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MODEL OF LAND USE AND LAND COVER CHANGE IN KOTO XI TARUSAN DISTRICT

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ABSTRACT: The article on models of land use change and land cover in Koto XI Tarusan District, Pesisir Selatan Regency, West Sumatra aims to model changes in land use and land cover in Koto XI Tarusan District and to find out the accuracy of the results of modeling changes in land use and land cover 2025 and 2030. The method used in this research is quantitative method using remote sensing data in the form of 2000 Landsat 5 images, 2009 Landsat 7 images, and 2019 Landsat 8 OLI images. The driving force used in this study is the distance from the road, the government center, health facilities, educational facilities, slopes, and elevations. The results showed that the results of modeling changes in land use and land cover in 2025 and 2030 indicated that there were changes in land cover of primary forest, secondary forest and mixed orchard. Land uses that have increased a built up area, and oil palm. The results of modeling accuracy test using the overall accuracy obtained in 2025 accuracy is 92.50 % and in 2030 is 89.75%. The accuracy results show that the modeling results have been very good.

Keywords: Land Use, Land Cover, Model

1. INTRODUCTION

Changes in land use and land cover often occur due to increased human activities in meeting needs, both primary, secondary and tertiary needs [1,3,5,6]. Meeting human needs often requires space for activities, whether physical, social, economic, and political [4,8,10]. The increase in human population on the surface of the earth is a separate threat, especially for the fulfillment of space as a human activity [16,18,23]. Increasing human population often results in changes in land use and land cover or is often known as land use / land cover change (LULC) [17,18,19]. Land use change and land cover (LULC) problems often have an impact on natural balance such as reduced water catchment areas, deforestation, cutting and filling of slopes which trigger natural disasters such as landslides, floods, flash floods, and drought [21,23,24,27].

The problem of land use change and land cover (LULC) also occurs in Koto XI Tarusan District, Pesisir Selatan Regency, West Sumatra Province. The increase in tourism activity in this area has led to changes in land use and land cover (LULC), especially in forest land cover and mixed orchard land use. The Koto XI Tarusan district area is one of the areas that has become a tourist destination in the Pesisir Selatan Regency, especially in the Mandeh Area which has beautiful scenery with several small islands in front of it. The development of the Mandeh Area to become a tourist destination in Pesisir Selatan Regency has resulted in changes in land use and land cover (LULC), especially the construction of roads connecting the Sungai Pisang area of Padang City with Koto XI Tarusan District, Pesisir Selatan Regency. The construction of this overland road was carried out by cutting steep slopes, this caused high sediment to enter the shore, causing damage to coral reefs. With the opening of the land route connecting the Sungai Pisang area of Padang City and the Mandeh Area in Koto XI Tarusan District, Pesisir Selatan Regency, it will also have an impact on changes in land use and land cover (LULC), especially the improvement of tourism supporting facilities and infrastructure in the Mandeh Area.

To predict land use and land cover (LULC) changes in the future, time series remote sensing data are often used [1,3,19,24]. Remote sensing data which time series provide information on land use and land cover (LULC) at a certain time period so that it can provide an overview of changes for the future data [11,14,16]. Marcov Chain_ Celluler Automata modeling is often used to determine changes in land use and land cover (LULC) for the future [24, 27,28]. The Marcov Chain model has the advantage of determining the transition matrix to determine the direction of change, while the Cellular Automata model has the advantage in spatial terms to determine the area that has undergone changes [2,5,12, 25]. This article aims to model changes in land use and cover in Koto XI Subdistrict, Tarusan District of Pesisir Selatan Regency, as well as to test the accuracy of the modeling.

2. METHOD

The method used in modeling changes in land use and land cover (LULC) in Koto XI Tarusan District, Pesisir Selatan Regency is a quantitative method with several stages, namely the preparation stage, the modeling stage, and the model interpretation stage. In the preparation stage, the activities carried out are in the form of literature studies, data collection of Landsat 5, Landsat 7, and Landsat 8 OLI imagery, as well as thematic maps related to the object of research.

The modeling phase of activities carried out is in the form of geometric and radiometric image rectification, image classification using supervision classification, driving force creation to determine variables that determine the direction of change, and modeling changes in land use and land cover using TerrSet (geospatial monitoring and modeling system) software. The model interpretation stages are determining trends and changes in land use and land cover and testing the accuracy of the modeling results.

Data

In modeling changes in land use and land cover (LULC) in Koto XI Tarusan district, Pesisir Selatan Regency, West Sumatra province requires some data, among others, as follows;

Table 1. Data Required for Modeling

NO	Date	Source	Uses
1	Landsat 5 imagery of 2000 year	USGS 2000	Determine land use and land cover in 2000
2	landsat _7 imagery of 2009 year	USGS 2009	Determine land use and land cover in 2009
3	Landsat 8 OLI imagery of 2019 year	USGS Tahun 2019	Determine land use and land cover in 2019
4	Indonesian Earth Surface Map scale 1: 125.000	Geospatial Information Agency	Research base map

The population and sample in this article are all pixels contained in the modeling of land use and land cover change (LULC) in 2025 and 2030. The sample in this article is determined based on the number of pixels that will be sampled in the area [9,12,15, 26]. The number of samples can be determined based on the following formula;

$n = N/(1 + (N \times e^2)$

Where:
n = number of samples
N = number of population (pixel)
e = precision

To determine the size of the sample size based on the class of land use and land cover change (LULC), the following formula is used;

$$ni = \frac{Ni}{N} * n$$

Where:
ni = number of sample members by class
Ni = number of population members by class
N = total population
n = total number of samples

Table 2. Number of Research Samples

No	Land use/Land Caver (LULC)	Number of Pixels	Number of Samples
1	Primery Forest	263.920	182
2	Secondary Forest	128.847	78
3	palm	1.847	33
4	Mangrove	3.491	3
5	Water Body	3.505	2
6	Bult up area	20.070	15
7	Paddy Field	20.418	15
8	Dry Land Farming	8.248	26
9	Open Ground	57	0
10	Mixed Orchard	77.231	46
	Total	527.634	400

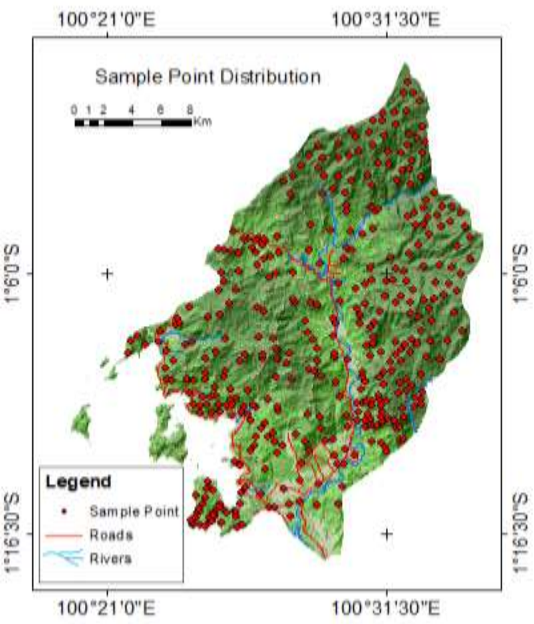

Fig. 1. Sample Point in the Research Area

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Data Analysis Technique

In order to model changes in land use and land cover in the study area, it is necessary to convert the digital number (DN) value into a reflected value by making radiometric corrections to the Landsat image [1,2,5] using the following formulations:

$$\rho\lambda = (M\rho * Q_{cal} + A\rho)/\text{Sin}(\theta)$$

Where;
$\rho\lambda$ = top of atmosphere reflectance
$M\rho$ = the multi_band reflectance value n of each channel, which is known from the meta data
$A\rho$ = the Add_band n reflectance value of each known channel from the meta data
Qcal = digital number (DN) value
θ = the value of the solar elevation angle obtained from the meta data

To determine the land use and land cover change (LULC) model, the Marcov Chain_celluler Automata model is used by assuming that changes in land use and land cover (LULC) for the future date xt + 1, at that time (t + 1) depending on conditions current represented by x_t. For the land use change and land cover (LULC) transition matrix, formulations [7,19,20,22] were used, as follows;

$$x_{t+1} = x_t * p$$

where p is the m * m matrix which shows the number of pixels (such as the number of land use and land cover classes (LULC), p is a pair of land use and land cover classes (LULC), I and j, which can be expressed as follows;

$$p = (pij) = \begin{matrix} p_{11} & p_{12}\ldots & p_{1n} \\ p_{21} & p_{22}\ldots & p_{2n} \\ p_{n1} & p_{n2}\ldots & p_{nn} \end{matrix}$$

Based on the above formulation, to determine the transitional matrix of land use change and land cover in the study area it can be written as follows;

$$p_{(n)} = p_{(n-1)}\, pij$$

determine the quality of the land use change and land cover (LULC) model, it is necessary to carry out an accuracy test which functions to see the quality of the model that has been produced using the overall accuracy, user accuracy, and producer accuracy using the formulation [10,13,17,24] which is as follows ;

$$Users\ accuracy = \frac{xii}{x+1} * 100\%$$

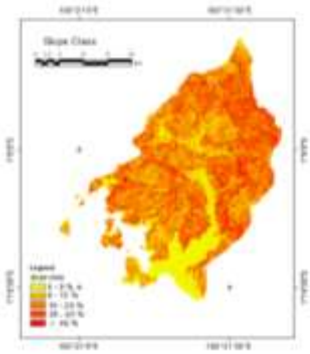
$$Produser\ accuracy = \frac{xii}{xi+} * 100\%$$

$$overall\ accuracy = \frac{\sum xii}{N} * 100\%$$

Where;
Xii = diagonal value of the contingency matrix of the i_ row and the i_ pool
Xi = number of pixels in row i
X + I = the number of pixels in the i_ column
N = number of sample pixels

3. RESULTS AND DISCUSSION

The land use and land cover change (LULC) model in Koto XI Tarusan District, Pesisir Selatan Regency requires several driving forces for changes in land use and land cover in the form of slopes, elevation, distance from roads, education centers, government centers, and public health center. in the following image;



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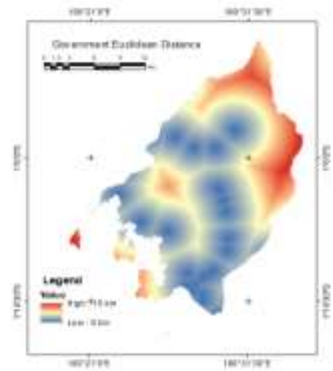

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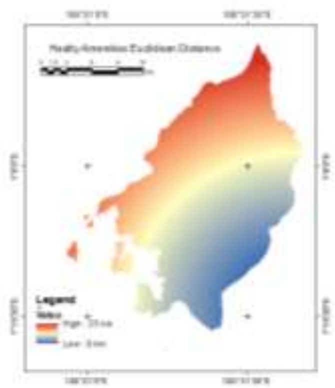

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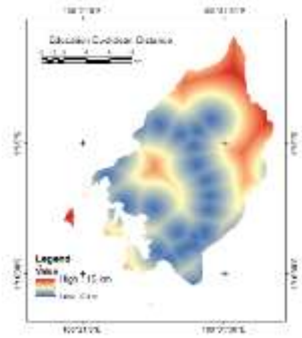

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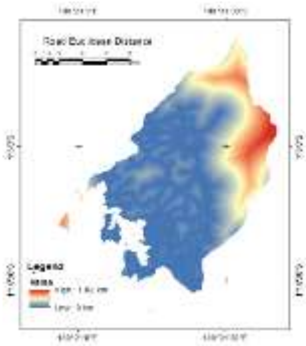

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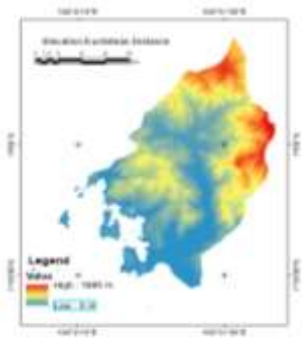

2f

Fig. 2. Land use change model and land cover in Koto XI Tarusan district

Based on the picture above, it can be seen that the factors that influence the land use change model and land cover in Koto XI Tarusan district, the distance from the most distantce road is 1.02 km, the area that has the potential to experience change is at a distance of less than 1 km from the road. The elevation of the Koto XI Tarusan area starts from 0 masl to 1,895 masl, this shows that this area has a morphology ranging from plains to mountains, with slopes from 0% to> 45%. Areas that have the potential to experience changes in land use ranging from an elevation of 0 masl to 500 masl with a slope of 0% to 25%. Health facilities that affect the land use and land cover change model have the farthest distance, namely 35 km from the Public health center located in the district government center, while the farthest distance from educational facilities is 15 km. Limited road access to educational facilities, especially at the junior and senior high school levels, has resulted in the development of land use change models that tend to follow road sections. To analyze the land use and land cover change model in Koto XI Tarusan district, it is necessary to know the transition matrix that determines the magnitude of land use and land cover changes that occur in the study area. This transitional matrix of land use and land cover changes is obtained from the comparison of land use and land cover in 2000 and 2009 obtained from the classification of Landsat 5 imagery and Landsat 7 imagery.To determine changes in land use models and land cover in the future, it is carried out with the Marcov Chain-Celluler Autumata model which can be seen in Table 3 and 4.

The table above shows that the transition matrix for the model of change land use and land cover in the study area starts from 0 to 1. This shows that a change in land use and cover changes to another land use and land cover. Changes in land use and land cover that experienced changes in land use and land cover to land use and other land cover occurred in mixed orchard with a transition matrix value of 0.3550, open land and mixed orchard. The land uses that have experienced a lot of additions are built-up land and mixed orchard.

The table above shows the transition matrix for the model of change land use and land cover in Koto XI Tarusan District, Pesisir Selatan Regency. Land use and land cover that have changed a lot, namely secondary forest to other land uses with a transition matrix value of 0.3440 to other land uses. Based on the transitional matrix model of changes in land use and land cover, it can be determined that changes in land use and land cover will occur in the future. The model of land use change and land cover in the Tarusan District of Pesisir Selatan Regency can be seen in the following table 5.

The table above shows the changes in land use and land cover in the study area. The land cover that has changed a lot is primary forest. The area of primary forest in 2019 is 23,752.80 ha (50.02%), in 2015 it is 23,236.38 ha (48.93%), and in 2030 is 21,602.25 ha (45%). Secondary forest in 2019 is 11,596.23 ha (24.42%), in 2025 it is 11,234.07 ha (23.66%), and in 2030 it becomes 9,295.29 ha (19.57%). The land use that has changed a lot is mixed orchard in 2019, namely 6,950, 79 ha (14.64%), in 2025 namely 6,642.83 ha (13.99%), and in 2030 namely 5,474.43 ha (11, 53%). The decline in land use and land cover was due to a change in function in the use of which generally became dry land farming land and oil palm plantations, while for non-agriculture, many of the functions were converted to developed land. For more details, it can be seen in the following figure 2.

Table 3. Model Transition Matrix of Land Use Change and Land Cover in Koto XI District Tarusan in 2025

NO	1	2	3	4	5	6	7	8	9	10
1	0.8574	0.0119	0.0560	0.0000	0.0000	0.0019	0.0003	0.0017	0.0092	0.0596
2	0.0000	0.6551	0.0280	0.0000	0.0000	0.0010	0.0002	0.0097	0.0086	0.2976
3	0.0000	0.0000	0.9995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
4	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0,0000
5	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.2365	0.0000	1.0000	0.0000	0.3550
9	0.0000	0.0000	0.2654	0.0000	0.0000	0.2965	0.0236	0.0236	0.0125	0,0000
10	0.0000	0.0000	0.2545	0.0000	0.0000	0.0056	0.0009	0.1110	0.0203	0.6077

Source: data analysis, 2020
Where::
1. Primery forest, 2. Secondary forest, 3. Palm, 4. Mangrove, 5. Water body, 6. Built up area, 7. Paddy field, 8. Dry land farming, 9. open ground, 10. Mixed orchard

Table 4. Model Transition Matrix of Land Use Change and Land Cover in Koto XI Tarusan District in 2030

	1	2	3	4	5	6	7	8	9	10
1	0.8170	0.0144	0.0782	0.0000	0.0000	0.0034	0.0005	0.0036	0.0093	0.0375
2	0.0000	0.5720	0.0520	0.0000	0.0000	0.0021	0.0003	0.0194	0.0103	0.3440
3	0.0000	0.0000	0.9993	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
9	0.0000	0.0000	0.3007	0.0000	0.0000	0.2988	0.2988	0.0385	0.0102	0.3046
10	0.0000	0.0000	0.3147	0.0000	0.0000	0.0091	0.0014	0.1365	0.0174	0.5208

Source: data analysis, 2020

Table 5. Models of Changes in Land Use and Land Cover in Koto XI Tarusan District in 2019, 2025, and 2030

NO	Land use/Land Cover (LULC)	2019 year		2025 Year		2030 Year	
		hectare	(%)	Hectare	(%)	hectare	(%)
1	Primery forest	23.752,80	50,02	23.236,38	48,93	21.602,25	45,49
2	Secondary forest	11.596,23	24,42	11.234,07	23,66	9.295,29	19,57
3	Palm	166,23	0,35	604,26	1,27	3.888,81	8,19
4	Mangrove	314,19	0,66	314,19	0,66	314,19	0,66
5	Water body	315,45	0,66	315,45	0,66	315,45	0,66
6	Built up Area	1.806,30	3,80	1.817,64	3,83	1.821,96	3,84
7	Paddy field	1.837,62	3,87	1.837,62	3,87	1.837,62	3,87
8	Dry land farming	742,32	1,56	1.479,69	3,12	2.931,39	6,17
9	Open ground	5,13	0,01	5,13	0,01	5,67	0,01
10	Mixed orchard	6.950,79	14,64	6.642,83	13,99	5.474,43	11,53
	Total	47.487,06	100,00	47.487,06	100,00	47.487,06	100,00

Source: data analysis, 2020

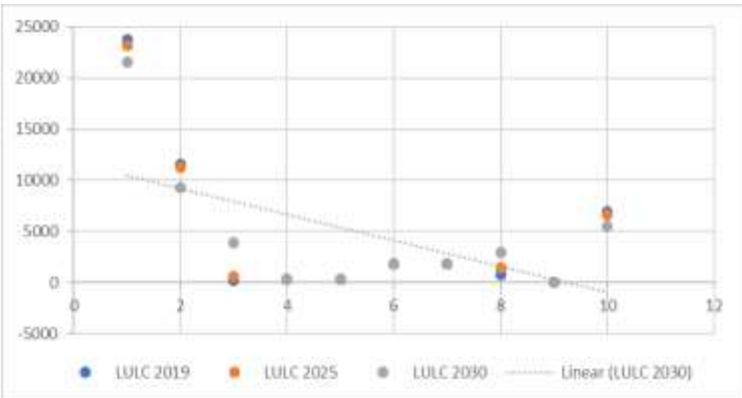

Figure 2. Comparison of Land Use Area and Land Cover in 2019, 2025 and 2030

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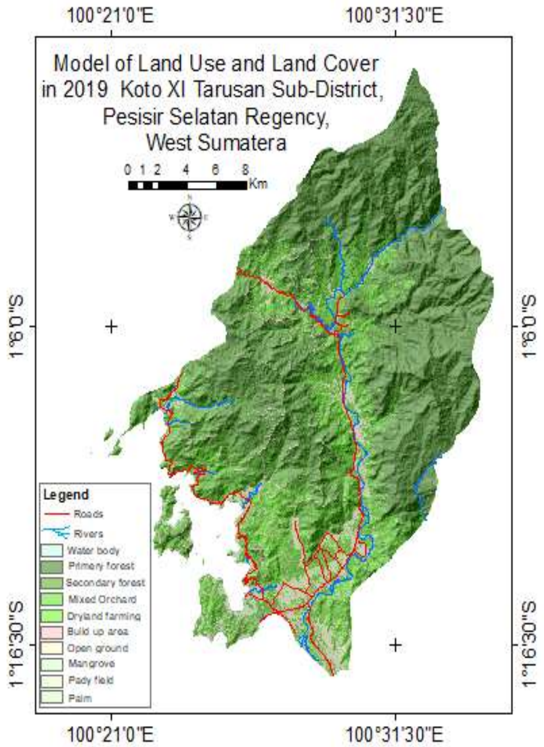
The graph above shows a decreasing trend in land cover for primary and secondary forest, while the land use that has changed a lot is mixed orchard. The land uses that have undergone a lot of changes are fields, oil palm, and developed land. The area of land use in 2019 was 742.32 ha (1.56%), in 2025 it had increased to 1,479.69 ha (3.12%, and in 2030 it became 2,931.39 ha (6.17). This change in land use is due to land conversion, especially in areas that have land cover for primary and secondary forest and mixed garden land use. Another land use that has changed a lot is oil palm. The area of oil palm land in 2019 is 166.23 ha (0, 35%), in 2025 to 604.26 ha (1.27%), and in 2030 to 3,888.81 ha (8.19%). This increase in oil palm land area has mostly occurred in areas that have hilly topography to have Steep slopes Other land uses that have changed are built-in land. The area of land built in 2019 is 1,806.30 ha (3.80%), in 2025 is 1,817.64 ha (3.83%), and in 2030 to 1,821.96 ha (3.84%) (Figure 3.abc) Change in use Many built lands are found in the area around the road that connects the City of Pada and Painan. Generally, people make use of existing road facilities to build settlements. The selection of road facilities is generally used by the community to make it easier to get to other suggestions and facilities such as health facilities, educational facilities, markets, and to make it easier to get to Padang and Painan City, in addition, road facilities are generally made in areas that have flat slopes making it easier to establish building. For more details, it can be seen in the following figure;



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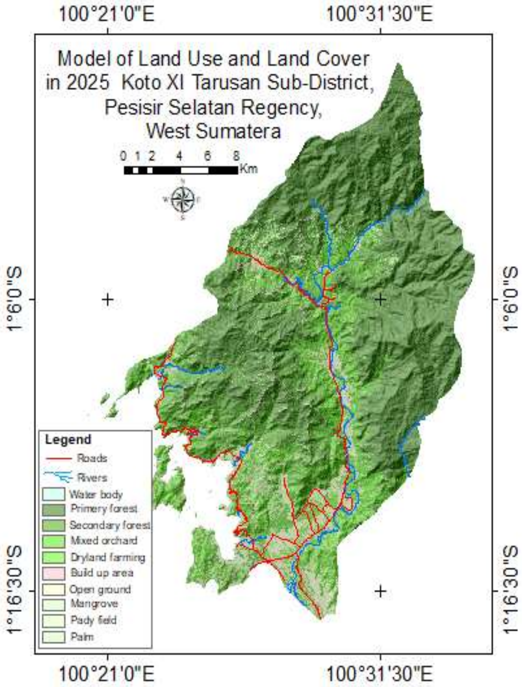

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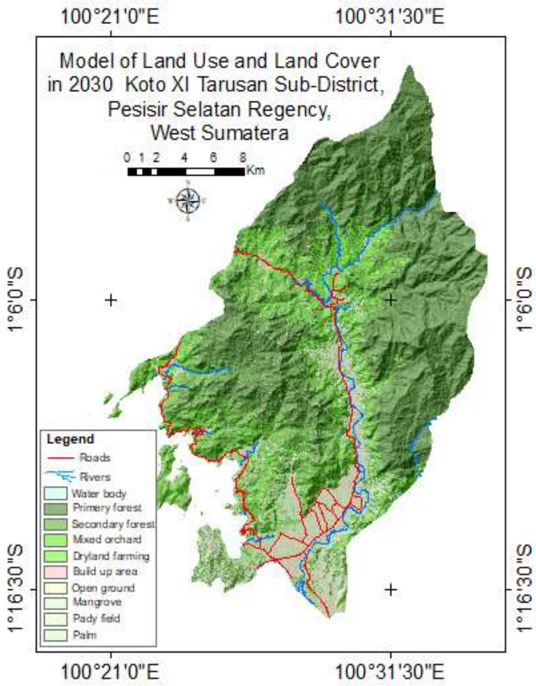

3c

Fig. 3. Road facilities are generally made in areas that have flat slopes making it easier to establish building

To see the modeling accuracy is done using overall accuracy, which consists of user accuracy, producer accuracy which can be seen in the following table 6.

Table 6. Accuracy Test of Land Use Change Model and Land Cover in Koto XI Tarusan District, Pesisir Selatan Regency in 2025

LULC	1	2	3	4	5	6	7	8	9	10	**User** Accuracy
1	180	2	0	0	0	0	0	0	0	182	98.90
2	0	72	3	0	0	0	0	3	0	78	92.31
3	0	0	43	4	0	0	0	0	0	47	91.49
4	0	0	0	30	1	1	1	0	0	33	90.91
5	0	0	0	0	3	0	0	1	0	4	75.00
6	0	0	0	0	0	2	2	1	0	5	40.00
7	0	0	0	0	0	0	15	3	3	21	71.43
8	0	0	0	0	0	0	1	13	3	17	76.47
9	0	0	0	0	0	0	0	1	12	13	100.00
Total	180	74	46	34	4	3	19	22	18	400	
Producer accuracy	100	97.29	93.47	88.24	75.00	66.67	78.95	59.09	66.67		

Source : data analysis, 2020

180+72+43+30+3+2+15+13+12 = 370/400*100

92.5 %

Table 7. Accuracy test of land use change model and land cover in Koto XI Tarusan sub-district, Pesisir Selatan District in 2030

LULC	1	2	3	4	5	6	7	8	9	10	User Accuracy
1	180	2	0	0	0	0	0	0	0	182	98.90
2	0	67	0	12	0	0	0	0	0	79	84.81
3	0	0	33	0	0	0	0	0	0	33	100.00
4	0	0	0	3	0	0	0	0	0	3	100.00
5	0	0	0	0	2	0	0	0	0	2	100.00
6	0	0	0	0	0	15	0	0	0	15	100.00
7	0	0	0	0	0	0	15	0	9	24	62.50
8	0	0	0	0	0	0	0	25	17	43	58.14
9	0	0	0	0	0	0	0	0	19	19	100.00
10	180	69	33	15	2	15	15	25	45	400	
Producer Accuracy	100	97	100	80	100	100	100	100	42.22		

Source; data analysis, 2020

=180+67+33+3+2+15+15+25+19
= 359/400*100
= 89,75%

Based on the accuracy test using the overall accuracy, the results of modeling changes in land use and land cover in 2025 were 92.50%, which means that the modeling results were very good. For modeling changes in land use and land cover in 2030 can be seen in the following table 7.

The table above shows that the results of the accuracy test results from modeling changes in land use and land cover in 2030 were 89.75%, which means that the results of modeling changes in land use and land cover in Koto XI Tarusan District, Pesisir Selatan Regency are very good. The results of modeling changes in land use and land cover in 2030 have decreased from the results of the 2025 modeling accuracy test, this shows that modeling changes in land use and land cover will be better if it has a relatively short time span or not too long.

4. CONCLUSION

The results of modeling changes in land use and land cover in 2025 and 2030 show changes in land use and land cover from year to year. The results of modeling changes in land use and land cover show that land cover of primary forest, secondary forest and mixed orchard land use has decreased from year to year, while land use that has increased is built-up land, fields, and oil palm. The results of the accuracy test using the overall accuracy obtained by the accuracy of modeling changes in land use and land cover in 2026 of 92.50% and in 2030 of 89.75%. The results of this accuracy test show that the results of modeling changes in land use and land cover in Koto XI Tarusan District have been very good.

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