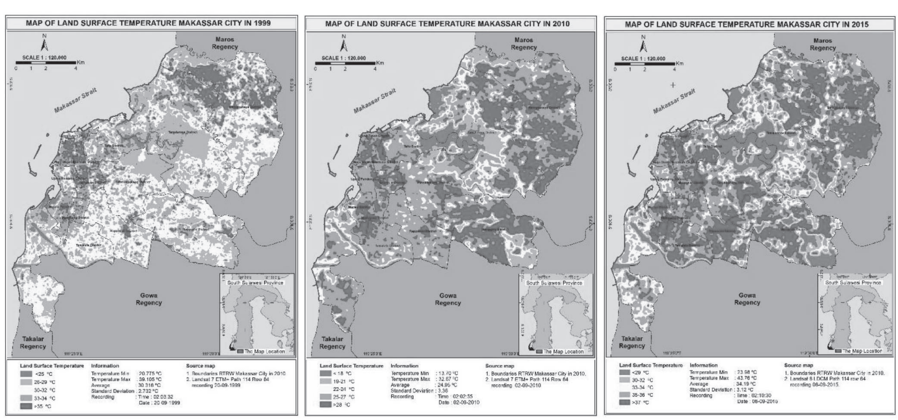
Spatial Patterns of land Surface Temperature Makassar City in 1999, 2010 and 2015

Table 3. Land Surface Temperature of Makassar City in 1999, 2010, and 2015.

Land Surface Temparature	1999 (oC)	2010 (oC)	2015 (oC)
Minimum	20,77	13,70	23,98
Maximum	39,10	32,67	43,76
Average	30,31	24,95	34,19

Based on the results of imagery processing can be known that the land surface temperature of Makassar City in 1999, 2010, and 2015 tends to be higher. This is caused by the sun radians reaches the surface of the earth that receives radiation depending on the shape and kind of surface of the earth that received radiation. The kind of buildings such as roof or asphalt is one of the factors that cause the occurrence of reflexifitation so that the air become hotter. In accordance with the Rosmini Maru analysis (2015) Trends analysis of Urban Heat Island phenomenon using Landsat The results of the study in May and July show the presence of hot islands in urban areas as a result of the lack of tree cover associated with newly developed housing environments, parking spaces, Apartment complexes and shopping centers, and data processing for the land cover area of Makassar City's built area is wider percentage.

The land surface temperature of Makassar City in 2010 tends to be lower than in 1999 and 2015, based on predictions by the Meteorology Climatology and Geophysics Agency (BMKG) and a number of world weather monitoring institutions such as NOAA (USA), BOM (Australia), Jamstec Japan) indicates a negative sea surface temperature anomaly. On August to September 2010 predicted a moderate La Nina phenomenon, while in October 2010 to January 2011 will occur a strong La Nina phenomenon (Daryono, 2010)



(a) (b) (c)

Figure 4. Map of Land Surface Temperature Makassar City in (a)1999, (b) 2010, and (c) 2015

Relationship between Land Surface Temperatures and Land Cover of Makassar City in 1999, 2010 and 2015

Based on the results of data processing presented as land cover map and land surface temperature map for the Makassar City can be seen that the highest temperature region class 5. It highly associated with land cover of built and open land. The lowest temperature regions of grade 1 and 2 can be found in land cover of inland waters. Shrubs and rice fields are generally located in class 3 and grade 4 temperatures. For more detail can be seen on the correlation graph between the land cover with the land surface temperature.

Land cover also affects the value of albedo. Albedo is a quantity that describes the comparison between sunlight that arrives at the surface of the earth and which is reflected back into space with an outgoing longwave radiation. In general, albedo is associated with local climate change. An analysis of land use or land cover is needed to determine the extent to which temperature changes occur which will result in local climate change to know the extent of the temperature changes that will occur Will result in local climate change.

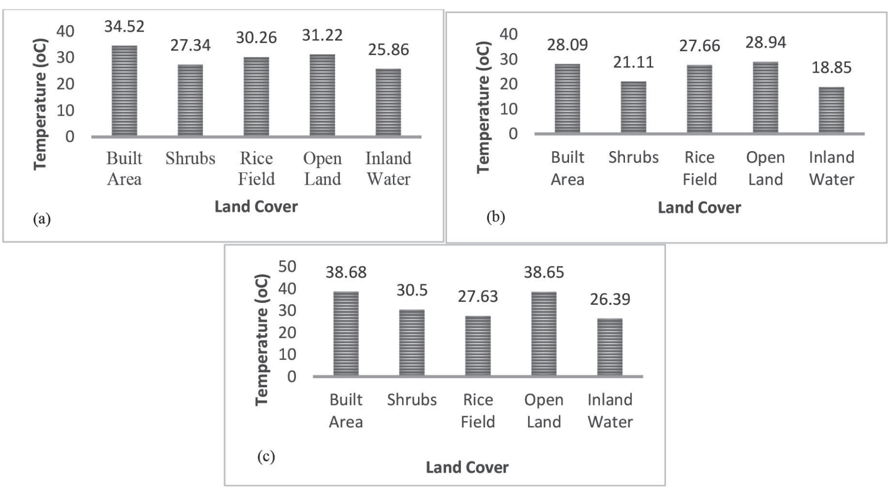


Figure 5. Graph of Relation Between Land Surface Temperature and Land Cover of Makassar City in (a) 1999, (b) 2010 and (c) 2015.

Relationship Between land Surface Temperatures and Vegetation Density of Makassar City in 1999, 2010 and 2015

Based on the calculation results by using the trust rate of 99% obtained r value of Makassar City r = -0.641 for 1999, r = -0.647 for in 2010, and r = -0.721 in 2015. Thus, the results show That the value of vegetation density with terrestrial surface temperature has a strong correlation in Makassar City. A spatial (qualitative) analysis by comparing the NDVI vegetation density map with respect to the LST map in 1999, 2010 and 2015, found that the spatial pattern of surface temperature of the land spatial pattern of vegetation density showed a pattern not much different each year. Vegetation density and land surface temperatures have negative correlation. It means, the higher the NDVI value so the lower the land surface temperature.

CONCLUSION

1. Land Surface temperatures of Makassar City in 1999, 2010 and 2015 increased with spatial patterns relative to urban, industrial and residential areas,
2. The most changing land cover are in Makassar City and increasing in 1999, 2010, and 2015 are built Area and open land
3. There is a relationship between land cover change and surface air temperature, characterized by similar patterns of land cover change and changes in spatial distribution of surface air temperature.
4. The surface temperature of the land is strongly correlated (negative) with vegetation density. The higher the surface temperature so the lower the vegetation density.
5. The existence of cases of non-built areas accompanied by high temperatures, possibly caused by other sources of heat in the area so that further analysis of land use land use is needed to determine the extent of temperature changes that occur and result in local climate change.

BIBLIOGRAPHY

Bintarto, R. & Hadisumarno. (1991) .Method of Geography Analysis. 4.th Jakarta Print: LP3ES.

Daryono. 2010. Rain In The Dry Season The Impact of La Nina. August 8, 2016. 15:20. Www.bmkg.go.id.

Chen, X., Zhao H., Li. P., & Yin Z. (2005). Remote Sensing Image-Based Analysis of the Relationship Between Urban Heat Island and LandUse / Land Cover Changes, Remote Sensing of Environment, 104,133-146.

Erna Sri Adiningsih, Hartati Soenarmo, S.Mujiningsih.2010. Study of Spatial Distribution of Air Temperature Due to Change of Land Coverage of Bandung basin case study. Field of Monitoring of Natural Resources and Environment, Pusjafta -LAPAN

Fadholi, Akhmad. 2013. Test for Change of Air Temperature and Rainfall Temperature in Pangkalpinang City. Pangkalpinang: Pangkalpinang Meteorological Station, Journal of Mathematics, Science and Technology. Vol.14 No.1 Hal: 11-25.

Faridah and Krisbiantoro. 2007. Mapping of Surface Temperature Distribution of Land Use Using ASTER Satellite Imagery in Sleman Regency 2007. Yogyakarta

Ilham Guntara. 2015. Utilization of Landsat Image 8 To Estimate Land Surface Temperature In Bantul District Using Split Window Algorithm. Remote sensing diploma program and geographic information system University of gadjah mada, Yogyakarta

Ilham Guntara. 2015. Utilization of Landsat Image 8 To Estimate Land Surface Temperature In Bantul District Using Split Window Algorithm. Remote sensing diploma program and geographic information system University of gadjah mada, Yogyakarta

Maru Rosmini., Ichsan Invanni., Baharuddin., Sulayman Zhiddiq, Amal Arfan, and Bayudin. 2015. Trend Analysis of Urban Heat Island Phenomenon in the City of Makassar, South Sulawesi, Indonesia using Landsat. Department of Geography, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Indonesia Purwadhi FSH. 2001. Digital Image Interpretation. Jakarta: Gramedia Widiasarana Indonesia.

Prahasta, E. 2001. Basic Concepts of Geographic Information Systems. Bandung: Informatics Publisher.

Purwadhi FSH. 2001. Digital Image Interpretation. Jakarta: Gramedia Widiasarana Indonesia.

Triyanti. 2008. Surface Temperature Pattern of Semarang City in 2001 and 2006. Bachelor Degree of Geography Department, Faculty of Mathematics and Natural Sciences, University of Indonesia.

Weng, Q., L. Dengsheng, and S. Jacquelyn. 2003. Estimation of Land Surface Temeperatur Vegetation Abundance Relationship for Urban Heat Islan Studies. International Journal of Remote Sensing of Environtment. 89, pp467-483