Relationship analysis of environmental factor change on the evidence of dengue fever diseases using image transformation (Case Study: Surakarta City)

Prima Widayani[1], Risky Yanuar S[1,*], Aulia Yogi H[1]

[1]Departement of Geography Information Science, Universitas Gadjah Mada, Sleman, Special Region of Yogyakarta, 55281, Indonesia

risky.yanuar@gmail.com

Abstract. Environmental factors change such as built-up area density, vegetation density, moisture and temperature can affect the health problems. Dengue Fever Disease (DFD) that are still high rates of incidence because of environmental factors change in Indonesia including Surakarta City. The purpose of this study are mapping environmental factors consisting of built-up area density, vegetation density, land surface moisture (LSM) and land surface temperature (LST) in Surakarta City 2002 and 2015 through image transformation and correlation analysis of environmental factors change on the evidence of DFD in Surakarta City. This research uses Landsat-7 ETM+, Landsat-8 OLI/TIRS and the evidence of DFD data on 2002 and 2015. Landsat image is processed by using LST, VGNIR-BI to be built-up area density, NDVI for vegetation density, NDMI for LSM. Based on the result of image transformation, built-up area density and LST in Surakarta City increased from 2002-2015, while vegetation density and LSM tended to decrease. The result of this research shows that the environmental factor change in the form of built-up area density, vegetation cover density, LSM and LST have correlation are 74%, 68%, 75% and 69% of the evidence of DFD in Surakarta, respectively. Overall, the environmental factors correlated 86.1% of the evidence of DFD in Surakarta City.

1. Introduction

Utilization of sustainable natural resources increase in line with the rate of development for the fulfillment of human needs. The environment continues to change, such as the change from bare or vegetated land to built-up [1]. These changes of environment factor also have an impact on changes in climate components such as land surface temperature (LST) and land surface moisture (LSM) [2]. On the other hand, the emergence of various types of diseases that attack humans with increasing number of cases into a separate question, that there is a correlation of environmental factors changes with increasing incidence of disease [3].

One of the disease that still be a problem is Dengue Fever Disease (DFD). The disease is caused by the bite of *Aedes aegipty* mosquito that carries dengue virus and cause death if the patient doesn't get the right treatment immediately. Ministry of Health Indonesia recorded the number cases of DFD in Indonesia from January to February 2016 as many as 8487 people with the number of deaths are 108 people. The case of DFD is closely related to environmental factors [4]. It is necessary to examine whether changes in environmental factors have an effect on the development of DFD. Research on the

IOP Conf. Series: Earth and Environmental Science **169** (2018) 012061 doi:10.1088/1755-1315/169/1/012061

effect of changing environmental factors in this case is represented by built-up area, vegetation, LSM and LST with the occurrence of DFD conducted in Surakarta City. Surakarta City has DFD cases increased sharply in 2016. Until the end of October there have been DFD's 462 cases.

Environmental factors change monitoring needs to be control and there are new technologies that can accelerate environmental factors change monitoring such as remote sensing technology [5]. One of the imagery processing methods that can be used to identify objects is image transformation. Image transformation is an algorithm involving multiple bands in the image used to sharpen the appearance of one objects in the surface. The transformation to shows the vegetation object called the vegetation transformation index. This transformation will change the digital image number to the index value, where the index value reflects the vegetation conditions [6]. There are other types of image transformations that can highlight objects other than vegetation, such as built-up objects. The transformation that accentuates the building object is called VGNIR-BI. Similarly, image data processing to the LST and LSM. There is a special algorithm to get temperature and moisture data.

Based on background then conducted a study by taking the research about relationship analysis of environmental factor change on the evidence of dengue fever diseases using image transformation. Not all environmental factors are examined, but only environmental factors are associated with DFD cases such as built-up area density, vegetation density, LSM and LST.

2. Material and Method

2.1 Study site and data specifications

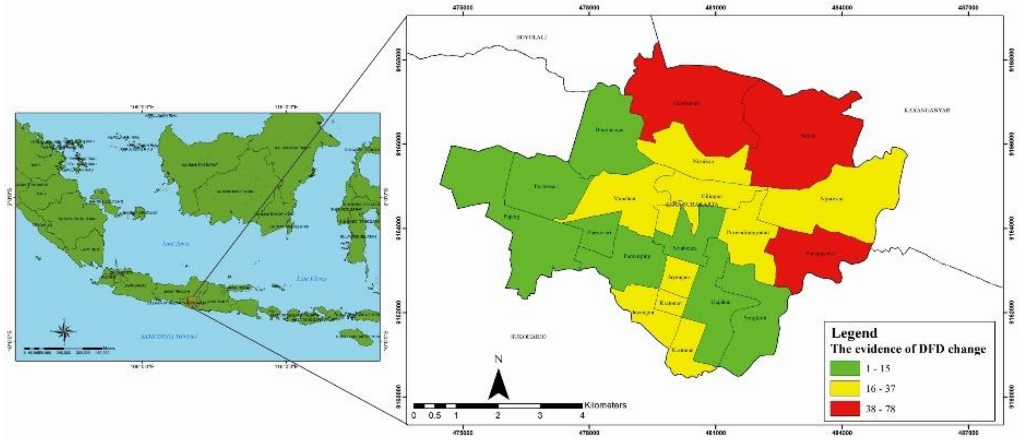

Figure 1. Map of the evidence of DFD changes in Surakarta City on 2002 and 2015 using *Puskesmas* unit area.

For this research, we use Surakarta City and surrounding area, Central Java Province, Indonesia. The population density in Surakarta is 11,675 people/km^2, which is the highest density in Central Java (the density of Central Java is only 1,038 people/km^2), so that the development of the built-up area is quickly developed.

In this research, the image used is Landsat-7 ETM+ and Landsat-8 OLI L1T (Standard Terrain Correction) image. This image can be found on path 119 and row 65 of the World Reference System (WRS). The Landsat-7 ETM+ image was acquired on May 13, 2002 and contains 8 bands, while Landsat-8 OLI is acquired on October 13, 2015 and contains 11 bands. The bands of Landsat-7 ETM+ image are stored as 8-bit digital numbers, while Landsat-8 OLI images are stored as 16-bit digital numbers [7].

Data on the number of the evidence of dengue fever disease (DFD) used is coverage Surakarta City area in 2002 and 2015 and derived from the Surakarta City Health Office. Data on the number of the evidence of DFD is in the form of point data along with the address of DFD patient stay in Surakarta

City. The coverage area of each evidence of DFD is located in every *Puskesmas* in Surakarta City. The number of *Puskesmas* in Surakarta City are 17.

2.2 Landsat-7 ETM+ and Landsat-8 OLI/TIRS data pre-processing

Satellite imagery data should be preprocessing first before used to find the indices value. The aim of preprocessing data to make pixel value in ideal condition so that it can be used for both visual and mathematical analysis [5]. Before performing image processing into a spectral indices, Landsat-7 ETM+ and Landsat-8 OLI/TIRS images should be performed radiometric calibration and atmospheric correction. The raw image value calibrated pixel value or digital number (DN) of the multispectral sensor must be converted into Top of Atmosphere (TOA) surface reflectance.

The TOA spectral radiance of multispectral bands of Landsat-7 ETM+ and Landsat-8 OLI imageries calculated using the formula. In this study, we used the radiometric calibration module available in the Environment for Visualizing Images (ENVI Ver. 5.2, Exelis Visual Information Solutions, Boulder, CO, USA) software to derive the TOA spectral reflectance.

The image processed into these spectral indices required atmospheric correction to the level of at-sensor reflectance. Atmospheric correction of Landsat-8 OLI/TIRS and Landsat-7 ETM+ image using histogram adjustment. The histogram evaluated is a histogram of reflected values on the sensor in the form of fractional numbers [8]. The method used in histogram adjustment is dark subtraction[9].

2.3 Image transformation

Land surface temperature (LST) obtained from calculation of image brightness value. It's assumed that the water content in the atmosphere is constant for a small region, so that atmospheric conditions can be considered uniform and the effect of atmospheric conditions on radiance temperatures can be ignored [10]. Normalized Difference Vegetation Index (NDVI) is used to determine the coverage of vegetation in the surface of a study area. Normalized Difference Moisture Index (NDMI) shows values that estimate the level of moisture content in any object recorded by the sensor [11]. VgNIR-BI is used to determine the built-up area in the surface of study area [12].

After processing into TOA surface reflectance, so it can be process to get LST, NDVI, NDMI, and VgNIR-BI values. Calculated LST using this equation:

$$T = \frac{K2}{In\left(\frac{K1}{L\lambda}+1\right)} - 273.15 \quad (1)$$

where T value is obtained from satellite sensor recording which shows the temperature value in Kelvin units. Lλ is the value obtained from the radiance spectral. K1 are the values of calibration constants one for Landsat ETM+ (666.09 $wm^{-2}sr^{-1}m^{-1}$), Landsat OLI band 10 (774.8853 $wm^{-2}sr^{-1}m^{-1}$), and Landsat OLI band 11 (480.8883 $wm^{-2}sr^{-1}m^{-1}$), K2 is the calibration constant two for Landsat ETM+ (1282.71 K), Landsat OLI band 10 (1321.0789 K) and Landsat OLI band 11 (1201.1442 K).

Calculated NDVI, NDMI and VgNIR-BI using this equation:

$$NDVI = \frac{NIR-Red}{NIR+Red} \quad (2)$$

$$NDMI = \frac{NIR-SWIR1}{NIR+SWIR2} \quad (3)$$

$$VgNIR - BI = \frac{Green-NIR}{Green+NIR} \quad (4)$$

where $Green, Red, NIR, SWIR1,$ and $SWIR2$ refer to the atmospherically corrected surface reflectance values of band 2, band 3, band 4, band 5 and band 7 in Landsat-7 ETM+ image, while band 3, band 4, band 5, band 6 and band 7 in Landsat-8 OLI/TIRS image, respectively.

The result of image transformation (NDVI, NDMI and VgNIR-BI) is done by linear regression analysis using field survey data to get NDVI information into vegetation cover density, NDMI becomes land surface moisture (LSM) and VgNIR-BI becomes built-up area density.

2.4 Correlation statistic analysis
Correlation analysis in this research use two scenario that is correlation analysis and multiple correlation analysis. Correlation analysis performs statistical analysis of the relationship between dependent variable and independent variable separately on each independent variable [13], while multiple correlation analysis performs statistical analysis of the relationship between two dependent variables or more with independent variables simultaneously [14].

The correlation test was performed on 17 sample selected by total of *Puskesmas* in Surakarta City. The sample has the information of the evidence of DFD, land surface temperature (LST), built-up area density, vegetation cover density, and land surface moisture (LSM). Correlation test using Pearson Product Moment correlation performed on the sample where the result obtained is a graph correlation between the evidence of DFD on LST, built-up area density, vegetation cover density and LSM.

Correlation analysis used in this research is using Pearson Product Moment method. Formulation for Pearson Product Moment Correlation [14] is shown as follows:

$$rxy = \frac{n(\Sigma xy)-(\Sigma x.\Sigma y)}{\sqrt{\{n\Sigma x^2-(\Sigma x)^2\}\{n\Sigma y^2-(\Sigma y)^2\}}} \tag{5}$$

where *r* is correlation coefficient, *n* is number of samples, *x* is independent variable, *y* is dependent variable.

Multiple correlation analysis in this study using correlation coefficient. Decision making in multiple correlation test can compare the probability value of 0.05 with the probability value of significance. A more detailed explanation of the probability significance can be found in [15]. Formulation for multiple correlation test is shown as follows:

$$R_{x1x2x3x4y} = \sqrt{\frac{r^2X_1Y+r^2X_2Y+r^2X_3Y+r^2X_4Y+2.rX_1Y.rX_2Y.rX_3Y.rX_4Y}{1-r^2X_1X_2X_3X_4}} \tag{6}$$

where $R_{x1x2x3x4y}$ is the coefficient of multiple correlation, X_1 is the independent variable (LST), X_2 is the independent variable (LSM), X_3 is the independent variable (built-up area density), X_4 is the independent variable (vegetation cover density), rX_1Y is the correlation coefficient between X_1 and Y, rX_2Y is the correlation coefficient X_2 and Y, rX_3Y is the correlation coefficient between X_3 and Y, rX_4Y is the correlation coefficient between X_4 and Y, and Y is variable dependent (the evidence of DFD).

Based on calculation of correlation coefficient (r) will show the relationship between the dependent variable with the independent variable with the range of values 0 to 1 and a detailed description of the classification of the range of correlation coefficient values can be found in [16].

3. Result and Discussion

3.1 Built-up area density
Built-up area density data is obtained from VGNIR-BI. The advantages of this transformation are on the green, red and near infrared band. On the green and red band, the built-up area will appear brighter and on the near infrared band the appearance of vegetation will be seen more clearly. Based on the shape, can be distinguished between the object of building and vegetation.

Built-up area density resulting from the transformation of VGNIR-BI in Surakarta City from 2002 until 2015 has increased. Map of built-up area density can be seen in figure 2. The difference are quite clear by comparing mapping result in 2002 and 2015. The built-up area density changes in 2002 and

IOP Conf. Series: Earth and Environmental Science **169** (2018) 012061 doi:10.1088/1755-1315/169/1/012061

2015 are spread equally across Surakarta City, The highest built-up area density change is located in District of Banjarsari and Seregan. When viewed visually, there appears to be a significant difference between map of built-up area density on the 2002 and 2015. In some locations, the density of the building is quite high up to 87.5%. Figure 2 also shows the difference built-up area density in 2 different sample locations.

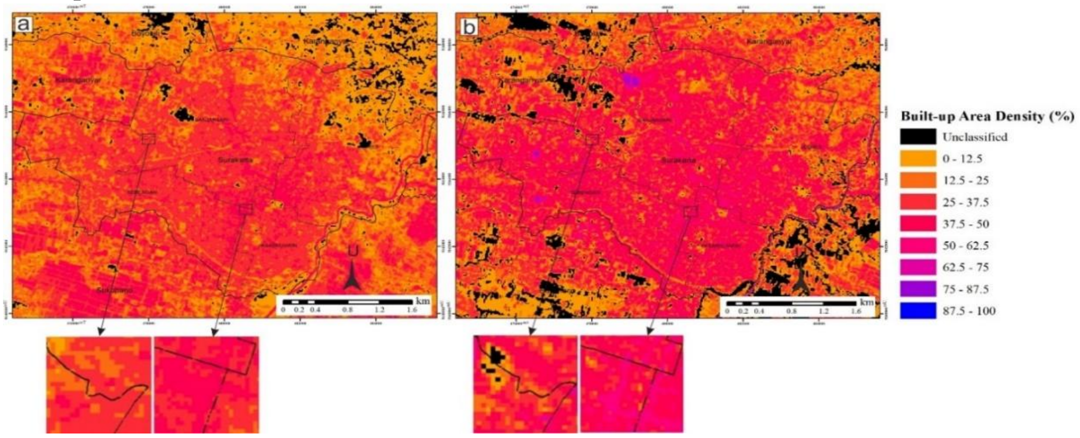

Figure 2. Map of built-up area density in Surakarta City on (a) 2002 and (b) 2015.

3.2 Vegetation cover density

This research uses NDVI to present vegetation density in Surakarta City. The NDVI is a combination of deterrence techniques with image reduction techniques and very often used in various studies. The band used in the NDVI transformation indice are the red band and the near infrared band.

Based on result of data procesing between NDVI and data from high resolution spatial imagery or field survey, the precentage of vegetation density on 2002 and 2015 is obtained. Figure 3 shows a change of vegetation density over 13 year period. The degradation of vegetation density on 2002 to 2015 most located in the middle of Surakarta City. Almost all district in Surakarta City has change vegetation density. This change is most often because the land convertion from vegetation area to built-up area. Figure 3 shows the change of color in some location from green to white, indicating that there has been a reduction in vegetation density up a density of 0 – 12,5%.

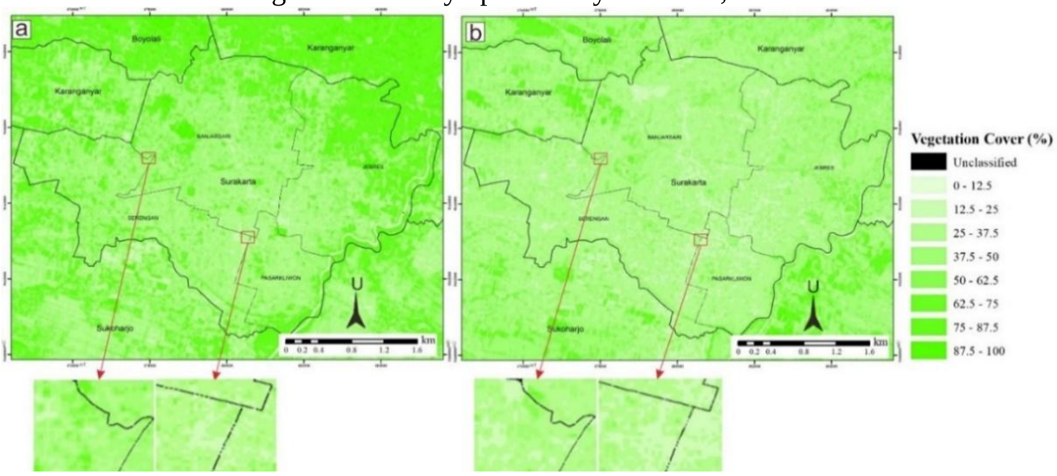

Figure 3. Map of vegetation cover density in Surakarta City on (a) 2002 and (b) 2015.

3.3 Land surface moisture (LSM)

The moisture value is obtained by using NDMI. NDMI using the near infrared and middle infrared band. The result of transformation indice and field survey resulted in moisture map which is a description of the moisture condition of the object in the field. The results in Figure 4 shows that there is a change of moisture from high moisture to low moisture. This means that land cover changes from high water content such as vegetated land into land that has low water content. This condition is indicated by a dark blue color that indicates high moisture to light blue color which indicates low moisture value. This result is in line with changes in built-up area density that tend to increase from 2002 to 2015 and changes in vegetation cover density tend to fall from 2002 to 2015.

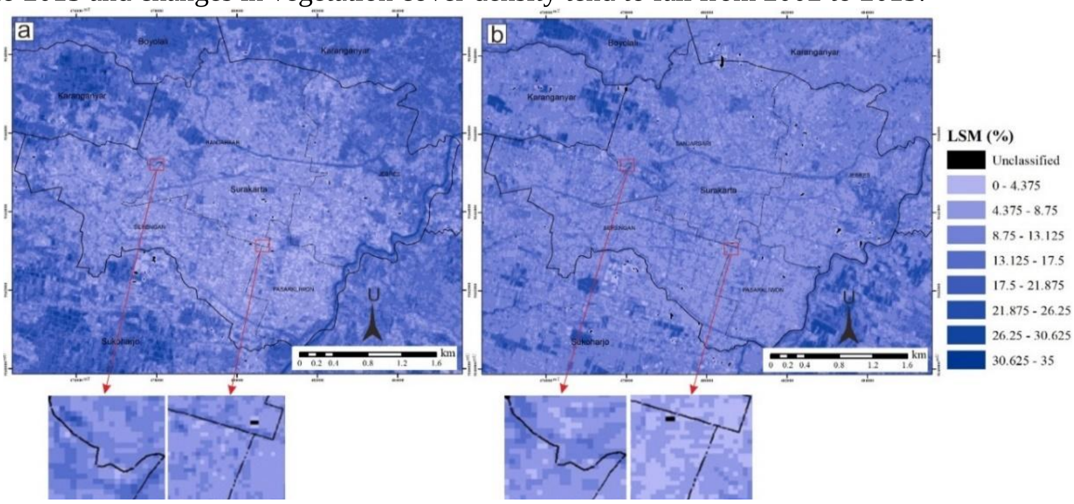

Figure 4. Map of LSM in Surakarta City on (a) 2002 and (b) 2015.

3.4 Land surface temperature (LST)

Land surface temperature (LST) is generated from processing image radiance value. Satellite images of previously applied atmospheric corrections are further processed using formulas (1) and (2) which have been described in methods section. Mapping of surface temperatures in 2002 and 2015 can be seen in figure 5. When viewed map, it appears that there was a change in surface temperature from 2002 to 2015. The change occurred due to land convertion from vegetated land to built-up area that has a hotter surface temperature. The result of LST processing shows that there is a logical variation of temperature which in the area with high built-up area density, land surface temperature will rise up to 50-55^{0}C.

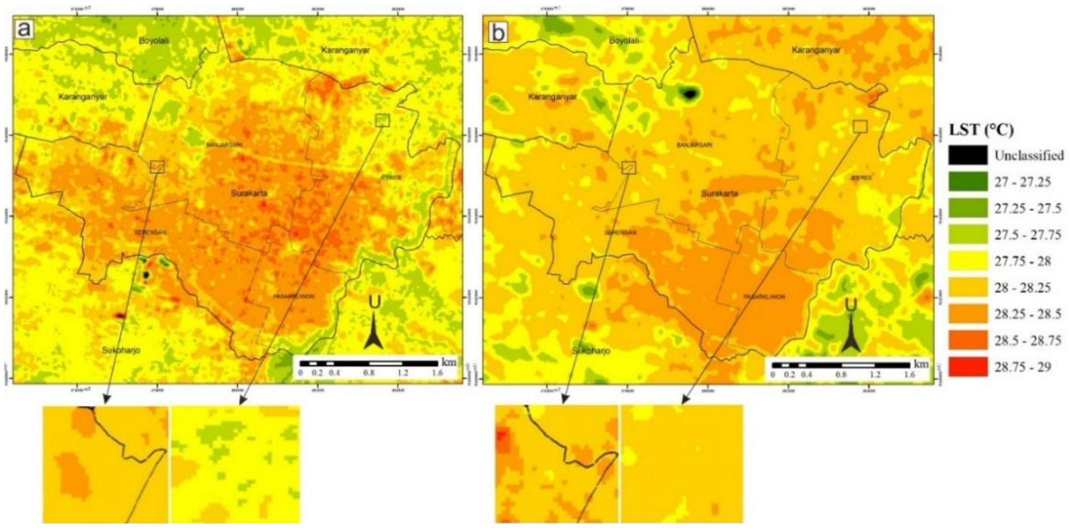

Figure 5. Map of LST in Surakarta City on (a) 2002 and (b) 2015.

The changes surface temperature object shown in figure 5 can be interpreted that over a period of 13 years there has been a change of landcover from vegetated land to built-up area or from low built-up area density to high built-up area density. The number of buildings, especially residential buildings, indicates that more and more people are living in the area. Increasingly people makes available places used by aedes mosquitoes to breed and lay eggs in the tubs of every home and other water reservoirs increasly. Increasingly people also indicated food for mosquitoes increasly. Therefore, it is very reasonable if there is an increase number of DFD in the city of Surakarta in 2015 better than previous years.

3.5 Correlation analysis of enviromental factor change on the evidence of DFD changes

Assessment to determine the effect of environmental factor change on DFD evidence is done by looking at the change of environmental factors that occur in every coverage area of Puskesmas. This is done considering the available DFD data is the total DFD cases data per coverage area of Puskesmas. Data DFD recorded in each Puskesmas is a disease case that occurred in the region. Thus, it can be said that the case of DFD recorded in each Puskesmas in Surakarta City is a reflection of the factors that affect the evidence of DFD in the region.

Table 1. Enviromental factors change and the evidence of DFD based on *Puskesmas*

Puskesmas	Vegetation Cover (%)			LSM (%)			Built-up Area (%)			LST (C)			The evidence of DFD changes
	2002	2015	changes	2002	2015	changes	2002	2015	changes	2002	2015	changes	
Banyuanyar	52.37	47.16	5.21	11.98	11.81	0.17	22.27	30.12	7.85	39.7	40.7	1	15
Gajahan	40.20	38.02	2.18	8.28	9.08	0.81	30.58	40.16	9.58	42.6	46.6	4	15
Gambirsari	53.96	42.78	11.18	10.80	12.46	1.67	21.50	34.78	13.29	41.4	45.7	4.3	58
Gilingan	39.57	37.84	1.73	7.44	9.61	2.17	31.36	40.67	9.32	47.8	45.1	2.7	20
Jayengan	37.38	38.12	0.74	6.58	8.66	2.07	32.29	39.34	7.05	47	45.2	1.8	33
Kratonan	42.07	39.07	3.00	7.83	9.04	1.20	29.35	38.71	9.36	45.2	46.5	1.3	22
Manahan	41.83	43.67	1.84	8.15	10.36	2.21	29.16	35.26	6.10	45.5	42.9	2.6	37
Ngoresan	53.05	47.26	5.79	11.70	11.57	0.14	21.55	29.91	8.36	42.4	41.4	1	24
Nusukan	40.84	39.79	1.05	8.39	9.75	1.37	30.83	38.69	7.86	46.1	43.7	2.4	25
Pajang	46.67	42.92	3.75	9.45	10.24	0.80	25.76	34.55	8.79	44.2	43	1.2	7
Penumping	40.38	40.74	0.36	7.66	9.82	2.16	30.13	36.64	6.51	47.1	45.3	1.8	13
Pucangsawit	47.14	43.28	3.86	10.98	8.80	2.19	22.77	35.32	12.55	42.6	45.4	2.8	58
Purwodiningratan	34.99	35.38	0.39	6.24	7.53	1.29	34.51	43.48	8.96	49.2	47.1	2.1	22
Purwosari	42.34	39.82	2.52	8.26	10.01	1.75	28.84	38.17	9.34	45.2	43.7	1.5	8
Sengkrah	45.97	41.05	4.92	9.28	9.04	0.23	26.38	35.78	9.40	43.6	45.7	2.1	7
Setabelan	36.14	39.14	3.00	6.57	7.01	0.44	33.49	38.84	5.34	48.6	47.1	1.5	1
Sibela	61.04	45.07	15.97	12.48	6.09	6.39	15.99	30.76	14.77	41.2	45.6	4.4	78

It should be noted that factors affecting DFD evidence are not only environmental factors but, including human habit factors and health care factors. However, this study will only be done to see how big the influence of environmental factors on DFD cases in Surakarta City. Table 1 is a data of environmental factor changes consisting of changes in built-up area density, vegetation cover density, LSM and LST.

Correlation of environmental factor change such as changes of LST, vegetation cover density, LSM, and built-up area density with the changes of DFD cases can be done with pearson product moment analysis. Correlation analysis value between the changes of environmental factor and DFD cases shows strong correlation value. Based on table 2, the lowest correlation value shows by the correlation value of vegetation cover density is 0.69, while LSM has 0.75 on the highest correlation value. LSM show the highest correlation value, means that LSM has the strongest correlation with the changes of DFD cases. The value of LSM getting lower in 2002 to 2015. This case also makes the higher value of mousquito that being a vector of DFD.

Table 2. The result of pearson product moment of environmental factors change on the evidence of DFD

	LST	Vegetation Cover Density	LSM	Built-up Area Density
The evidence of DFD	0.69	0.68	0.75	0.74

The highest built-up area density change in Surakarta City is in the District of Gambirsari. The built-up area density in 2002 was 21.50%, and in 2015 changed to 34.78%. The lowest change occurred in the Manahan sub-district from 29.16% in 2002 to 35.26% in 2015. The result of statistical analysis to assess the regression between changes in built-up area density and the change of DFD cases obtained R^2 value of 0.55 means that the effect of changes in built-up area density on the change of DFD cases by 55%, 45% influenced by other factors.

The effect of built-up area density on the evidence of DFD is the highest built-up area density can be connected with the increasing population. High population numbers can affect the evidence of DFD, which will provide enough food for mosquitoes. Built-up area density factors will impact on other environmental factors such as drainage conditions and other environmental health. Figure 6 shows the results of the linear regression between changes in built-up area density and changes in DFD cases. Increased built-up area density can increase DFD cases if not balanced with public awareness to create cleanliness of the environment and changes in living habits.

Changes in vegetation cover density affect 45.9% of DFD cases change in Surakarta City. As it is known that the condition of vegetation in Surakarta City from 2002 - 2015 has decreased from the area and its density. This condition is a result of changes in land cover from vegetated land to built-up area. Vegetation will affect the temperature and moisture of the air, where temperature and moisture affect the metabolism and life cycle of mosquitoes.

The relationship between LST change and DFD case change can be seen in figure 6, LST gives 47% effect to DFD case change. Based on the temperature aspect, although mosquitoes can survive at low temperatures, the ability of the mosquito's metabolism process decreases or even stops when the air temperature falls below the critical temperature. At temperatures above 35°C have an impact on the physiological processes of mosquitoes. While the optimum temperature of the average growth of mosquitoes between 25°C-27°C. The growth of the mosquito will stop completely at temperatures of less than 10°C or more than 40°C. While for the larva growing process requires a temperature between 25°C-30°C.

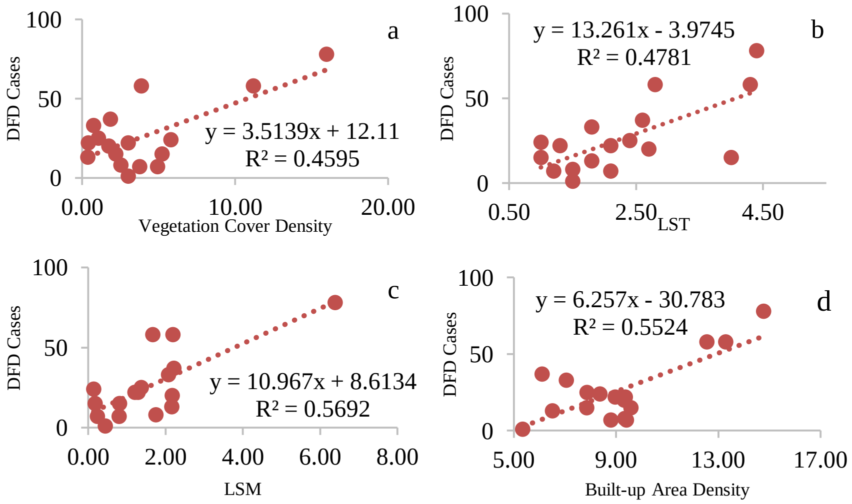

Figure 6. Linear Regression graph the evidence of DFD on changes of (a) vegetation cover density, (b) LST, (c) LSM and (d) built-up area density.

The regression between the LSM change of the object and the change of DFD case can be seen in figure 6, The LSM gives 56% effect to the change of DFD case. Moisture is certainly the effect of air temperature, so that can be drawn relation between moisture objects, air temperature and mosquito metabolism. While the LSM aspect is an important factor in the growth of mosquitoes. Optimum moisture required for mosquito growth between 60% and 80%. If the LST and LSM are optimal, the age of the mosquito can reach one month (age *Aedes aegypti* female mosquitoes on average 10 days). LSM factors can indirectly affect the age of mosquitoes. For example, the high moisture causes the mosquito to become so rapid that it can cause death. Whereas in moisture less than 60% of age mosquitoes will be short.

3.6 Multiple correlation analysis of enviromental factor change on the evidence of DFD changes

Correlation analysis is not only done by using correlation of each environmental factor to the number of dengue cases. Correlation analysis between changes in environmental factors and the change of DFD cases can be done simultaneously using multiple correlation analysis. The results shown can be used to strengthen the relationship between environmental change and the change of DFD cases.

Table 3. Result of multiple correlation of environmental factor on the evidence of DFD changes

R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
				R^2 Change	F Change	df1	df2	Sig. F Change
0.861	0.742	0.656	12.33684	0.742	8.625	4	12	0.002

The result of multiple correlation analysis is shown by table 3. The table 3 shows R that the correlation between environmental factors such as LST, LSM, vegetation cover density, and built-up area density on the evidence of DFD in Surakarta City is 86.1% or in other words indicates a very strong influence. The value of R^2 shows a value of 0.742 which states that these environmental factors simultaneously have an effect of 74.2% on the evidence of DFD, while 25.8% are factors other than those environmental factors. In addition, the level of significance (Sig. F Change) has a value of 0.002 < 0.05 so that, environmental factors affect simultaneously and significantly to the evidence of DFD.

Table 4. Coefficient value of environmental factor on the evidence of DFD changes

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlation		
	B	Std. Error	Beta			Zero-order	Partial	Part
(Constant)	-15.698	14.512		-1.082	0.301			
Vegetation	0.764	1.202	0.147	0.635	0.537	0.678	0.180	0.093
LSM	5.990	2.821	0.412	2.123	0.055	0.754	0.523	0.311
Built-up	2.373	2.196	0.282	1.080	0.301	0.743	0.298	0.158
LST	3.371	4.100	0.176	0.822	0.427	0.691	0.231	0.121

The table 4 that shows the information that can be used to determine the role of each environment factor against the evidence of DFD. Based on the table 4, it is known that the regression equation is Y = -15.698+(0.764*X1)+(5.990*X2)+(2.373*X3)+(3.371*X4). Value X1, X2, X3 and X4 shows vegetation cover density, LSM, built-up area, and LST, respectively. The regression equation shows that LSM has the highest influence on the evidence of DFD in Surakarta City from unstandardized coefficients (B) is 5.99, followed by LST, built-up area density and vegetation cover density.

4. Conclusion

Environmental factors consisting of built-up area density, vegetation cover density, land surfcae moisture (LSM) and land surface temperature (LST) of objects in Surakarta City 2002 and 2015 can be mapped through remote sensing image transformation. Based on the result of VGNIR-BI, the result of built-up density increased from 2002-2015. Based on NDVI, vegetation cover density decreased from 2002-2015. Through the LSM obtained the percentage of moisture objects tend to increase and from the LST algorithm obtained land surface temperature results of objects that tend to increase from the year 2002-2015.

Result of correlation analysis using pearson product moment are change of environmental factor of built-up area density influenced 55%, vegetation cover density influential equal to 45.9%, land surface moisture influential equal to 47.8% and land surface temperature of influence object 56.9% to spread of DFD in Surakarta City. Meanwhile, the results of multiple correlations indicate that the relation between environmental factors such as LST, LSM, vegetation cover density, and built-up area density on the evidence of DFD in Surakarta City is 86.1% or in other words shows very strong influence. These environmental factors simultaneously have an impact of 74.2% of the evidence of DFD in the Surakarta City. LSM has the highest influence on the evidence of DFD in Surakarta City from unstandardized coefficients (B) is 5.99.

References

[1] As-syakur, Abd. Rahman, I Wayan Sandi Adnyana, I Wayan Arthana, and I Wayan Nuarsa 2012 Enhanced built-up and bareness index (EBBI) for mapping built-up and bare land in an urban area *Remote Sensing* vol 4(10) pp 2957-2970.
[2] Hereher, Mohamed E 2017 Effect of land use/cover change on land surface temperatures – The Nile Deltra, Egypt *Journal of African Earth Sciences* vol 126 pp 75-83.
[3] Confalonieri, Ulisses E C, Carina Margonari, and Ana Flavia Quintao 2014 Environmental change and the dynamics of parasitic disease in the Amazon *Acta Tropica* vol 129 pp 33-41.
[4] Demelle, Eric, Michael Hagenlocher, Stefan Kienberger, and Irene Casas 2016 A spatial model of socioeconomic and environmental determinants of dengue fever in Cali, Colombia *Acta Tropica* vol 164 pp 169-176.
[5] Campbell James B and Wynne Randolph H 2011 *Introduction to remote sensing* (New York: The Guilford Press) p 305.
[6] Gandhi, Meera G, S. Parthuban, Nagaraj Thummalu, Christy A 2015 NDVI: Vegetation change detection using remote sensing and GIS – a case study of Vellore District *Procedia Computer Science* vol 57 pp 1199-1210.
[7] Rashed Tarek and Jürgens Carsten 2010 *Remote sensing and digital image processing: Remote sensing of urban and suburban areas* (London: Springer) p 33.
[8] Danoedoro Projo 2012 *Introduction to Digital Image Processing* (Yogyakarta: Andi Press) pp 168 and 186.
[9] Zha Y, J Gao and S Ni 2003 Use of normalized difference built-up indice in automatically mapping urban areas from TM imagery *International Journal of Remote Sensing* vol 24(3) pp 583-594.
[10] Chen X, Zhao H, Li P, and Yin Z 2005 Remote sensing image-based analysis of the relationship between urban heat island and land use/land cover change *Remote Sensing of Environment* vol 1(104) pp 133-146.
[11] Wilson Emily H and Sader Steven A 2002 Detection of forest harvest type using multiple date of landsat tm imagery *Remote Sensing of Environment* vol 80(3) pp 385-396.
[12] Estoque, Ronald C, and Yuji Muraya 2015 Classification and change detection of built-up lands from Landsat-7 ETM+ and Landsat-8 OLI/TIRS Imageries: A comparative assessment of various spectral indices *Ecological Indicators* vol 56 pp 205-217.
[13] Cohen J, Cohen P, West S G, and Aiken L S 2013 *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge.
[14] Kemp F 2003 Applied multiple regression/correlation analysis for the behavioral sciences. *Journal of the Royal Statistical Society: Series D (The Statistician)* vol 52(4) pp 691-691.
[15] Peter A Rogerson 2011 *Statistical methods for geography* (London: SAGE Publications) p 105.
[16] Miguel F Acevedo 2013 *Data analysis and statistic for geography, environmental science and engineering* (London: CRC Press) p 112