1. INTRODUCTION

1.1. Background

The change of land cover condition from forest into non forest cover is often called deforestation. This change is very dynamic, changing rapidly and often uncontrolled. Recently, forest degradation and deforestation have occurred in Riau Province, particularly in Rokan Hulu, which has certainly been a great national attention. Forest clearing efforts have occurred in the Riau Province for the palm oil plantation, which is the driving force of economic growth in the province. As noted by Sachiho (2008) Riau is a region that has the largest plantations and oil palm industry in Indonesia. Furthermore, Greenpeace (2007) found in 2005, 1.4 million hectares (ha) of oil palm plantation and 835,000 ha of natural forests that have been converted into industrial timber in Riau Province.

As well as in Rokan Hulu, deforestation occurred not only in production forest but also in protected forest. As noted by Himawan (2009), 70% out of 78,000 ha of protected forest in Rokan Hulu Regency Riau Province has been changed into several uses such as oil palm plantation, rubber plantation and settlement. There are three protected forest areas namely Sei Rokan 20,000 ha, Bukit Suligi 30,000 ha, and Mahato 28,800 ha. However, the exact area of changes had not been well estimated, because the prediction is solely based upon terrestrial measurement.

The high pressure on forest resources and the lack of data and adequate information are encouraged to perform periodic monitoring of the changes. It is an essential action to keep the conservation and the control of forest natural resource. Nowadays, remote sensing technologies can be used to identify forest natural resource. Utilization of remote sensing satellite through multi temporal data allows the monitoring of forest to observe changes that occur from year to year in harmony with the increase of population and economic requirement. Landsat multi temporal satellite is a very effective way to evaluate that change because of continuous production support in a relatively short time, low cost and wide coverage compared with field observation. The advanced stage of this work
is focused on developing Markov Cellular Automata to simulate forest cover change rate in Rokan Hulu in GIS environment over time period of seven years. Moreover, some change detection techniques had been also developed.

Markov Cellular Automata process begins with land cover classification of each Landsat 7 ETM+ time series data. This was done to obtain thematic information in the form of land cover class. In this study, semi automatic method has been used by on screen digitizing technique called visual classification. The three time series used are namely 2002, 2005 and 2009 to change projection through Markov Chain process. As noted by Lambin (1994), Markov Chain is a mathematical model to explain a gradually change process from a set of conditions.

Change detection is a process to identify differences in the presence of forest at three time series in Rokan Hulu Regency. Markov Chain has a simple concept of transition probability of Land Use and Land Cover Change (LULCC), in this study the future forest is determined by the past and present conditions. Although, various forest change detection techniques have been developed with the strengths and weaknesses of each such as differencing method, Normalized Difference Vegetation Index, Principle Component Analysis, Chi Square and others. These methods are relatively easy to be applied and interpreted, but cannot show changes in the information matrix.

However, Markov Chain can indicate changes in the information matrix and predict the distribution of the future forest through transition probability matrix and transition area matrix. Besides advantages, there are weaknesses that cannot explain the interaction among the causes of change and do not represent spatial aspects. Based on these limitations, integration between the principle of Markov Chain and Cellular Automata is used to analyze and predict forest change regarding to the rate of change in spatial dimension.

Recently, several studies on change detection using the Markov Chain have been done (Wijanarto, 2006; Yuliang et al, 2008; Cabral et al, 2009). Wijanarto (2006) has applied Markov chain detection technique to detect land cover change from Landsat ETM. Markov is a good technique having great capability on generating information relating to changes of specific themes.
Furthermore, Yuliang et al, (2008) reported that the transition probability matrices can simulate and forecast the forest dynamic transformation pattern and the forest-transforming tendency in the future. Unfortunately, Cabral et al, (2009) found that the Markov Chain prediction is not spatial because it was assumed that the area units are spatial independence.

The Cellular Automata can represent spatial dimension from a dynamic process, in this case the forest change. It is simplicity, transparency and strong capacities for dynamic spatial simulation model where discrete at time dimension, place, and condition consists of a regular grid of cells (e.g Batty, 1998; Leguizamon S, 2006; Messina et.al, 2000). Cellular Automata have been utilized as a prediction technique in the study of an impressively wide range of dynamic phenomena also exude superior performance in simulating land changes compared to conventional models (Hegde et.al, 2008).

Moreover, compared to GIS models in general, cellular automata models have better modeling capability in simulation of forest change and LULCC. The GIS models have limitation in simulation complex of land dynamic without using local rules. Iterative looping usually uses static spatial variable in the simulation. However, it has some limitations such as in determining their parameter values considered to be more complex when implemented in multiple Land Use and Land Cover (LULC). In addition, statistical method may also have some limitations.

Various studies have been done by the process of dynamic model of spatial change using integration model between the concepts of Markov Chain with Cellular Automata based on raster. Weng (2002) has successfully analyzed the direction, rate and spatial pattern from land use change by integrating the Markov Chain and Cellular automata. Furthermore, Houet et al. (2006) had modeled and projected the LULCC by the Markov Cellular Automata which considered a probability matrix from possible future state respecting a general trend for each LULC class. They noted that this model could also be considered to explore scenarios and it is relatively easy to be implemented, but due to the different strategies and policies, which it is not possible to implement the Markov Cellular Automata model.
Integration of Markov chain and cellular automata is known as Markov Cellular Automata (M-CA) approach incorporating the principles of forest change in a cell related to the surrounding cells (Cellular Automata Principle) with changes in the future forest determined by current and past conditions (Markov Chain). The Markov transition probabilities are used as the basis for transitional provisions to the possible changes of each cell. Another parameter is the map of land probability that defines the direction of changes in surrounding cells.

Therefore, this study presents application of M-CA Model to simulate the change of forest cover in Rokan Hulu regency. Simulation results of spatial trend are evaluated through developing Kappa Index Agreement (KIA) to validation using spatial distribution of forest change structure to achieve the two time series simulation and final prediction of forest cover change simulation map of 2009.

1.2. Research Objectives

The objective of the research is to evaluate the use of Markov Cellular Automata to predict forest cover changes in Rokan Hulu Regency, Riau Province, between 2005 until 2009.