Spatial Pattern of Land Cover Change in The Coastal Area of Gresik Regency, Indonesia Using Land Change Modeler

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Abstract. Industrial activities could cause multiplier effects; one of them is increasing other supporting activities such as housing, trade and services, and transportation. The rapid growth of the industrial sector in Gresik Regency and the existence of the Java Integrated Industrial Port Estate (JIPE) can trigger new activities, that could led the change in land use and land cover. This study aims to observe the patterns of land cover change before and after the implementation of the regional spatial plans (RTRW) from 2002 to 2012. The results indicated that, in 2002 to 2007 there was an increase in built-up area by 6016 ha while green open space and empty land decreased by 6416 ha. The implementation of the shifts towards the border areas has no longer occurred in urban areas.

Keywords: land use, land cover, land change modeler

1. Introduction

The industrial sector in Gresik regency becomes the dominant sector with value-added created by 2015 was almost IDR 49 trillion ($3, 46 billion). Processing industry contribute about 48.2 % in 2015 gross domestic product (GDP) of Gresik regency [1]. In 2015, the number of new industrial permits are 55 companies. It has increased 12% compared to 2014 with only 49 companies [2]. Due to the increased industrial growth, the Indonesian government in 2013 built the Java Integrated Industrial Port Estate (JIPE) with the aim of facilitating the industries in Gresik Regency.

The construction of JIPE itself could cause multiplier effect in coastal area. New industries tend to build its factory near JIPE to save the transportation cost. Increasing industrial activities in coastal area could led to increasing supporting activities such as housing, trade and services. Increased activities could result in land use and land cover change with increasing built-up areas and decreasing non-built-up areas. The construction of JIPE itself is in accordance with the regional spatial plans (RTRW), but changes in land cover resulting from the multiplier effects of JIPE and other industries could led to the uncontrolled land cover changes. The regional spatial plans (RTRW) was made with the main goal of community welfare by controlling land use to maintain environmental sustainability, thus enabling optimal and sustainable use of space. This study examines the patterns of land cover changes before and after the implementation of regional spatial plans (RTRW), to observe the differences on land cover changes that occur in the study area before and after the regional spatial plans (RTRW).
2. Materials and methods

2.1. Study area
The coastal area of Gresik Regency (7°01’19.14”S and 112°39’01.16”E) with 833, 59 Km2, is located in Indonesia’s East Java province. The study area consists of ten districts, with six districts are located along coastline (seen in figure 1). About 50% of the study areas are dominated by fish farm areas. The area is not considered fertile due to the lack of agricultural area and productive fish farm area. Sedimentations occur in the estuary of Bengawan Solo River, especially in the Northern area where Ujungpangkah district is located. Reclamation ground or landfill could be found along coastline in Manyar, Gresik, and Kebomas districts. Most of industrial estates in coastal area were formed from land reclamation process.

2.2. Land cover mapping and accuracy assessment
Three Landsat 7 images from the years 2002, 2007, and 2012 with TM sensors (path/row: 118/65), were utilized to produce historical land cover maps. The radiometric correction was performed by using top of atmosphere correction [3] and dark-object subtractions [4] methods. The geometric calibration is less required due to the root mean square image (RMSE) of all images of < 0.5 pixel [4]. Only images with less than 20% were selected [5]. The failure of Scan Line Corrector (SLC) in Landsat 7 caused data gaps. Neighbourhood Similar Pixel Interpolator (NSPI) algorithm was employed for filling the data gaps in 2007 and 2012 images. The algorithm assumes that neighbourhood pixels close to the un-scanned (gap) pixel share have similar spectral characteristics and temporal patterns of changes to the un-scanned pixel(s). By combining the information provided by the neighbourhood pixels, the value of the missing pixels can be determined [6]. Contrast stretching and colour composite images from three bands (543) were created.

Training site were selected for each year by on-screen interpretation of the colour composite image and by reference data obtained from National Mapping Agency of Indonesia (1:25,000 topographic map) and Development Planning Agency of Gresik regency (1:100,000 land use and land cover maps). A
supervised classification with maximum likelihood algorithm (MLA) was used to classify colour composite image [4]. Image classification was performed with ENVI 5.1 [7]. Accuracy assessment of land cover maps was carried out by confusion matrix or error matrix [8], with a stratified random sampling was employed to select a total 360 points for all the land cover maps. These points then were compared with the ground control points obtained from GPS [4]. Overall accuracy and Kappa coefficients were calculated, and images with > 80% value were considered to be accurate [9].

2.3. Change Analysis
Change analysis tools in Terrset Land Change Modeller (LCM) were used. Land cover maps for 2002 with 2007 and 2007 with 2012 were utilized for changes detection [4]. Change detection was performed by cross-tabulation method for each land cover classes [10]. Gains and losses of land cover from each classes and trend maps were evaluated [4], [10].

3. Results and Discussion

3.1. Accuracy assessment of land cover maps
Multi temporal land cover maps from years 2002, 2007, and 2012 were produced from maximum classification method and were validated with controlled ground control points. The overall Kappa and overall accuracy of each land cover maps was calculated by confusion matrix. The overall Kappa of 2002, 2007 and 2012 land cover maps was 80%, 89% and 93%, respectively (table 1). The commission and omission error of each land cover classes were also obtained from confusion matrix (table 2).

| LULC Maps       | Overall accuracy (%) | Overall kappa accuracy (%) |
|-----------------|----------------------|---------------------------|
| 2002 (obtained August 23rd) | 83                   | 80                       |
| 2007 (obtained August 5th)    | 91                   | 89                       |
| 2012 (obtained March 27th)    | 94                   | 93                       |

| LULC classes                | 2002 CEa and 2007 CEa and 2012 CEa and OEb | 2002 CEa and 2007 CEa and 2012 CEa and OEb |
|-----------------------------|--------------------------------------------|--------------------------------------------|
| Sea                         | 3.3, 3.3                                  | 1.8, 6.7                                  |
| Built-up areas              | 21.1, 6.8                                 | 7.9, 3.3                                  |
| Agriculture (rice fields)   | 15.3, 0                                   | 9, 0                                      |
| River or water beds         | 0, 48.3                                   | 4.4, 26.7                                 |
| Fish farm areas             | 28.6, 11.3                                | 17.8, 7.5                                 |
| Green open space and/or empty land | 12.5, 30                             | 6.3, 10                                   |

3.2. Change Analysis
Analysis of land cover changes in this study is divided into two parts to facilitate the understanding of changes that occur before and after the implementation of regional spatial plans.

3.2.1 Before spatial plans (2002-2007)
Green open space and empty land experienced the highest decline compared to other land cover classes (6416 ha). Built-up areas becomes the highest land cover (6016 ha) and has not decreased. Industrial areas, warehouses and settlements began to grow a lot in this period. Rice fields and fish farm areas also experienced more increase compared to the decline. In this period, the majority of the community still worked in the agriculture and fisheries sector because the industrial sector had not developed as rapidly as it is today. The community extends agricultural and fishery areas by utilizing open green space and
existing empty land. This causes the highest decrease in green open space and empty land as the conversion expands into rice fields and fish farm areas ‘figure 2’.

The highest trend of land cover change from non-built-up areas into built-up areas occurred in urban areas, including Gresik, Kebomas and Manyar Districts. The majority of land use changes in urban areas are for housing and industrial areas development. The location is considered strategic for industrial investors and housing developers because there are already toll roads that connect Gresik Regency and Surabaya City. Other locations with higher trends are in the border area with Lamongan Regency, such as Ujungpangkah, Dukun, and Cerme Districts. In this period, limestone-mining activities began to develop in Ujungpangkah District, causing a high trend of land cover change due to the existence of new residential areas that grew around the mining area. The majority of land use change in Dukun and Cerme District for the new residential areas is presented in ‘figure 4’.

![Figure 2. Gains and losses of each land cover classes in 2002-2007](image)

### 3.2.2 After spatial plans (2007-2012)

Regional spatial plans of Gresik Regency (RTRW) has been ratified in 2010 and has a validity period up to 2030. In 2007 to 2012, built-up areas are the highest increase among all land cover classes (4246 ha) not as much as before the spatial plans implementation. The highest decline was experienced by rice fields (3839 ha). Open green space, empty land and fish farms areas have also increased and decreased with the same ratio. Open green space and empty land have increased because the rice fields and fish farms areas have been processed into empty land before turning into built-up areas, causing green space and empty land to decline and increase in the same time with almost balanced ratio. The community into fish farms areas processes the amount of sedimentation in the river estuary. The fisheries sector is still one of the main livelihoods of coastal communities even though its productivity is not as high as before. Sedimentation is also processed into fish farms areas that will be processed by industrial investors into empty land. This causes the fish farms areas also have a balanced decline and increase. The enactment of the spatial plans reduces the amount of reclamation in the coastal area, where the decline in sea is not as much as the previous period. However, the decline in river or waterbeds that changed the river boundary into built-up areas indicates the weak supervision and implementation of the spatial plans regarding river-border conservation areas as presented in ‘figure 3’.

Locations with high trends after the spatial plans implementation have shifted towards the border of Lamongan Regency and no longer in urban areas. Districts that have high trends of change are Sidayu, Dukun, Ujungpangkah and Dukun. The majority of changes are for the new settlements. Industrial workers who cannot afford to buy houses in urban areas choose to live in the border area causing a high
trend of land cover change. National roads with good asphalt pavement roads in ‘figure 5’ have completed the border area.

Figure 3. Gains and losses in 2007-2012

Figure 4. Land use and land cover trends in amount of area changes
4. Conclusions

The amount of changes in land cover before the implementation of regional spatial plans (RTRW) is more extent than after the implementations. Built-up areas have not decreased either before or after the implementation of regional spatial plans (RTRW). Built-up areas increased by 6016 ha prior to the enactment of the spatial plans, but decreased after the enactment of the spatial plans with only 4264 ha. Thus, it indicates that the enactment of the spatial plans could control changes in land cover from non-built-up areas into built-up areas. Open green space and empty land did not decrease as much as before the implementation of spatial plans. However, the river border areas has been more decreased than before the enactment of spatial plans, which indicates that Gresik District Government does not carry out a policy of conserving river border areas that are part of the regional spatial plans (RTRW).

Built-up areas always increase both before and after the implementation of spatial plans, while open green space and empty land always decline. The fish farms areas had experienced an increase in 2007 because the industrial sector was still not developing as rapidly as it is today. Thus, the majority of coastal communities work as fish farmers. In addition, 2007 was the time of increased popularity Vaname shrimp cultivation; so that the community intensified fish farm, areas to meet the demand for Vaname shrimp. However, at the time of spatial plans implementation in 2012, the fish farms areas were decreased. Despite experiencing the decline after the enactment of the spatial plans in 2012 (3839 ha), rice fields have increased after experiencing a decline in 2007. The increase in rice fields occurred due to policies related to sustainable food agriculture (LP2B) which was a valid start in 2013, resulting an increase in rice fields in 2012 as a form of fulfilment the policy allocation ‘figure 5’.

Location of the highest trends in land cover changes before the implementations of regional spatial plans (RTRW) occurred in urban areas and border areas in Ujungpangkah District. After the implementation of the spatial plans (RTRW), the highest trend location occurred in the border areas. The implementations of spatial plans determining land cover change in urban areas so that the trend
shifts towards the border region. In addition, expensive land prices in urban areas have caused border areas to grow into new settlements because of cheaper land prices (as presented in figure 5).

Besides being cheaper, the availability of empty land in urban areas is limited before the implementation of spatial plans, decreasing the trend of land cover change in urban areas. The implementation of the spatial plans causes the location of the trend to shift, which is no longer near the city center, but rather in the border area between Gresik Regency and Lamongan Regency.

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