LAND-USE PREDICTION IN PANDAAN DISTRICT PASURUAN REGENCY

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ABSTRACT: Land-use change in Pandaan District was identified as the fourth-highest in East Java Province. This change is due to the population increase caused by the strategic location of the Pandaan Sub-district, which is passed by the Surabaya-Malang City connecting road, creating a rapid development of built-up land. The spread of built-up land development with low density becomes the initial identification of the sprawl phenomenon. Changes in land-use due to push factors caused inconsistencies in the development of existing land as stipulated in spatial planning documents. This study aims to determine land-use change and land-use prediction in Pandaan Sub-district to be used for future planning. Research methods incorporated spatial analysis of land-use change and the land-use planning process in ArcMap and SELVA IDRISI. The land use forecasts for modeling are based on the use of the Cellular Automata (CA) -Markov method and the ANN / MLP method. Land-use changes were identified through land-use comparisons in recent years. The land-use prediction was determined through the land-use change transition by including the motivating and inhibiting variables of land-use changes. The results of the study stated that the most significant land-use change occurred in rural/urban villages passed by arterial and collector road connecting Surabaya-Malang City. CA-Markov results showed that the results of land-use prediction have a linear development pattern in the spreading road networks and residential settlements. The prediction results show that settlement increase13,62% and industry increase 20,7%..

Keywords: Rapid development, Cellular automata, Land-use change, Prediction of settlement

1. INTRODUCTION

The land is defined as a plot of earth that has a designation, generally owned and used by individuals or institutions for specific activities [1]. In general, land-use can be grouped into two main classes, namely agricultural land-use and non-agricultural land-use. Agricultural land-use is distinguished based on water supply patterns and commodity or plant species found on the land. Other types of land-use classified as agricultural land-use are dry land or upland agriculture or agriculture on non-irrigated land, wetland or paddy agriculture, farm, production forests, protected forests, etc. Non-agricultural land-uses can be divided into several types of land, namely residential settlements, recreation, mining, industrial estates, trade and service areas, and so on [2].

Changes in land-use can occur due to population growth and regional activity development. Meeting the needs of the land will cause land-use changes in the region. Winoto [3] defined that the land-use conversion from agriculture to non-agriculture was not a physical phenomenon of reduced land area, but rather a dynamic phenomenon related to aspects of human life. Land-use conversion is correlated with changes in the social, economic, cultural, and political orientation of the community. Meanwhile,

according to Irawan (2005) [4], land conversion occurs due to competition in land-use between agricultural and non-agricultural. This change in land-use causes the degradation or decrease of non-built-up land that is converted into a built-up land [2].

One area that has experienced relatively high land-use conversion in East Java Province in Pasuruan Regency. Pasuruan Regency ranks fourth in land-use conversion from regencies/cities in East Java Province [5]. The change of land-use that occur in Pasuruan Regency is not evenly distributed throughout the region. One of the areas experiencing the biggest land-use change is Pandaan Sub-district. The most significant land-use change is converting agricultural land and developing them to residential settlements and industrial estates.

Determination of the Provincial Strategic Economic Region, RTRW of East Java Province in 2011-2031 [6] in the Malang-Surabaya connecting road causes Pandaan Sub-district to experience rapid development of built-up lands. The strategic location of the Pandaan Sub-district is on the main connecting road of Surabaya and Malang. Also, Pandaan Sub-district is one of the sub-district capitals in Pasuran Regency which is designated as a Local Promotion Activity Center (PKL-p), in 2009-2029 Pasuruan Regency RTRW (Regional Planning Document) [7], which further encouraged

the development in recent years [8, 9].

The rapid and irregular development of the built-up lands will result in urban sprawl. Urban sprawl can occur through the uneven or scattered development of built-up lands in an area that tends to move away from the center of the region [10]. Urban sprawl is a phenomenon that occurs due to a city's rapid development but has limited availability of land, extending the impact of city development on the suburban or periphery areas [9, 11]. In addition, urban sprawl is a phenomenon of unplanned development, unstructured spread, and has a low level of density [12].

Urban sprawl is viewed from two dimensions, namely the spatial physical dimension and the non-physical dimension [13]. Initially, urban sprawl can be determined by comparing the level of population density with the built-up land with smaller regional units [10]. The development of irregular built-up areas in Pandaan Sub-district in 2018 reached 10.6% of the total existing building, with the growth of built-up land reaching 670.4 Ha (Preliminary Survey 2018). In addition, urban sprawl can be identified from several aspects such as the physical aspects, by comparing the distribution of existing built-up lands with the previous year and from the non-physical aspects by calculating population density.

Comparing the distribution of the built-up land encourages land-use change, causing discrepancies or deviations between spatial planning (District RTRW and Provincial RTRW) and existing conditions. This study was conducted to determine deviations or inconsistencies between plans and the real conditions at the research location, and to determine and estimate the future development of the built-up land. Development estimates of the built-up land can be done by modeling/predicting the CA-Markov method using data in the previous period (data series) [14].

CA-Markov is a modeling tool used to simulate various possible future changes in land-use [15]. The condition of cellular automata is determined by the variables of each cell. Cellular automata work with discrete-time stages, where the value of cell variables is influenced by the value of neighboring cell variables in the previous time step. Neighboring cells are adjacent cells to a cell [15]. Cell variables are renewed simultaneously, based on the value of the variable owned by the cell and its neighbors in the previous time step, based on specific local rules [16]. This land-use change prediction can be used to determine land development patterns based on land-use trends in recent years and can be done to simulate future spatial planning.

2. RESEARCH METHOD

The analytical method used a descriptive and evaluative analysis method obtained from the results of field observations and calculations of secondary data. The location of this research is in Pandaan Sub-district, Pasuruan Regency, East Java Province – Indonesia.

2.1 Population

The observation unit in this study is the entire Pandaan Sub-district area, where the population is the land-use in all villages with the dominant land-use classified as residential settlements, industrial estates, wetland/paddy agriculture, dryland/upland agriculture, and open green spaces. Field observations are made to validate the image interpretation with existing conditions in the field.

2.2. Analysis Techniques

The analysis techniques used in this study include:
   a. Spatial Analysis of Land-use Change
   b. Land-use prediction analysis.

3. DISCUSSION

3.1 Changes in Land use 2010-2018

Data on land-use change can be obtained through digitization and interpretation of multi-temporal satellite imagery in the research location. The satellite imagery used is the data in 2010 and 2018 to interpret land-use. The results of the interpretation of satellite imagery are classified into five types of land-use: residential settlements consisting of housing and supporting facilities, industrial estates, non-built-up land in the form of rice fields/wetlands, dry fields/dry land, and green spaces which is the results of digitization of land-use in 2010. The following are the results of the interpretation of satellite images (Fig. 1 and Fig. 2) and Table 1 of landuse and the area of each landuse classification in Pandaan Sub-district

Based on the results of interpretation of satellite images in 2010, the results of the calculation of the geometry of land area in each land use classification (Figure 1), are as follows:
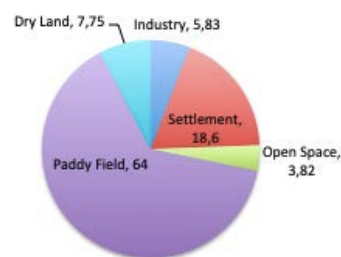

Fig. 1 Land Use in 2010 (in percent)

3.1.1. Land-use in 2018

The following is the map of the existing land-use, the digitization of the 2018 images are matched with the field surveys related to the existing land-use. Toll road construction has already taken place, and the development of built-up lands in the Malang-Surabaya corridor (Figure 2).

Built-up lands spread to all villages / sub-districts in Pandaan Sub-district, especially in rural/urban villages located in the middle of Pandaan Sub-district and the western part of the national road and the Malang-Pandaan toll road. The dominance of the built-up land in the form of residential settlements is located in Petungasri Village, Pandaan Village, Kutorejo Village, and Jogosari Village. While the industrial estate is along the arterial road that connects the city of Surabaya and Malang.
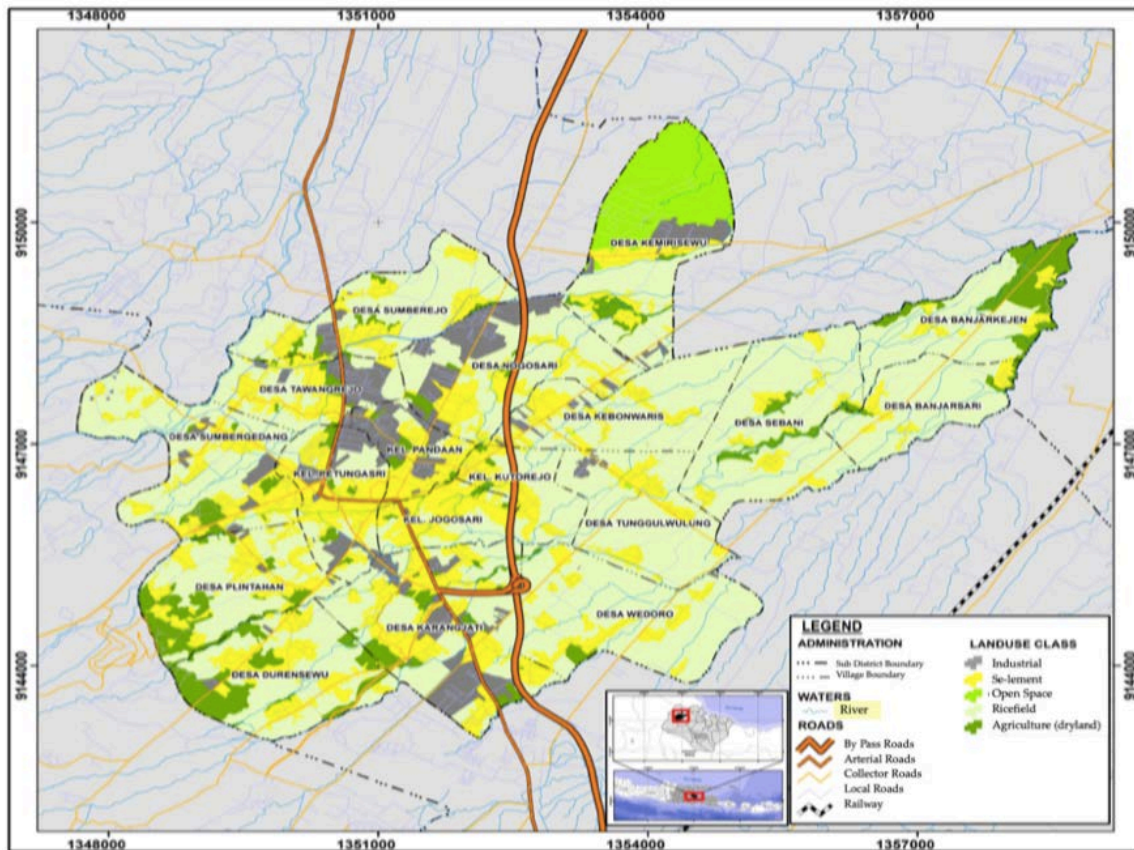

Fig. 2 Land Use in 2018

Table 1 Resulting Area of Land-use Changes in 2010-2018

Land Use	Year - Areas (Hectare)		Changes (Ha)	Percentage (%)
	2010	2018		
Industrial	254.01	329.94	75.93	1.742
Settlement	810.64	955.21	144.56	3.317
Open Space	166.39	165.96	-0.44	-0.010
Paddy Field	2789.21	2575.52	-213.69	-4.903
Agriculture (dry land)	337.81	331.44	-6.37	-0.146
Area of Pandaan District	4358.07	4358.07		

Based on the digitization of maps and satellite imagery in 2018, as well as field survey observations, the geometry of land-use in the Pandaan Sub-district in 2018 was obtained in Figure 3 as follows:
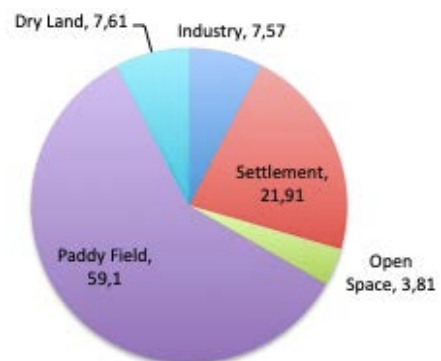

Fig. 3 Land Use in 2018 (in percent)

The results of the interpretation were matched with the field observations which are in the form of the existing land-use condition of the built-up lands and non-built-up lands. The highest area decrease was paddy fields which have changed use into residential settlements scattered throughout villages and industrial estates which have developed to follow the road with arterial hierarchy.

Based on the calculation of the land-use area of Pandaan in 2010 and 2018 (the existing year), the pattern of the land-use changes area according to the classification is as follows (Fig. 4).

Changes and development of built-up lands were in the form of residential settlements and industrial estates, which initially covered an area of 1,064.65 hectares and increased to 1,285.15 hectares, or increased by 5.059% or takes up 220.49 hectares from the total area of Pandaan Sub-district. The increase in built-up lands led to a significant conversion of land, namely a decrease in the area of non-built-up land in the form of rice fields/wetlands covering 213.69 hectares or 4.903% of the total area of Pandaan Sub-district.
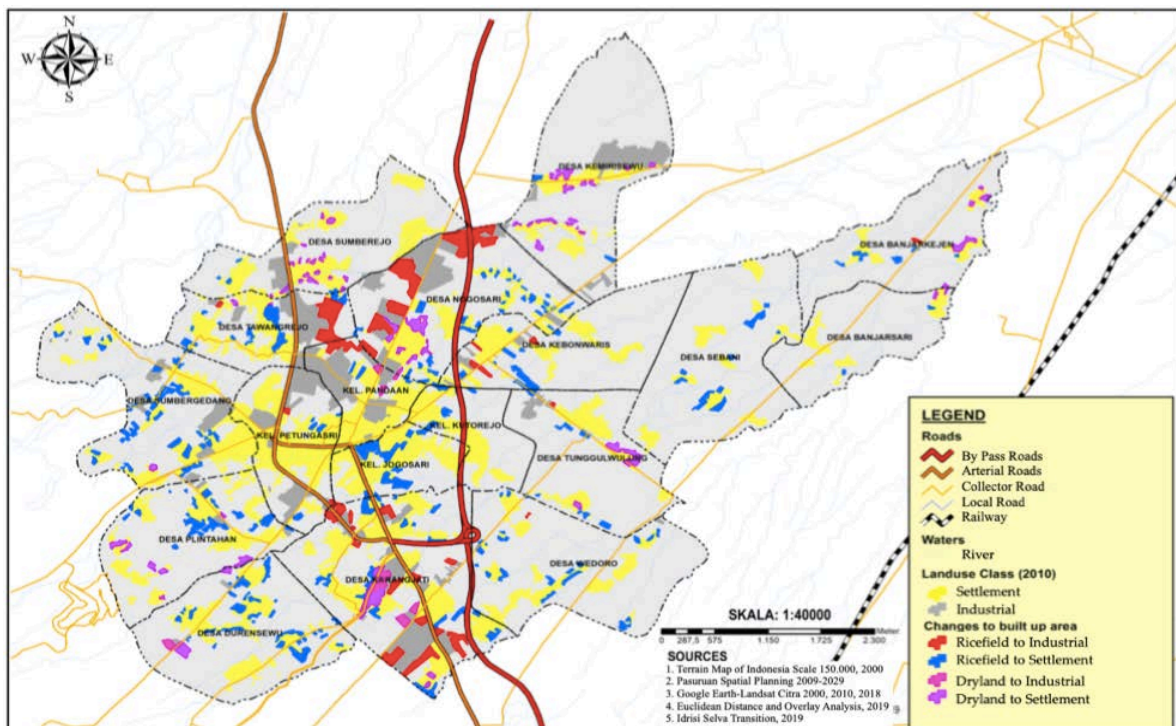

Fig. 4 Map of Built-Up Area in 2010-2018

3.1.2. *Analysis of Land-use prediction in 2026*

The process of land-use prediction is conducted by considering several things, namely the trend of land-use changes over several periods, and the motivating and inhibiting factors of land-use changes.

Motivating and Inhibiting Factors
The classification of the motivating and inhibiting factors of land-use change is based on the literature study and adjusted to the characteristics of the existing condition of the research location. Factors motivating land-use change include existing residential settlements, regional activity centers, and a road network with arterial and collector hierarchies.

The applications used in the land-use predict-tion process are ArcMap and SELVA IDRISI.

Future land-use predictions or modeling in the Pandaan Sub-district uses the Celular Automata - Markov Chain method, which uses a raster data approach in the form of pixels as the unit of observation. The initial stage was to prepare Pandaan Sub-district land-use data in 2002 and 2010 to obtain land-use change transition data. This land-use change transition data is used as a reference in conducting land-use prediction in 2018. The results of the 2018 land-use prediction simulation will be used as the input data for the validation process, which is to compare with the existing land-use. The following is a description of the results of the 2018 land-use prediction simulation and the results of the land-use prediction in 2026 in the Pandaan Sub-district.

The inhibiting factor in Pandaan Sub-district is the existence of built-up lands in the form of industrial estates that presumably will not be

converted into residential settlements. Sustainable food agriculture land (LP2B) and green space are also the inhibiting factors of land-use change.

3.1.3. Simulation of 2018 Land-use prediction 2018

Before predicting future land-use, it is necessary to conduct a simulation prediction of the current year (2018) by considering previous land-use trends and the motivating and inhibiting factors.

The results of the 2018 land-use prediction simulation can be seen in Figure 5. On this map, the prediction of residential settlements (in red) can be seen spreading unevenly to all villages in the Pandaan Sub-district. While the industrial area (blue) only develops around the existing industrial area on the Malang-Surabaya toll road corridor.
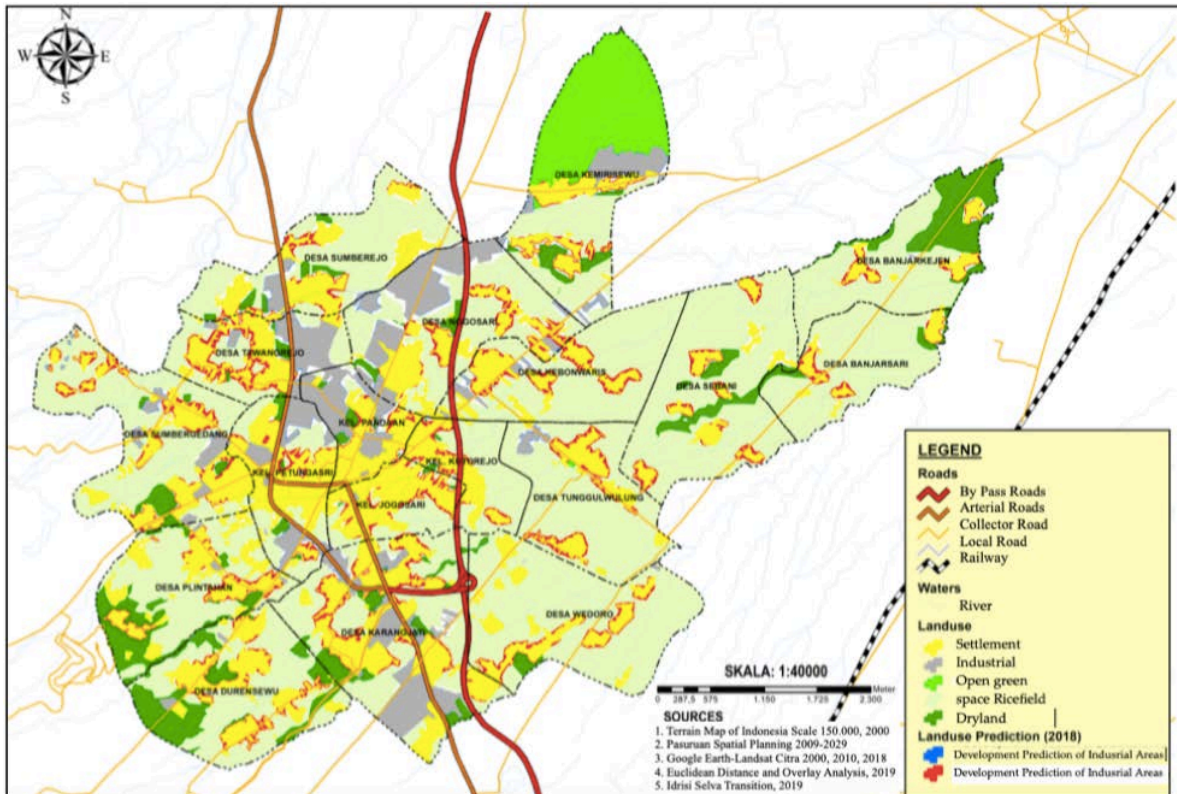

Fig. 5 Simulation of Landuse Change in 2018

The results of the 2018 land-use prediction simulation can be seen in Figure 5. On this map, the prediction of residential settlements (in red) can be seen spreading unevenly to all villages in the Pandaan Sub-district. While the industrial area (blue) only develops around the existing industrial area on the Malang-Surabaya toll road corridor.

Land-use prediction simulation is conducted to validate the resulting prediction data. It is first carried out by comparing the prediction simulation map results with the 2018 existing land-use maps. The validation results showed that the ROC/Ksatandard has a value of 0.874 in Figure 15. According to the CA-Markov validation standard, modeling or prediction results and the influencing factors can be accepted if it has a value >0.70. Thus, the Kstandard result of 0.8742 means that the predicted results can be accepted.

The Kstandard value of Kappa index shows that the level of conformity of the spread of land-use prediction in 2018 is 87.42% or 0.8742. The value of 0.8742 falls into the "Very Good" category, which is the Kappa Value Conformity Table. This shows that the prediction results of land-use in 2018 are considered valid because they have a kappa or kstandard index of more than 0.70 or above 70%. This value also determined that the accuracy of the related variables, when used in future spatial planning, will be better.

The following is a comparison map of the results of the simulation map with the existing map of land-use in 2018 in Figure 6. The map shows that the level of conformity is more dominant as indicated by the dominance of the green color, while the red color shows the area of the land-use simulation results that are not in conformity with the existing conditions of land-use in Pandaan Sub-district.
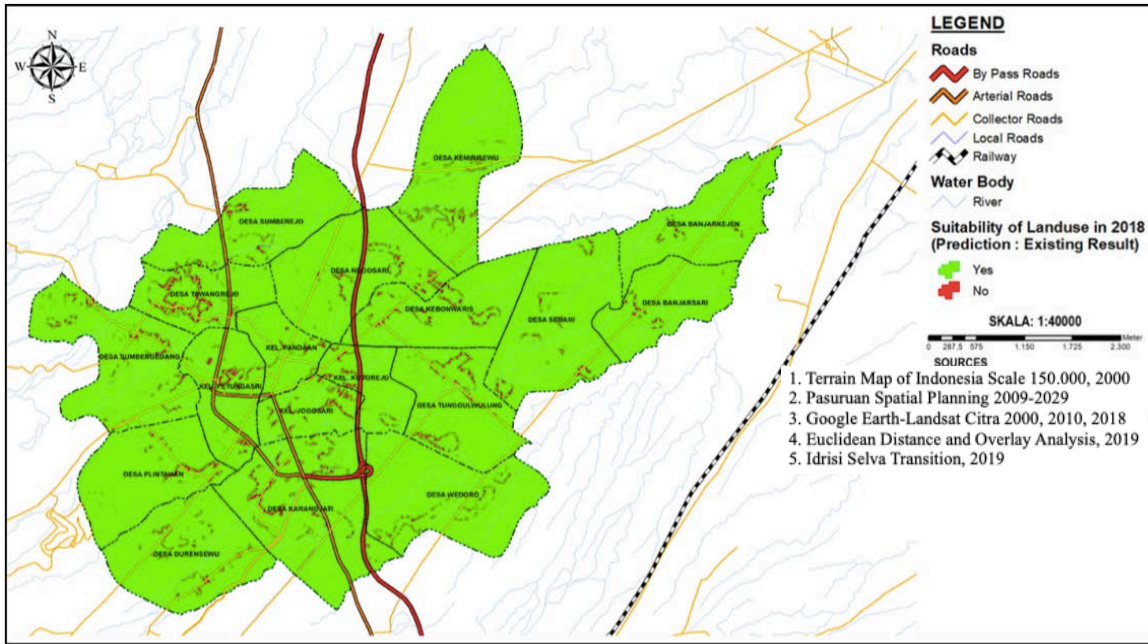
Fig. 6 Map of Comparison of Simulation
Land-use and Existing Land-use in 2018

3.2. Land-use prediction 2026

After the validation values and transitional land-use change transition maps are obtained, then the land-use predictions can be carried out for the year 2026. The results of land-use prediction in 2026 showed the development of industrial estates in Malang-Surabaya bypass (blue) and residential settlements that are spread throughout the Pandaan Sub-district area (red) as seen in Figure 7. No development of new built-up lands was found, other than in areas around existing built-up lands.

The development pattern of built-up lands in the form of industrial estates and residential settlements in 2026 tends to spread throughout the region. However, the periphery areas which are far from the center and main roads have an insignificant built-up land conversion rate but form a spreading pattern around the existing built-up lands (**Figure 7**). This finding, when correlated with scoring results of the influencing variables (**Figure 5**), match the most influential variables, namely the center of activity, as well as road network, and the developing patterns tend to follow the existing built-up lands. Table 2 shows the result of the geometry calculation of the area of land-use prediction of Pandaan Sub-district in 2026.
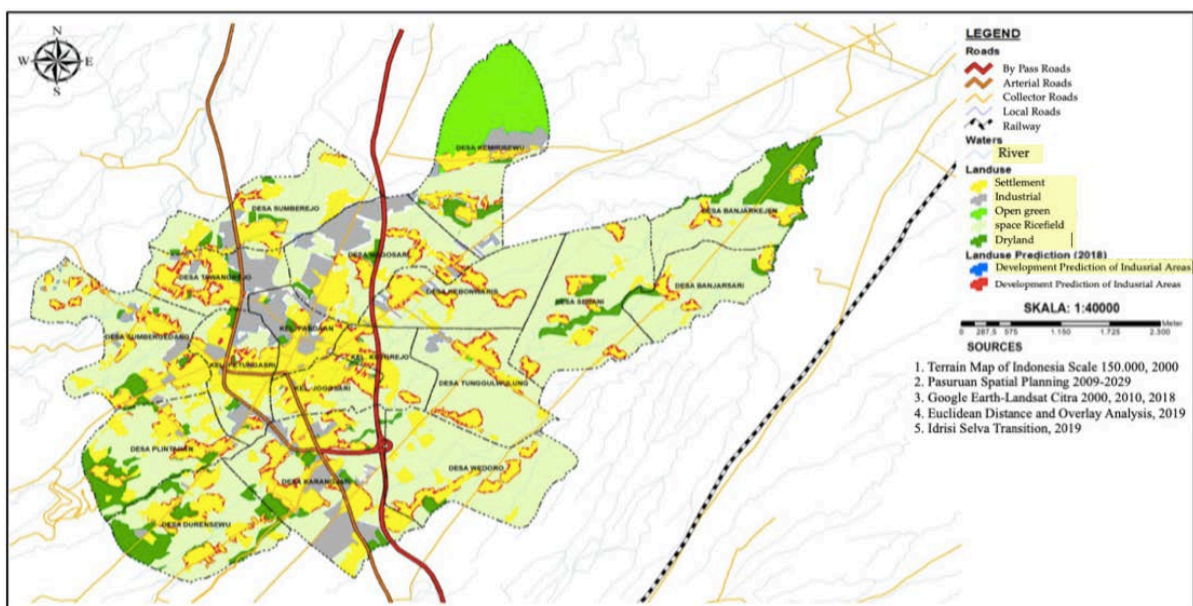

Fig. 7 Land-use Prediction in 2026

Table 2 Resulting Area of Built-up land-use Prediction in 2026

Village/Kelurahan	Areas in 2018 (Ha)		Areas in 2026 (Ha)		Changes (Ha)	
	Industry	Settlement	Industry	Settlement	Industry	Settlement
Banjarkejen	0,27119	18,54281	0,515261	22,74737	0,244071	4,204559
Banjarsari	0	16,28351	0	16,96989	0	0,686378
Durensewu	2,533696	65,17602	3,610076	78,8142	1,07638	13,63818
Karangjati	70,48078	119,3521	91,98891	136,6461	21,50813	**17,29395**
Kebonwaris	6,973516	43,21985	8,824609	48,14858	1,851093	4,928729
Kemirisewu	29,29499	38,15715	33,63882	44,2336	4,343834	6,076446
Nogosari	74,49059	60,29912	100,0345	72,96328	**25,54394**	12,66416
Plintahan	2,725788	63,1291	2,725788	75,06917	0	11,94006
Sebani	0	34,03731	0	39,14114	0	5,103824
Sumberejo	10,66262	60,73173	10,77551	64,74425	0,112882	4,012527
Sumbergedang	17,6389	78,26526	17,6389	92,03492	0	13,76966
Tawangrejo	34,08026	48,60023	42,2874	56,51043	8,207148	7,910203
Tunggulwulung	5,532256	36,05615	5,720786	42,429	0,18853	6,37285
Wedoro	0,537528	46,79623	0,607517	52,8762	0,069989	6,079971
Kel. Jogosari	0,850281	64,16083	0,985171	74,36163	0,13489	10,2008
Kel. Kutorejo	0,04442	37,63375	0,04442	40,08965	0	2,455898
Kel. Pandaan	40,95461	44,00967	45,30901	45,13692	4,354398	1,127249
Kel. Petungasri	32,86889	80,7554	33,56938	82,39667	0,700499	1,641277
Total Areas	**329,9403**	**955,2063**	**398,2761**	**1085,313**	**68,33578**	**130,1067**

Source: Result of Calculating and Digitizing, 2019

The area results of the land-use prediction simulation in 2026 are obtained from the calculation of the geometry images from raster data that is reprocessed into vector data. Therefore, the resulting map can calculate the area, and the level of change can be identified during the period of 2018 to 2026. The following data shows that in total for the settlement increase from 955,206 Ha to 1085, 313 Ha (13,62%) and for industry increase 20,7%. Karangjati Village has the highest growth prediction of residential land-use compared to other villages, reaching 17.3 hectares. In 2026, Nogosari Village has a growth of industrial land area reaching 25.54 hectares. These results indicate that the growth of built-up land refers to the trend of land-use change in the previous period and is based on the pretested and predetermined variables or influential factors.

Land-use prediction certainly helps in simulating government policies related to spatial planning. Spatial planning in Indonesia covers many influential aspects; if the government wants to simulate spatial planning policies, it would be better to use modeling applications or spatial prediction applications such as this Selva Idrisi, or LanduseSim. Spatial planning simulation can support and facilitate government programs related to the "one map policy" in Indonesia. This policy will be significantly supported by the assistance of this spatial modeling/projection program, especially in including variable maps - thematic maps in spatial planning and non-physical aspects in planning.

4. CONCLUSION

Based on the results of the analysis, the following conclusions are obtained, namely:
1. Increased need for built-up land due to increased population and increased community activities in the Pandaan Sub-district, thereby encouraging land conversion. Changes and development of built-up lands in the form of residential settlements and industrial estates, which initially covered an area of 1064.65 hectares, increased to 1285.15 hectares, or increased by 5.059% or covers 220.49 hectares from the total area of Pandaan Sub-district. The increase in built-up lands caused a significant conversion of land, namely a decrease in the area of non-built-up land in the form of rice fields/wetlands covering 213.69 Ha or 4.903% of the total area of Pandaan Sub-district.
2. The most significant land-use change to an industrial estate is located in Nogosari Village, Tawangrejo Village, Pandaan Village, and Karangjati Village, which are passed by the arterial road connecting Surabaya-Malang whereas the highest land conversion into residential settlements occurred in Jogosari Village, Durensewu Village, Plintah Village, and Sumbergedang Village.
3. The result of land-use prediction showed the direction of the built-up lands development in the form of residential and industrial estates, namely following the pattern of the road

network and developing industrial estates around the arterial and collector road network that stretches in the middle of the sub-district, while the residential settlements have a spreading and uneven development pattern in the Pandaan region. This result is determined from the change in land-use trends in 2002, 2010 and 2018 which were validated and based the motivating and inhibiting factors for land conversion for the transition matrix, thus, obtaining a validation value of 0.8742.

5. ACKNOWLEDGMENTS

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