

# Spatiotemporal Analysis of Urban Land Cover: Case Study - Pekanbaru City, Indonesia

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**Abstract:** The number of people has an increasing pattern by years and it will impact spatial aspects. One of the impacts was land cover changes from the non-built area into the built-up area. Pekanbaru is one of developing city in Indonesia that has a high number of the population surge. The purpose of this paper was to analyse the land cover change in the urban area of Pekanbaru city. The analysis spatiotemporal has been done by using Landsat Imagery year of 2000, 2005, 2009 and 2014. The method of this paper was digital classification using maximum likelihood and their integration with Geographical Information Systems (GIS). Land cover classification divided into two classes such as built-up area and non-built up land area. Based on the results, the built-up land area has been increased by years, on the other hand, the non-built up area has declined. The percentage of built-up area change from 29,51% into 59,99%. The spatial distribution of and cover change dominantly occurs in south part of Pekanbaru city. The mean of accuracy index for the land cover map in this research was 85,17%. The land cover change of Pekanbaru city has a decreasing pattern where the year of 2000-2005 has a significant number and decreasing by years massively.

## 1 INTRODUCTION

Globally, the number of populations has an increasing pattern. Based on the report of Worldmeters (Wor, 2020), the rate of increasing population was 1,09% by years. Specifically, Indonesia has the number of population amount of 267.630.499. Indonesia categorized as a country that has high urbanization index in Asia around 2,75% by years and it's above the national index around 1,49% per year (Indrayani et al., 2017).

The increasing population will have some consequences. In the spatial aspect, the dimension of space has been pushed out by the increasing population. Yunus (Yunus, 2005) explained that spatial consequences were increasing demand for space to accommodate the population activities in the form of infrastructure and other physical structure. That will be seen the massive of land cover change from the non-built area into the built-up area. Land cover changes can be categorized by the complex interactions of structural and behavioural factors associated with technological capacity, demand and social relations that affect both environmental capacity and the demand along with the nature of the environment of

interest (Veldkamp and Verburg, 2004) (Butt et al., 2015). Land cover change is one of the main driving forces of global environmental change, is central to the sustainable development debate (Hegazy and Kalooop, 2015). Land cover change becomes one of the significant issues for planners and decision-makers in urban and regional policy (Wijaya and Susilo, 2013). In line with the issue of increasing population, land cover change become an interesting issue to explore in a developing country, especially in Indonesia. Wijaya (Wijaya and Susilo, 2013) highlight that issue has been thriving because of the lacking of law enforcement and the policy inter-institution horizontally and vertically. The study of land cover change is very essential to understand human activities and natural phenomenon.

The study of land cover change has been developed with different methods and cases (Purwanto and Bayuardi, 2016). One of the methods to determine that is the integration of remote sensing data and Geographic Information Systems (GIS). For example, in China the land cover change was obtained by using the integrated remote sensing data and GIS at years of 1992, 1996, 2001, 2004 and 2008 (Purwanto and Bayuardi, 2016). In Indonesia, several studies have

been done, one of them was Indrayani et al (2016). It has been done to evaluate land cover change and its relations with the ecological connectivity index using remote sensing data year of 1997 until 2012 in Makasar city.

The technology advance, especially on remote sensing and GIS, gives some benefit to obtain some information about earth surface such as land cover. One of them is remote sensing data can give quick information and multi-series data (NUGRAHA, 2016). GIS advance can be used for measurement, mapping, monitoring and modelling (Star and Estes, 1990). To ease the used remote sensing data and GIS in land cover studies, it can be done by making land cover classification (NUGRAHA, 2016).

Pekanbaru is a central city in Riau Province and categorized as a developing city in Indonesia. Pekanbaru city connects the north-south littoral of Sumatera, and it also connects the East and West of this island (Kausarian et al., 2018). Pekanbaru consists of twelve (12) districts, there area Bukit Raya, Lima Puluh, Marpoyan Damai, Payung Sekaki, Pekanbaru Kota, Rumbai, Rumbai Pesisir, Sail, Senapelan, Sukajadi, Tampan and Tenayan Raya (figure 1). Based on Statistical data (Pekanbaru, 2016), Pekanbaru has total populations amount 1.038.118 in the year of 2015. For the comparison, In 2000 Pekanbaru has the number of populations around 586.223. In 15 years, Pekanbaru has 451.895 of people accretion and it will affect the spatial condition in Pekanbaru city. The research purpose was to review the land cover of Pekanbaru city year of 2000, 2005, 2009 and 2014 by using Landsat imagery and digital classification. To achieved purposed, some step will be done. There were :

- a) Determine the land cover of Pekanbaru city
- b) Determine the accuracy of the land cover map
- c) Determine the land cover change of Pekanbaru city

## 2 METHOD

To achieve the purpose of the research, some primary and secondary data were needed. The data were Landsat imagery, Rupabumi Indonesia Map (Base Map), The draft of Spatial Regulation Document of Pekanbaru year of 2006. For further information, the required data were:

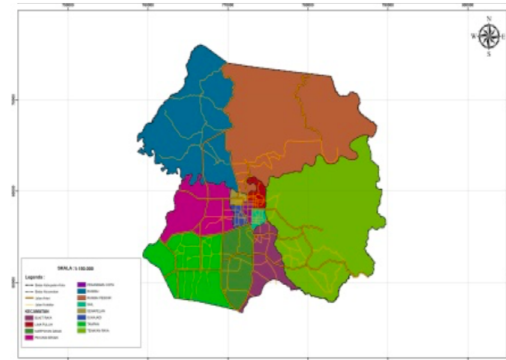


Figure 1: Administrative map of Pekanbaru

Table 1: The Data Requirements

No	Data	Sources
1	Landsat ETM+ year of 2000, 2005 and 2009. Landsat 8 year of 2014	USGS
2	Rupabumi Indonesia	Related Institutions
3	The draft of Spatial Regulation Document of Pekanbaru year of 2006	Related Institutions
4	The form of Land Cover Change	Field Observation

### 2.1 Determine The Land Cover of Pekanbaru City

To determine the land cover of Pekanbaru city, we used the classification of maximum likelihood method by using ENVI 4.5. The maximum likelihood is categorized as supervised classification. This method is classified as the pixel based on their value to the particular class. Technically, the sample was collected from Landsat imagery that has spatial resolution 30 m by selecting the Region of Interest (ROI). The land cover present into two classes, there were built up area and non-built up area.

### 2.2 Determine the Accuracy of The Land Cover Map

The accuracy assessment was needed to determine the correctness of the land cover map. The method is the Kappa index assessment. This method is compared to the land cover map with the actual condition on the field. For the sample, we used 60 points that randomly distributed. The minimum index that allowed is 85% (Jensen et al., 2004). The matrix of the accuracy index is explained below.

$$\text{The total accuracy} = \frac{a+d}{T} \quad (1)$$

Table 2: The Matrix of Accuracy Index

Field	Interpretation		
	A1	A2	Total
A1	a	b	a+b
A2	c	d	c+d
Total	a+c	b+d	T

Source: (Sutanto and Leung, 1999) with modification

### 2.3 Determine The Land Cover Change of Pekanbaru City

The land cover change was obtained by overlaid the land cover map. This stage has been done to determine the spatial distribution of the change by using ArcGIS. This method was using the raster calculator. For further analysis, field observation is needed. The land cover change information will be guided to the field observation. This step will be done to obtain information about the form of land cover change in Pekanbaru city.

## 3 RESULTS AND DISCUSSION

### 3.1 The Land Cover of Pekanbaru City

For this stage, we used the application of ENVI 4.5. From the Landsat images, we generated two classes of Region of Interest (ROI). There were built-up area and non-built up area. There were 100 samples for each class. Here below the figure 3, shows the land cover of Pekanbaru city 2000-2014.

Based on figure 2, we can see that the land cover of Pekanbaru city dominantly by the built-up area shown by the red mark on the map. Generally, the built-up area in Pekanbaru has been developing. In 2000, the built-up area amount of 208.712 pixels or around 29,51% from the total of land cover in Pekanbaru City. For the comparisons, in the year of 2014, built up area was increasing. It is shown by the number of pixels of the built-up area around 424.362 pixels (59,99%). For the distribution, the built-up area distributed randomly in Pekanbaru especially in the south part of Pekanbaru. It was because in the south part of Pekanbaru found some of the development centres as a triggered factor such as the centre of education, the centre of government and centre of trading. For the further, the pixel number of land cover in Pekanbaru shown on the table below.



Figure 2: The Land Cover Map of Pekanbaru City; (a) year of 2000, (b) year of 2005, (c) year of 2009, (d) year of 2014

Table 3: The Pixel Number of Land Cover in Pekanbaru City

Year	Built Up Area	Non Built-Up Area	Lake	River
2000	208712	491813	5377	1451
2005	349080	351445	5377	1451
2009	402534	297991	5377	1451
2014	424362	276163	5377	1451

### 3.2 The Accuracy of Land Cover Map

First step of this stage was determined the training area or point as a sample. The number of samples were 60 points that randomly spread around Pekanbaru city. The mean of accuracy from Landsat image was 85.17%. For the detail information about the accuracy shown on table below.

Table 4: The Accuracy of Land Cover Map

Year	Accuracy
2000	84.2
2005	85.5
2009	85.0
2014	86.0
Mean	85.17

### 3.3 The Land Cover Change of Pekanbaru City

The information about the land cover change in this paper was obtained from the land cover map that extracted from the Landsat image. The thematic map will be overlaid by using Raster Calculator tool on ArcGIS application. The unit analysis for the land cover change is a pixel. We used the pixel to described the change value. The land cover change in Pekanbaru city occurred in the form of the non-built up area like vegetation, swamp area transforms into the built-up area such as settlement, trading and service. The significant change occurred in 2000 until 2005. It is shown on the map, that change has been noticed by the red mark and been seen on the south part of Pekanbaru significantly. Meanwhile, the change between 2005-2009 and 2009-2014 has a small portion and distribute more equal to the north part of Pekanbaru city. Figure 3 shows the land cover change in Pekanbaru city 2000-2015.

Based on the analysis, the land cover change in Pekanbaru city has decreases pattern. From 2000 until 2005 the land cover has been massively changed from the non-built area into the built-up area. From

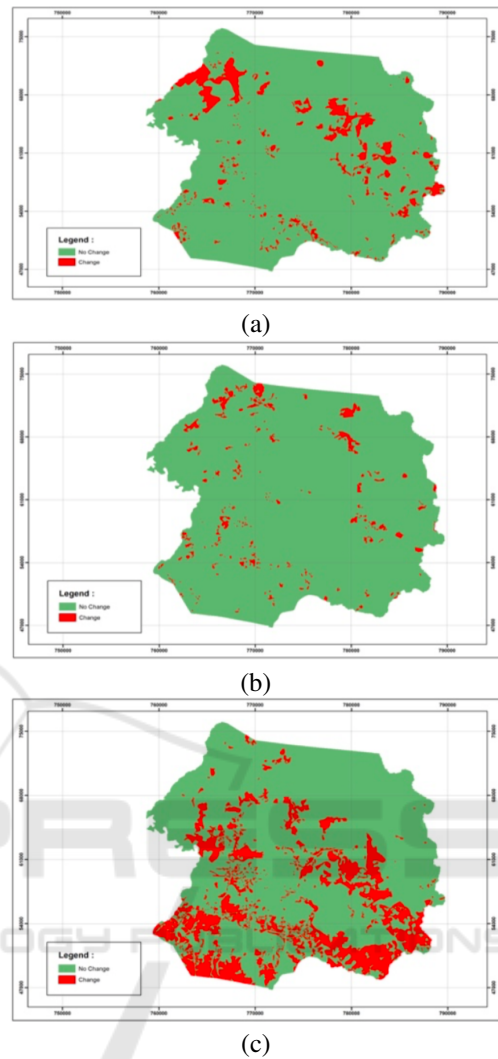


Figure 3: The Land Cover Change Map of Pekanbaru City; (a) year of 2000-2005, (b) year of 2005-2009, (c) year of 2009-2014

the total pixel around 707.503 pixels, the land cover change reaches 140.368 pixels (19,84%). From 2005-2014, the change has declined pattern, it looked from the percentage. The percentage of change 2005-2009 amount of 53.454 pixel (7,5%) and 2009-2014 around 21.828 pixels (3,0%). For the detail information, the pattern of land cover changes Pekanbaru city present in figure 4 below.

The next stage of the paper is the land cover analysis. We analyze the land cover change by using district administration as a unit and classified it into two classes (change and no change). We used the draft of Spatial Regulation Document of Pekanbaru City as other input. Pekanbaru city consists of 12 districts with each district has different size and number of populations. Based on the analysis, we found



Table 5: The Number of Land Cover Change in Pekanbaru City 2000-2014 (pixel)

Districts	2000-2005		2005-2009		2009-2014	
	Change	No Change	Change	No Change	Change	No Change
Tampan	30118	34024	2150	61992	1394	62748
Marpoyan Damai	7404	26881	1252	33033	995	33290
Bukit Raya	7437	20391	1925	25903	652	27176
Sail	250	3622	*	3872	*	3872
Lima Puluh	346	6020	*	6366	*	6366
Pekanbaru Kota	36	2316	*	2352	*	2352
Sukajadi	17	4258	*	4275	*	4275
Senapelan	81	3302	*	3383	*	3383
Payung Sekaki	9240	38352	1960	45632	2290	45302
Rumbai	20101	125565	18327	127339	7627	138039
Rumbai Pesisir	8289	165976	13398	160867	4956	169309
Tenayan Raya	57049	136278	14442	178885	3914	189413
Total	140368	566985	53454	653899	21828	685525

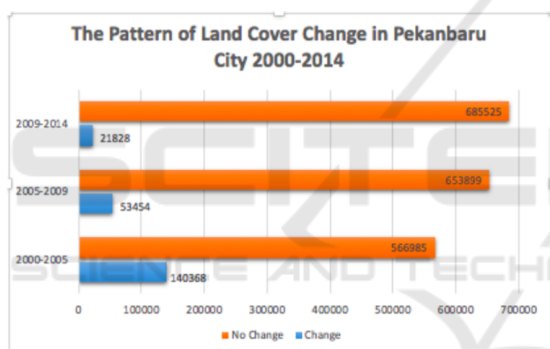


Figure 4: The Pattern of Land Cover Change in Pekanbaru City 2000-2014

that there were five districts has “no change” class from 2005 until 2014. It could occur because they located in the city centre with the least number of the non- built up area were available. Commonly, the other districts in Pekanbaru city have a decreasing pattern. For example, Tampian district and Tenayan Raya district has the high number of change during 2000- 2005, but decreasing in a heavy way by years. It showed that during 2009-2014 there were approximately 1000-4000 pixel has been changed.

In over decades, Pekanbaru hit by land cover change phenomenon as consequences of urban expansions. The increasing of populations due to fertility and migrations will impact the land cover conditions in Pekanbaru city. During 2000-2014, the land cover change in Pekanbaru city has a decreasing pattern. The main reason was the limited access to the land

due to availability and land value. Based on the research, people have the tendency to develop the land around the edge of the city. So for the future, the research related land cover change in the sub-urban area of Pekanbaru city. Regarding the remote sensing data, in this research, we used Landsat imagery as the main input. It has the spatial resolution around 30 m. For future research, the used high resolution of remote sensing data is needed.

#### 4 CONCLUSIONS

For this paper, we can conclude some points there were: 1) The land cover in Pekanbaru city was dominantly by the built-up area. It shows by the percentage of built-up area in 2014 was 59,99% from the total of Pekanbaru city, 2) The accuracy of the land cover map measured by using the short method. The mean index of the accuracy was 85,17%, and 3) the land cover change from the non-built up area into the built-up area has the decreasing pattern. It’s related to land availability and land value.

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