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# Prediction of Land Cover Change in Bodetabek Area using Remote Sensing Technique

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***Abstract*: There are many parts of the world that have been affected and changed because of humans activities. Land use/cover change (LULC) is one them. Monitoring and forecasting changes of LULC is very important which aims at development of conservation and sustainable utilization, one them is urban land use plan. In this study the main objective was to analyzed and forecasted land cover changes that will happen in the future based on historical changes which happened 11 years before. To achieve the goals, there are 11 years (2007 to 2017) of remote sensing images (MODIS MCD12QI V6) from Bodetabek area which has been classified into 16 classes based on University of Maryland classification scheme (UMD) and has been processed in several stages to be use as the dataset. There are view of method has been use to finished the experiment, change detection method has been used to computed the data to be analyzed and forecasted used least squares method.***

***Keyword: Land Use/Cover Change, LULC, Land Cover Changes, Forecasting and MODIS***

## I. INTRODUCTION

Technology and science are currently developed rapidly and have a major impact on human life. From the development of technology and science, many facets of life are facilitated. Monitoring the change in land use/land cover (LULC) with remote sensing is one example of the impact of both technological and scientific developments.

The observation of LULC changes is very important in urban land use plan. Correct observation steps can prevent unwanted LULC changes that can adversely affect some aspects of life. Given that development and regional changes will always occur, LULC monitoring must be carried out by the government to support the urban land use plan process.

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Manually observing and analyzing LULC requires large costs and takes a lot of time, due to the large area. Therefore, the use of remote sensing techniques can answer these problems and at the same time can help formulate the urban land use plan to be more effective and efficient. Remote sensing technique is a technique of observing the distance to the surface of the earth without any physical contact with the geographical object being observed [1]–[3].

The preparation of urban land use plan in Indonesia as a developing country very often is not in accordance with its implementation which can adversely affect various aspects. By looking at infrastructure development data, Jakarta as the nation's capital carries out a lot of development and a significant increase in population, so that the expansion of urban areas is increasing and has to forfeit many areas such as forest and agricultural areas.

Regarding this problem, to support the implementation of the urban land use plan properly and maintain the stability of the amount of infrastructure development in Jakarta, observing LULC changes needs to be done regularly. The Bodetabek areas (Bogor, Depok, Tangerang, and Bekasi) as the closest areas to Jakarta, hold a strategic role in development in Jakarta. Observing LULC changes in the Bodetabek region is expected can answer the problems.

LULC change observations in the Bodetabek area can contribute well to development in the Bodetabek region and can support development in Jakarta as the capital city of the country. In addition, LULC's observation and analysis at Bodetabek will provide convenience for the local government in processing the Spatial Plan and can also expand the scope of research in the field of remote sensing.

There are so many kinds of remote sensing satellites that can be used to do the long-distance measurement. Each satellite has a different task. There are Landsat, SPOT, and MODIS that can be used to monitoring land. There are Seasat, Nimbus, MOS, SeaWiFS that can be used to monitoring sea and for monitoring meteorological, the satellite that can be used are NOAA, GOES, and DMSP [3].

Monitoring and analysis of LULC changes in the Bodetabek area were carried out using remote sensing data made by NASA (National Aeronautics and Space Administration), MODIS (Moderate Resolution Imaging Spectroradiometer). Fashionable data is obtained from NASA's official website (https://modis.gsfc.nasa.gov/data/). The MODIS data used is MODIS data in an eleven-year period. This study will focus on analyzing land cover changes in the Bodetabek area, based on the results of the MODIS data classification that has been carried out.

Related to the classification that has been done there are seven classes including, waterbody, forest, shrub, wetland, urban cropland, and non-vegetated land. A comparison of results will be presented in the table by comparing each analysis result.

There is so much research about change detection by implementing remote sensing techniques with a different purpose or research objective. Based on the research topic there are some related works. There is research about measuring a change of amazon vegetation using MODIS. The objective of this research is to monitor the change of the amazon rainforest by comparing the result using conventional MOD09/MY D09 approach product and Multi-Angle Implementation of Atmospheric Correction approach [4]. Based on the study literature of the topic, there is an analysis of land cover change of Cerrado and Caatinga Brazilian for two-decade (1990-2010). This paper has discussed an overall agreement between those years [5].

Same to the other related works, there is research that discussed implementing remote sensing to monitoring land changes where the main objective of the research is to make land-use change mapping and analysis using remote sensing and Geographical Information System (GIS). The remote sensing data that users are Landsat 5 and SPOT 5 [6]. Change detection can also be used to generate spatial information with a good level of accuracy. There is research that implementing a change detection method for remote sensing images that can generate a good level of spatial information based on Markov Random Field that's has improved [7].

The results of the analysis of this research can be achieved by conducting a review of changes in the Bodetabek region LULC. By doing a comparison of each class the results of the classification and presented in the form of a table so that it can be the percentage change in each class within a period of two years. The existence of this research is expected to help the government to monitor and manage the number of development and implementation of the urban land use plan properly.

## II. STUDY AREA

With an annual increasing population in Indonesia, the change in land that occurs is the main focus of the government to make good spatial and regional arrangements. Bodetabek is a group of a city that has a similar main focus besides Jakarta. Jakarta; having an important role in infrastructure development, Bodetabek as a buffer zone of the city of Jakarta was more or less affected by the development. To maintain the stability of the amount of infrastructure development in Jakarta, observing LULC changes on a regular basis needs to be done in Bodetabek.

To analyze and predict changes in land use/cover that occur, this research was conducted in four major cities in Indonesia, namely Bogor, Depok, Tangerang, and Bekasi. The body is limited by 106o20'44.27 "BT to 107o17'50.45" BT to 5o5'50.78 "LS to 6o47'5.76" as illustrated in Fig. 1. Class labels that will be observed for the change process in this study are divided into seven class classes namely Waterbody, Forest, Shrub, Wetland, Urban, Cropland, and Non-vegetated.

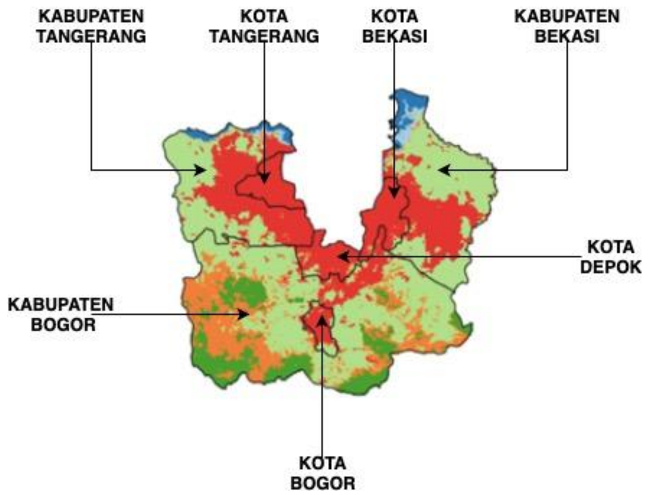


**Fig. 1. Bodetabek**

## III. EXPERIMENT AND METHODOLOGY

This section consists of data collecting, data preprocessing and change detection analysis, and all of the steps needed to achieve the goals of this study. Data collecting as the first stage of this section contains how the data is collected and used in this study. Next, data preprocessing and change detection analysis consist of several main stages of how to prepare the data that have been collected, Which is consist of vectorization, class generalization, and area calculation. The explanation of data collecting and the step in data preprocessing and change detection analysis are explained consecutively in this section.

### A. Data Collecting

To conduct analysis and prediction of land cover changes in Bodetabek area, the data needed was a shape file from ROI and remote sensing images. Shapefile ROI was obtained from the Database of Global Administration Area website (gadm.org). This website provides all shapefiles from all countries in the world. Remote sensing images used were MODIS instruments made by NASA which can be obtained from USGS website. The MODIS instrument used was MODIS MCD12Q1 V6 for eleven year period; 2007 to 2017.The product has spatial resolution ranging from 500 m and have 13 science data sets (SDS). In this study SDS used was land cover type 2 which classified into sixteen class labels using the University of Maryland Classification Scheme (UMD).

### B. Data Pre-processing

The process of data preprocessing and change detection calculation consists of several stages, where each stage plays an important role in achieving preprocessed data and accurate total calculation results. The main objective of this series of steps was to prepare the all data that been used to calculate the total area of Bodetabek to be analyzed and made a prediction model.


**Fig. 2. The Stages of Data Pre-Processing**

The first stage of data pre-processing was vectorization. Change detection is an example of using raster data for analysis purposes. Broadly speaking, what is done in this process is to change the format of raster images into vector format. Vector format is a format where the surface of the earth is represented in the form of points, lines and polygons [8]. After the raster images has been converted into vector, the next stage was class generalization. Based on UMD there are 16 classes that has been labelled or has classified by NASA using MODIS land cover classification algorithm (MLCCA) [9]. Basically, the aim of this stage was to combine the classes into a new classes based on the characteristic of the classes.

The third stages was area calculation which was the last stage of data pre-processing. the process of area calculation starts with collecting total area from each classes for 17 years period, using tools in QGIS. Total area of each classes were used as an input to calculate land cover change using Eq. 1 where, change is land cover change, $trend\ DN_m$ is trend of the class and $\sum trend$ is the summed of trend.

$$change = \left(\frac{trend\ DN_m}{\sum trend}\right)(100) \qquad (1)$$

And the difference every two years was calculated using Eq. 2. Where $diff$ is the difference between two years, $trend_x$ is the class area of first year and $trend_y$ is class area of second year.

$$diff = \left(\frac{trend_x - trend_y}{trend_x}\right)(-100) \qquad (2)$$

The result of area calculation has been transferred into a graphic to ensure that there won't be any extreme anomaly. for analysis purposes, land change difference has been displayed into image.

### C. Change Detection Analysis

In this study, change detection has been used as a method to analyzed the calculated area. Change detection is the process of identifying changes in the status of an object or phenomenon by observing it at different times (Singh, 1989). Change detection on remote sensing has a general goal to assess the accuracy of the results of change detection, identify geographical location, and the types of changes that occur [10]. Change detection method could be used to help monitoring ecological changes that happened as an example of land use / cover changes [11]. Change detection was done to measure changes between images with existing conditions at different times [12]. To describe land changes in each of the existing categories, change detection analysis is an efficient way to be applied [13].

In this study, the method used was least squares method. The least squares method is used to predict the land cover changes in the future using preview data. The least squares method will fit the line to the data that minimize the sum of the squares of the vertical distance between each data point and its corresponding point on the line [14]. The equation of least squares (Eq. 3) use to prove whether the result has a positive relationship between each variable or not.

$$Y = a + bX \qquad (3)$$

Where, Y is dependent variable computed by the equation, a and b is the coefficient, X is the time period. To determine a and b use Eq. 4 where, a is Y intercept, b is slope of the line, and n is number of data points.

$$a = \bar{y} - \overline{bX} \quad \text{and} \quad b = \frac{\sum x_y - n\,\bar{x}\,\bar{y}}{\sum x^2 - n\,\bar{x}^2} \qquad (4)$$

## IV. EXPERIMENT

Based on the method, the experiment was starts with pre-processing all MODIS images which has been collected. Pre-processing data begins with converting the raw raster images format into vector format. The result of the process can be seen in Fig. 3.

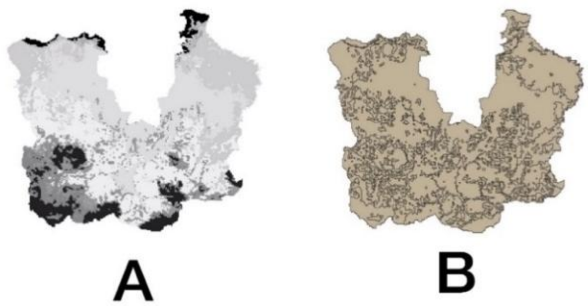


**Fig. 3. (a) MODIS in Raster Format (b) MODIS in Vector Format**

Based on UMD classification scheme, classes are generalized and combined into larger classes based on the characteristics of the class. The classes are generalized into seven classes, there are Water body, Forest, Shrub, Wetland, Urban, Cropland, and Non-vegetated new classes with new value also. Based on table 1, water body remains a class with value 0, then classes with values 1 to 5 were combined into new class as forest with a class value 1, classes with values 6 to 10 were combined into new class as Shrub with a new value 2, wetland was labelled with value label 3, class with value 12 and 14 were combined into new class as crop land with a new class value 4, and the Urban and Build-up Lands with class value 13 were changed to 5 with a new class named Urban, and the last non-vegetated land class was made into a non-vegetated class with a class value 6. The detail process of class Generalization is illustrated in Table 1.

**Table 1. Joining class label**

| Label | Value | New Label | New Value |
|---|---|---|---|
| Water Bodies | 0 | Water body | 0 |

| | | | |
|---|---|---|---|
| Evergreen Needleleaf Forest | 1 | Forest | 1 |
| Evergreen Broadleaf Forest | 2 | | |
| Deciduous Needleleaf Forest | 3 | | |
| Deciduous Broadleaf Forest | 4 | | |
| Mixed Forest | 5 | | |
| Closed Shrublands | 6 | Shrub | 2 |
| Open Shrublands | 7 | | |
| Woody Savannas | 8 | | |
| Savannas | 9 | | |
| Grasslands | 10 | | |
| Permanent Wetlands | 11 | Wetland | 3 |
| Croplands | 12 | Cropland | 4 |
| Urban and Build-up Lands | 13 | Urban | 5 |
| Cropland/Natural Vegetation Mosaics | 14 | Cropland | 4 |
| Non-Vegetated Lands | 15 | Non-vegetated | 6 |

## V. RESULTS AND DISCUSSION

### A. Urban Prediction

Calculation result of linear trend projection using least square method:

**Table 2. Calculation result of urban linear trend projection**

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | -51327.788 | 1189.2483 | -43.159859 | 9.61E-12 |
| Year | 26.416636 | 0.5910769 | 44.692382 | 7.03E-12 |

Based on Table 2, the model of urban that can be produced from linear trend projection using least square method:

$$Y_{(t)} = -51327.788 + 26.4166364_{(t)} \quad (1)$$

Model 1, shows that there is positive relationship between urban area and year with very good significant value which is less than 0.05. Urban area has increased 26.417 every year that can be proved in urban area line fit.

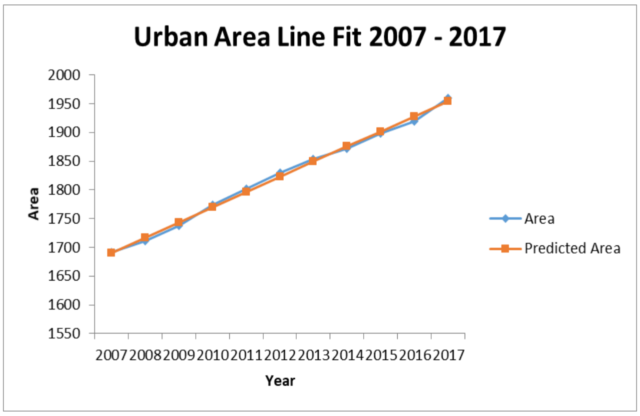


**Fig. 4. Urban area line fit 2007-2017**

To find out the feasibility of the equation model which obtained using the least squares method, one must compare or correlate the prediction results with the actual data using correlation theory. The calculation result of correlation theory is shown in Table 3.

**Table 3. Regression statistic of urban area**

| Regression Statistics | |
|---|---|
| Multiple R | 0.99775467 |
| R Square | 0.99551437 |
| Adjusted R Square | 0.99501597 |
| Standard Error | 6.19926723 |
| Observations | 11 |

From the calculation result of correlation, a correlation value (Multiple R) of 0.997 is obtained. Based on the correlation size table, correlation values is greater than 0.7 have a very strong relationship, thus, it can be defined that using the quadratic method can be used in forecasting urban areas in the following years.

### B. Cropland Prediction

Calculation result of linear trend projection using least square method:

**Table 4. Calculation result of cropland linear trend projection**

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | 60322.937 | 4116.5473 | 14.65377 | 1.38E-07 |
| Year | -28.711364 | 2.0459951 | -14.032958 | 2.01E-07 |

Based on Table 4, the model of cropland that can be produced from linear trend projection using least square method:

$Y_{(t)} = 60322.9373 - 28.711364_{(t)}$ (2)

Model 2, shows that there is negative relationship between cropland area and year with very good significant value which is less than 0.05. cropland area has decreased 28.711 every year that can be proved in cropland area line fit.

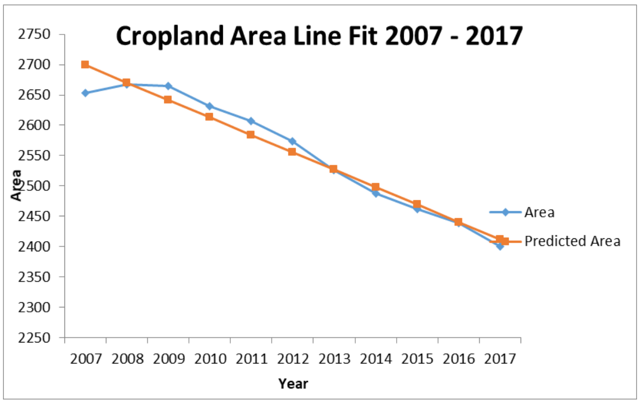


**Fig. 5. Cropland area line fit 2007-2017**

To find out the feasibility of the equation model which obtained using the least squares method, one must compare or correlate the prediction results with the actual data using correlation theory. The calculation result of correlation theory is shown in Table 5.

**Table 5. Regression statistic of cropland area**

| Regression Statistics | |
|---|---|
| Multiple R | 0.97790313 |
| R Square | 0.95629454 |
| Adjusted R Square | 0.95143837 |
| Standard Error | 21.4585778 |
| Observations | 11 |

From the calculation result of correlation, a correlation value (Multiple R) of 0.997 is obtained. Based on the correlation size table, correlation values is greater than 0.7 have a very strong relationship, thus, it can be defined that using the quadratic method can be used in forecasting cropland areas in the following years.

## C. Shrub Prediction

Calculation result of linear trend projection using least square method:

**Table 6. Calculation result of shrub linear trend projection**

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | 37277.126 | 3469.6804 | 10.743677 | 1.96E-06 |
| Year | -18.035755 | 1.7244911 | -10.458595 | 2.46E-06 |

Based on Table 6, the model of shrub that can be produced from linear trend projection using least square method:

$Y_{(t)} = 37277.1257 – 18.035755_{(t)}$ (3)

Model 3, shows that there is positive relationship between shrub area and year with very good significant value which is less than 0.05. shrub area has decreased 18.036 every year that can be proved in shrub area line fit.

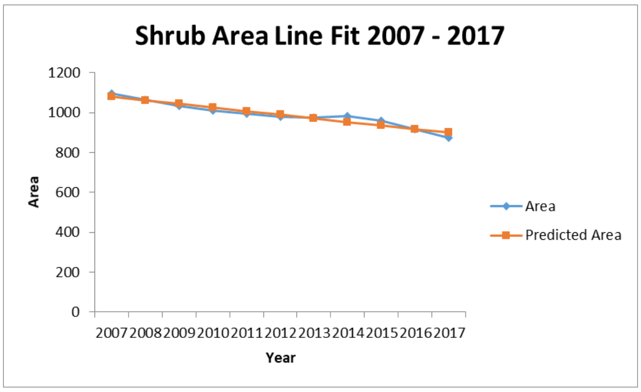


**Fig. 6. Shrub area line fit 2007-2017**

To find out the feasibility of the equation model which obtained using the least squares method, one must compare or correlate the prediction results with the actual data using correlation theory. The calculation result of correlation theory is shown in Table 7.

**Table 7. Regression statistic of shrub area**

| Regression Statistics | |
|---|---|
| Multiple R | 0.96123622 |
| R Square | 0.92397507 |
| Adjusted R Square | 0.91552785 |
| Standard Error | 18.0866154 |
| Observations | 11 |

From the calculation result of correlation, a correlation value (Multiple R) of 0.961is obtained. Based on the correlation size table, correlation values is greater than 0.7 have a very strong relationship, thus, it can be defined that using the quadratic method can be used in forecasting shrub areas in the following years.

## D. Forest Prediction

Calculation result of linear trend projection using least square method:

**Table 8. Calculation result of forest linear trend projection**

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | -38048.596 | 3300.4174 | -11.528419 | 1.08E-06 |
| Year | 19.191209 | 1.6403645 | 11.699357 | 9.55E-07 |

Based on Table 8, the model of forest that can be produced from linear trend projection using least square method:

$Y_{(t)} = -38048.596 + 19.1912091_{(t)}$ (4)

Model 4, shows that there is positive relationship between forest area and year with very good significant value which is less than 0.05.

forest area has increased 19.191 every year that can be proved in forest area line fit.

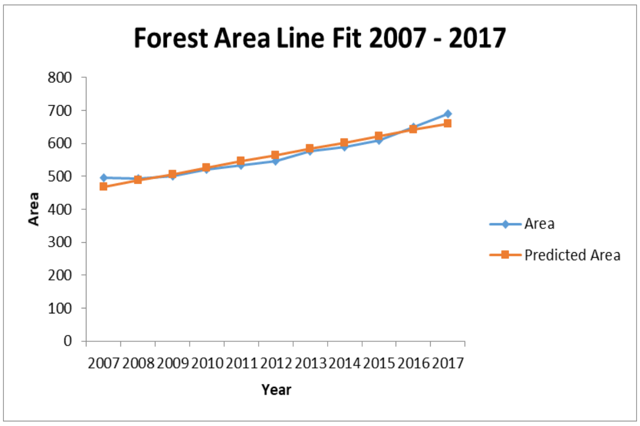


**Fig. 7. Forest area line fit 2007-2017**

To find out the feasibility of the equation model which obtained using the least squares method, one must compare or correlate the prediction results with the actual data using correlation theory. The calculation result of correlation theory is shown in Table 9.

**Table 9. Regression statistic of forest area**

| Regression Statistics | |
|---|---|
| Multiple R | 0.96866058 |
| R Square | 0.93830332 |
| Adjusted R Square | 0.93144813 |
| Standard Error | 17.2042879 |
| Observations | 11 |

From the calculation result of correlation, a correlation value (Multiple R) of 0.969 is obtained. Based on the correlation size table, correlation values is greater than 0.7 have a very strong relationship, thus, it can be defined that using the quadratic method can be used in forecasting forest areas in the following years.

## E. Wetland Prediction

Calculation result of linear trend projection using least square method:

**Table 10. Calculation result of wetland linear trend projection**

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | -2334.6901 | 111.92028 | -20.860296 | 6.26E-09 |
| Year | 1.1963455 | 0.0556263 | 21.506827 | 4.78E-09 |

Based on table 10, the model of wetland that can be produced from linear trend projection using least square method:

$$Y_{(t)} = -2334.6901 + 1.19634545_{(t)} \quad (5)$$

Model 5, shows that there is positive relationship between wetland area and year with very good significant value which is less than 0.05. wetland area has increased 1.196 every year that can be proved in wetland area line fit.

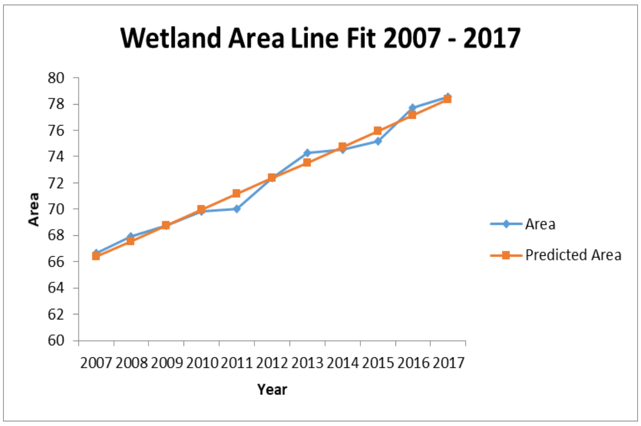


**Fig. 8. Wetland area line fit 2007-2017**

To find out the feasibility of the equation model which obtained using the least squares method, one must compare or correlate the prediction results with the actual data using correlation theory. The calculation result of correlation theory is shown in Table 11.

**Table 11. Regression statistic of wetland area**

| Regression Statistics | |
|---|---|
| Multiple R | 0.9904109 |
| R Square | 0.98091375 |
| Adjusted R Square | 0.97879305 |
| Standard Error | 0.58341369 |
| Observations | 11 |

From the calculation result of correlation, a correlation value (Multiple R) of 0.990 is obtained. Based on the correlation size table, correlation values is greater than 0.7 have a very strong relationship, thus, it can be defined that using the quadratic method can be used in forecasting wetland areas in the following years.

## F. Non-Vegetated Prediction

Calculation result of linear trend projection using least square method:

**Table 12. Calculation result of non-vegetated linear trend projection**

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | 547.37127 | 77.919369 | 7.0248422 | 6.15E-05 |
| Year | -0.2710909 | 0.0387273 | -7 | 6.32E-05 |

Based on Table 12, the model of non-vegetated that can be produced from linear trend projection using least square method:

$$Y_{(t)} = 547.371273 - 0.2710909_{(t)} \quad (6)$$

Model 6, shows that there is positive relationship between non-vegetated area and year with very good significant value which is less than 0.05. non-vegetated area has decreased 0.271 every year that can be proved in non-vegetated area line fit.

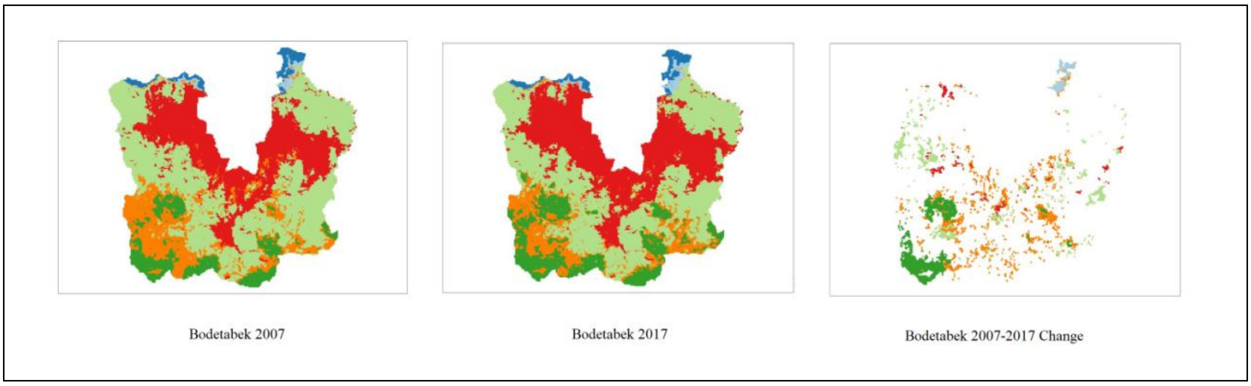


**Fig. 10. 2007 – 2017 change and difference of Bodetabek**

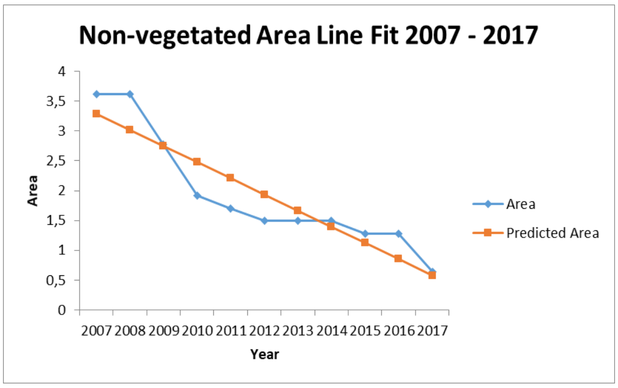


**Fig. 9. Non-vegetated area line fit 2007-2017**

To find out the feasibility of the equation model which obtained using the least squares method, one must compare or correlate the prediction results with the actual data using correlation theory. The calculation result of correlation theory is shown in Table 13.

**Table 13. Regression statistic of non-vegetated area**

| Regression Statistics | |
|---|---|
| Multiple R | 0.91914503 |
| R Square | 0.84482759 |
| Adjusted R Square | 0.82758621 |
| Standard Error | 0.40617506 |
| Observations | 11 |

From the calculation result of correlation, a correlation value (Multiple R) of 0.919 is obtained. Based on the correlation size table, correlation values is greater than 0.7 have a very strong relationship, thus, it can be defined that using the quadratic method can be used in forecasting non-vegetated areas in the following years.

### G. Changes Analysis

Based on result of the whole process, the highest changes of forest area is from 2015 to 2016 with a total change of 6.70 and the sum of total changes is 33.89, which mean forest area has increased every year. Next, the highest changes of Shrub area is from 2013 to 2014 with a total change of 0.72 and the sum of total changes is -22.21, which mean shrub area has decreased every year. The highest changes of Wetland area is from 2015 to 2016 with a total change of 3.40, and the sum of total changes is 16.65, which mean wetland area has increased every year. The highest changes of cropland area is from 2007 to 2008 with a total change of 0.54 and the sum of total changes is -9.94, which mean Cropland area has decreased every year. Next, the highest changes of urban area is from 2016 to 2017 with a total change of 2.13 and the sum of total changes is 14.88. Which mean Urban area has increased every year. And the last class is Non-vegetated. the highest changes of Non-vegetated area is from 2010 to 2011 with a total change of -11.1 and the sum of total changes is -142.20. Which mean Non-vegetated area has decreased every year. The change and the difference of the first year and the last year can be seen in Fig. 10.

## VI. CONCLUSION

Based on the experiment result we came to the conclusion that :

1) Every year urban area has been change 1.49. Total changes of 14.88 is obtained from 2007 to 2017. Which mean, urban area has increased every year. Forecasting using least square model has indicated that urban area will be increased 26.417 every year.
2) Every year cropland area has been change -0.99. Total changes of -0.94 is obtained from 2007 to 2017. Which mean, cropland area has decreased every year. Forecasting using least square model has indicated that cropland area will be increased 28.711 every year.
3) Every year shrub area has been change -2.22 Total changes of -22.21 is obtained from 2007 to 2017. Which mean, shrub area has decreased every year. Forecasting using least square model has indicated that shrub area will be increased 18.036 every year.
4) Every year forest area has been change 3.39 Total changes of 33.89 is obtained from 2007 to 2017. Which mean, forest area has increased every year. Forecasting using least square model has indicated that forest area will be increased 19.191 every year.
5) Every year wetland area has been change 1.67 Total changes of 16.65 is obtained from 2007 to 2017. Which mean, wetland area has increased every year. Forecasting using least square model has indicated that wetland area will be increased 18.036 every year.

6) Every year non-vegetated area has been change -14.22 Total changes of -142.20 is obtained from 2007 to 2017. Which mean, non-vegetated area has decreased every year. Forecasting using least square model has indicated that non-vegetated area will be decreased 0.271 every year.

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