Modelling cellular automata for the development of settlement area Bengkulu City

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Modelling cellular automata for the development of settlement area Bengkulu City

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Abstract: Population and development activity increasing push will demand higher settlements. Population density is low and becomes higher along with population growth rate and leads to centralization of settlements in certain sub-districts that will shape the dispersion pattern of settlements. The research method used in this research is Cellular Automata Modeling and Geographic Information System. The purpose of this research to identify the pattern of distribution of settlements based on population density in 2032 in Bengkulu city. The results show that the pattern of settlement distribution in the western part of Bengkulu city has high Density level and distribution pattern of *clustering* settlements while the North-East-South has medium to low density of population and distribution pattern of *random* settlement.

1. Introduction

Bengkulu city is a coastal city located on the western coast of the island of Sumatra, which is directly leads the Indian Ocean. As the capital of Bengkulu Province, Bengkulu became the destination of migration of the population in Bengkulu Province. Centralization of the population in Bengkulu encourage the compaction of the population and resulted in the need for settlement / build area also increased. The number of settlement development conducted, it urge the development of the area of Bengkulu [1,2].The main consequences of the rapid population increase in the world are the rapidly change of land use, and this is alarming the global environmental change and the transformation of fertile land into urban land.

The development of urban area is one of the phenomenon that occurs due to the rapid development of population and human mobility [3]. This led to an increase in land cover. Land cover change of urban settlement that occur will shape towards where the development of residential areas in the future.

The physical development of residential areas encourage the expansion of land use that gives effect to the surrounding areas. One of the result of this effect is the reduction of empty land cover due to the increasing number of settlement development. The bigger land that is suitable to be develop as a settlement area will be greater chances of new settlement.

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Urban development and its effect on the environment, public health, land resources and energy consumption have drawn the attention of increasing research [4]. More people migrate to the cities will make farmland disappears with expanded areas especially in fast-growing areas [4]. Urban growth modeling is a promising tool for understanding the history of urban development and designing future scenarios to support decision-making and risk management [4,5].

That's underlying the research to see the direction of development of residential areas in Bengkulu in 2002, 2010, 2017 and predict the settlement development of Bengkulu in 2032 with Cellular Automata as one of the monitoring and controlling development of residential areas in the next few years.

2. Methods

2.1 Study Area

The research location is in Bengkulu, which administratively covers 9 district. District of *Muara Bangkahulu, Sungai Serut, Singgaran Pati, Selebar, Kampung Melayu, Gading Cempaka, Ratu Agung, Teluk Segara and Ratu Samban* (Figure 1).

Figure 1. Map of Bengkulu

2.2 Source

- Satellite Data : Landsat Image path/row 126/63 Landsat 5 TM for 2002, Landsat 7 ETM for 2010 and Landsat 8 OLI for 2017. Satellite acquisition date is March to June.
- Software : Idris Selva 17, ENVI 5.1, Arc GIS 10.1

2.3 Analysis Data

- Image Classified: Land Cover classification is carried out using guided classification in ENVI 5.1 software. Classification software produces a land cover settlement map for 2002, 2010, and 2017.
- Land Cover Change: The land cover change is done by detection of post classification changes

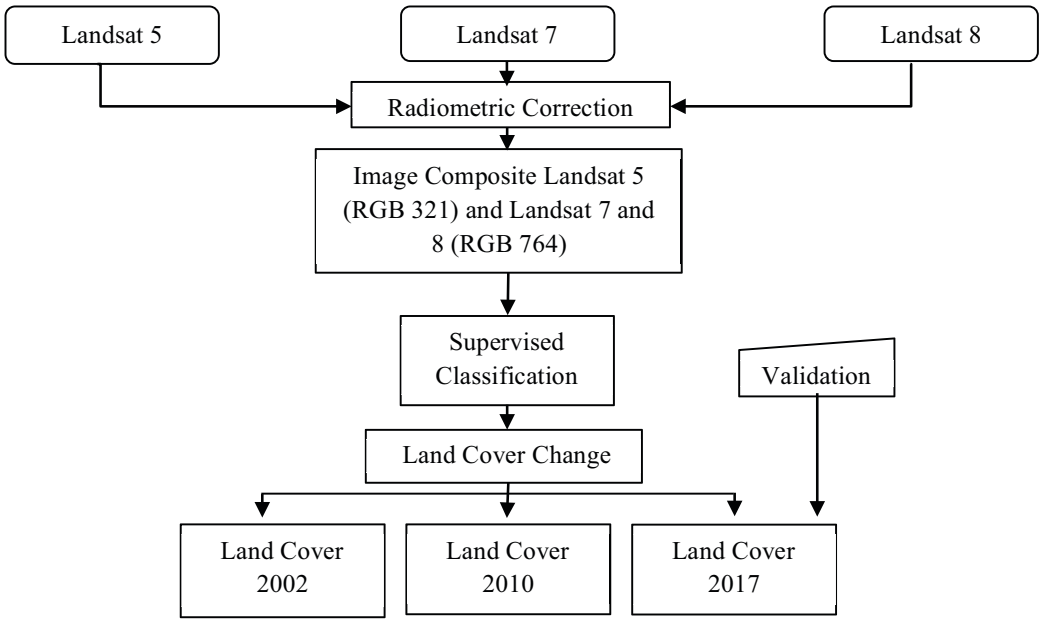

Figure 2. Process and Image Analysis

- CA-Markov models: Markov chain and CA are both discrete dynamic models in time and state. One problem with Markov is that it does not provide a geographical explanation. Transition probabilities may be accurate by category, but there is no knowledge of the spatial distribution of events in each land use category. CA is used to simulate land cover in 2032. It also adds spatial characters to the model. In this study, we used the IDRIS SELVA software to simulate settlement land cover in Bengkulu City. the driving factors used in this research are *slope, height, distance from road, distance from river and the distance from shoreline*.
- Development of residential areas: to see the direction of development of residential areas in 2032. Obtained from settlement land cover in 2032 with suitable land suitability to be developed as a residential area. Land suitability is obtained from overlay 5 driving factors, *slope, height, distance from road, distance from river and the distance from shoreline*.

3. Results and Discussions

3.1 Land cover change from 2002 to 2017

The five classes of land cover include: agricultural area, non-agricultural area, open area, water bodies and settlement. Test result of Landsat Image interpretation accuracy in 2017 visually gives Overall acuraccy value of 87.61%. Validation value are appropriate so they can be used in research.

The land cover interpretation map of the result can be good if it has an accuracy of more than 70% in land cover change from 2002 to 2017 are shown in figures. The result show that in Bengkulu there was a very significant change in 2002 to 2017, the land cover decreased up to 9,85 ha, non-agricultural area cover decreased to 2.009.1 ha, open area decreased to 365.3 ha. On the other hand the area of settlement increased up to 1.919.4 ha and agricultural area cover increased to 464.8 ha.

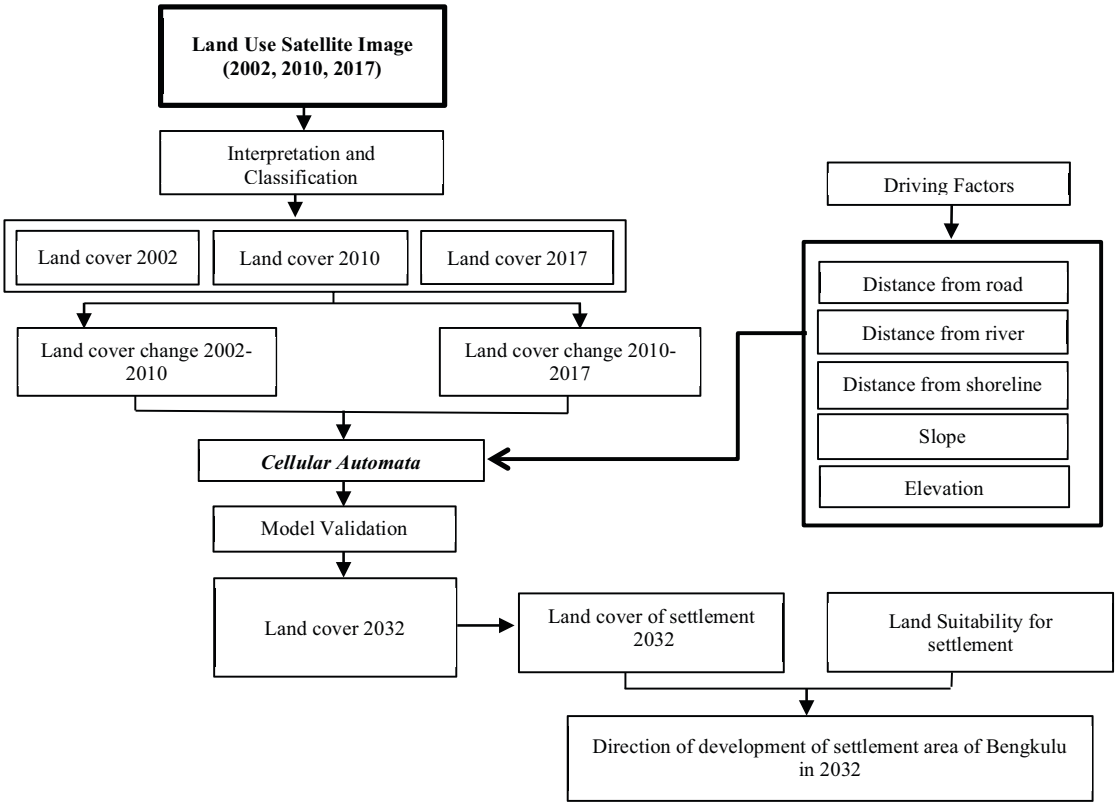

Figure 3. Cellular Automata Model Process for Development of settlement Area

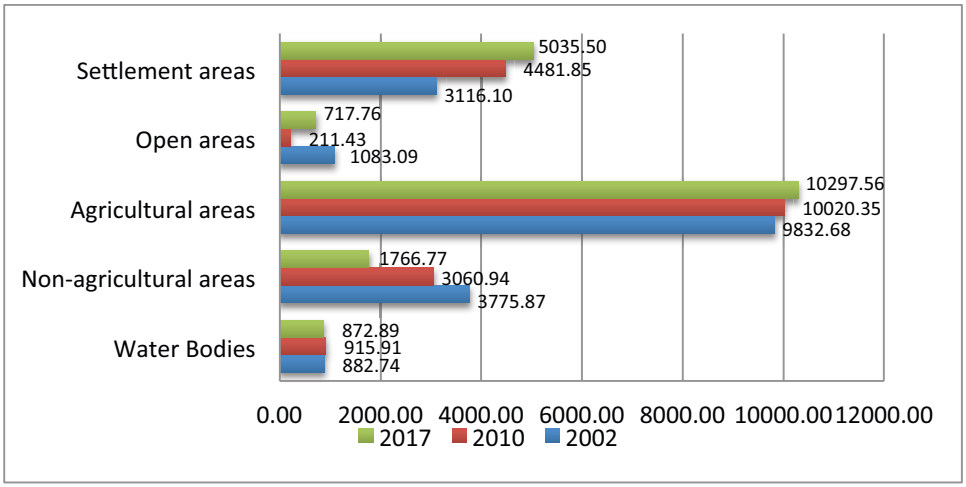

Figure 4. Land Cover of 2002, 2010 and 2017

Land cover in 2002 was dominated by agriculture area of 9.832,68 ha and water body is the smallest land cover that is 882,74 ha. Year 2010 is still dominated by agricultural land cover increment of agricultural land cover to 10.020,35 ha. Coverage of settlement land increased to 4.481,85 ha. In other side there was a decrease of open land up to 211.43 ha and became the smallest land cover in 2010 Land cover

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In 2017 the land cover is still dominated by agricultural area that is 1.0297.96 ha while the smallest is open area 717,76 ha. There is an increase and decrease of land cover area in 2017 but which experienced a significant decrease that is not-agricultural area up to -1,294.18 ha and land cover area of water body is decreased by -43,03 ha.

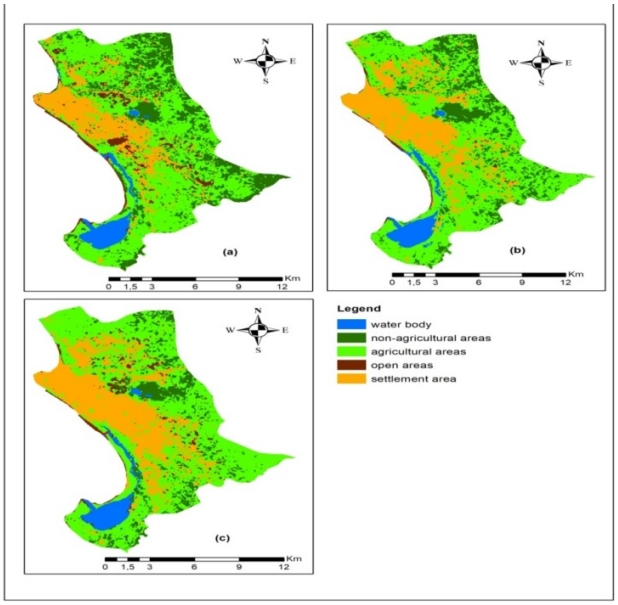

Figure 5. Land Cover Change of 2002, 2010 and 2017

3.2 Land Cover Simulation 2017

The result of the accuracy value is 87.66% while the accuracy rate received in this modeling range is 60%. The magnitude of the figure on the TPM indicates the possibility of a land cover being transformed into another land cover. Number 1 on the water bodies and settlement areas means that the land cover will remain waters and settlement while the number 0 indicates that no change from another land cover.

Table 1. Transitional Probability Matrix to 2017

	I	II	III	IV	V	Information:
I	1	0	0	0	0	I: Water Bodies
II	0	0,4693	0,509	0,002	0,0197	II: Non-agricultural area
III	0	0	0,765	0	0,0932	III: Agricultural Area
IV	0	0	0	0,1357	0,4822	IV: Open Area
V	0	0	0	0	1	V: Settlement

3.3 Land Cover Prediction in 2032

Land cover in 2032 is dominated by agricultural area of 9.717, 26 ha, settlement area 6,771, 24 ha and non-agricultural land 1,132.98 ha. While open area has the lowest area of -213, 25 ha (Figure 6).

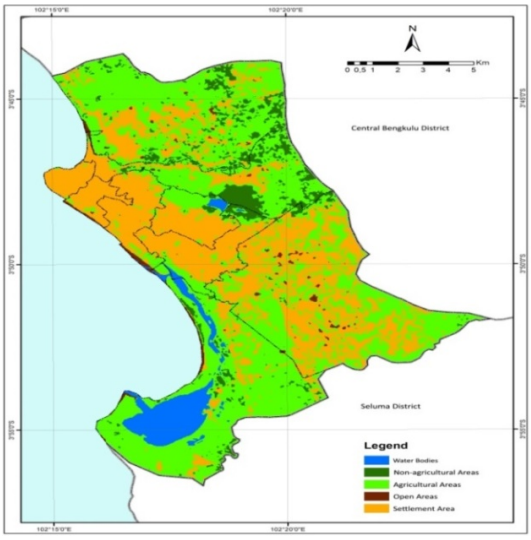

Figure 6. Land Cover Prediction 2032 in Bengkulu

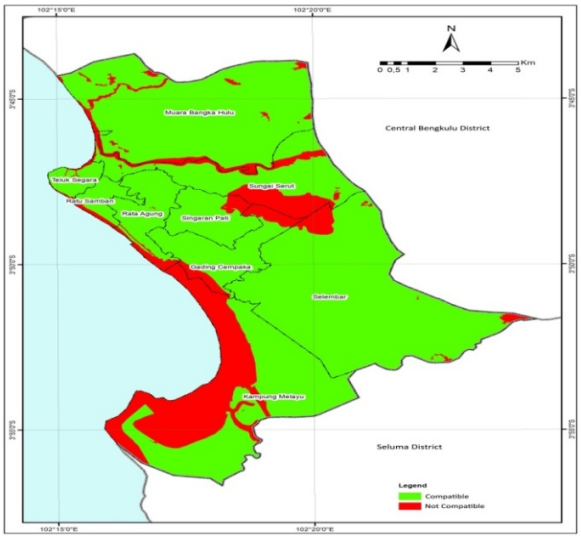

Figure 7. Suitable Map for Settlement Area

3.4 Settlement Land Sustainability

The score indicates the possibility of the increase of settlement in the area means 3 (three) score indicates big possibility for the expansion of settlement Area (Figure 7).

Table 2. Variable scoring of Physical Condition and Infrastructure of Bengkulu

No	Parameter	Class	Score	Information
1	Distance from Shoreline	<100 m	1	Unsuitable
		100-2000 m	2	Suitable
		>2000 m	3	Very Suitable
2	Distance from River	0 – 25 m	1	Unsuitable
		25 – 50 m	2	Suitable
		50 – 12000 m	3	Very Suitable
3	Slope	15-40%	1	Unsuitable
		3-15%	2	Suitable
		0-3%	3	Very Suitable
4	Elevation	0-7 m	1	Unsuitable
		7-25 m	2	Suitable
		25-100 m	3	Very Suitable
5	Distance from Roads	>1000 m	1	Unsuitable
		100 – 1000 m	2	Suitable
		0-100 m	3	Very Suitable

3.5 Development Direction of Bengkulu Settlement Area

The development of the settlement area of the City of Bengkulu as seen from changes in land cover shows that the direction of development of residential areas is the northern part (Muara Bangkahulu sub-district) and east (Selebar District) Bengkulu City. The highest area of residential land cover in 2002 until 2017 is in Selebar District. While the lowest settlement land area in 2002 to 2017 is Teluk Segara Subdistrict

Based on physical conditions such as slopes, heights, to the road network of the Muara Bangkahulu District and Selebar District have physical conditions that support the development of residential areas. In addition, the Muara Bangkahulu District and Selebar District based on the planning of the Bengkulu City Spatial Plan will be developed as a center for government and education.

Whereas based on the results of modeling predictions for the development of residential areas in 2032 that the development of residential areas in the city of Bengkulu was centered on the North and South of Bengkulu City.

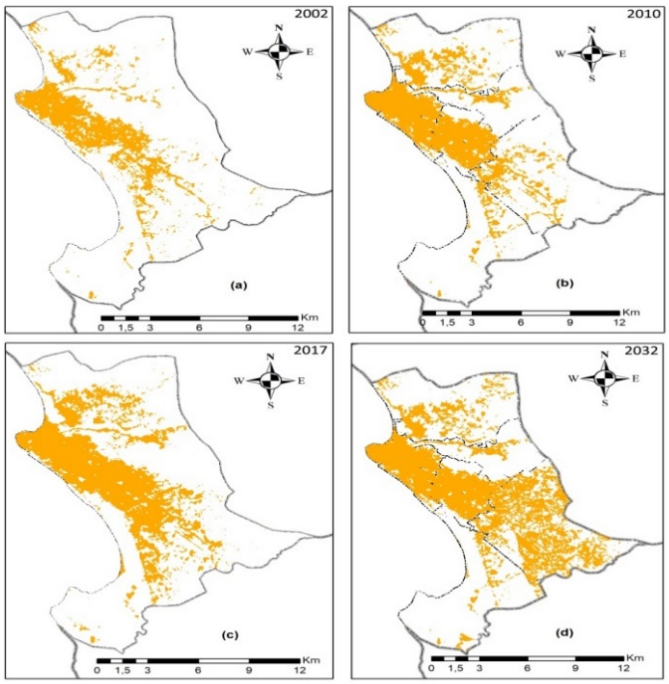

Figure 8. Land Cover Settlement in 2002, 2010, 2017 and 2032

4. Conclusion

This research result to analyze and predict land cover using remote sensing data and Cellular Automata Model. From this research, land cover in Bengkulu from 2002 – 2017, some conclusions of settlement land cover change increased 1,675,74 ha. The development of residential areas in 2032 leads to North of *Muara Bangkahulu* and Eastern sub-district *Selebar*.

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