Study of Land Use Change in Regional Scale of Java Island, Indonesia

(インドネシアのジャワ島地域における土地利用変化に関する研究)

Name: Yudi SETIAWAN (Student ID No: 201030334)

Doctoral Program in Sustainable Environmental Studies
Graduate School of Life and Environmental Sciences

Abstract

The island of Java has a long history of agriculture and settlement, and is characterized by high population density and high productive land. About 70.62% of Java is considered to be agricultural land use as follows: paddy fields, mixed gardens, uplands/dry lands, open grass, fishponds, and plantations, with as much as 5.43% of the area covered by settlements.

The awareness on land use information has increased considerably in global and regional scales, since it is the key to a wide range of environmental issues including land degradation, loss of biodiversity, food security and environmental sustainability. On the other hand, in tropical regions such as Java Island, Indonesia, many land use databases and maps exist in various places and in diverse forms, but they are still far from being sufficient for current needs. A large amount of the land use and its change information exists are not accurate enough over large geographic areas. Most are limited to an inconsistent mixture of land use and land cover classes. These themes indicate that the technical issues related to data, such as classification and scale of land use land cover, are still considered to be an important issue.

The objectives of this study are: (1) to examine the feasibility of using long-term satellite datasets for detecting and quantifying the change in land use, (2) to identify systematically the process or pathway of such changes, and (3) to provide insight information about the future role of the land use change in Java based on their biophysical-environment characteristics. Achievement of these objectives will improve the understanding of land use and land cover dynamics on Java Island.

This dissertation consists of eight chapters, and has been organized following the “paper route” which encompasses three scientific papers submitted for publication. In Chapter 1, I provide an introduction to contextualize my research, followed by the research problems and the main objectives to be addressed. In Chapter 2, I present a description about the study area and datasets used in my research. Chapters 3 to 6 correspond to stand-alone papers, two chapters are published or currently in press, one chapter is submitted and one chapter is prepared for paper submission. In Chapter 7, I present the general discussions which correspond to the objectives of the study. Finally, in Chapter 8, I present the overall conclusions of this thesis and some policy implications.

Characterizing temporal vegetation dynamics of land use

In this Chapter, the temporal vegetation dynamics of long-term MODIS data sets was characterized, and then their patterns were used as pattern signatures to generate a land use map. Accuracy assessment of the results showed the need to evaluate such methods for land use types that do not have a consistent yearly pattern. On the other hand, the identification of the intensive agriculture lands, such as paddy rice and upland, was satisfactory. Although the mixed pixel issue is quite problematic when using MODIS data, the results indicate that MODIS data offer great promise for characterizing seasonal as well as multi-year variation at large scales. Indeed, the methodology proposed in this research distinguished among many specific land use classes based on temporal land cover information properties. This chapter provides a detail description of each

land use type and their distribution in Java Island, which then provides basis information on land use types used in the next chapters.

Detecting land use change from seasonal vegetation dynamics

In this Chapter, the temporal vegetation dynamics from the wavelet-filtered MODIS EVI is used to detect the land use change over Java. The results show that detecting the change from seasonal vegetation dynamics is applicable to distinguish the actual land use change from land cover dynamics. However, such outstanding capability of the method was limited by mixtures of land covers since the spatial dimension of MODIS are 250 m by 250 m. The result was evaluated using 18,626 reference pixels and showed an overall accuracy of 76.10%. The weakest results are in upland and timber forest plantation uses, and these were caused by temporal complexity related to the climate-driven change of land cover existing in the study area. On the other hand, for land use types which are not significantly affected by climate variability such as paddy rice fields with sufficient irrigation systems, natural forest and mangrove, the accuracy results are satisfactory.

Change processes of regional land use in Java: A case study of forestlands

This Chapter deals with characterizing temporal vegetation dynamics continuously in the forestlands and monitoring their changes in order to understand the land use change processes. Moreover, the method applied is also linked with a concern about the net change area of forest within the contexts of deforestation, forest degradation, reforestation and forest regrowth. As argued in the previous chapter, the change in the forest lands could be recognized from the change pattern on the long-term vegetation dynamics, either forest losses or gains.

This chapter is a case study of recognizing the change of land use in detail and understanding their change processes through the continuous analysis of satellite imagery. In case of forestlands, it concerns on the net of change area within the contexts of the forest losses and gains.

Biophysical spatial modeling of land use change in Java Island

This Chapter introduces a biophysical spatial modeling for land use change on Java Island considering neighborhood interactions between land use types and the change area. Then, these neighborhood characteristics used in logistic regression model to estimate the probability of the change events occurrence. Moreover, the future role of land use change is then projected using the Markov model based on the annual land use changes map from 2001 to 2007.

The results indicate that paddy rice with irrigation system (double cropping), especially in upland areas has a high positive spatial autocorrelation with the change areas. Residential area, paddy rice, and upland with intensive cropping have a high effect to the probability of change occurrences. Meanwhile, barren lands/dry land, bush-shrub and mixed garden give a negative impact to the change occurrences in agricultural lands. In the case of forestland, the results show some land use types such as upland with intensive cropping and plantation have positive contribution to the change of land.

The future role of land use change was projected using the transition area and probability of Markov model. The accuracy of the model was also assessed through comparison the projection with the actual area in 2007. The results indicate that the future role of each land use type is different based on the trend period predictor in the model For example, agricultural land in dry land areas/upland can be projected regarding their trends in period 2001-2002, 2002-2003 and 2003-2004, with different areas are 0.65%, 0.38% and 0.35%, respectively.