Dynamic Model of Land Area Changes in the East Coast of Surabaya

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Abstract. Management of coastal areas on the east coast of Surabaya (Pamurbaya) is very important because this region is largely a conservation area which serves to maintain the balance of the ecosystem of Surabaya. This study aimed to analyze changes in the coastal land and create a dynamic model of coastal land area changes in Pamurbaya. The method used is the field survey, the linear regression method and dynamic modeling. Dynamic modeling using the software Stella 4.0. The results showed that the changing of used land can be explained by the dynamic model described by a linear regression model. The result is useful to predict the pamurbaya condition for next few years and useful as inputs to city government in managing coastal areas of Pamurbaya.

Introduction

Coastal dynamics in Pamurbaya is very large. It is seen from the development activities or the activities of a natural phenomenon. Development activities in the region include: reclamation of Kenjeran beach, housing development, utilization of the fishery and tourism development. Coastal development activities is strongly associated with the utilization of coastal resources that exist, such as: coastal land, mangroves and fish resources.

On the other hand, the activities of the natural phenomena i.e. erosion process and sedimentation processes. The erosion process in some places has been eroded the coastline, causing a loss of some residential land and mangroves as well as increasing land elsewhere. In other places, especially near the mouth of the river raised the sedimentation process is quite large.

With the sedimentation process takes place in coastal areas leads to changes in the coastline which tend increasingly towards the sea and was followed by changes in the condition of mangrove. The emergence of new lands in Pamurbaya population used for various activities. Changes in mangrove areas especially coastline which includes changes in land use and the coastline itself can be detected through remote sensing satellite imagery. Moko et.al. has also made evaluation of land cover changes in the coastal zone of Sidoarjo and Surabaya with multi-temporal satellite[3]. Prasita et al. had evaluated the areas of mangrove conservation in Pamurbaya[5,6].

Based on the above background, the research problems can be formulated as follows: (1) How does the changing patterns of land conservation in Pamurbaya ?, (2) How to predict changes in land conservation for coastal development scenarios in Pamurbaya ?.

The purpose of this study are (1) Analysis of the land area changes in the MCA of Pamurbaya, (2) Design and create a dynamic model of the coastal land area changes in the MCA of Pamurbaya. The benefit of this research is a model that can be used as a basis for providing input Surabaya coastal development planning, especially the East Coast area of Surabaya.

Research Methods

This study was conducted in March-October 2015. The location of research is Pamurbaya mangrove conservation area in East Java, in position 7°12’ South Latitude - 112°36’ East longitude and 7°21’ South Latitude - 127°54’ East Longitude.

The data used in this study is a topographical map scale of 1: 25,000, satellite imagery and Google Map TM 1996, 2002, 2007, 2011, and 2014, as well as secondary data from relevant agencies. The tools used for the survey is a GPS unit and a computer for data processing and
ARCVIEW 3.1 software for the analysis of satellite imagery and STELLA 4.0.2. for the design of dynamic models.

Flowchart of the study stated in Fig. 1 below.

The methodology used for this model are as follows: (1) literature; (2) data collection; (3) formulation of the model; (4) the calibration and validation; (5) the determination of sensitive variables (leverage); (6) simulation.

Literature studies is conducted to determine the basic equation modeling and variable - related variables. The collection of data is to get the data used as the basis for simulation modeling. Data obtained from the previous studies and agencies. Formulation of the model is the process of creating / designing a model using Stella software. This process begins with making a simple model in the form sub models, and then combined into one integrated dynamic system. Each of these sub-models must be calibrated and validated in advance with the existing data. For submodel that is valid/correct, then examined the variables that are sensitive (Leverage). Furthermore, the resulting model used for the simulation. Results of the simulation models used to explain the phenomenon as well as the prediction of the condition of mangrove conservation area in Pamurbaya for management planning.

**Result and Discussion**

**Boundary changes of mangrove conservation area (MCA) and land changes of the coast.** In 2007, MCA was determined based on *Perda Kota Surabaya No 3 Tahun 2007* [4]. According to [1], the areas of MCA was ± 2503.9 Ha, as shown in Fig. 2a. From these maps, with satellite images registered in 2007, the extent of MCA acquired an area of 2503.9 ha and the length of the perimeter of MCA was 31219.741 m.
In 2012, the region has changed the limit, but the extent remains 2503.9 Ha and the length of the perimeter of MCA was 31741.179. It can be seen from the length of the perimeter. The limit changes in detail can be seen in Fig. 2b.

![Fig. 2. Boundary changes of the MCA](a) (b)

In 2007 through 2012 (for five years), changes in land conditions of MCA Pamurbaya, namely: in the west (the land) of 1,170,417.675 m² (117,042 ha), with details of the addition of 72022.161 m² (7.202 ha) and a reduction of 1,098,395.514 m² (109.839 ha) are shown in Table 1. This change occurs in a non-naturally allegedly due to the influence of conservation area management policy. In this model will be used assumptions to the conditions above, the rate of increase of MCA limit of (72022.161 / 5 = 14404.432) m²/year and a reduction in the rate of its MCA limit of (1098395.514 / 5 = 219679.108) m²/year.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Id</th>
<th>Area</th>
<th>Perimeter</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polygon</td>
<td>1</td>
<td>972987.480</td>
<td>6427.167</td>
<td>Minus</td>
</tr>
<tr>
<td>Polygon</td>
<td>2</td>
<td>8268.775</td>
<td>701.442</td>
<td>Plus</td>
</tr>
<tr>
<td>Polygon</td>
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<td>125408.034</td>
<td>2177.002</td>
<td>Minus</td>
</tr>
<tr>
<td>Polygon</td>
<td>4</td>
<td>49006.946</td>
<td>1093.931</td>
<td>Plus</td>
</tr>
<tr>
<td>Polygon</td>
<td>5</td>
<td>14746.440</td>
<td>798.561</td>
<td>Plus</td>
</tr>
</tbody>
</table>

Changes in the east (ocean side) are more affected by the erosion and accretion. This was taken into consideration in determining the limit of MCA forward. Therefore, changes in land area on the sea side will be affected by changes in the coastline and to be important for dynamic modeling.

Results of digitization of some satellite images for 18 years, from 1996 until 2014. The calculation results of the coastal areas are presented in the table below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Areas (m²)</th>
<th>Land Changes (m²)</th>
<th>Acresion (m²)</th>
<th>Abrasion (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>20688044.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>23988043.55</td>
<td>3299998.86</td>
<td>3408401.44</td>
<td>108402.58</td>
</tr>
<tr>
<td>2007</td>
<td>25031686.24</td>
<td>1043642.69</td>
<td>1061079.19</td>
<td>17436.5</td>
</tr>
<tr>
<td>2011</td>
<td>25997855.97</td>
<td>966169.73</td>
<td>1058223.76</td>
<td>92054.03</td>
</tr>
<tr>
<td>2014</td>
<td>26753562.17</td>
<td>755706.2</td>
<td>841029.41</td>
<td>85323.21</td>
</tr>
</tbody>
</table>
From the calculation of the land area changes, land use change graphed against time with the amount of land area change as a plot point. The resulting plot shows lines that tend to be linear so used linear regression approach. Linear line shown in Fig. 3.

Linear equation for land area changes in the conservation areas as follows:

\[ Y = 20955987.72 + 321440.98 \times \]  

Correlation of Pearson coefficient \( R = 0.975 \) and the determination coefficient \( R^2 = 0.95 \).

Dynamic model design for land changes of the MCA. Model of land changes of the MCA is designed to be used to see the pattern of land use change under the influence of man and nature. Land changes caused by humans may occurred because of government policy and society. This will depend on the execution/implementation of regulations in the MCA. When regulations are strictly enforced, the tendency of the changes will be smaller, but on the contrary, if the regulations are loosely enforced, the tendency will be great changes in the land so that the rate of change will be great.

In addition, the land use change can occur naturally. Changes in the land can be caused by accretion events (additional land) and abrasion (reduction of land). In Pamurbaya, accretion rate greater than the rate of soil erosion that appear extended lands (“tanah oloran”). To see how many are these extended lands, then we make a model. In addition, this model can predict the areas for the next few years. The design of the model is shown in Fig. 4.

Fig. 4. Dynamic model design for land changes of the MCA
Result of the Dynamic Model for Land Changes of the MCA. Results of running dynamic model expressed in the form of graphs and tabular form. Expressed in graphical form in Fig. 5 and form tables are presented in Figure 6. To monitor the results of running the model, used for important variables that want to see the pattern. Currently, these variables are (1) MCA land, (2) land change speed of MCA, (3) natural land change speed, and (4) non natural land change speed. Ordinate values 1,2,3 and 4 related to the maximum amount of variables that are displayed. With these values, the amount of variability is monitored separately. For example, for a variable of MCA land, the trend line is increasing.

![Fig. 5. Graph of land changes in MCA](image)

![Fig. 6. Result of running model of land changes of the MCA](image)
Conclusion

This research concludes that model of land area changes in Pamurbaya is a simple model because the pattern is linear. This is in accordance with the actual conditions of the land area changes in the MCA of Pamurbaya which is linear. This model can be used to predict the condition of the land area changes for the next 20-30 years because this model is based on the data 20 years ago.

References


