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Land Cover Change Prediction Model Using the Cellular Automata Method in 2036 in North Kotabumi District

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Abstract

High population growth will of course be followed by increasing needs, including the need for land both for housing and other supporting facilities. Remote sensing is one technology that can be used for these activities. This research aims to find out how land cover changes occur and predict land cover changes in North Kotabumi District in 2036 using the Cellular Automata (CA) method. This research uses Landsat images from 2008, 2015 and 2022. The classification method used in this research is Maximum Likelihood. The variables used in this research are slope, road, settlement and soil type. The results of the research show that there will be changes in land cover in Kotabumi Utara District in 2036, one of which is a reduction in the area of land cover for dry land agricultural types, namely 146.95 hectares or 1.58%.

Keywords: *Land Cover; Cellular Automata; Satellite Imagery; GIS*

Introduction

Indonesia's high population is caused by high population growth, Indonesia's population growth rate in 2022 was recorded at 1.13%, which is quite a high figure (BPS, 2022). High population growth will of course be followed by increasing needs, including the need for land both for housing and other supporting facilities (Keivani & Werna, 2001; Muhammad, 2021) so that land conversion is needed to meet needs. Land conversion activities themselves will cause changes in the form and function of land which will slowly cause changes in existing land cover.

The occurrence of changes in land cover can be based on several factors such as population growth as the main cause (Hailu, et al., 2020), factors that influence changes in land cover are topography, population, land value, accessibility and facilities. as well as infrastructure and environmental carrying capacity (Sari, et al., 2019). Changes in land cover will certainly affect planning and development activities in an area, so a strong foundation is needed in making policies that regulate

governance and development so that development does not occur that is not in accordance with its function.

There are several regions in Indonesia which are recorded as having population growth rates greater than the national growth rate, one of which is North Kotabumi District. This subdistrict has a growth rate of 1.3%, while Indonesia's growth rate is only 1.13%. This high growth rate has caused the population in this subdistrict to experience quite significant changes over time, it was recorded that in 2022 the population in this subdistrict will be 34,356 people (BPS North Lampung 2022). North Kotabumi District is also one of the areas in Lampung Province that received the national transmigration program implemented by the central government in 1977-2009, the location where the transmigrants lived was precisely in Wonomarto Village. The following is data on changes in population in North Kotabumi District in 2008, 2015 and 2022.

North Kotabumi District experienced a significant increase in population over a period of 7 years, there was an increase in population of 2,572 people, this is in accordance with existing data, namely this subdistrict is the subdistrict that has the number one growth rate in North Lampung Regency at 1.33% (BPS North Lampung Regency, 2022).

In line with the high rate of population growth, the need for land in North Kotabumi District will also increase every year, causing changes in land cover (Miswar, et al., 2020; Nugraheni & Usman, 2024). It is necessary to know the direction of land cover changes in the future so that development can run effectively and minimize the risk of disasters (Hapsary, et al., 2021). Changes in land cover will have an impact on people's lives in both the long and short term and can have positive or negative impacts.

Based on this, careful monitoring and planning of land cover changes from year to year is of course necessary to find out how developments and changes will occur in the future so that they can be taken into consideration in the regional planning and development process (Nahib, 2015; Dedy, et al., 2023). One technology that can be used to monitor land cover changes is remote sensing, which is able to provide information on spatial diversity on the earth's surface quickly, widely, precisely and easily (Ban, et al., 2015).

In its application, remote sensing technology can be combined with computer technology, namely Geographic Information Systems (GIS), so that it can be processed and used to assess land cover changes by adding indicators driving land cover changes. One of the features provided by the combination of these two technologies is Cellular Automata (CA), which is a model that can be applied with various combinations of analysis. Cellular Automata (CA) is a model that adopts geosimulation or spatial prediction.

One of the most important elements in CA is the transition probability model (transitionpotential modeling), namely the degree that shows the occurrence of changes from one land cover class to another class in the future (Park, et al., 2011), so that the final result of combining the two programs will produce information about what land cover will look like in the future so that it can be used as consideration in regional planning and development to reduce risks and potential threats of disasters in the future.

Based on the background above, to try to provide a solution to the problem of monitoring development planning in the future, research is needed regarding the application of the Cellular Automata (CA) method to predict land cover changes in North Lampung Regency, especially in North Kotabumi Regency, using Cellular simulation in coming. Automata uses a plugin, namely MOLUSCE (Modules for Land Use Change Simulations) which is found in the QGIS tool.

The driving factor variables used in modeling land cover changes are roads, settlements, soil types and slopes in order to predict land cover in North Kotabumi District in 2036 using a land cover change model in the 2008-2022 period. The time period 2008-2022 was chosen because in that year there was a lot of development in the North Kotabumi area, resulting in changes to the land cover in this subdistrict. One of the developments being carried out was the construction of the East Sumatra highway through the North Kotabumi Subdistrict which of course will has a lot of influence.

Method and Material

1. Research Method

The type of research used in this research is quantitative research. According to Bryman (1998), quantitative research involves a structured and systematic scientific approach to collecting numerical data. This data is then analyzed using statistical techniques to obtain reliable and objective findings. In this research, we analyze land cover changes that occurred in North Kotabumi District in 2008, 2015 and 2022, then explain the predictions of land cover in 2036 in North Kotabumi District.

2. Variables and Variable Operational Definitions

Variables are everything that will become a variable in a study. The variables used in this research are changes in land cover in 2008, 2015 and 2022 and predictions of land cover in North Kotabumi District.

1. Changes in Land Cover in North Kotabumi District

Land cover change is a change that occurs in the physical appearance of land to other land cover caused by humans who aim to fulfill their living needs. The indicators used to see land cover changes are the type of land cover change and the area of land cover change.

a. Land Cover Type

The types of land cover used in land cover classification generally include built up land, open land, water, wetland agriculture, dry land agriculture and empty land.

b. Extent of Land Cover Change

The area of land cover change is the amount of change in the area of land cover that experienced changes before and after 2008 to 2022 in hectare (ha) units.

2. Prediction of Land Cover for North Kotabumi District

Land cover prediction is an effort to model land cover at a certain time. In carrying out the modeling process, variables driving land cover change are needed. In this research the driving variables used are as follows:

Table 1. Variables Driving Land Cover Change

No.	Variables Driving	Description
1	Soil Type	Know the type of soil because it has different properties and therefore has different characteristics
2	Slope	The size of the slope of a land with a slope classification percentage of 0-8% (flat), 8-15% (sloping), 15-25% (rather steep), 25-45% (steep), >45% (very steep)
3	Settlement	Settlement is measured based on land cover use
4	Distance to road	Distance to existing roads, both arterial and collector roads

Source: Research data processing, 2024

3. Data Collection Techniques

Data collection techniques are techniques or methods used to collect data to be researched. This means that data collection techniques require strategic and systematic steps to obtain data that is valid and in accordance with reality.

1. Observation

Observations are carried out with the aim of knowing the condition of the field directly and ensuring the suitability of the field data with the processed data. Observation activities are carried out by going out in the field and observing research objects in detail, objectively and factually. In this research, observations were carried out directly to obtain a general overview of the research location as well as observe and record changes in land cover in North Kotabumi District.

2. Document (Document)

Documents are a data collection technique by studying documents to obtain data or information related to the problem being studied (Marfai, 2015). The final data collection technique is documents in which researchers take research sources or objects from documents or records of past events, whether in the form of writing, images, or someone's monumental work. In this research the documentation used is as follows:

1. Administrative maps, roads and settlements are obtained via the Ina Geoportal site.
2. Landsat images for 2008, 2015 and 2022 were obtained via the USGS website.
3. Slope data is obtained through DEMNAS data.

4.Data Analysis Techniques

Data analysis techniques refer to the methods or approaches used to analyze data collected in research. This aims to produce meaningful information, identify patterns or relationships, and draw conclusions that are supported by data. Data analysis techniques help researchers process, compile and interpret data systematically.

This research uses a data analysis technique, namely logistic regression. Logistic modeling or logistic regression is a statistical analysis technique used to predict the probability of occurrence of a binary event. In the context of mollusce mapping, to apply logistic regression to mollusce mapping, the general steps are as follows:

1. Collect data

Namely the required shp and image data. SHP data can be obtained through related service agencies such as the Public Development Service.

2. Prepare Data

Perform data pre-processing such as cleaning invalid or missing data, resolving inequalities in data formats, and converting categorical variables to dummy variables if necessary.

3. Model Evaluation

After training the model, evaluate its performance using the test set. Prediction and mapping Once the model is evaluated and deemed adequate, you can use it to predict mollusce categories based on the given features. For example, if you want to map a mollusce to a particular species, you can provide morphological features or other characteristics as input to the model and generate predictions of possible species.

Result And Discussion

A. Land Cover Changes 2008-2022

Many land cover changes occur in North Kotabumi District, in this district there are 6 types of land cover, namely built up land, open land, wetland agriculture, dry land agriculture, waters and forests. North Kotabumi District has land cover that is dominated by dry land agriculture, wet land agriculture

and open land so that land cover changes will occur a lot. A significant increase in population is the main factor in changes in land cover because it will increase the need for land. A detailed explanation of land cover changes in North Kotabumi District is included in the discussion below:

1.Land Cover in 2008

Land cover refers to the layers or types of vegetation that cover the land surface in an area. It includes various elements, such as forests, grasslands, agricultural land, and built up areas. Land cover plays an important role in ecosystems, influencing local climate, biodiversity and soil quality. Related to this, the distribution of land cover can be seen in the following figure.

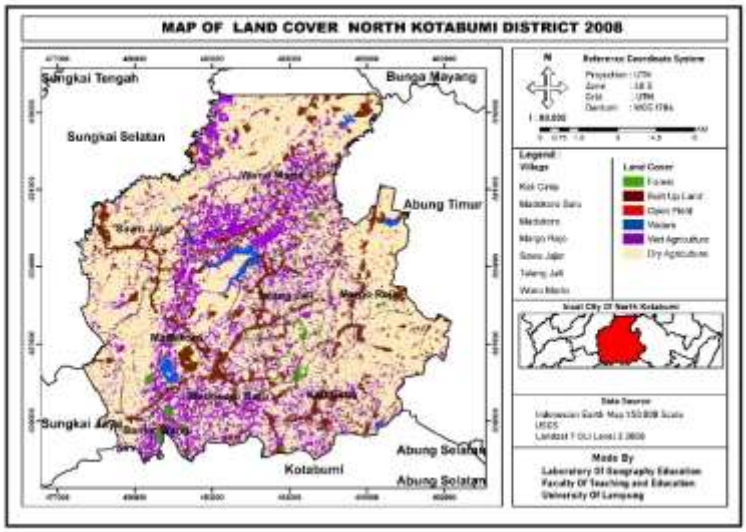

Figure 1. Land Cover Map of North Kotabumi District in 2008

Figure 1, shows that the area of the 6 existing land covers, Through image analysis of land cover distribution, we can understand environmental conditions, plan resource management, and identify areas that require protection or restoration. The data obtained is as follows:

Table 2. Land Cover of North Kotabumi District in 2008

No	Land Cover	2008 (ha)
1	Forest	234,54
2	Empty Land	112,21
3	Built up Land	1.576,66
4	Waters	172,78
5	Wetland Agriculture	2.607,43
6	Dry Land Agriculture	9.621,38

Source: Research Results, Year 2024.

Table 2, can be seen that in 2008 in North Kotabumi District there were 6 categories of land cover, namely forest, empty land, built up land, water, wetland agriculture and dry land agriculture with the largest total being dry land agriculture with an area of 9,621, 38 hectares and the smallest area is empty land with a land cover area of 112.21 hectares. Dry land agricultural land cover is spread across all villages in this subdistrict, the village with the largest dry land farming area is Kalicinta Village with an area of 1,785.12 hectares, while the smallest dry land agricultural area is Banjar Wangi Village with an area of 350.65 hectares. The land cover of empty land types is generally spread throughout the village, the area that has the largest area of empty land cover is Sawojajar Village with an area of 24.79 hectares, while the village that has the least amount of empty land cover is Banjar Wangi Village with an area of 0.73 hectares. Forest land cover is spread across all existing villages, the village with the largest forest

area is Madukoro Village with an area of 54.45 hectares, while the smallest forest area is Sawojajar Village with an area of 4.70 hectares.

2. Land Cover in 2015

Land cover in 2015 was still dominated by dry land agricultural land cover which was spread across all areas in the subdistrict. To see the distribution, you can see the distribution in the image below.

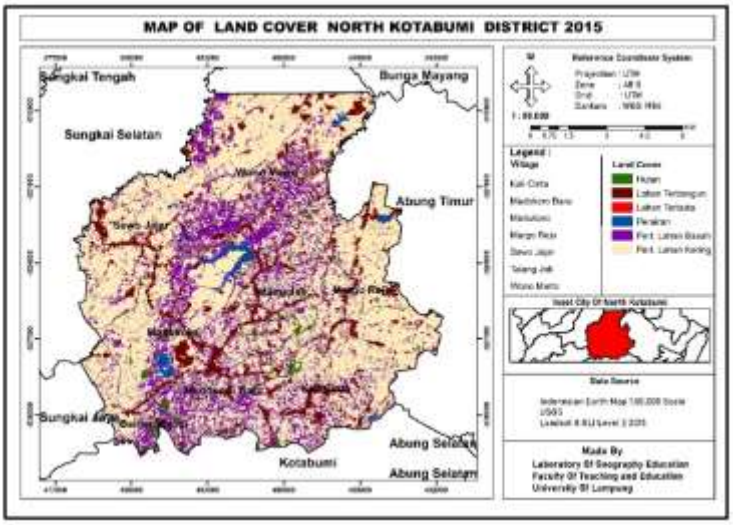

Figure 2. Land Cover Map of North Kotabumi District in 2015

Figure 2, shows that the area of the 6 existing land covers, Through image analysis of land cover distribution, we can understand environmental conditions, plan resource management, and identify areas that require protection or restoration. The data obtained is as follows.

Table 3. Land Cover of North Kotabumi District in 2015

No	Land Cover	2015 (ha)
1	Forest	235,82
2	Empty Land	151,47
3	Built up Land	1.657,21
4	Waters	172,84
5	Wetland Agriculture	2.603,70
6	Dry Land Agriculture	9.503,95

Source: Research Results, Year 2024

Table 3, can be seen that in 2015 in North Kotabumi District there were 6 categories of land cover, namely forest, empty land, built up land, water, wetland agriculture and dry land agriculture with the largest total being dry land agriculture with an area of 9,503, 95 hectares and the smallest area is empty land with a land cover area of 151.47 hectares. Dry land agricultural land cover is spread across all villages in this subdistrict, the village with the largest dry land farming area is Kalicinta Village with an area of 1,768.30 hectares, while the smallest dry land agricultural area is Banjar Wangi Village with an area of 345.92 hectares. The land cover of empty land types is broadly spread throughout the villages, the area that has the largest area of empty land cover is Sawojajar Village with an area of 30.87 hectares while the village that has the least amount of empty land cover is Banjar Wangi Village with an area of 1.49 hectares . Forest land cover is spread across all existing villages, the village with the largest forest

area is Madukoro Village with an area of 54.74 hectares, while the forest area with the smallest is Sawojajar Village with an area of 4.84 hectares.

3. Land Cover in 2022

Land cover refers to the type and distribution of earth's surface cover which includes various categories such as forests, agricultural land, settlements, waters and other open areas. It describes how land is used or covered by natural and man-made elements. To see the distribution of land cover in 2022, see the following image.

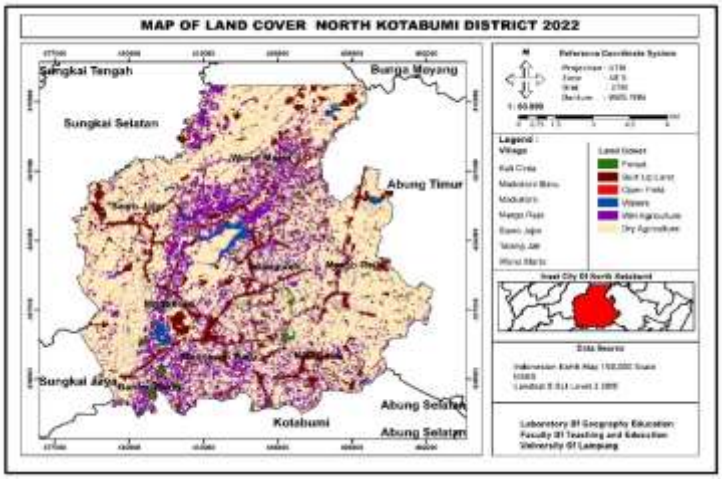

Figure 3. Land Cover Map of North Kotabumi District in 2022

Figure 3, shows the extent of the 6 existing land covers. Through image analysis of land cover distribution, we can understand environmental conditions, plan resource management, and identify areas that require protection or restoration. The data obtained can be seen in the following table.

Table 4. North Kotabumi District Land Cover in 2022

No	Land Cover	2022 (ha)
1	Forest	237,87
2	Empty Land	205,99
3	Built up Land	1.829,47
4	Waters	173,63
5	Wetland Agriculture	2.643,80
6	Dry Land Agriculture	9.244,80

Source: Research Data Processing Results, Year 2024.

Table 4, can be seen that in 2022 in North Kotabumi District there are 6 categories of land cover, namely forest, empty land, built up land, water, wetland agriculture and dry land agriculture with the largest total being dry land agriculture with an area of 9,244, 80 hectares and the smallest area is empty land with a land cover area of 151.47 hectares. Dry land agricultural land cover is spread across all villages in this subdistrict, the village with the largest dry land agricultural area is Kalicinta Village with an area of 1,732.77 hectares, while the smallest dry land agricultural area is Banjar Wangi Village with an area of 336.11 hectares. The land cover of empty land types is broadly spread throughout the villages, the area that has the largest area of empty land cover is Sawojajar Village with an area of 40.47 hectares while the village that has the least amount of empty land cover is Banjar Wangi Village with an area of 12.45 hectares . Forest land cover is spread across all existing villages, the village with the largest forest area is Madukoro Village with an area of 55.74 hectares, while the forest area with the smallest is Sawojajar Village with an area of 4.98 hectares. Land cover from 2005, 2015 and 2022 can be seen in the following image.

Land Cover 2008 Land Cover 2015 Land Cover 2022

Figure 4. Land Cover of North Kotabumi District in 2008, 2015, and 2022

Information:

(Forest) (Empty Land)

(Built up Land) (Wetland agriculture)

(Waters) (Dryland agriculture)

Table 5. Changes in Land Cover from 2008 to 2015

No.	Change Land Cover 2008-2015 (ha)	Forest	Empty Land	Built up Land	Waters	Wetland Agriculture	Dryland Agriculture
	Village Banjar Wangi						
1	**2008**	14,05	0,73	28,85	1,14	90,37	350,65
	2015	13,91	1,49	32,94	1,48	91,62	345,92
	Wide change	-0,14	0,76	4,1	0,35	1,25	-4,73
	Village Kali Cinta						
2	**2008**	38,28	5,51	278,46	7,98	384	1.785,12
	2015	39,18	9,51	289,96	8,22	386,8	1.768,30
	Wide change	0,9	4	11,5	0,24	2,86	-16,82
	Village Madukoro						
3	**2008**	54,45	8,44	304,63	65,86	452,5	1.658,66
	2015	54,74	13,9	316,44	65,46	452,5	1.641,44
	Wide change	0,29	5,47	11,81	-0,4	0,05	-17,22
	Village Madukoro Baru						
4	**2008**	39,09	4,12	103,13	3,04	289,7	530,2
	2015	39,02	6,83	110,09	3,07	287,9	520,06
	Wide change	-0,06	2,7	6,96	0,03	-1,74	-10,14
	Village Margorejo						
5	**2008**	10,64	12,09	160,47	13,44	71,4	1.001,22
	2015	10,83	14,15	165,43	13,36	73,58	992,54
	Wide change	0,2	2,06	4,96	-0,08	2,18	-8,69
	Village Sawo Jajar						
6	**2008**	4,7	24,79	218	12,07	298,8	1.630,40
	2015	4,84	30,87	227,67	12,29	299	1.616,69
	Wide change	0,13	6,08	9,66	0,21	0,17	-13,71

	Village Talang Jali						
7	**2008**	29,63	5,79	124,45	2,34	186,7	503,33
	2015	29,63	8,47	127,61	2,35	186,9	497,3
	Wide change	0	2,68	3,16	0,02	0,18	-6,03
	Village Wonomarto						
8	**2008**	41,05	44,35	341,5	66,75	775,4	2.234,48
	2015	41,47	55,14	376,3	66,62	770,7	2.275,68
	Wide change	0,42	10,79	34,8	-0,13	-4,68	-48,8

Source: Results of research data processing, Year 2024.

Table 5, shows that changes in land cover occurred in all existing land cover, the largest changes occurred in built up land in each village from 2008 to 2015. This occurred in Kali Cinta Village and Madukoro Village. Meanwhile, land cover that is reduced is dry land farming, everything changes in existing villages. The following data is a recapitulation of the extent of land cover changes from 2008 to 2015.

Table 6. Recapitulation of Area Changes in District Land Cover (Ha) from 2008 to 2015

No	Land Cover	2008 (ha)	2015 (ha)	Change (ha)
1	Forest	234,54	235,82	1,28
2	Empty Land	112,21	151,47	39,26
3	Built up Land	1.576,66	1.657,21	80,55
4	Waters	172,78	172,84	0,07
5	Wetland Agriculture	2.607,43	2.603,70	-3,73
6	Dry Land Agriculture	9.621,38	9.503,95	-117,43

Source: Results of research data processing, Year 2024.

Table 6, shows the changes in land cover in North Kotabumi District over a period of 7 years, namely from 2008 to 2015. The following is a detailed description of land cover changes that occurred in North Kotabumi District. Overall, if we look at the area, the biggest change in land cover that occurred in North Kotabumi District was the change in land cover for the dry land agricultural type, namely a reduction in area of 117.43 Ha. The village that experienced the largest reduction in dry land agricultural land cover was Wonomarto Village with an amount of 48.80 Ha. This dry land agricultural land cover is turning into built up land, this is due to the high need for land which is caused by increasing population needs due to the increasing population. This is in line with the discussion outlined at the beginning that population growth and accessibility and roads are the causes in Although land cover change is not the only factor, it is one of the influencing factors. The first type of land cover that experienced a change towards an increase in area was the land cover type of built up land which experienced an increase in area of 80.55 Ha.

The increase in the area of built up land cover itself is due to many factors, such as the increasing population and supporting road access. In North Kotabumi District itself, the village with the largest increase in built up land in the past 7 years is Wonomarto Village with a total built up land area of 376. 30 Ha. This was followed by Madukoro Village with a built up land area in 2015 of 316.44 Ha. The third largest increase in built up land was in Kali Cinta Village, namely 289.96 Ha. For the direction of development of land cover, the types of built up land in North Kotabumi District itself have directions, namely east and west, this is because the development of built up land follows the road pattern in North Kotabumi District so that the built up land pattern in North Kotabumi District is linear. follow the existing road pattern.

The next area of land cover that experienced an increase was land cover of the vacant land type, which in 2008 was 112.21 Ha, then in 2015 it increased by 151.47 Ha, resulting in an area change of 39.26 Ha. It was recorded that each village in the 7 year period experienced an increase in the area of empty land, Wonomarto Village experienced an increase in the area of large empty land of more than 10 Ha, then Sawo Jajar Village amounted to 6.08 Ha, Kali Cinta Village amounted to 54 Ha and Madukoro Village amounted to 5 .47 Ha. The increase in the amount of vacant land is caused by many factors, one of which is because land which initially had fertile soil properties and was good for plants over time loses its fertile properties so that the land can no longer be used by residents as agricultural land or another possibility is that the land is undergoing a process of rejuvenation. to restore the fertile properties that are starting to be lost.

Forest land cover experienced an increase in area, although not significant, namely 1.28 Ha. This change occurred in several villages, but the largest increase in area was Kali Cinta Village, namely 0.90 Ha, while in several villages the increase and decrease were not very significant. The next land cover is wetland agriculture, this type of land cover experienced a decline in the 7 year period, namely 3.73 Ha. The village that experienced a decrease in the area of wetland agricultural land cover was Kali Cinta Village, which was more than 10 Ha, while several other villages experienced a less significant decrease. This change is in line with the increasing need for land so that land conversion is very likely to occur. This can be seen in the following table.

Table 7. Changes in Land Cover from 2015 to 2022

No.	Change Land Cover 2015-2022 (ha)	Forest	Empty Land	Built up Land	Waters	Wetland Agriculture	Dryland Agriculture
1	**Village Banjar Wangi**						
	2015	13,91	1,49	32,94	1,48	91,62	345,92
	2022	13,9	2,45	40,43	1,67	93,04	336,11
	Wide change	-0,01	0,96	7,49	0,19	1,42	-9,82
	Village Kali Cinta						
	2015	39,18	9,51	289,96	8,22	386,8	1.768,30
	2022	39,65	13,72	312,62	8,31	394,99	1.732,77
	Wide change	0,48	4,2	22,66	0,09	8,19	-35,53
	Village Madukoro						
	2015	54,74	13,9	316,44	65,46	452,5	1.641,44
	2022	55,03	21,04	339,75	65,51	458,38	1.604,79
	Wide change	0,29	7,14	23,31	0,04	5,88	-36,65
	Village Madukoro Baru						
	2015	39,02	6,83	110,09	3,07	287,93	523,06
	2022	39,1	9,53	117,52	3,07	290,24	510,52
	Wide change	0,07	2,7	7,43	0,01	2,31	-12,54
	Village						

Margorejo						
2015	10,83	14,15	165,43	13,36	73,58	992,54
2022	11,18	17,02	177,87	13,32	77,06	973,47
Wide change	0,35	2,87	12,44	-0,04	3,49	-19,07
Village Sawo Jajar						
2015	4,84	30,87	227,67	12,29	298,99	1.616,69
2022	4,98	40,47	251,78	12,4	304,94	1.577,19
Wide change	0,14	9,6	24,12	0,11	5,95	-39,5
Village Talang Jali						
2015	29,63	8,47	127,61	2,35	186,91	497,3
2022	29,82	11,19	134,25	2,36	189,59	485,06
Wide change	0,19	2,72	6,64	0	2,68	-12,24
Village Wonomarto						
2015	41,47	55,14	356,3	66,62	770,7	2.215,68
2022	42	69,41	384,91	66,57	775,24	2.168,10
Wide change	0,53	14,27	28,6	-0,05	4,54	-47,58

Source: Results of research data processing, Year 2024.

Table 7, can be seen that changes in land cover occurred on built up land and empty land in each existing village. To see the distribution shown in the picture.

Table 8. Changes in District Land Cover (Ha) in 2015 and 2022

No	Land Cover	2015 (ha)	2022 (ha)	Chnage (ha)
1	Forest	235,82	237,87	1,64
2	Empty Land	151,47	205,99	54,36
3	Built up Land	1.657,21	1.829,47	170,55
4	Waters	172,84	173,63	0,43
5	Wetland Agriculture	2.603,70	2.643,80	36,49
6	Dry Land Agriculture	9.503,95	9.244,80	-263,48

Source: Results of research data processing, Year 2024.

Table 8, shows data on land cover changes in villages in North Kotabumi District over a period of 7 years, namely 2015 to 2022. The following is a detailed description of land cover changes that occurred in North Kotabumi District. Overall, if we look at the area, the biggest change in land cover that occurred in North Kotabumi District was the change in land cover for the dry land agricultural type, namely a reduction in area of 263.48 Ha. All villages in North Kotabumi District within a period of 7 years all experienced an increase in the area of dry land farming in detail. The village that experienced the largest reduction in land cover area for dry land farming was Madukoro Village with an area of 36.65 Ha, then followed by Kali Cinta Village with a large reduction of 35.53 Ha, this dry land agricultural land cover has shifted to various new land covers, one of which is built up land, this is due to the high need for land caused by increasing population needs due to the increasing population, this is in line with the discussion

It was explained at the beginning that population growth and accessibility as well as roads are the causes of changes in land cover, although they are not the only factors but are one of the influencing factors. The direction of dry land agricultural land in North Kotabumi District is spread across the central part of North Kotabumi District.

The land cover that experienced the second biggest change was that the built up land experienced a change in area of 170.55 Ha, in 2015 the built up land area was 1,657.21 Ha, then in 2022 it was recorded at 1,829.47 Ha. The increase in the area of built up land cover itself is due to many factors, such as the increasing population and supporting road access. In North Kotabumi District itself, the village with the largest increase in built up land in the past 7 years is Wonomarto Village, which has increased by 28.60 Ha, Sawo Jajar Village has built up land of 24.12 Ha, Madukoro Village has built up land of 23.31 Ha, Kali Cinta Village has built up land of 22.66 Ha, the direction of development of built up land in North Kotabumi District is to the east and west following walking pattern.

The next area of land cover that has increased is the land cover of the empty land type, which in 2015 was 151.47 Ha, then in 2022 it increased by 205.99 Ha, resulting in an area change of 54.36 Ha. It was recorded that each village in the 7 year period experienced an increase in the area of vacant land, Wonomarto Village experienced an increase in the area of empty land of more than 14.27 Ha, then Sawo Jajar Village amounted to 9.60 Ha, Kali Cinta Village amounted to 4.20 Ha and Madukoro Village is 7.14 Ha.

The increase in the amount of vacant land is caused by many factors, one of which is because land which initially had fertile soil properties and was good for plants over time loses its fertile properties so that the land can no longer be used by residents as agricultural land or another possibility is that the land is undergoing a process of rejuvenation. to restore the fertile properties that are starting to disappear. Forest land cover has increased in area, although not significantly, namely 1.64 Ha. This change occurred in several villages but the largest increase in area was Wonomarto Village, namely 0.53 Ha, while in several villages the increase and the reduction is not too significant.

The next land cover is wetland agriculture, this type of land cover in the 7 year period experienced an expansion of 36.49 Ha, all villages in the subdistrict experienced an increase in area, the largest increase in area was Kali Cinta Village, which was 8.19 Ha. then Sawo Jajar Village with an area of 5.95 Ha. The increase in the area of wetland agricultural land cover is due to the increase in population which causes the need for food to also increase so that residents use existing land for wet agricultural land to meet their living needs. To view related data

Table 9. Matrix of direction of change in land cover area in 2008, 2015 and 2022

No	Land Cover	2008 (ha)	2015 (ha)	2022 (ha)
1	Forest	234,54	235,82	237,87
2	Empty Land	112,21	151,47	205,99
3	Built up Land	1.576,66	1.657,21	1.829,47
4	Waters	172,78	172,84	173,63
5	Wetland Agriculture	2.607,43	2.603,70	2.643,80
6	Dry Land Agriculture	9.621,38	9.503,95	9.244,80

Source: Research Results, Year 2024.

Table 9, data land cover can be seen from the matrix of the direction of changes in land cover area above. You can see changes in land cover area from year to year, which in this study took a period of 7 years, namely 2008, 2015 and 2022. It can be seen that the 6 types of land cover in North Kotabumi District all experienced changes in land cover area, either decreasing or increasing. The land cover that experienced an increase in area included forests, empty land, waters and built up land, while the land cover that experienced a reduction in area included wetland agriculture and dry land agriculture. To see changes in land cover from 2008 to 2022, see the following table.

Table 10. Changes in Land Cover in North Kotabumi District

Land Cover		Wide Change (Ha)
2008	**2022**	
Forrest	Wetland Agriculture	-4,41
Forrest	Dryland Agriculture	-2,97
Open Land	Built of Land	-2,97
Open Land	Wetland Agriculture	-0,72
Open Land	Dryland Agriculture	-10,08
Waters	Wetland Agriculture	-0,81
Wetland Agriculture	Forrest	5,67
Wetland Agriculture	Open Land	16,11
Wetland Agriculture	Built of Land	33,84
Wetland Agriculture	Dryland Agriculture	111,24
Wetland Agriculture	Forrest	8,28
Dryland Agriculture	Open Land	202,59
Dryland Agriculture	Built of Land	935,64
Dryland Agriculture	Wetland Agriculture	289,53

Source: Results of research data processing, Year 2024.

Table 10, can be seen that the land cover changes that have seen the most changes are dry land agriculture and wet land agriculture, while the land cover that has had very little change is open land. To see the distribution, see the following map.

4.3 Analysis of Predictions of Land Cover Changes in North Kotabumi District in 2036

Predicting land cover using cellular automata at this stage is first done not directly looking for predictions for 2036 but looking for predictions of changes in land cover for 2022 as a result, so that later the prediction results for 2022 will be validated with existing land cover. At this stage it will also produce land cover predictions for 2036.

Table 11. Predicted and Existing Land Cover Area (Ha)

No.	Land Cover	2022 (E) (ha)	2022 (P) (ha)	Difference (ha)	Difference (%)
1	Forest	237,87	235,10	-2,77	-1,16
2	Empty Land	205,99	168,28	-37,71	-18,39
3	Built up Land	1.829,47	1.774,94	-54,53	-2,98
4	Waters	173,63	157,95	-15,68	-0,9
5	Wetland Agriculture	2.643,80	2.607,55	-36,25	-1,3
6	Dry Land Agriculture	9.244,80	9.391,75	146,95	1,58

Source: Results of research data processing, 2024.

Table 11, can be seen that there is a difference between the predicted land cover classes and the digitized land cover. In empty land cover, there was the largest difference, namely 18.29%, with a

difference of 37.71 Ha, then in built up land cover, the percentage was 2.98%, covering an area of 54.53 Ha, then there was dry land agricultural land cover with an amount of 1.58%. with an area of 146.95 Ha. Based on the explanation above, there is a difference between the data processing results and the digitization results, this is because it has a kappa value of 0.67 or 67% in the good category, and has not yet reached the level of 80 to 100 percent in the very good category as explained in chapter 2 of the review. library. Prediction Results of Land Cover Changes in 2036.

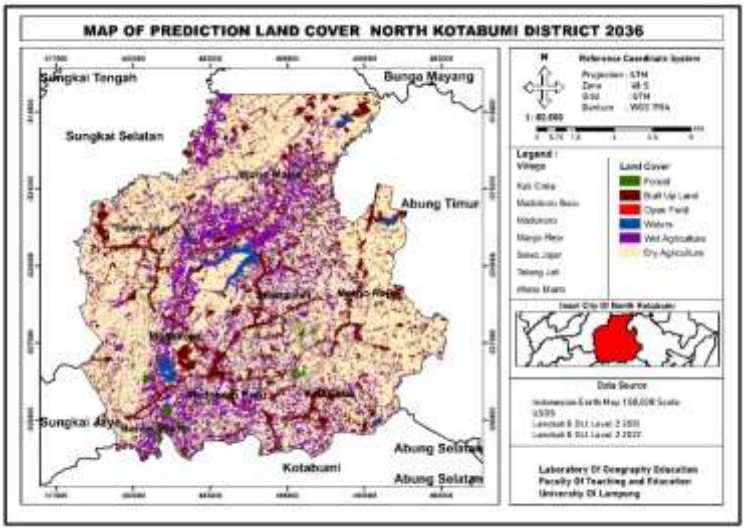

Figure 5. Map of Land Cover Prediction for North Kotabumi District in 2036

Figure 5, shows that the extent of the 6 existing land covers is known, Through image analysis of land cover distribution, we can understand environmental conditions, plan resource management, and identify areas that require protection or restoration. The data obtained is as follows:

Table 12. Predictions of Changes in Land Cover Area in 2036.

No.	Land Cover	2036 (ha)	Change (ha)
1	Forest	232,07	1,62%
2	Empty Land	175,56	1,22%
3	Built up Land	2.058,96	14,36%
4	Waters	170,88	1,19%
5	Wetland Agriculture	2.638,30	18,40%
6	Dry Land Agriculture	9.059,14	63,20%

Source: Results of research data processing, 2024.

Table 12, can be seen that the process of predicting land cover changes in North Kotabumi District in 2036 which has been carried out shows that the predicted results of land cover areas and types of land cover classes in 2036 are like the data above, based on the description of land cover change data from 2022 to 2022. 2036, during these 14 years in North Kotabumi District there have been many changes in the existing land cover, each of which has experienced significant increases and decreases. In 2036, the largest land cover will be dry land agriculture with an area of 9,059 Ha or 63.20%, then followed by wetland agriculture with an area of 2,638.30 Ha or 18.40%, then there is the type of built up land cover with a percentage of 14 .36%, then the land cover with the least area in North Kotabumi District is water land cover with a percentage of 1.19%.

Built up land in North Kotabumi District in 2036 is predicted to experience an increase, which can be seen from the description of existing data that built up land in every village in North Kotabumi District in the next 14 years will experience an increase, villages are predicted to experience The biggest

increase in the amount of built up land is Wonomarto village which experienced a spike of 69.75 Ha, in 2022 the amount of built up land will be 384.91 Ha, then in 2036 the number is predicted to be 454.66 Ha.

The increase in the number of built up land types of land cover is in line with the increase in population so that the need for land for housing and settlements increases so that the number of built up land also increases. A significant increase in the amount of built up land also occurred in Sawo Jajar Village with a total increase of 56.90 Ha. There was also Madukoro Village which experienced an increase in land cover of built up land types of 52.89 Ha.

The increase in land cover area in the built up land class in 2036 itself requires attention for control because this can cause several problems if the built up land cover class continues to increase. Problems that will arise such as excessive use of natural resources, why is this because with the increasing area of built up land, it can be assumed that the population will increase so that the need for food and clothing will increase where the ability to meet needs is limited so that humans will exploit nature excessively. The second problem that can arise if the class of built up land is allowed to increase significantly is that pollution will increase, both air pollution and noise pollution. The third problem that can arise if the class of built up land continues to increase is the increasing crime rate in the community, this is due to the increasing needs of the community while the ability to meet these needs does not exist, so the community will use inappropriate methods to fulfill their daily needs, such as stealing, robbing and mugging. The next problem that can arise is the reduction in the area of agricultural land, the area of agricultural land will decrease because the amount of built up land will increase because humans will use agricultural land for their residences so that agricultural land will become increasingly narrow.

With the estimated problems that will arise in 2036, it is appropriate to give attention and solutions to these estimated problems from both the government and local communities, the role of local governments in this problem is very large, they can provide real solutions to overcome these problems, such as family planning programs, creating new jobs and equitable development and much more. Then for other land cover classes such as wetland agriculture, forests, waters, open land, dry land agriculture, in general, there has been a significant decline in each class, where the biggest decline is agricultural land cover, both wet and dry. Dry land farming from 2022 to 2036 will experience a decline of 335.34 Ha. This reduced land cover has turned into built up land cover and the land cover that was predicted to decrease has now experienced a decline in area.

Conclusion

Based on the results and description of the discussion of the research that has been carried out, the following conclusions can be drawn from the presentation that has been described:

1. Changes in land cover in North Kotabumi District in 2008-2022 were dominated by a reduction in land cover in the classes of dry land agriculture, wetland agriculture, open land, forests, waters, during these 7 years there was actually a reduction and increase in land cover classes but the majority occurred subtraction. The land cover class that consistently experiences increases every year is the land cover type of built land class due to the high need for land caused by increasing population needs due to the increasing population. Population growth and accessibility as well as roads are the causes of changes in land cover, although they are not the only factors but are one of the influencing factors. The direction of dry land agricultural land in North Kotabumi District is spread across the central part of North Kotabumi District.
2. The results of predictions of land cover area and types of land cover classes in 2036, it is predicted that changes in land cover in 2022-2036 in North Kotabumi District will experience significant increases and decreases. In 2036 the largest land cover will be dry land agriculture with an area of 9,059 Ha.

References

Badan Pusat Statistik (BPS) Kecamatan Lampung Utara. 2022. Jumlah Penduduk Menurut Kecamatan Dan Jenis Kelamin (Tahun 29). Bps.Go.Id. (Diakses Pada Tanggal 26 April 2023).

Badan Pusat Statistik (BPS) Kecamatan Lampung Utara. 2022. Jumlah Penduduk Menurut Kecamatan Dan Jenis Kelamin (Tahun 2015). Bps.Go.Id. (Diakses Pada Tanggal 26 April 2023).

Badan Pusat Statistik (BPS) Kecamatan Lampung Utara. 2022. Jumlah Penduduk Menurut Kecamatan Dan Jenis Kelamin (Tahun 2022). Bps.Go.Id. (Diakses Pada Tanggal 26 April 2023).

Ban, Y., Gong, P., & Giri, C. (2015). Global land cover mapping using Earth observation satellite data: Recent progresses and challenges. ISPRS journal of photogrammetry and remote sensing, 103, 1-6.

Batty, M., Xie, Y., Sun, Z. 1999. Modeling Urban Dynamics Through Gis-Based Cellularautomata. Computers, *Environments and Urban Systems*, 23, 205-233.

Delarizka, A., Sasmito, B. And Ah, H. 2015. Analisis Fenomena Pulau Bahang (Urban Heat Island) Di Kota Semarang Berdasarkan Hubungan Antara Perubahan Tutupan Lahan Dengan Suhu Permukaan Menggunakan Citra Multi Temporal Landsat‟, Jurnal Geodesi Undip.

Dedy, M., Agus Suyatna, A. S., Wan Abbas Zakaria, Z. W., Wahono, E. P., Yazid, S., & Suhendro, S. (2023). Geospatial modeling of environmental carrying capacity for sustainable agriculture using GIS. International Journal of Sustainable Development and Planning, 18(1), 99-111.

Hailu, A., Mammo, S., & Kidane, M. (2020). Dynamics of land use, land cover change trend and its drivers in Jimma Geneti District, Western Ethiopia. Land use policy, 99, 105011.

Hapsary, M. S. A., Subiyanto, S., & Firdaus, H. S. 2021. Analisis Prediksi Perubahan Tutupan Lahan Dengan Pendekatan Artificial Neural Network Dan Regresi Logistik Di Kota Balikpapan. *Jurnal Geodesi Undip*, *10*(2), 88-97.

Ichsan, A., Najib, M., & Ulum, F. 2020. Sistem Informasi Geografis Toko Distro Berdasarkan Rating Kota Bandar Lampung Berbasis Web. *Jurnal Teknologi Dan Sistem Informasi*, *1*(2), 71-79.

Keivani, R., & Werna, E. (2001). Modes of housing provision in developing countries. Progress in planning, 55(2), 65-118.

Laily, K. 2021. Buku-Pengaruh Kondisi Lahan (Tanah, Warna Lahan, Ketebalan Bahan Organik Dan Tutupan Lahan) Dan Tata Air (Sumber Air, Kualitas, Air (Fisik, Kimia, Bakteriologis, Debit Air) Terhadap Ketersediaan Air Bersih Dirawan Banjir Dan Pertambangan Di Kabupaten Banjar.

Marfai Aris, M. 2011. Pengantar Pemodelan Geografi,Panji Budi, Red Carpet Studio, 96 Halaman.

Miswar, D. M., I Gede Sugiyanta, G. S., & Yarmaidi, Y. 2020. Analisis Geospasial Perubahan Penggunaan Lahan Sawah Berbasis LP2B Kecamatan Pagelaran Utara. Media Komunikasi Geografi, 21(2), 130-143.

Miswar, D., Salsabilla, A., Yarmaidi, Y., Susanti, E., Aryati, F. 2021. Study of Sustainable agriculture (LP2B) Using Spatial Approach South Pringsewu District. International Journal of Multicultural and Multireligious Understanding, 8(12): 74-86.

Muhammad, I. A. (2021). Analisis Faktor Perubahan Pemanfaatan Lahan Di Kecamatan Watang Pulu Kabupaten Sidrap. *Losari: Jurnal Arsitektur Kota Dan Pemukiman*.

Nahib, I. 2015. Prediksi Spasial Dinamika Areal Terbangun Kota Semarang Dengan Menggunakan Model Regresi Logistik. *Majalah Ilmiah Globe*, *18*(2), 95.

Nugraheni, I. L., & Usman, M. (2024). Analysis of Regional Spatial Regulation Policies Pesawaran District. Journal of Law and Sustainable Development, 12(1), e2039-e2039.

Park, S., Jeon, S., Kim, S., Choi, C., 2011. *Prediction And Comparison Of Urban Growth By Land Suitability Index Mapping Using Gis And Rs In South Korea. Landscape And Urban Planning*, 99(2), 104-114.

Peruge, T. V. D. Arief, S. Dan Sakka. 2012. Model Perubahan Tutupan Lahan Menggunakan Cellular Automata - Markov Chain Di Kawasan Mamminasata. Makassar: Fakultas Matematika Dan Ilmu Pengetahuan Alam. Universitas Hasanuddin.

Pratomoatmojo, N. A. 2018. Pemodelan Perubahan Tutupan Lahan Berbasis Cellular Automata Dan Sistem Informasi Geografis Dengan Menggunakan Landusesim. Jurnal Penataan Ruang, 13(1), 25-2008.

Rijal, S., Barkey, R. A., Nur Saputra, M., Ardiansah, T., Tahir, M. A. S., & Radeng, A. K. 2019. *Penginderaan Jauh Dalam Bidang Kehutanan*. Fakultas Kehutanan, Universitas Hasanuddin.

Sampurno, R. dan Thoriq, A. 2015, "*Klasifikasi Tutupan Lahan Menggunakan Citra Landsat 8 Operational Land Imager (Oli) Di Kabupaten Sumedang*", Jurnal Teknotan, Vol.10, Hal. 61–70.

Sari, Y. A., & Dewanti, D. 2019. Perubahan Tutupan Lahan Dan Faktor-Faktor Yang Mempengaruhi Di Sekitar Area Panam Kota Pekanbaru. In *Seminar Nasional Geomatika* (Vol. 3, Pp).

Singh, A. K. 2023. Modelling Land Use Land Cover Changes Using Cellular Automata In A Geo-Spatial Environment. Itc.

Wijaya, M. S., & Susilo, B. 2013. Integrasi Model Spasial *Cellular Automata* Dan Regresi Logistik Biner Untuk Pemodelan Dinamika Perkembangan Lahan Terbangun (Studi Kasus Kota Salatiga). *Jurnal Bumi Indonesia*, *2*(1).