Dear Authors,

We are pleased to inform you that your paper entitled "Urban land use change analysis using temporal multispectral imagery and image difference" was reviewed by 2 reviewers and got positive opinion. This, paper has been accepted for publication at the peer-reviewed, indexed and abstracted "International Journal of Academic Research", Baku, Azerbaijan to be published in May 31, 2011.

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ABSTRACT

As the second largest city in Indonesia, Surabaya city with a population of more than 3 million people that has a function as a center of business, commerce, industry, and education in Eastern Indonesia into a strong attraction for the urban thereby providing an increasing number of residents each year. Based on Landsat TM and Landsat 7 ETM+ Surabaya city has an area of 372.667 pixels or 335.4Km², physically experiencing very rapid growth of the city for almost 20 years (1990-2009) 55.5% and 13.6% of the total area of the city. Most shape of growing cities in Indonesia, where are always faced with problems with the shrinking of the green area. Through remote sensing and GIS technologies, carried out the stages of processing of Landsat TM (1990) and Landsat 7 ETM years 2000-2009, where Landsat imagery in 2007 and 2009 should be processed first, for the missing data can be improved, needs to be done charging referred to as the filling scan gap. Performed supervised classification using Maximum Likelihood method and the overlay with GIS technology from the year 1990-2009. The study shows a green area with land use: vegetation and mangrove from the years 1990-2009 Surabaya shrinkage is very rapid, from 48% (1990) shrank 37.1% to just 10.9% in 2009, when calculated on the basis of extensive due 335.4Km² siltation thereby increasing the land area on the east side of the city of Surabaya at 7.1Km².

Key words: land area, Surabaya city, temporal multispectral imagery, image difference

1. INTRODUCTION

The growth of cities in general take a complex effect. According to Blackman [1] "principally land supply has been reduced", made the city increasingly heavy burden to bear the need to build them. It was not easy for the government to provide facilities to answer that desire. Surabaya city is located 07 ° 21 'South latitude and 112 ° 36' - 112 ° 54 'East Longitude with an area 335.4Km² which has city activities very diverse with a population of more than 3 million inhabitants. High space demands, urging land use change. Qihao Weng [2] distinguishes land use change by comparing the built up area and unbuilt-up areas, whereas by its nature can be divided into impervious surfaces and infiltrate surfaces based on the year after or earlier. The impervious surfaces are all surface water can not soak into the soil and is generally associated with transportation activities such as road, highway, pedestrian, parking, and buildings.

Utilization of green areas can not be avoided from year to year to meet the needs of the space. The opening of new lands began to prepare for the construction of city infrastructure facilities like housing, commercial, education, roads, and others. Without realizing it until the year 2009, the vast green area shrinks sharply, often as a result of other city problems such as flooding due to the loss of absorption changed into impervious surfaces, the temperature increase due to reduced urban green areas to reduce reflection of sunlight.

To find out how much shrinking green areas in Surabaya city, have done extensive searches of green area in previous years. Collecting data on the previous year by way of manual certainly not simple, because it relates to the location and position (coordinates), which is never the same. Using Landsat TM and ETM+ for 19 years (1990-2009), as data to be processed through the remote sensing technology. By relying on the uniqueness and characteristics of different wavelengths, and emitted by every object on the surface of the earth, the diversity of urban land use will be recognizable.

Remote sensing is the science or art to obtain information about the object, area or a symptom, by way of analyzing the data obtained by using the tool, without direct contact with the object, area or phenomenon to be studied [3,4]. After the information obtained through remote sensing, then analyzed using GIS (Geographic Information System) technology. GIS technology is the way a system capable of digging, check, integrate, manipulate, analyze, and display data spatially and refer to the condition of the earth.

Information about the shrinking green areas due to the use of other land use is necessary for the purposes of study, planning and decision-makers (stakeholders). This study focuses on land use changes in urban environments which are limited in the built up and unbuilt up area or physically is green area. Research question is, 'how is land use changes that occurred in Surabaya city during the years 1990-2009, using remote sensing and GIS technology?'

Key words: land area, Surabaya city, temporal multispectral imagery, image difference
2. METHODOLOGY AND DATASET

The area of research is Surabaya city, where located at 07°21’S and 112°36’-112°54’E with an area 335.4Km² has a very diverse city activities with a population of more than 3 million people scattered in 31 districts. As the second largest metropolitan city in Indonesia, certainly the main attraction for the newcomers in order to live, work, and leisure. Average economic growth of Surabaya City is 6.8% until the year 2010 (www.surabaya.go.id/profilpemerintah/rpjm/Lampiran%20Tb-5-3.pdf, accessed 2011), have an impact on improving the development, work, and leisure. Average economic growth of Surabaya City is 6.8% until the year 2010 (www.surabaya.go.id/)

Technology Landsat satellite, the generation of TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper Plus) which has the ability of sensors to produce a multispectral image with spatial resolution, spectral resolution and radiometric resolution better than previous generations, will help provide accuracy in classification with increased resolution radiometric from 6 bits to 8 bits (http://landsat.gsfc.nasa.gov, accessed 2011).

Methodology used Maximum Likelihood supervised classification and overlay with GIS technology from years 1990-2009 to obtain green area class on each image. Maximum Likelihood formula, is written:

\[ P(x|w) = \frac{1}{\sqrt{2\pi \sigma_{ij}}} e^{-\frac{1}{2}(x - \mu_{ij})^T \Sigma_{ij}^{-1}(x - \mu_{ij})} \]

Where:
- \( \Sigma_{ij} \) = covariance matrix of class \( w \) with dimension \( p \), \( \mu_{ij} \) is the mean vector of class \( w \), and \( x \) denotes the determinant.
- \( P(x|w) \) = the probability of coexistence (or intersection) of events \( x \) and \( w \)
- \( (x - \mu_{ij})^T \) = vector transpose \( (x - \mu_{ij}) \)

This study emphasizes the total population of green area in 31 districts, each year through the image. Original shape and character of Surabaya city is ribbon shaped city, following the path of water transport on the Kalimas river in the 19th century [5], which then formed not perfect square until 2002. Along with the growing demands of development due to population increase, growth shape gradually move toward the West (2009), because growth is constrained waters (sea). In the western part are also constrained the hill, which has a height of up to 40m from mean sea level, so that growth shape become unpatterned city. Distribution of the unpatterned city growth also affect land use change, especially in green areas, making it difficult to know precisely the distribution of green areas and large amount left over, and land use change has occurred. It is expected that by using remote sensing and GIS (Geographic Information System) technology, difficulties in obtaining information on the distribution and total area of green areas can be known precisely.

The main data used in this study are Landsat image, which are distinguished, based of observations, for the 1990 image data using Landsat TM and image data in 2000-2009 using Landsat ETM+. Bands in different generations are: on the Landsat TM has a visible band (blue, green, red), near IR, middle IR, far IR, Thermal IR, and the Landsat ETM+ has a panchromatic band, blue, green , red, near IR, middle IR, far IR, and Thermal IR band. But for the purposes land use change analysis, both on Landsat image TM and ETM+ used only blue, green, red, near IR, middle IR, far IR band or 1,2,3,4,5, and 7 band. Using ErMapper software, which acts as Landsat image processing starting from geometric correction, classification, to produce land cover, then created a thematic map of land use by developing land cover maps using ArcGIS 9.3 on its activities.

Landsat image coverage for this research area is in the path 118 and row 65 with cloud cover below 10%. Especially on image after 2003 should be filling the data gap, due to damage to the satellite sensors since May 2003. To be obtained by filling the data close to perfect, selected image of that same year to avoid the occurrence of changes in land use is too large with a number of at least 3 images. Observations of pixels before being subset, measuring 964x587 pixels or 565.868 pixels (= 565.868x30x30m² = 509.281.200m² = 509.3Km²), become 335.4Km² after the subset, which is located at coordinates 675292.1S, 9204680E - 702592.1S, 9210500E with UTM projection and datum WGS-84.

It has been noted previously that the shape of the city is unpatterned city, one of the reasons was due to natural obstacles such as elevation contours, in general land with flat contour, more rapid land use change if compared with the height contours, as in the region in the western region of Surabaya City.

Land cover in Surabaya city depend on the activities listed above, which is physically realized by land use variety. From several sources said between land cover and land use have bias understanding [2], so that land cover change is identical with the land use change. Detecting the occurrence of land use change in the scope of remote sensing, is knowing first the pattern of relationships each object or pixel in the study area and then one or more than one pixel is grouped in a single label/ type of object, as the radiometric information in the image, then converted into thematic information, for example: built-up areas, plant species, and water [6].

In this research, understanding of land use is land that is used in connection with human activity, and there are rules in its use. Meanwhile, land cover is a form of the earth's surface that looks physically. So, do not always land use is land cover such as: use of paddy fields that appears on the land cover, is water because it has not been time to grow, so we need ground truth to integrate land use and land cover in order to obtain more precise information. Urban land cover can be divided into a built-up areas including urban activities such as pavement,
road, white cement/concrete based material, and the unbuilt-up areas, for example; bare soil, and vegetation such as: forests, parks, and mangrove.

3. RESULTS AND DISCUSSIONS

Remote sensing technology relies on spectral reflectance and wavelength that can demonstrate and distinguish the land cover materials such as: water, dry land, and plants. Furthermore, the sensor receives spectral reflectance and wavelength, then stored and processed through the image to identify a wider range of other materials depending on its needs. Spectral is, the separation of objects based on the electromagnetic spectrum used for data recording and influence the radiometric (gray level).

Through image processing and Maximum Likelihood supervised classification method, pixels that have maximum similarity of the spectral sensitivity and wavelength form a pixel density, in the form of thematic maps of land use of built-up areas and the un built-up areas. Image processing performed on Landsat images, in 1990, 2000, 2002, 2007, and 2009. The steps undertaken to obtain thematic maps land use change on the green area are as follows (figure 1):

Using the accuracy of root mean square error (RSME) ≤ 0.2 pixels or (= 0.2x30x30M² = 180M²) less than 1 pixel (= 900M² of land cover) so that at the time of the geometric correction, the error overlay of other images in the different years can be minimized. Furthermore, through the training area is in the image classified, which distinguishes a built-up areas and the un built-up areas. While based on character are urban class, vegetation, mangroves, bare soil, white cement, road. The classes are based on thematic, is a map of land use that has a large dimension and turned into other land use because of the urgent need for space.

The limited land area that never grew, often reduce the extent of other land use, if the space requirements increase due to an increased activity. Reduced land area of certain land use generally occurs because they do not have economic value. Without thinking about consequences, land use green area subjected to physical development over the years, and eventually become another problem in urban areas.

Density of 1 pixel in each class represents a spatial resolution of Landsat 30x30M² shown in table 1 and figure 3. In the year of observation 2009, the vast area of green (vegetation and mangrove), the remaining 10.9% or nearly 11% of the total area of 335.4Km² Surabaya (table 2 and figure 2).
**Table 1.** Results of classification and class area in pixels

<table>
<thead>
<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td></td>
<td>40.439</td>
<td>60.547</td>
<td>70.174</td>
<td>90.409</td>
<td>90.964</td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td></td>
<td>176.910</td>
<td>84.952</td>
<td>63.849</td>
<td>43.548</td>
<td>39.275</td>
<td></td>
</tr>
<tr>
<td>Mangrove</td>
<td></td>
<td>2.173</td>
<td>3.721</td>
<td>3.042</td>
<td>1.749</td>
<td>1.475</td>
<td></td>
</tr>
<tr>
<td>Bare Soil</td>
<td></td>
<td>27.924</td>
<td>9.953</td>
<td>11.897</td>
<td>11.941</td>
<td>20.550</td>
<td></td>
</tr>
<tr>
<td>Water Body</td>
<td></td>
<td>45.526</td>
<td>46.485</td>
<td>46.628</td>
<td>48.785</td>
<td>52.454</td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td></td>
<td>16.978</td>
<td>25.370</td>
<td>44.916</td>
<td>43.895</td>
<td>48.288</td>
<td></td>
</tr>
<tr>
<td>Total Area</td>
<td></td>
<td>364.778</td>
<td>372.667</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Table 2.** Results of classification and class area in km²

<table>
<thead>
<tr>
<th>CLASS</th>
<th>PIXEL AREA (Km²)</th>
<th>90-09</th>
<th>2009</th>
<th>90-09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mangrove</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bare Soil</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Body</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Cement</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Area</td>
<td></td>
<td>Increased area = 7.1 km²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Baku, Azerbaijan | 249**
Lack of green areas is 19%, of a minimum 30% proportion of boundary area of the city would have been very worrying, unless the emergence of environmental problems in cities can not be avoided [7]. During observations in 1990 until 2009, green areas (vegetation and mangrove) reduced area of 124.5 Km$^2$. The average reduction in green areas on every 10 years from the year 1990-2000 is 8.1 Km$^2$, and from 2000 - 2009 is 4.8 Km$^2$.

Decreasing green areas in the last 10 years an area of 43.2 Km$^2$ (12.9%) was lower than the 11 to 20 years ago an area of 81.4 Km$^2$ (24.2%), but the growth of urban areas is actually higher in the last 10 years (2000-2009) covering an area of 27.4 Km$^2$ (8.2%) compared to the previous 10 years (1990-2000) covering an area of 18.1 Km$^2$ (5.4%) of the area of the city.
From figure 3, in chronological series known more compact city growth in 2009, but which part the growth occurs, an overlay technique needs to do every 10 years as in Figure 4. Urban growth in 1990-2000 (figure 5) covering an area of 5.4% spread to the North (A) near the bridge construction plan of Surabaya to Madura Island, Southern region (B) there was a plan to build Gunungsari Satellite toll roads, and the Western region (C) that access to Manukan and Tandes roads.

In the years 2000-2009 (figure 5), there is increased urban growth covering 8.2% widely spread to the North (A1) near the Surabaya-Madura Bridge access (called SuraMadu Bridge), to the North-West (C1) is an industrial estate and Margomulyo housing which access Surabaya-Gresik toll road, and there is less growth to the south (B1) on industrial estates and Rungkut housing that access to Rungkut road.

4. CONCLUSION

In this study using Maximum Likelihood supervised classification of great help when the pixels on the Landsat difficult to recognize, and the interpreter had doubts when reading pixels. One of the advantages of these methods is to classify an unknown pixel based on the similarity of the same pixel density values. But, cloud cover unavoidable in the Landsat image is 6.7% in year 2009, slightly annoying, so that the overlay technique was used to overcome such problem of the classification results of the previous year and review the field. Changes in green area that is big enough, especially in the years 1990-2000 amounted to 24.2% of total area of the city, through observations with the overlay technique is not solely due to urban expansion but switched to non urban areas of the gardens with plants without branches or grass and bare soil. Garden with plants without branches does not include classes of vegetation or trees with branches and twigs are large enough. Generally, urban growth of the Surabaya city is strongly influenced by the availability of access roads and the construction of SuraMadu Bridge, so that the distribution pattern of urban growth led to the North side. On the West side follow the road access to the Gresik city, and less development towards the South because it is limited by the level density building.

5. REFERENCES

6. Brandt Tso, Paul Mather, 2009, Classification Methods For Remotely Sensed Data, Taylor & Francis Group, LLC