Article

Estimation of Green Land to Urban Change Based on Cellular Automata (CA) Method in Singaraja City and its Surrounding Areas

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Abstract

Singaraja city is the second largest city in Bali which have a fairly rapid growth. Growth and development of the region in urban areas of Singaraja give the positive impact on the economy of the community but also give the negative impact on the environment. Land use change and land conversion into one of the negative issues of the development of urban areas in Singaraja. This study intends to calculate the amount of land conversion occur on the green land into urban areas within 14 years (2001-2015) and predict land use change in 2020 and 2025 in Singaraja City and Its Sorrounding Areas. Landsat 7 and Landsat 8 imageries were used to determine the land use map. Land use map obtained through the process of image classification using supervised method then verified using data field. Land use maps in 2015 and 2001 used to obtain the amount of change of urban areas and green land during the period of 14 years. This results show increasing amount of urban areas as 11,37% (3.153,74 ha) whereas green land decreased by 11,17% (3.097,68 ha). Land use change was predicted by Markov method. The projection results show the amount of urban areas in 2020 was 27,40% (7.598,45 ha) and 35,97% (9.974,55 ha) in 2025. The results obtained with this prediction accuracy rate of 0.91.

Keywords: *land change; green land; urban land; and cellular automata (CA)*

1. Introduction

Singaraja city is the second largest city in Bali which have a fairly rapid growth. Growth and development of the region in urban areas of Singaraja give the positive impact on the economy of the community but also give the negative impact on the environment. Land use change and land conversion into one of the negative issues of the development of urban areas in Singaraja.

Various methods for modeling land use change have been applied by several researchers. Wijaya et al. (2011) was modeling using Multinomial Logistic Regression (MLR) method. Wu et al. (2006) used regression analysis to model the land use changes in the city of Beijing China and predicting land use 20 years into the future with Markov Chain models. CLUE (Conversion of Land Use and its Effects) model used by Veldkamp and Sresco (1996) to analyze land use changes in Costa Rica on a local, regional and national. By using a different size scale, this model shows that at local, regional and national levels can produce an opposite effect. Cellular Automata (Markov Chain) in this study is used to determine the location or any area of agricultural land

use that could potentially turn into a built up region (White and Engelen, 1993). Geographic Information System (GIS) used to develop a spatial aspect and constructed the driving variables that affect changes (Batty et al., 1999). Some of the variables that led to change in land use are the distance to roads, distance to rivers, distance to settlements, slope, climate, population density and revenue. In this study there are four variables used as factors driving and inhibiting changes in land use such as distance to road, distance to rivers, road network density and slope. Therefore, by combine Cellular Automata method with GIS is expected to give a better answer in modeling the land use change.

The porpuse of this reaearch are 1). To know change of green land into urban land in Singaraja City and its surrounding areas occurred during the periode of 2001 – 2015, 2). To know the projection of land use change of green land into urban land in Singaraja City and its surrounding areas in 2020 and 2025, 3). To know the accuracy of Landsat image classification and land use projection. This study intends to calculate the amount of land conversion occur on the green land into urban areas within 14 years (2001-2015) and predict urban change in 2020 and 2025 in Singaraja City and Its Sorrounding Areas.

2. Materials and Methods

This research was conducted in Singaraja City and surrounding areas. The study area is located in the three districts, they are district of Buleleng, Banjar, and Sukasada with total area of 27.732,31 ha. This research was conducted in two phases, namely the interpretation of satellite imageries and land use projections. Image interpretation conducted to obtain the land use map. Projection of land use conducted to know how the use of land in 2020 and 2025.

The interpretation of satellite imageries conducted to get land use map. Its took a few step to get land use map, namely: 1). Downloaded Landsat 8 imageries (Landsat of 2015 and 2013) and Landsat 7 imageries (Landsat 2003 and 2001) path 117 row 66 from USGS; 2). Convert DN value of Landsat Imageries into reflectance value of the surface (radiometric correction); 3). Created composite RGB of Landsat imageries; 4). Cloud remove and gap filled; 5). Cropped Landsat Imageries; and 6. Landsat imageries classification used supervised method.

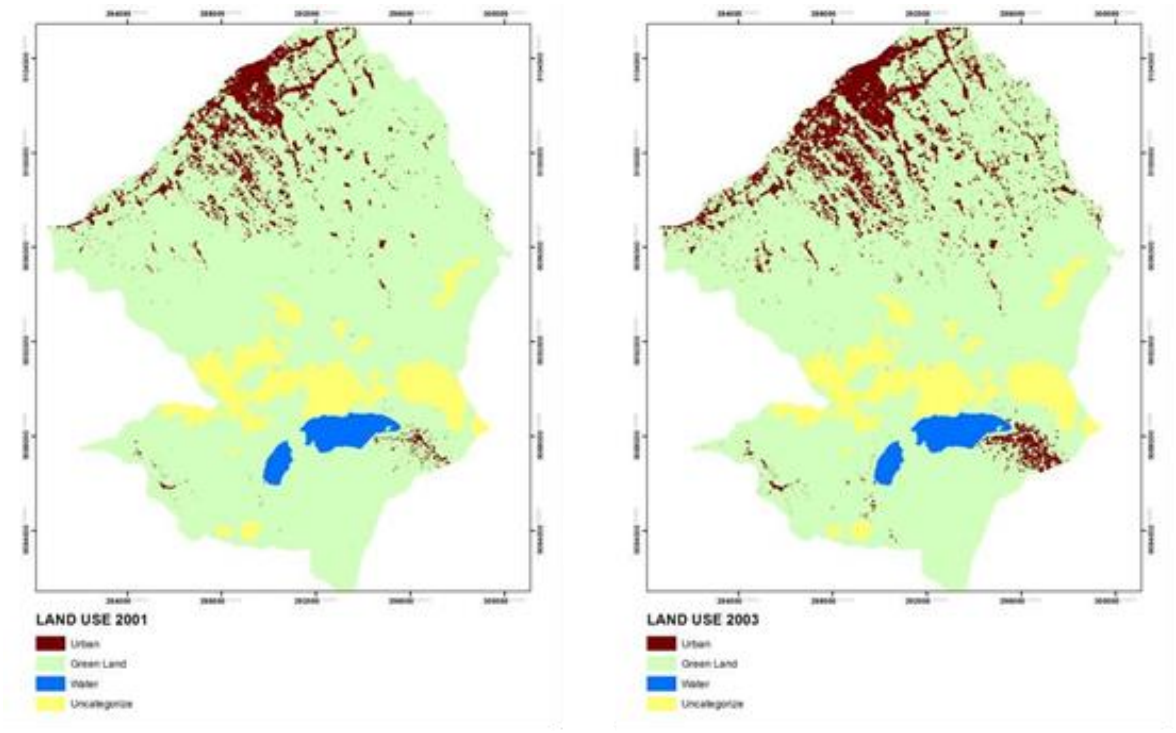

Figure 1. Land Use Map of Singaraja City in (left) 2001 and (right) 2003

Projections of land use in 2020 and 2025 conducted in three steps namely: 1). Calculated the area of each land use for all map; 2). Calculated the amount of land use changes that occur from green land into urban area during periods 2001 - 2015; and 3). Projected land use in 2020 and 2025 used Cellular Automata Method.

3. Results and Discussion

3.1 Land Use Change

Image classification conducted used supervised method. This method was used to simplify the determination of the class that was based on the observation results. Based on data field on the observation then made the training area as a basis in determining land use classes. Training area is a collection of pixels that represent a particular class. Training area then used to construct a land classification for full image.

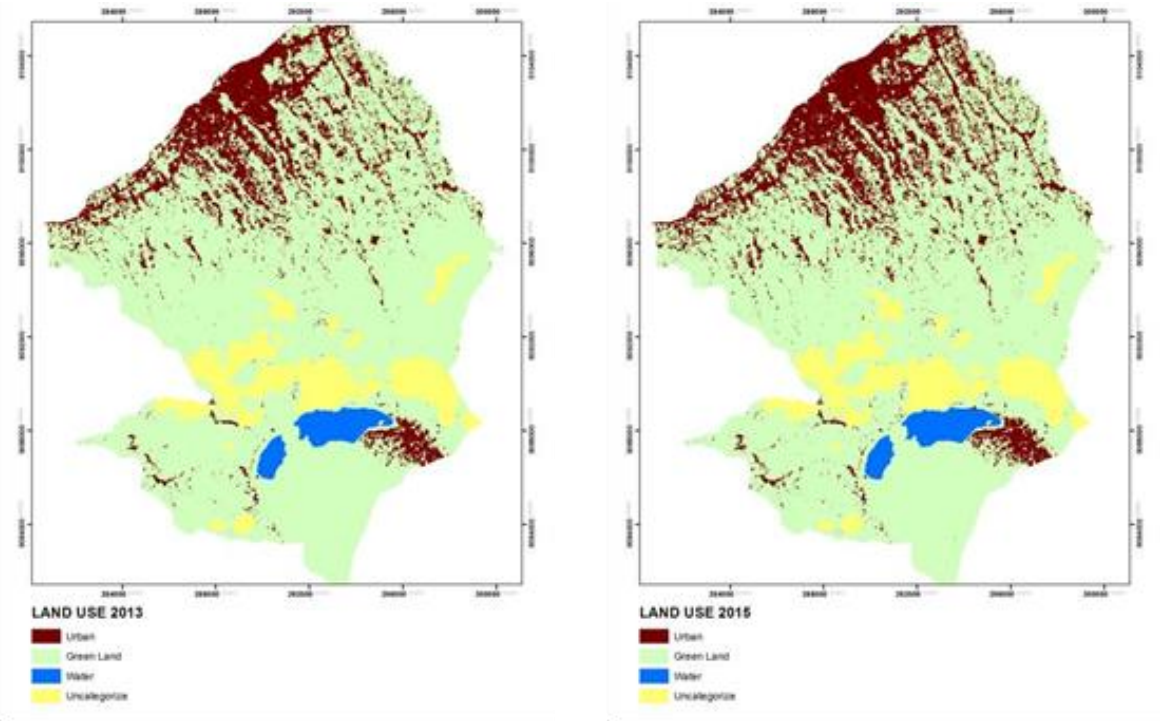

Figure 2. Land Use Map of Singaraja City in (left) 2013 and (right) 2015

Table 1. Error matrix

No	CLASSIFIED DATA	REFERENCE DATA				TOTAL	Error of Commission	Producers Accuray
		Urban	Green Land	Water	Uncategorize			
1	Urban	27	2	0	0	29	0.07	0.93
2	Green Land	1	28	1	0	30	0.07	0.93
3	Water	0	0	27	0	27	0.00	1.00
4	Uncategorized	2	2	2	0	6	1.00	0.00
TOTAL		30	32	30	0	92		
Error of Ommission		0.10	0.13	0.10	0.00			
Users Accuracy		0.90	0.88	0.90	0.00			
Overall Accuracy		0.89						
Kappa Accuracy		0.84						

Land use classification results were showed in Figure 1 and Figure 2. Land use map show how the distribution of land use for each classes. The accuracy of classification process show in Table 1. The greater the value the better the accuracy of the data used for further processing.

Based on eror matrix analysis so-called analysis of the validity, the result of the classification was good. The kappa value of validation analysis was 0,85. That value mean, 85% of the classification results accordance to the data field. This kappa value show that the results of the qualification acceptable to the process of further analysis.

Land use classification results were showed by the map of land use in the Figure 1 and Figure 2. Those land use map shows that there was a change of land use which was primarily from green land into urban areas. The biggest change of land use occurs in the city center which was dominated by built up area. The patterns tendency of land use change more rapidly in city center as compared to the surrounding areas. In addition, the areas tend to change was the land passed by transportation lines. Those showed that the change in land use is influenced by the proximity to the city center and transport links. The number of area for each land use class in Singaraja city and Its surrounding areas over a period of 14 years can be seen in Table 2 and Table 3.

Table 2. Land use from 2001-2015

NO	SURFACE	Year			
		2001	2003	2013	2015
1	Urban	1,642.68	2,721.08	3,923.38	4,796.43
2	Green Land	23,003.38	21,940.53	20,721.82	19,905.70
3	Water	596.30	580.76	597.16	540.24
4	Uncategorized	2,489.95	2,489.95	2,489.95	2,489.95
TOTAL		27,732.31	27,732.31	27,732.31	27,732.31

Table 3. Land Use Change from 2001 – 2015

NO	SURFACE	Urban Changes 2001-2003		Urban Changes 2013-2015		Urban Changes 2001-2015	
		Ha	%	Ha	%	Ha	%
1	Urban	1,078.39	3.89	873.04	3.15	3,153.74	11.37
2	Green Land	-1,062.85	-3.83	-816.12	-2.94	-3,097.68	-11.17
3	Water	-15.54	-0.06	-56.91	-0.21	-56.06	-0.2
4	Uncategorized	0	0	0	0	0	0

Within 14 years from 2001 to 2015, the total increase in value of urban areas reached 11,37 % (3.153,74 ha). At the same time, green land decrease about 11,17 % (3.097,68 ha). Water decreased by 0,20 % (56,06 ha). Overall it can be concluded that within 14 years there was increase of urban areas of 11,37 % coupled with the reduction of green land by 11,17 %. There was a difference in value between the green land and urban areas by 0,20 %. The difference was caused by the change of green land into water body.

3.2 Land Use Change Prediction

Predictions was conducted to know the urban change in 2020 and 2025. Ten-years period of prediction is based on two main reasons, namely: 1) the method of Markov Chain is not suitable for long-term forecasting and 2) to adjust the evaluation period obedient of space planning documents. Its require at least 3 maps to make predictions of urban change in 2020 and 2025 they are land use map in 2001, 2013 and 2015. Land

use map in 2001 and 2013 are used to create a predictive model with Cellular Automata (CA) Markov method. While validation is performed by using a map of land use in 2015. The validation process conducted by making the prediction maps of land use in 2015 by the tendency of change of land obtained in the previous stage. Comparison of predicted results with the data of the existing land use in 2015 showed the level of accuracy of the prediction of land use.

The first step did to get the prediction of land use in near future conducted by of land use map in 2001 and land use map in 2013. This analysis means to get how the changes of green land into urban areas. The tends of changes then use as basic rules of CA Markov to create a prediction. Figure 3 showed the result of crosstab analysis. The map showed the tendency of the changes that occurred from 2001 to 2013. Based on these maps, it is known that the tendency of change of urban areas occurred on the orange color (2 | 1). Changes of urban areas were scattered in the city center, center of settlements, and traversed land of transportation access.

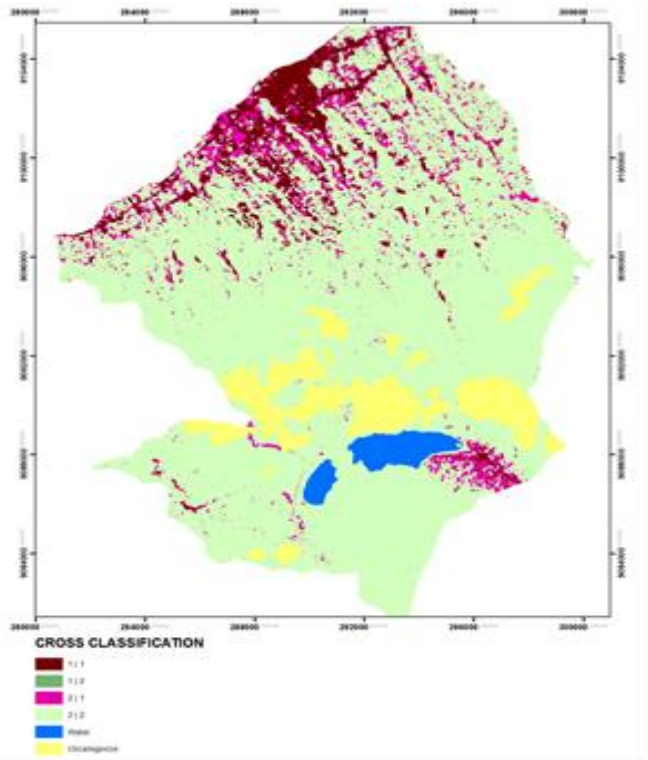

Figure 3. Cross Classification: Land Use 2001 | Land Use 2013

Figure 3 shows how the changes of green land into urban areas during 12 years. The orange one (2 | 1) shows the changes from green land into urban class. The change occurs most rapidly in the city center as service center of Buleleng Regency. Center of settlement and the main road also got that change.

Urban change was predicted by CA Markov method. The second step of this process was to create transition matrix and transition map of urban change during period 2001 – 2013. The value of probability of changes or transition value of urban areas and green land in Singaraja city and Its Surrounding Areas shown by Table 4.

Table 4. Urban change transition matrix

No		Urban	Green Land
1.	Urban	0,8497	0,1503
2.	Green Land	0,3432	0,6568

The off diagonal value of urban areas showed in Table 4 was bigger than green land value. This mean that the probability of change from urban areas into green land was bigger than otherwise change.

The third step of predicting land use change in Singaraja city is to create the predicting map in 2015 by used the transition matrix and transition map from the previous analysis. The result of this analysis was showed in Figure 4.

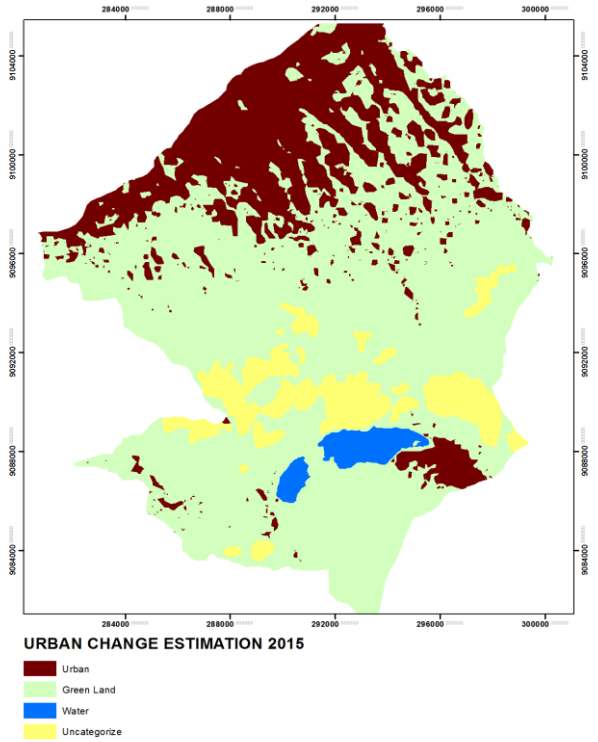

Figure 4. Land Use Prediction in 2015

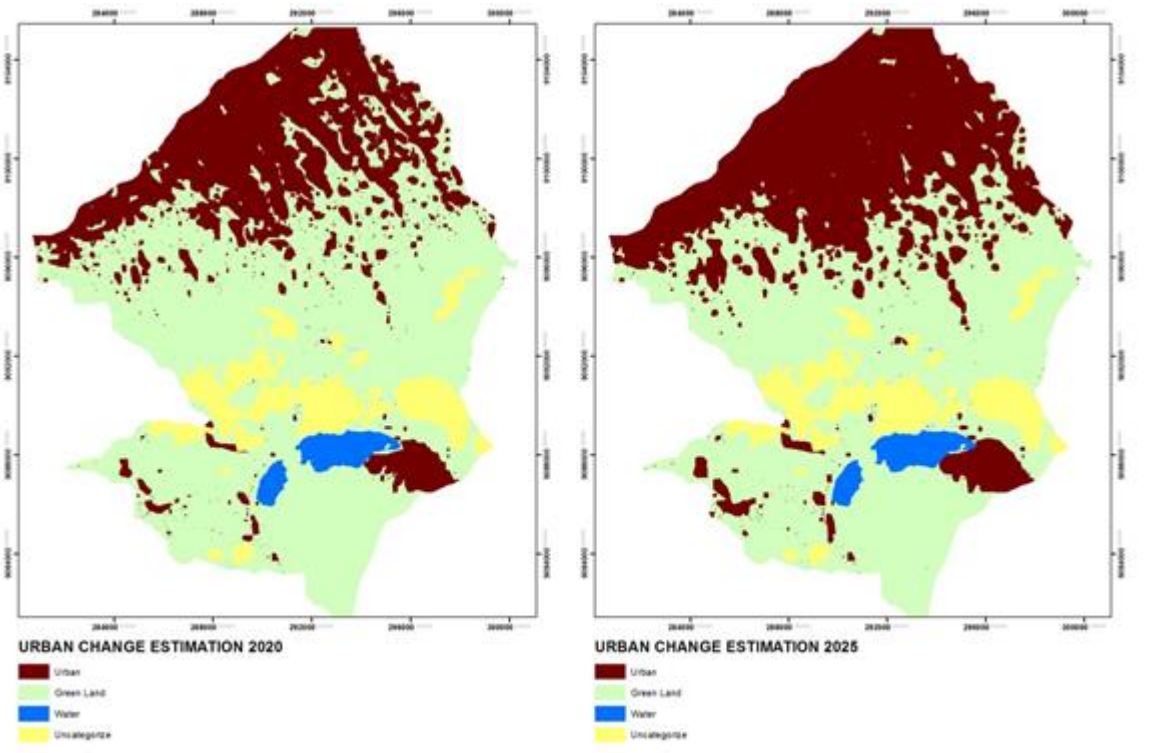

Figure 5. Land Use Prediction in (left) 2020 and (right) 2025

Figure 4 shows the projected land use maps in 2015. Distribution of land seems alike to the land use existing map in 2015. To find out how accurate the prediction results of this predicting process. It should take the fourth step, namely the validation process. Kappa values for the validation of the prediction results of land use in 2015 showed that 91.21 percent of predicted results represent actual conditions. This show that the predicted results were very suitable for prediction of land in the city of Singaraja. The prediction of land use in 2020 and 2025 show in Figure 5.

Figure 5 shows the land use change occur from green land into urban areas. That changes mostly occur in the city center of Singaraja, center of settlement, and the develop following the main road. The amount of urban areas in 2020 was 27,40 % (7.598.45ha) and 35,97% (9.974.55 ha) in 2025.

4. Conclusions and Suggestion

4.1 Conclusion

The study of land use change is very important for the region. The change of urban area isn't always occur the needs of land for settlements but also other function of development need such as infrastructure, facilities, industry etc. This study showed that there is a change of land use which is high enough from green land into urban areas within 14 years in the city of Singaraja. The amount of green land change into urban areas is 11,37 % (3.153,74).

The results showed that green land class experienced fairly rapid conversion pressure mainly in the city center, centers around settlements and land transportation lines. The transition matrix showed that the probability of land use change from urban to green land is lower than green land to urban. The prediction result of land use in 2020 is 27,40 % (7.598.45ha) and 2025 is 35,97% (9.974.55 ha).

Land use classification obtained with accuracy of 0.84 which shows the land use classification results is good enough for further analysis. Land use projections showed a very good level of accuracy that is equal to 0.91 which shows the projected results is very good.

4.2 Suggestion

The result of this study is quite good due to the worse input data. Meanwhile there are some suggestion need to take to get the better result.

1. Classification results showed kappa values were quite varied from 0.84 to 0.89. This value could be better if prepared with the good input data of Landsat Imageries. All of Landsat images was used in this study were covered by cloud. So that the good quality of Landsat images need to be used to get the best result of land use map. Otherwise it need the other process to improve the quality of satellite images.
2. Its need more precision satellite image to get the better result of land use map.
3. This study just used transition matrix and transition map to create the predicting of land use in near future. To get the better result it should be combine with driving and inhabiting factor of land use change. So that we know precisely the factor might affect the change of land use.

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