CHANDRA IRAWADI WIJAYA. Land Use Change Modeling in Siak District, Riau Province, Indonesia Using Multinomial Logistic Regression. Under the supervision of HARTRISARI HARDJOMIDJOJO and LILIK BUDI PRASETYO.

Siak District as a new district, which is an enlargement from some parts of Bengkalis District that was established in 1999, has been developing their region in order to support the people activities and also try to be at the same level as other districts. The development, that has been conducted so far, has altered land uses which involve land conversion from a type of use to other uses. In this study, land use change modeling would be developed in Siak District that may facilitate the understanding of the process of land use change and its relevant factors in the research site. The objectives of the research of Land Use Change Modeling in Siak District are (1) to analyze the land use change during 2002 – 2005 and 2005 – 2008, (2) to develop the land use change schemes of Siak District, (3) to identify the driving factors of land use change and develop the land use change model of Siak District using Multinomial Logistic Regression (MLR) model, and (4) to examine the performance of MLR model in modeling the land use change.

The research location is Siak District which is located in Riau Province, Indonesia. Geographically, Siak is bounded by latitudes 0°21'19.50" - 1°14'43.87" North and longitudes 100°54'46.31" - 102°58'27.34" East and located in 0 - 110 m above sea level. Siak is located in Siak Watershed with Siak River as the main river. The landscape of Siak mostly is wetlands, and only little part in west side is hilly. Based on the spatial analysis, Siak District has area about 868,117.82 Ha, and about 59% of the total area is allocated for crop and timber plantation and 9% for production forest. Furthermore, Siak Government has also allocated land for other uses such as agriculture area. There are two types of agriculture area in Siak: wetland agriculture and dry land agriculture. The preeminent commodities of crop plantation, which are managed, are rubber, oil palm, coconut and coffee which are run by private company and community. Siak also has large oil and gas resources, incorporated by international company which contributes in increasing the economic growth there (Siak District Government 2008).

The research of land use change modeling would be developed in Siak District that might facilitate the understanding of the process of land use change and its relevant factors in the research site. Land use change modeling in Siak District would be conducted in four main activities: (1) Field data collection, (2) Land use classification, (3) Land use change detection, and (4) Land use change modeling. Field data collection has been done in order to collect primary and secondary data which would be used in the research, while land use classification done in order to derive the information of land use categories of Siak District in 2002, 2005, and 2008. Land use change detection aimed to identify the transformations of land uses during 2002 – 2005 and 2005 - 2008 in Siak District. Furthermore, the land use change modeling aimed to determine the significant
variables of land use change and to find a good model which can represent the land use change in Siak District.

Based on the result of land use classification, during 2002 – 2008, Siak District was dominated by Forest land, Cropland and Grassland. In 2002, Forest land occupied up to 46.8% of the total area of Siak District, Cropland occupied 31.3% of Siak District, and Grassland for about 16.2%. Forest land decreased dramatically which occupied only 36.9% of Siak District in 2005 and then drop to 27.2% in 2008, in the same time Cropland and Grassland were increased gradually. Moreover in 2008, Cropland area exceeded Forest land area by occupying 43% of Siak District. In 2002, Settlements occupied for only 7,909 ha, but in 2005 it increased almost twice became 14,054 ha, and in 2008 became 19,340.58 ha or 2.2% of Siak District. During 2002 – 2008, Other lands were the land use category which changed dynamically, and Wetlands were assumed in stable condition.

The land use change scheme 2002 – 2005 and 2005 - 2008 shows that all land use categories tended to not transform into other land uses (stable condition) with high probabilities. The land use change scheme 2002 – 2005 also show that the three dominant land use categories in Siak District, which are Forest land, Cropland, and Grassland, transformed each other which constructed the triangle of major land use transitions with reciprocal transitions. However, during 2005 – 2008 the transformations from Forest land to Cropland and Grassland (deforestation) happen in one-way transitions, and the reforestation did not count as major land use transitions.

In this research, the land use change model has been developed in two scenarios: (1) using all significant variables determined by the MLR model analysis and (2) using observed variables determined by the observation of existing condition in the field. In the 1st scenario, the likelihood ratio tests for each independent variable show that there were 24 variables from total 28 variables which were considered as significant variables of land use change in Siak District. Natural environment contributed 6 variables, human environment contributed 15 variables, and policy contributed 3 variables to the final model. Otherwise, the variables were not included to the model were altitude, slope, distance from health service, and the area of sub district. The two tests for final model have been conducted, likelihood ratio test for the final model and pseudo r-squared, indicate that the final model of land use change in Siak District which was developed using MLR model is a good model that could explain most of the variability of land use change happen in the research site. However, the model validation for the 1st scenario which has been conducted spatially indicates that the final model could not fit the actual spatial data layers into the actual condition of land use change 2005 – 2008.

In the 2nd scenario, the observed variables included in the MLR model analysis were the existences of crop and timber plantation, the existences of road network, the spatial plans at national, province, and district level. The result of likelihood ratio tests for each observed variable done in MLR model analysis show that all observed variables may be considered as significant variables of land use change in Siak District and would be included into the final model. The two tests for final model which have been conducted, likelihood ratio test for the final model and pseudo r-squared, indicate that the final model of land use change in
Siak District is a good model that can explain most of the variability of land use change in the research site. However, similar with the 1st scenario, the statistical properties produced from model validation show that the final model could not fit the actual spatial data layers into the actual condition of land use change 2005 – 2008.

The two scenarios done in statistical MLR model indicate the land use change models which have been developed are adequate models which can explain many variability of the land use transitions. However, the model validations which have been conducted spatially indicate the final model could not fit the actual spatial data layers into the actual condition of land use change 2005 – 2008. This result may be caused by the nature of MLR model as generalized logistic regression model which forces every land use transitions to be driven by all significant parameters that have been determined, while in the real world each land use transition probably has unique combination of parameters which drive each land use transition.

By considering the research findings on the performance of MLR model in this research, the binary logistic regression would like to be recommended for the future research in order to develop the adequate land use change model which is good statistically and spatially. The binary logistic regression would find the best fit model for each land use transition individually by considering unique combination of parameters of each land use transition which involve into its model. Hopefully, the binary logistic regression may produce the conditional probability maps of land use transitions which can cover the whole area or most of the research area, increase the probability values for each projected land use transition, and also narrow the range and data distribution of the probability values of each projected land use transition compared to its actual land use transition.

Another issue considered in this research is about the effects of the predictor variables/parameters of MLR model on the dependent variable which can only be interpreted for direct effects on the dependent variable when the other predictor variables are held constant. Millington et al. (2007) proposed Hierarchical Partitioning (HP) method might be chosen to address that issue. Hopefully, HP can observe the effects of the predictor variables/parameters to the land use change, both independently and in conjunction with all other variables.

Based on the land use change scheme 2002 – 2008, the situation that should be highlighted and considered by Siak District is the increasing of deforestation probability as one of major land use transitions during 2002 – 2008. This situation was getting bad, since the reforestation was not done significantly and was not also visible as major land use transitions according to the land use change scheme 2005 – 2008. If this situation continues, it is not impossible that the Forest land in Siak District, which the majority is Peatland Forest, will continue to decline and probably in the future will be exhausted and will be replaced by Cropland as the most increasing land use category during 2002 – 2008. Synchronized spatial plans among different administrative levels (national, province, and district) may prevent the undesirable land use change and furthermore may support the sustainable natural resources management in Siak District.