Monitoring of landscape change in paddy fields: Case study of Karawang District – West Java Province

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Abstract. Paddy field is an important agricultural land in Indonesia, as one of the largest rice producing-country in the world. At least 26 from 33 provinces in Indonesia are characterized by the existence of paddy field landscape. However, due to the increasing of population and development of infrastructure building, a conversion of paddy field rapidly occurs in many sites. This study aimed to examine the dynamics change in paddy field in Karawang District-West Java during the period of 1994-2015. The method used in this study mainly by the remote sensing technique using satellite images data. The result indicated that conversion of paddy fields to built area/infrastructure in Karawang is approximately 10.326,6 ha. It took up 56% from the paddy that were changed. Based on the result, the changes are likely to occur in the middle of karawang district, near the central city. This result showed the change of paddy field in 1994 converted into some built-up areas such as settlement or roads in 2015. However, about 85.597,56 ha paddy field is not changed during these period. The study showed that paddy fields landscape is facing a changes over the last two decades.

1. Introduction

Rice paddy is one of the important agricultural commodity in Indonesia. Even in the world, Indonesia is known as one of the top three rice paddy producers. This is because paddy is staple food for Indonesian people. Based on data from BPS [1], it is known that 26 of 33 provinces in Indonesia have paddy field landscape. But unfortunately, this paddy field landscape also facing the changes. In fact, paddy field landscape especially wet land paddy field can support in cultivating fishes (agro-fisheries), controlling the flood, filling the ground water reserve, and maintaining ecosystems and biodiversities[2]. In the other side, paddy field can also be cultural heritage, particularly at terraced paddy field and rice fish culture as founded in China, Japan, Republic of Korea, and Philippines [3]. They became part of site countries that are designated as GIAHS (Globally Important Agricultural Heritage Systems) in Asia and the Pacific region. In Indonesia, we call cultural landscape such paddy field and its water management as Saujana Heritage. We found it in Subak System, Bali region.

In this research, Java Island has chosen as the research area due to the facts as follow: First, based on BPS data [1], three provinces with the highest amount of crop yield were West Java, East Java, and Central Java, respectively. Those provinces are in Java Island. Second, based on Verburg, Veldkamp, and Bouma [4], the level of urbanization in Java Island is higher than the other with the density more than 800 people/km^2. The existence of Jakarta as the largest city in Indonesia also carry a huge

influence. The increasing of socio-economic activities in this city have led to massive land use changes [5]. The changes are happened in its surrounding areas, not only Bodetabek area as usual but also Karawang District. Types of the changes are in the form of green areas such as forests, paddy fields, into settlements and the other built up areas. Certainly, Karawang as one of paddy's production center that was very close to Jakarta will get influence of the existence of that largest city. Third, based on Handayani [6], the growing and developing economy and social change were consequenced of urbanization. It indicates that higher the level of urbanization, the higher its impact on social and economy. Those facts encourage researcher to know whether there is a change or not in paddy field landscape in Karawang.

We need some satellite images data to know the change and how fast it changed. The result will be extracted to be land cover map and it applies the remote sensing technique. This research aimed to get land cover change map of paddy field in Karawang District-West Java. Using this land cover change map, we can give recommendations so that more changing would not be happen in the future.

2. Materials and methods

2.1. Study area

This study was conducted in Karawang District-West Java, which located latitude S5º56′ - S6º34′ and longitude E107º02′ - E107º40′. This area has also chosen as the research area based on some facts as follow: *First*, Based on BPS data [1], West Java is the province with the highest crop yield in Indonesia, and Karawang is one of paddy's production center. *Second*, Karawang is in the distance 112 km from Jakarta [1], and it is known that the area around Jakarta has faced the high level of urbanization [7].

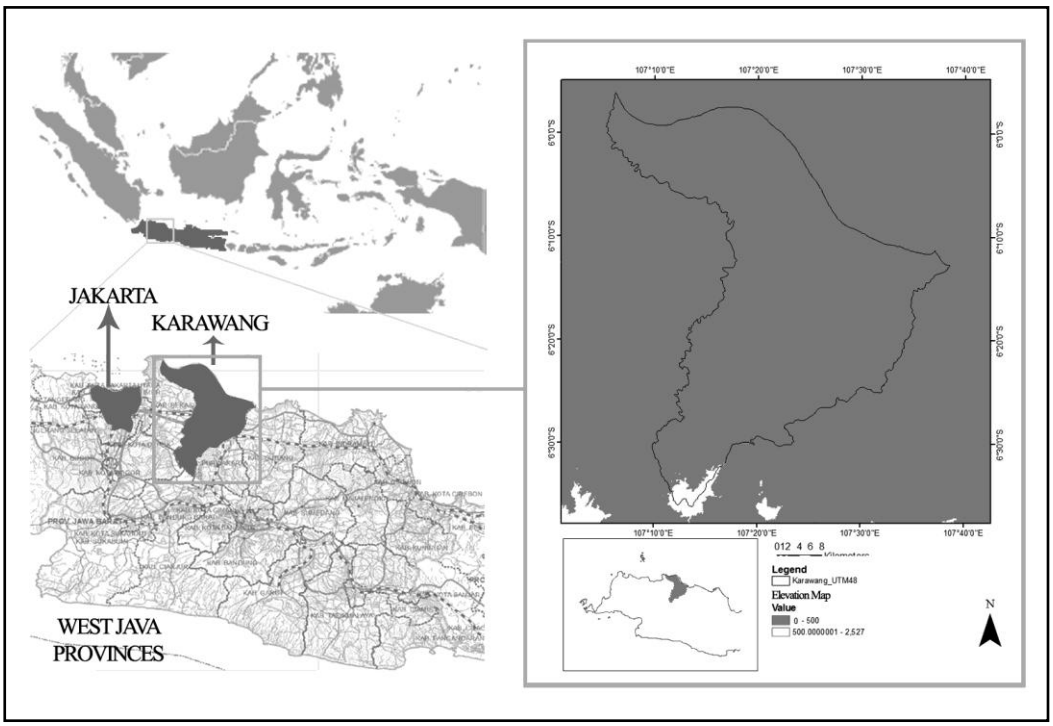

Figure 1. Study area

The figure 1 above is the location map of Karawang. Originally, it is an elevation map of this area. The elevation map was extracted from ASTER Global Digital elevation Model (ASTER GDEM) and was classified due to the height of planting paddy from *Balai Besar Padi* [8]. According to this classification, approximately 95% of Karawang District is in low land area (0-500meter above sea level) in which classified as S1 category (very suitable) for planting the paddy. Based on Integrated Crop Calendar, the average rainfall in Karawang is 272 mm/month [9].

2.2. Data collection

The main data used in this research is satellite images data. The images data are Landsat 5 (1994) and Landsat 8 (2015). Besides the satellite images, this research also need Indonesia Digital Map (RBI) at Karawang scene. This RBI data will be used for geometric correction and as a reference on supervised classification process. The tools that used in this research were varied. The main tools are ArcGIS software and Erdas Imagine 9.1. These tools serve to collect, to save, and to analyze data.

Table 1. Research's material, source, and its function.

Material	Unit	Source	Tool's function
Digital Map (RBI)	Vector	Geospatial Information Agency	Earth Surface Map
Satellite Images Path 122 row 064	Landsat 5 and Landsat 8 (Raster) 30x30 m pixel resolution	National Aeronautics and Space Administration	Land Cover Change Analysis
Aster GDEM	Raster (30x30m)	National Aeronautics and Space Administration	Elevation and Slope

2.3. Land cover analysis

This research follows the research process as illustrated at study flowchart (figure 2). Images data were selected using purposive sampling with considering the quality of images (cloud free) and time interval. The time interval is related to probability of change's time that is closely related to the change of technology, economy, and government policies.

Land cover analysis in this research use the Maximum Likelihood Classification (MLC method). This is a standard method that often used in supervised classification algorithm. It quantitatively evaluates the varian and covarians from spectral response of an unknown pixel [10]. The algorithm of MLC method is able to know the spectral characteristic of each class on an unknown data set using statistic data. This statistic data obtained from training site that had done before [10]. The algorithm is assumed normal distribution of multivarians from each spectral classes. The average vector and matrix covarians from a distribution can be used to explain it completely. With these parameters, it is possible to approximate the statistic opportunity from pixel value that given to be part of a spectral class [10]. Simply, this method facilitates us to categorize pixels into specific class. This MLC method delivers land cover map.

2.4. Land cover change analysis

On this stage, the result of MLC method will be processed further to detect the changes. But previously, we need to do accuracy assessment that can corrected the land cover map of each year. The input of accuracy assessment comes from the points that we take using GPS on each land cover through all area of Karawang District. The PCC method will be executed if the result of accuracy assessment reach 80% or more.

Change detection analysis that using this method is done at model maker in Erdas Imagine. Basically, this method is comparative analysis of classification result at different year using simply mathematical combination pixel per pixel.

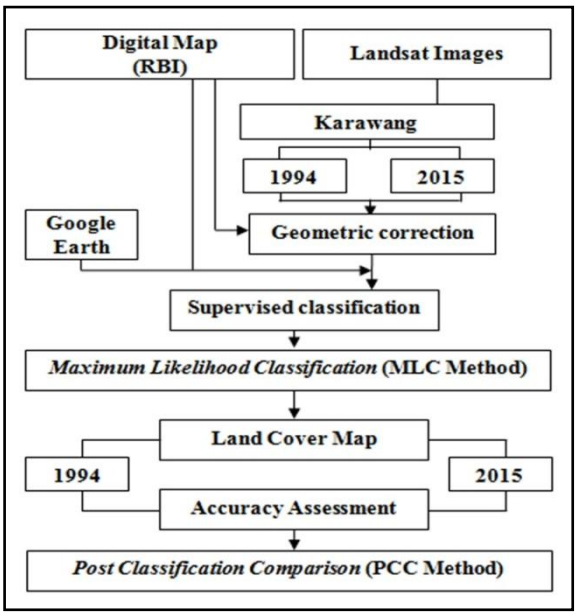

Figure 2. Study flowchart

3. Results and discussions

Based on the result at supervised classification process, the images were classified into 7 classes: bare land, dry land/mix garden, paddy field, built area, forest, fishpond, and water. This classification produces land cover map year of 1994 and 2015 (figure 3 & 4). The result of overall classification accuracy reaches 87.79 % for 1994's image and 89.43 % for 2015's image.

The paddy field landscape (figure 5 and 6) is still dominated the area in 1994 and 2015. Visually, the built area (in the middle of Karawang District) is increased in 2015 while the paddy field area is decreased. From those figures, we completely see that paddy field is decreased with amount of 7178.5 ha and built area is increased with amount of 6598 ha. In figure 7, we will see the paddy field landscapes that were changed and were not changed during 1994-2015 period.

At figure 7, there was 18460.8 ha paddy field landscapes that were changed from paddy to other classes. At this, we can focus on Paddy to Built Area (see the legend at figure 7). This area is paddy field landscapes in 1994 that were changed to built area in 2015, with a wide area reached 10326.6 ha. Please see figure 8 and 9 for detailed information.

From the figures 8 and 9, the change in the form of paddy to built area is the highest in wide area. It took up more than half. In summary, we can conclude that 56% of paddy field landscapes in 1994 have changed to settlements/infrastructures in 2015.

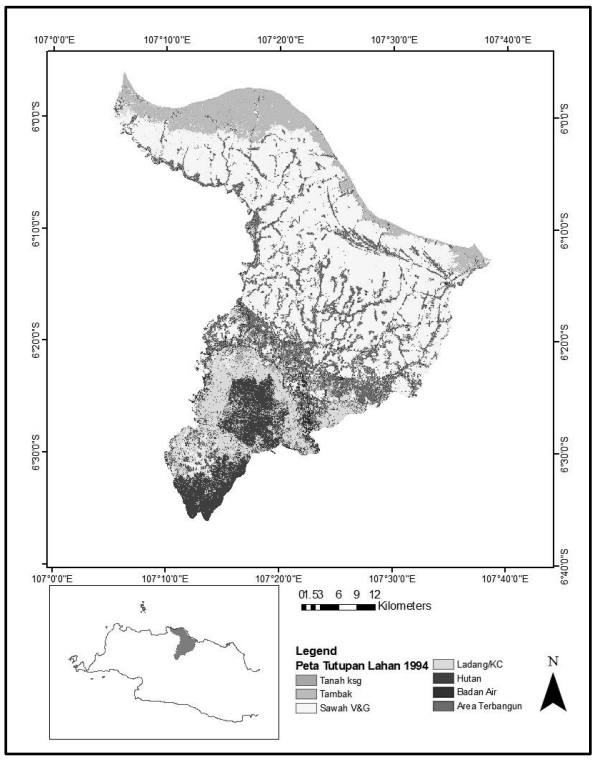

Figure 3. Land cover map 1994

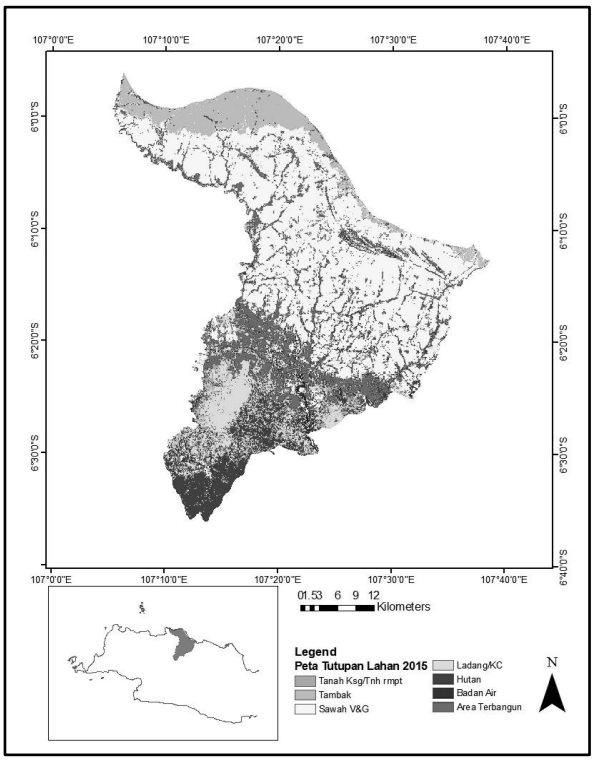

Figure 4. Land cover map 2015

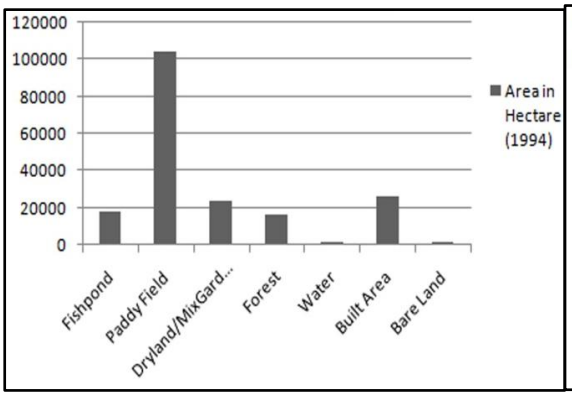

Figure 5. Wide area in 1994

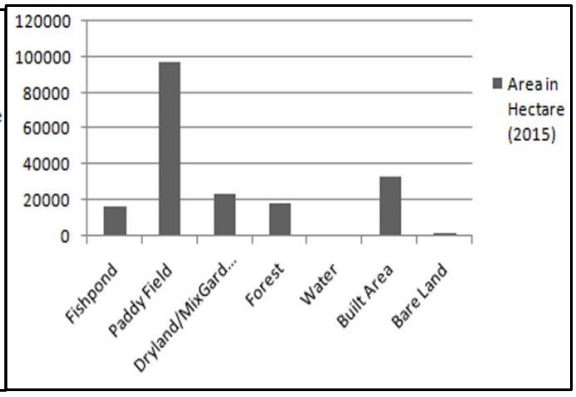

Figure 6. Wide area in 2015

Furthermore, based on land cover map 2015, Karawang District is faced to a very significant development. More clearly, at the land cover change map (1994-2015), the changes are dominantly take place in the center of the city. Through the ground check and RBI data, area in the center of the city is dominated by housing and commercial area. At this area, there are toll road and arterial road too. From those facts, it can be assumed that beside the population growth which characterized by the increasing of housing, the existence of road access and commercial buildings were estimated as driving factors of change. But, it needs a further research to prove it.

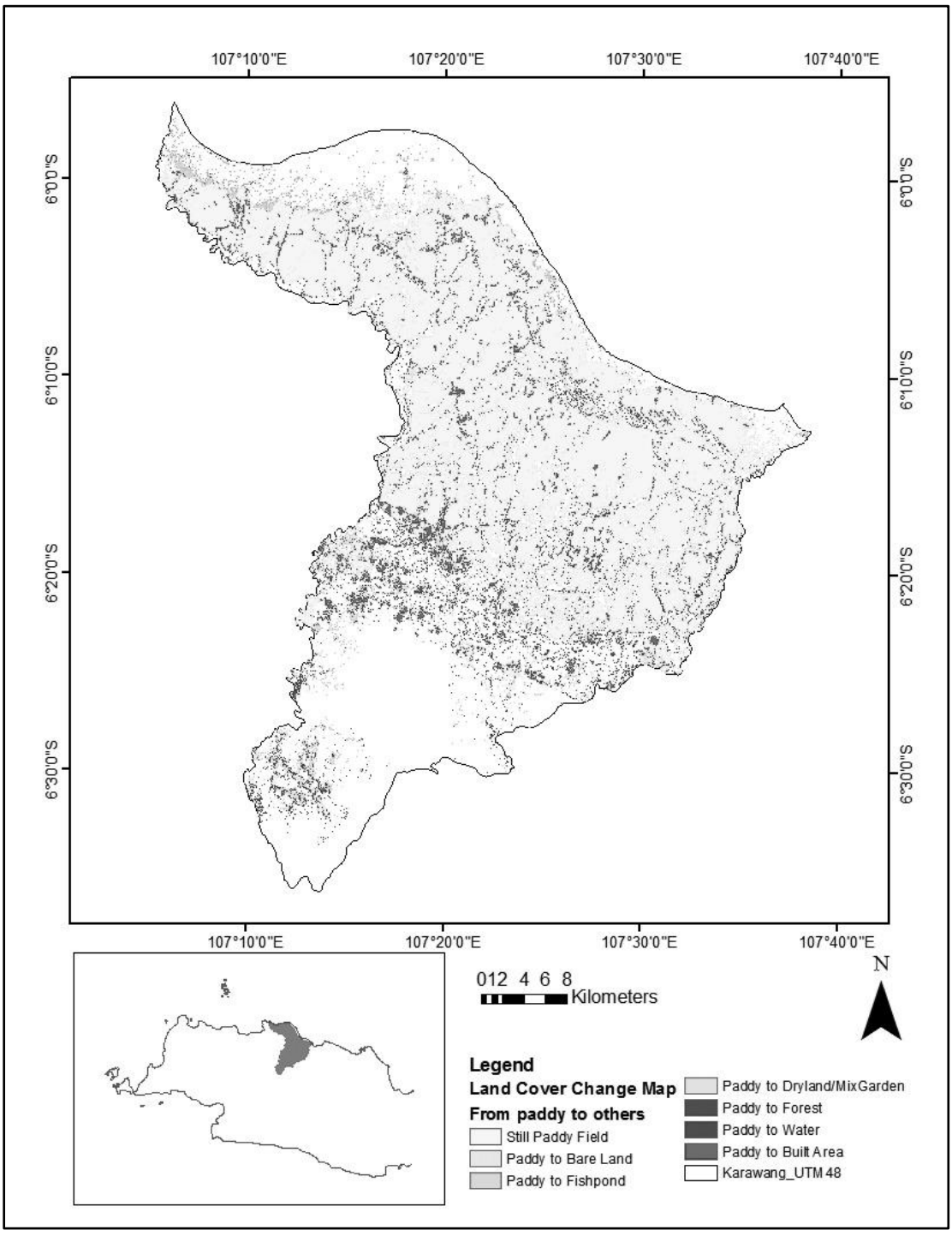

Figure 7. Land cover change map from paddy to other classes (1994-2015)

4. Recommendation

We need to maintain the paddy field area, especially near the area that was estimated as driving factors of change. Housing area, commercial building area, and economy area need to be maintained so that the paddy keep produce well. As mentioned before, we also need to do a further research especially in driving factors analysis. In the other side, a good supervision and spatial arrangement will be helpful in preventing the changes. The legislation that protects the area of food production is also needed.

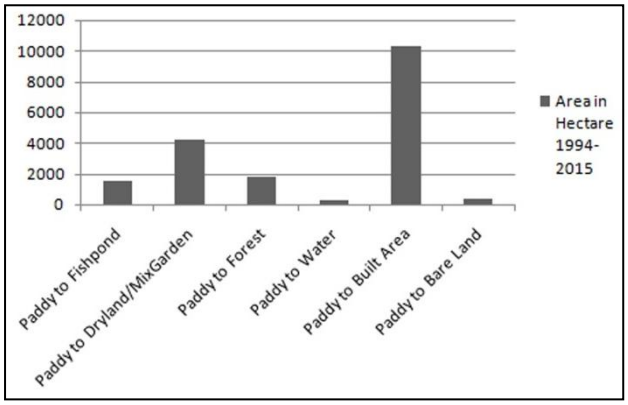

Figure 8. Wide area of paddy fields that were changed to other land cover classes

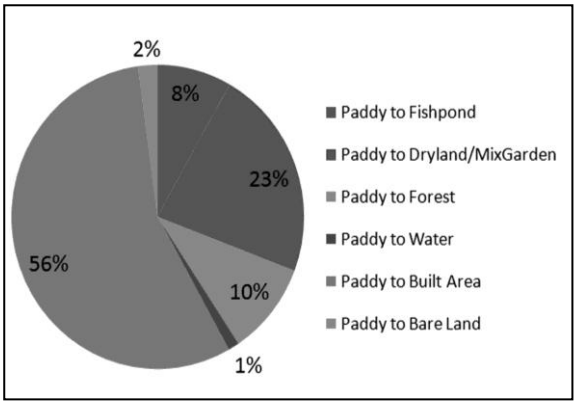

Figure 9. Pie chart of wide area of paddy fields that were changed

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