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Book Review
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Land Use, Climate Change and Biodiversity Modeling: Perspectives and Applications, 2011, 512 pages

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Geographic Information Systems (GIS) is one of the fastest growing technologies. It is hard to resemble definitions of GIS, because it has such a broad application. Principally, it is combining technology and processing capabilities of map and its attributes. One of general definition is a system used to store, manipulate, analyze and display spatial data that has reference to the earth. In the early of its development, GIS is only used for digital mapping for the purposes of resource inventories, cadastral, planning, transportation and census, but by this time GIS has been widely used for modeling and decision making. Along with advances in GIS, remote sensing technology is also increasingly available with different levels of temporal and spatial resolution. Remote sensing data can be used as inputs and spatial modeling validation using GIS.

The book of Land Use, Climate Change and Biodiversity Modeling: Perspectives and applications, writen by Yongyut Trisurat, Rajendra P. Shretha & Rob Alkemade tries to explain how GIS and remote sensing technology can be used to understand the relationship between the land use and land cover change, climate change and biodiversity. It was written by scholars from various universities and disciplines. The book is divided into 4 sections consisting of 20 chapters. The first section is the introduction. The second section has 3 chapters which describe techniques for building biodiversity data, land-use and consequences of climate change on biodiversity. The third section consists of five chapters describing the various methods/models to predict the changes in land use and biodiversity. Section 4 provides case study with diverse topics from many sources.

In the introductory chapter, the author describes the basic concepts and illustrates the importance of biodiversity. Value/service of biodiversity (genetic, species, and ecosystem), either directly or indirectly in an ecosystem can be divided into four, namely, Provision Service (food, feed, pharmaceutical, and energy), Regulating Services (carbon, waste decomposition and detoxification, pest and disease control), Supporting Service (seed, dispersal, and nutrient cycling), and Cultural Services (recreation, scientific, cultural, and spiritual).

Land Use (LU) and Land Cover (LC) are habitats/homes for biodiversity. Changes in land cover/land use, deforestation and forest fragmentation will greatly affect to the viability of the species. It is based on an assumption that changes in LU/LC will change the habitat suitability of the area for a particular species. This assumption may be greatly simplified, so that a deep understanding of the suitability of habitat for a species/species groups in different land-use/land covers, and the extent of the influence of the presence and abundance of species, are very important in making the model.

The survival of the species cannot be separated from the effects of climate change. Countries that joined as the Inter-Governmental Panel on Climate Change (IPCCC) have been in line with impending global climate change due to rising concentrations of greenhouse gases (GHG). Some scenarios of climate change have been made with a variety of models including the General Circulation Model (GCM). GCM is a proper model to predict future variations in climate change. GCM has been built with a better accuracy with a spatial resolution of 250 km, but is still too rough to predict the impact of climate change on biodiversity. This is due to the flora and fauna are highly dependent on the condition of landscape/habitat on a smaller scale. Nevertheless, the Convention on Biological Diversity has estimated the effect of climate change on biodiversity, including the loss of species, changes in phenology, changes of hatching and changes immigration of insects, birds and mammals, changes in species distribution to areas of higher or closer to the poles. The second section discusses the role of forests in climate change and centers of diversity, how to get information distribution and extent of land cover and land use (LU/LC), and what influence the change of LU/LC.

Forest has been identified as a regulator of climate as it affects the composition and circulation of gases in the atmosphere, so it acts as a shaper of global water cycle and stabilizer of the local weather. Forests are also the habitat of various flora and fauna that are beneficial to human survival. They monitor the changes in the distribution of LU/LC on a regular basis then they are also the primary need in understanding the impact of climate change on biodiversity. LU/LC will always be changed dynamically, due to the indirect influence/driving force (population growth, agricultural commodity prices) and the direct influence (expansion of agricultural land).

The need overseeing these changes is also encouraging the development of a range of satellite technology that monitors the earth on a global scale, regional/national and local. Global data of LU/LC can be built at a spatial resolution of 0.5–1 km by using the Moderate Resolution

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Imaging Spectroradiometer (MODIS) or the Advanced Very High Resolution Radiometer (AVHRR). LU/LC on a scale of Regional/National can use Landsat and MODIS data at a resolution of 30–500 m and at a local scale can use the Linear Imaging Self Scanner (LISS), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Satellite Pour l'Observation de la Terre (SPOT), and IKONOS. If there is difficulty in processing the satellite data, the LU/LC data are also freely available for download at several sites, including the FAO, CERES, and WRI. Data of LU/LC are built to be used as input of various spatial models including General Ecosystem Model (GEM), the Conversion of Land Use and Its Effects (CLUE), Spatial Markov Models, Cellular Automata, and others.

Section 3 discusses the various modeling for LU/LC and Biodiversity. Among them are the Integrated Environmental Change (IMAGE), CLUE Scanner Model, GLOBIO, and Maxtent. IMAGE was built in 1980 by the National Institute and the Environment (RIVM) in Bilthovem, Netherlands. After having various improvements, the current IMAGE has reached version 2.4. IMAGE is a combination of various models. In principle, the model is divided into three sub-models/sub-systems, namely (a) the socio-economic system as a driving force of changes in LU/LC (demography, agricultural economics & trade, the world economy, supply and demand of energy), (b) earth system (managed land, natural vegetation, atmospheric and ocean systems Atmospheric chemistry), and (c) the impacts on climate, land degradation, water, biodiversity and pollution of water and air.

Projection of population growth as a driving force has been adopted from existing models, namely the model of the United Nations (UN), and International Institute for Applied Systems Analysis (IIASA), which has been displayed in a form of grid. Energy supply and demand use TIMER model. TIMER is a simulation model which describes the dynamics of long-term energy production and consumption. Need of agriculture and trade use the Global Trade Analysis Project (GTAP). GTAP will estimate the consumption and trade of agricultural materials to calculate regional and global market, which is derived from the production function, including capital, labor and land prices. The first, LC/LU uses the data from remote sensing, while the basic rules (rule-based) of land allocation takes into account the productivity of agricultural land, land suitability and proximity to surface water sources. The consequences of changes in LU/LC are the changes in the carbon cycle, which are approximated by using the Carbon Cycle Model Explicit Geographically. Moreover, the consequences of changes in LU/LC also cause changes in surface-nutrient balance and nitrogen emissions, both from point and non-point source. Coincidently, the changes (land and energy systems) will affect the composition of gases in the atmosphere. The changing dynamics of the model will be approached with the Atmosphere-Ocean System Model. The impact of changes to biodiversity will be approached by the GLOBIO model. Results from the IMAGE will become the basis of decision making. IMAGE has been widely applied in various studies IPCC, UNEP, OECD and others.

The second model is the CLUE-Scanner Model. This model is a development of the CLUE and Dyna-CLUE made by Peter Verburg of the Institute for Environmental Studies (IVM) University Amsterdam. This model is made by using a cellular automata approach, which simulates changes in LU/LC based on the surrounding LU/LC. The basic rule changes are constructed by arranging a transition matrix based on historical changes in the area. Thus this model predicts the changes not only in one type of LU/LC but also all types of LU/LC. It is an advantage of the CLUE model compared with other explicit models, e.g. using logistic regression models, which only simulate the change from one type of LU/LC only. Based on this model, the changes in LU/LC are determined by four things, namely Spatial policy and restriction, Land use requirements (demand), Land use type specific conversion settings, and location characteristic.

The third model is GLOBIO. GLOBIO is modeling to take into account the impact of environmental change on biodiversity, on a global scale, regional and local. GLOBIO Framework is based on Driver, Pressure, State, Impact and Response (DPSIR) approach which was introduced by the United Nations Environmental Program (UNEP). The indirect drivers are population growth and economic growth, which would then affect the environment (climate change, habitat fragmentation, infrastructure, LU/LC). Driver spatial data can be the output of IMAGE or CLUE model. As Drivers and Pressure Response, the response options can be selected from stakeholders, e.g. establishing protected areas or forest plantation development. The output of GLOBIO is an indicator of biodiversity, including the Mean Species Abundance (MSA) and the good ecosystem distribution. MSA is the naturalness indicator, which is defined as the abundance of species compared with the abundance of the species in its natural habitat. MSA of 100% means that the abundance of species is the same with the abundance of species in natural/original conditions, while the MSA of 0% means that the ecosystem has been totally destroyed, and there is no longer the original species.

The fourth model is the Maximum Entropy (Maxent) which is compared with Logistic Regression and applied to model the habitat suitability of elephant (*Elephas maxymus*) in Thailand. Two models of this work are based on the function of opportunities, but they have a difference of principle, namely their input data. Logistic regression requires presence and absence data, whereas Maxent need the presence data only. Maxent will maximize relationship between the existence of species and underlying variables. Maxent is suitable for use on a mobile species, or very hard to find or very rare in supporting data.

To map the suitability of habitat for elephants, some thematic maps are used, such as land-use maps, elevation, slope, accession to permanent water sources, distance from roads, distance from ranger and the distance from the village. The results of the analysis showed that there are big major differences. Logistic regression estimates that 56% of the study area as suitable habitat for elephants, but Maxent estimates only 9%. This does not mean that the logistic regression is better than Maxent, but the logistic regression more emphasizes the need of strategy in model selection. Consideration of the data will determine the completeness of

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the chosen model. If the absence and presence data are available in sufficient quantities, it is more advisable to use Logistic Regression.

The fourth section is about of the case study. There are 9 case studies presented and 4 of them are description of diversity status in Thailand, Ukraine, tropical highlands of the Andes, and Asia. This description is not reviewed one by one in this paper, because it is out of the context. The main topic of this book is emphasizing the spatial model. The spatial model used in the case study is CLUE (Thailand), GLOBIO (Tropical Andes, Thailand, and Ukraine), CLUE and GLOBIO (Thailand), and Logistic Regression (Indonesia). The review focused on the case in Thailand and Indonesia.

In the case in Northern Thailand, the changes of LU/LC are performed using CLUE model and their impact on biodiversity is done by GLOBIO 3. CLUE requires 4 kinds of input, which will create a variety of conditions and CLUE will determine the best solution. The 4 inputs are (a) land use requirements/demand, (b) location characteristic, (c) spatial policy and restriction, (d) matrix conversion.

Land use requirements are built by using three selection options: (a) the current trend/business as usual (BAU), (b) the national scenario, and (c) conservation-oriented scenario. Characteristics of the location are a combination of biophysical conditions, social and economic. Spatial restriction policy is government policy to protect the national park, meaning that in the national park are not allowed to land changes. While the land use change matrix prepared on the assumption of type LU/LC can be changed after 10, 20 and 30 years, not based on historical changes in land previously. This makes scenario unrealistic.

The results of the analysis of the CLUE model become the input for the GLOBIO 3 model, after processing by using FRAGSTAT 3.0. FRAGSTAT 3.0 is used to quantify the landscape, by calculating various indices based on area and polygon perimeter, such as the total area (TA), total patch (number of patch /NP) for certain LU/LC, mean patch size (MPS), a broad average core (core mean ares/MCA) and Largest Patch Index (LPI). The landscape indices reflect the landscape in the study area. The higher number of patch and the smaller MPS indicate that the landscape is fragmented into a small area, which will be bad for biodiversity. Combined CLUE and GLOBIO are able to provide an overview of the dynamics of changes in LU/LC and the effect to biodiversity.

In the case of Indonesia, the binary logistic regression model was applied to predict deforestation in Java Island. The driving force is the bio-physical and economic conditions, the smallest unit of village analysis. The variables are the slope, elevation, road density, population density, agrarian population density, and non-agrarian population density. All variables are standardized to 8 bits of data, with the minimum value is 0 and the maximum is 255. Deforestation becomes dependent variable, where deforestation occurs when there has been a loss of forest area of > 20 km^2. As the basis of establishment model is the data of LU/LC in the period 2000 and 2005, while the comparable data to determine the level of accuracy of the model is the data of LU/LC generated from MODIS satellite data in 2008. The scenario used is a 1.2% increase in population per year (increase of low population) and 2.4% per year (moderate increase of population).

Deforestation simulation using moderate scenario shows that in 2020, the deforestation occurred on rural on Java Island, including in national parks. The implication of this model is that the government should pay more attention to rural communities with open access to non-farm employment (not dependent on the land), so the pressure on forests can be reduced. Good access in Java Island will also encourage the community to plant trees because the constraint to carry wood harvest is easy.

This book gives a fairly complete overview of the application of GIS and remote sensing for modeling that can be used to help make decisions. Although the reader should seek from primary sources to get more detailed information about the various models used. It is highly recommended that this book can be read by various groups not only limited to researchers and students, but also the decision makers.