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PREDICTION OF DEVELOPMENT DIRECTION IN KENDARI CITY BASED ON CHANGES IN DENSITY OF BUILT-UP AREA

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ABSTRACT

This research was conducted to determine changes in the area of built land and the direction of development of the city of Kendari in 2039 by using Landsat imagery at different times in Kendari City in 1999, 2009, and 2019. The method used is digital interpretation technique using NDBI algorithm (Normalized Difference Built-Up Index) to obtain building density information. Overlay analysis is used to determine changes in the density of built land over the past 20 years and Cellular Automata analysis to predict the density of built up land in the next 20 years. Testing the accuracy of the sample utilizes the confusion matrix on the actual constructed land density information in 2019. The results obtained in the form of information on the developed land density and its changes in 1999, 2009, and 2019 as well as information on the direction of development of the city of Kendari in the next 30 years. The analysis shows that in the period 1999 to 2009 there was a change of 2,206.09 Ha or as much as 8.17%. Then in the period 2009 to 2019 there was a change of 4,024.25 Ha or 14.90% of the total area of the study. There is a tendency for Kendari City to develop towards Baruga Districts and Puwatu Districts for the next 20 years.

Keywords : *Remote Sensing, NDBI, Cellular Automata, built up*

A. INTRODUCTION

The phenomenon of random and unplanned urban growth (urban sprawl) occurs in almost all metropolitan cities throughout the world. This phenomenon has a very detrimental impact, and most countries have difficulty controlling it. The growth of big cities in the world has implications for the expansion of spatial use beyond the city limits. The results of previous studies indicate that the cause of this growth is the emergence of new residential areas as a place to meet the needs of the population, the development of housing, industry, and commercial activities.

The city spatial that was formulated in the future, Yunus (2005) argues that understanding the physical characteristics of the city is needed to avoid the negative impacts of the development of the city. Land use for settlement must be appropriately regulated so that it is by urban planning, taking into account the balance of ecological aspects so that there is no degradation in land quality. The development of cities in various indicators is often associated with the development of built land because one of the physical characteristics of urban development is by expanding and increasing built-up land. This built-up land is by the theory that the existence of urban development can be viewed from various dimensions, one of

which is the urban morphology dimension which emphasizes the physical aspects of the city, in this case, reflected in the road network system and building blocks.

Kendari City is the capital of Southeast Sulawesi Province, which has a very rapid level of regional development. The topographical condition of the city of Kendari is in good condition, and the geographical location of Kendari City makes the city continue to grow from time to time. The development of the city of Kendari is seen in terms of physical as well as in terms of population development (urbanization). The cities economic activity is also growing which results in higher growth of built land. The developed land has increased development, in the form of residential areas on the hinterland of urban areas to serve the demand for housing, meet lifestyle, as well as means of speculation and investment by middle and upper-class people. This developed land causes a change in land use from a green land to land built in urban areas. The indifference and unpreparedness of the devices and the lack of government capacity that causes spatial control, infrastructure provision, transportation services, and social facilities cannot be done correctly, which can lead to urban planning problems in the future. This problem happens because urban areas physically develop randomly or are scattered (urban sprawl) and increasingly out of control. Based on the problems that have been raised, this study aims to determine changes in the density of land built over the past 20 years as a material consideration to predict the direction of urban development in the next 20 years.

B. METHOD

The scope of the analysis area in this study, in accordance with its objectives, is the entire administrative area of Kendari City, Southeast Sulawesi Province.

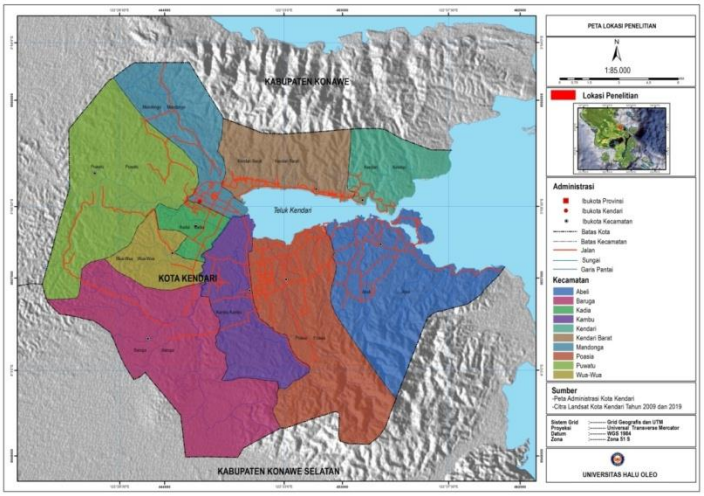

Figure 1. Research location map

1. Population and Sample

The population is a collection and elementary units that have the same essential characteristics, which are reflected in specific measurements (Yunus, 2010). The population in this study is all land use (built land and non-built land) in the Kendari City, Southeast Sulawesi Province. The sample in this study was selected using a purposive sampling technique, which is a sampling technique with the desired researchers so that the sample can represent characteristics of the population that

had been known previously. The number of land use samples and settlement densities are adjusted using the FitzpatrickLins formula [4].

$$N = \frac{Z^2pq}{E^2} \quad \text{..... (1)}$$

Information:

N = TotalofSamples
z = The normal standarddeviation(value given by 2)
p = ExpectedAccuracy
q = Differencebetween 100 andExpectedAccuracy
E = ExpectedError

Based on the above formula, the sample obtained from the mathematical multiplication operation results can be written as follows:

$N = \frac{4(90*10)}{100}$

N = 36.

The total of samples in this study were 36 samples.

2. Types and Data Sources

The data needed in this study are primary data and secondary data. Primary data was collected through processing Multitemporal Landsat Satellite Imagery and direct observation of research objects in the field. Secondary data can be collected through various previous studies, reports, and various policy documents, plans, and programs originating from government agencies (central or regional), NGOs, research institutions and universities.

3. Analysis Technique of Data

a. Analysis of Built Land Density

Multitemporal Landsat image data processing has been done through two stages, namely the NDBI transformation and the combination of the NDBI-NDVI transformation. NDBI transform uses middle infrared (SWIR) and near-infrared (NIR) wave data. This NDBI algorithm uses DN data that has been converted to spectral reflectance, with a range of values of -1 to 1. The NDBI transformation is formulated as follows:

$$\text{NDBI} = \frac{\text{IMTg}-\text{IMD}}{\text{IMTg}+\text{IMD}} \text{.....(2)}$$

The pixel value resulting from the NDBI transformation still has a disturbance of vegetation value. The built-up information can be enhanced by combining the NDBI-NDVI transformation to reduce the disturbance of vegetation values and optimize existing information by obtaining a new image. The formula used is as follows:

$$\text{Built-Up Area} = \left(\frac{\text{IMTG}-\text{IMD}}{\text{IMTG}+\text{M}}\right) - \left(\frac{\text{IMD}-\text{M}}{\text{IMD}+\text{M}}\right) \text{.....(3)}$$

Built-Up is the resultant binary image value by displaying pixels that have built up land and have positive values so that the built-up area can be mapped automatically.The results of digital interpretations that have been processed will be tested for accuracy by using an error matrix. The method used to test the mapping accuracy is a confusion matrix table. This table will connect the results of the mapping using classification with direct field observations.

b. Analysis of Changes in Built Land Density

Analysis of changes in the density of built land is used to determine changes in the level of developed land density over the last 20 years from 1999, 2009, to 2019. This analysis involves data on developed land density that has been interpreted digitally using the NDBI (Normalized Difference Built-Up Index) approach. The map of the developed land density is then overlaid to obtain new information about the changes in the density of the built land, and it can be calculated the amount of change in land area at any time from 1999, 2009 to 2019.

c. Prediction Analysis of Development Direction in Kendari City

The simulation of the direction of urban development in this study is integration between transition probabilities based on the CA model. The Cellular automata model consists of four components that interact with each other in the time dimension and can be written with the notation

U – S – N - T

Information:
U: spatial dimensions of cells (universe)
S: states (values) that a cell might achieve (states)
N: the number of neighboring cells considered in determining the value of a cell (neighborhood)
T: A set of rules (principles) used in determining the value of a cell (transition).

Cell (S) changes from the initial state (St) at time t to (St + 1) at time t + 1 is a function of the surrounding conditions (N) and a specific transition principle (T). Mathematically the change function can be written with the notation

S t+1 = *f* (St, N, T)……..(4)

The probabilistic cellular automata model adopts the Markov transition probability principle by considering environmental aspects. The number of neighboring cells used in cellular automata is generally four (Von Neumman neighborhood) or eight (Moore neighborhood), as shown in the following figure 2.

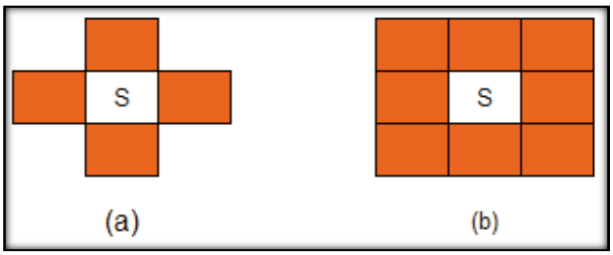

Figure 2. (a) configuring neighborhood in cellular automata von neumann neighborhood (b) moore neighborhood

C. RESULTS AND DISCUSSION

1. The spread of Land Density Built-in Multitemporal

The distribution of land use in 1999 in the study area was still highly dominated by non-developed land with a presentation rate of around 97% of the total area of the study. The area of distribution of developed land is dominated by the medium category, where West Kendari District is the area with the most extensive

distribution category of around 105.02 Ha, followed by MandongaDistricts and Kadia Districts with an area of ± 96.23 Ha and 89.64 Ha respectively**.**

The low developed land density category is the category that dominates in the study area, where Kadia District is the area with the most distribution category, namely 11.57 Ha. The category of high built land density is the land density category with a distribution area of at least 86.08 Ha. Mandonga Subdistrict and West Kendari Subdistrict are the regions with the broadest distribution category. Kambu District is the area with the least density distribution for this category, which is only about 0.27 Ha of the total area of the subdistrict. Spatially presented in Figure 3.

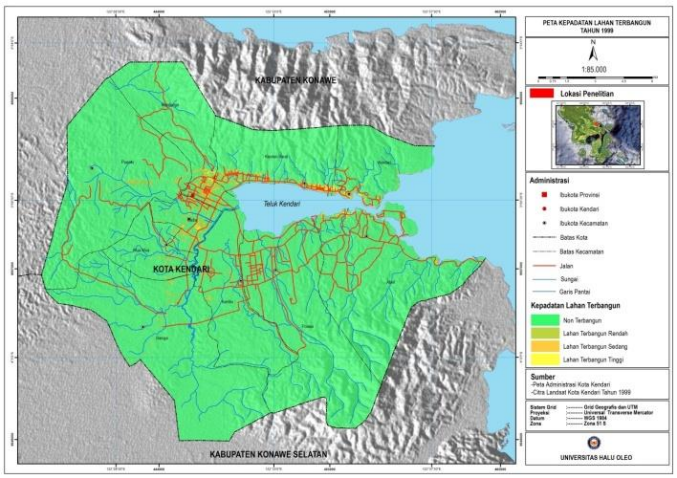

Figure 3. Map of Density of Land Built in 1999

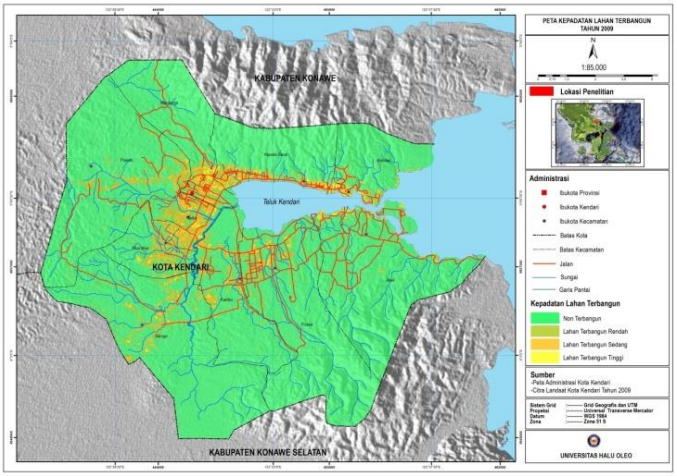

Figure 4. Map of Density of Land Built in 2009

The existence of non-developed land in 2009 in the study area began to undergo a gradual conversion into developed land. The area of land developed for Kadia District is the area with the broadest category of developed land, which is around 416.79 Ha, followed by the District of West Kendari and Wua-wua District with an area of ± 314.22 Ha and 310.78 Ha respectively. The category of developed land

density is still dominated by the medium density category, which covers an area of 1,741.4 Ha. Spatially is presented in figure 4.

The distribution of land developed in 2019 has increased significantly in each district. The high population growth rate likely influences this distribution in Kendari City during the last ten years. Baruga and Puwatu subdistricts have the most developed land area, which is 1,055.09 ha and 782.68 ha. The highest density distribution is dominated by the low-density category, with an area of about 2,337.08 Ha. The medium and high-density categories also increased with an area of ± 2,162.57 Ha and 1489.29 Ha, respectively. Spatially presented in Figure 5.

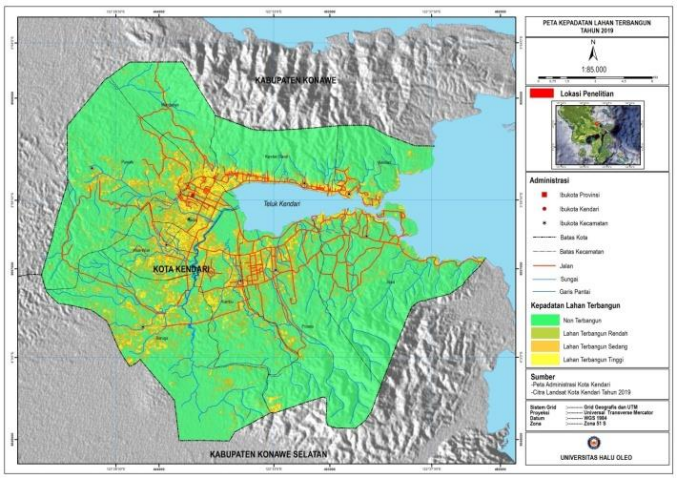

Figure 5. Map of Density of Land Built in 2019

2. Accuracy Test Interpretation Results

An accuracy test is carried out between the density of built-up land found in the field and the developed-land density obtained from the visual interpretation that has been done. The level of accuracy will be directly proportional to the level of confidence in the results of interpretations conducted, where the higher the level of accuracy, the higher the level of confidence in the results of the interpretation. The accuracy level requirement needed so that the map of interpretation results can be used 85%, as explained by Nurazizah (2015). The results of the land use accuracy-test based on the Sutanto classification system using the confusion matrix method can be seen in table 1.

Table 1. Confusion Matrix Test Accuracy of Interpretation Results

Type	Digital Interpretation			
	Non-Built Up Area	**Low Of Built-Up Area**	**Medium Of Built-Up Area**	**High Of Built-Up Area**
Non Built Up Area	9	0	0	4
Low OfBuilt Up Area	0	9	0	0
Medium OfBuilt Up Area	0	0	9	0
HighOfBuilt Up Area	0	0	0	5

Source: Data processing, 2019

Based on the results of the confusion matrix, processing can be calculated as the level of accuracy of interpretation that has been done. The results of the level of accuracy can be seen below.

Level ofaccuracy= $\frac{The\ appropriate\ total\ of\ sample}{Total\ of\ \ Samples}\ x\ 100$

Level ofaccuracy=$\frac{32}{36}$ x 100 = 88,89%

The level of accuracy of the map of the constructed land density interpretation results is 88.89%. Previous research results that have been stated previously that the interpretation of the data can be used for further analysis if the value of the results of the accuracy of the test data reaches 85%. Misinterpretation was found in high-rise land density units. This misinterpretation is likely due to the ability of the NDBI algorithm to differentiate land density units based on the reflection value of pixel so that vacant land / open land is read the same as high density built land.

3. Change in Land Density Is Built

The rapid development of Kendari City can be identified by using remote sensing. The changes that occur can be spatially known as shown in Figure 6 and Figure 7. There is an indication that there is a reasonably significant change in density, which causes the development of Kendari City to continue to increase from the CBD area towards the outskirts of the city.

Tabel 2. Changes in Land DensityBuilt-in 1999-2009 and 2009-2019

Modification	Year	
	1999-2009	2009-2019
PermanentDensity	538,37	1978,91
Non Built Up Area	24.234,68	20.975,98
Non Built Up Area- Low OfBuilt Up Area	611,64	1.721,61
Non Built Up Area-Medium OfBuilt Up Area	1.335,7	1.103,32
Non Built-Up Area-HighOfBuilt-Up Area	168,03	433,8
Low OfBuilt Up Area- Medium OfBuilt Up Area	10,62	37,61
Low OfBuilt Up Area-HighOfBuilt Up Area	0,63	12,51
Medium OfBuilt-Up Area-HighOfBuilt-Up Area	79,47	715,4
Total (Ha)	**26.979,14**	**26.979,14**

Changes that occur in suburban areas where initially there are no buildings turn into areas that are built. For example, in the orange suburbs of Kendari City, there are indications of changes. Processing results illustrate that the periphery is dominated by non-developed land that has turned into built land that has low, medium, and even high density in 2009. This density continues to increase significantly in 2019. Low density tends to increase most widely with an area of 611, 64 ha, and experienced a significant change in 2019, amounting to 1721.61 Ha. Land changes that occur are caused by a variety of things, one of which is accessibility. Accessibility increases so that people are increasingly encouraged to build settlements in sub-urban areas and not too close to the CBD.

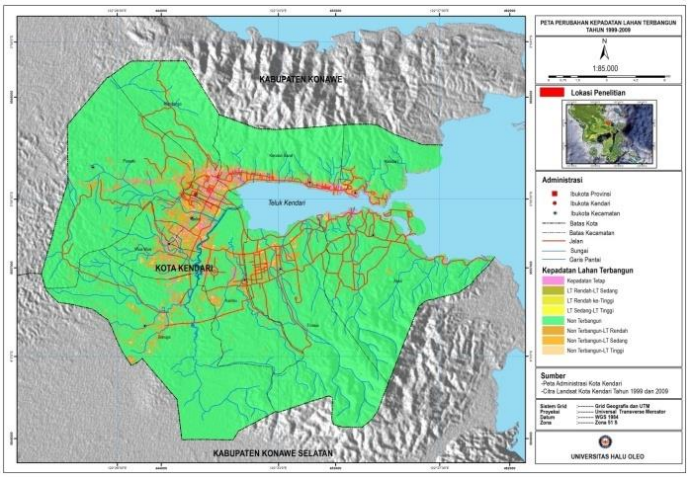

Figure 6. Map of Changes in Land Density Built in 1999-2009

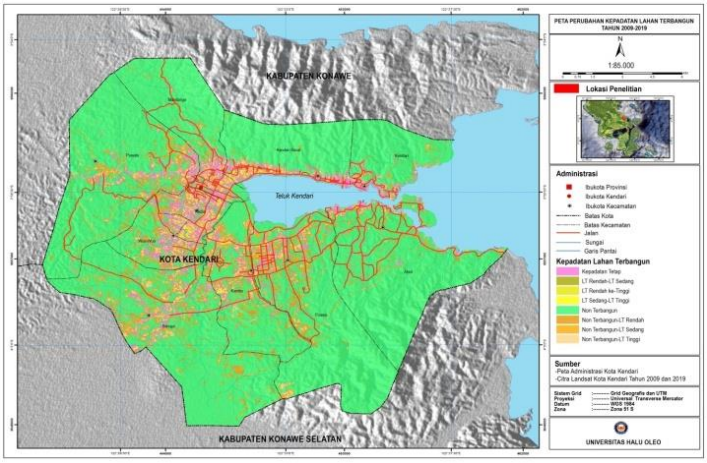

Figure 7. Map of Changes in Land Density Built in 2009-2019

4. Prediction of the Direction of Development of Kendari City

Based on Figure 8, it is known that the development of the research area in the next 20 years mostly leads to the District of Baruga and the District of Puwatu. In table 3,it can be seen that Baruga District has increased its area from 2019 with an area of 782.68 Ha to 2358.6 Ha and is the area with the broadest distribution.Then followed by the District Baruga with an area that is not much different from the District of Puwatu which is 1,974.01 hectares. Besides, the development of the study area is also predicted to develop into the Poasia District to Abeli District, where the area of the distribution is 4,222.24 Ha and 3,947.65 Ha, respectively (Figure 8).

Table 3. Built up result 2039

Distric	Non Building	Low	Medium	High	Total (Ha)
Abeli	2819,98	424,28	345,93	347,99	3947,65
Baruga	2944,61	1057,23	372,28	544,5	4923,67
Kadia	0,22	89,81	116,69	441,57	648,63
Kambu	818,24	542,88	300,3	536,24	2198,3
Kendari	812,28	70,02	309,66	242,39	1437,4

Kendari Barat	1295,59	97,2	257,65	386,35	2039,05
Mandonga	1129,41	280,58	393,13	360,6	2166,67
Poasia	2427,28	909,65	333,4	548,68	4222,24
Puwatu	1976,56	787,35	951,12	620,13	4336,74
Wua-wua	129,54	272,37	274,95	381,93	1058,79
Total (Ha)	14353,71	4531,37	3655,11	4410,38	26979,14

Source: Data processing, 2019

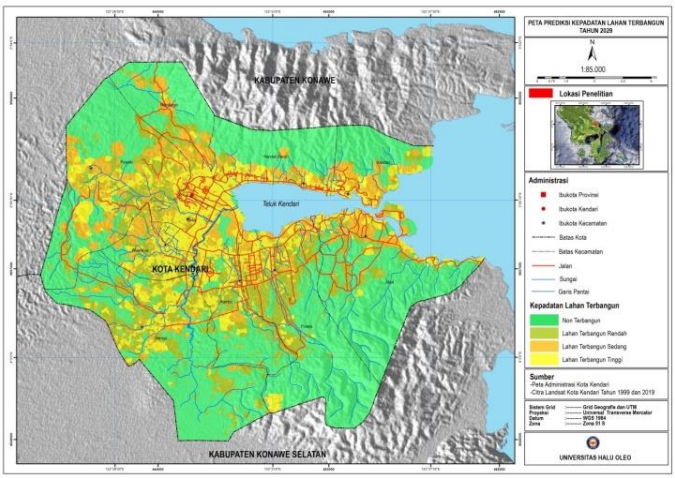

Figure 8. Map of Prediction of Land Density Built in 2039

D. CONCLUSION

This study concludes that in the period 1999 to 2009, there was a change of 2,206.09 Ha or 8.17%. In the period 2009 to 2019, there was a change of 4,024.25 hectares or 14.90% of the total area of the study. Whereas the direction of development of Kendari City in the next 20 years tends to move towards Baruga and Puwatu Districts. In the District of Baruga experienced an increase in area from 2019 with an area of 782.68 Ha to2358.6 Ha and became the area with the broadest distribution. Then followed by the District Baruga with an area that is not much different from the District of Puwatu that is equal to 1974.01 Ha.

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