Urban-Rural Transformation and Urban Growth Scenario Using Cellular Automata in Lebak District - Banten Province

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Abstract. The development of Lebak District has been significant during the previous ten years, with the impact of urbanization, changing the community's physical, social, and economic shape. The construction of the Serang-Panimbang toll road, which facilitates access to the Metropolitan City of DKI Jakarta, has rapidly transformed Lebak District, which indicates an urban-rural transformation. This study aims to see how rural-urban transformation occurs in Lebak District and to create a scenario of urban development in Lebak District in 2030. Assessment of the level and pattern of transformation based on physical, social, and economic aspects using geographic information system (GIS) applications is conducted. This research uses cellular automata to create urban development scenarios in Lebak District in 2030. The results of this study indicate that the urban-rural transformation in Lebak District occurred due to the influence of urbanization and the construction of a toll road that connects Lebak District with the metropolitan city of Jakarta. Lebak District has four development areas. First is the urban agglomeration of Rangkasbitung, the hub of administration and economy. Second, coastal development areas are located in the southern region of Lebak District. The third strategic development area is the toll road integration area, with a development plan for an integrated industrial region. The fourth location has modest development and is located in terrain with limited accessibility. The results of urban development scenarios using cellular automata show that the development of the Serang-Panimbang toll road led to an increase in urban growth by 21% in 2030.

Keywords: *Cellular Automata, Urbanization, Urban-Rural Transformation, Scenario, Urban Growth*

1. Introduction

Urbanization, in addition to increasing the population in urban areas, also entails the transformation of an agricultural-based rural economy into an industrial-based urban economy and rural-urban migration [1–4]. Urbanization can also be seen as a spatial transformation, with people moving from rural to urban areas [5–7]. Population expansion and fast agglomeration will increase the demand for transportation infrastructure [6,8]. On the other hand, population expansion and rapid population agglomeration will raise transportation infrastructure requirements [9]. Transportation infrastructure is closely related to the economic development of a city [10,11]. In general, urban areas will expand according to the pattern of roads connecting with other cities. This urbanization process can transform

rural into urban activities, urban area expansion, and rural-urban migration that causes a region's physical, social, and economic transformation [12–14].

Usually, areas that have a stronger attraction to visit will turn faster into urban areas [8]. Urbanization will increase and concentrate the urban population, increasing the demand for transportation infrastructure as public infrastructure. Also, developing transportation infrastructure will encourage population movement to urban areas [6,15]. The transformation that occurs cannot only focus on urban physical concentration, but rural areas must also undergo changes so that there is no bigger gap [16].

In low-middle-income (developing countries), urbanization is one of the most influential transformation processes to transform urban and environmental systems [17]. As happened in Indonesia, especially in Lebak District, urbanization and transportation infrastructure influence each other. Over the last ten years, Lebak District has experienced massive growth with a lot of built-up land growth and various infrastructure developments. Among them is the construction of electric rail trains (KRL) in 2013, which encouraged the acceleration of development in the Lebak District, especially in "Kota Baru Maja." In addition, the construction of the Serang-Panimbang toll road in 2017 also increased accessibility to the Lebak District area.

In addition, in response to the construction of the Serang-Panimbang Toll Road, the Lebak District government intends to build an Industrial Designation Area (KPI), which the Ministry of Investment also promotes to accelerate growth in the Lebak District. The construction of the Serang-Panimbang Toll Road in 2017 stimulated the growth of new businesses in the Rangkasbitung Sub-district, the city center of Lebak District. In addition, in response to the construction of the Serang-Panimbang Toll Road, the Lebak District government plans the construction of an Industrial Designation Area (KPI), which is also encouraged by the Ministry of Investment to encourage the acceleration of development in the Lebak District. If not controlled, the higher level of urbanization due to this infrastructure development will cause a gap between urban and rural areas [12].

Several previous studies have explained the transformation of rural-urban from various sides. Assessment of the processes and factors that influence the rural-urban transformation [18,19] is the main approach in identifying the transformation level of the rural-urban phenomena [12,20,21]. These studies entirely analyze the rural-urban transformation taking place in China as the reference. Meanwhile, research on urban development modeling [22] rarely links with the process of rural-urban transformation. Furthermore, there is no research about rural-urban transformation and modeling in the Lebak District.

This study aims to see how rural-urban transformation occurs in Lebak District and create a scenario of urban development in Lebak District in 2030. This study uses quantitative methods with several calculations to obtain the value of rural-urban transformation, as Yang et al. (2018) described. Then the urban growth scenario is carried out using cellular automata. The scenario used in this study assumes that toll road development does not have a significant effect because the development is not used correctly. Another assumption is that this toll road is well utilized so that it can encourage faster urban development. Based on the assumptions prepared, urban development scenarios are made to see the extent of differences in urban development between the two scenarios.

2. Data & Methods

2.1. Data

Analysis of rural-urban transformation can be seen from the level of urbanization of several aspects, including physical, demographic, and economic aspects [12]. These three main aspects can show how rural-urban transformation occurs in an area. Using these three aspects, an analysis was conducted to see the rural-urban transformation. Some data is required to identify the transformation in physical, demographic, and economic perspectives (see **Table 1**, **Table 2**, and **Table 3**).

Table 1. Lebak District Built-up Land Area Based on Area Status 2010 and 2020 in Hectares

2010			2020			Urban Growth 2010-2020
Sub-districts	Status		Sub-districts	Status		
	Rural	Urban		Rural	Urban	
Banjarsari	211.57	-	Banjarsari	272.02	122.90	183.35
Bayah	144.25	28.44	Bayah	346.22	214.27	387.80
Bojongmanik	100.83	-	Bojongmanik	141.52	-	40.69
Cibadak	173.22	100.20	Cibadak	18.81	615.56	360.95
Cibeber	206.88	-	Cibeber	364.68	74.71	232.51
Cigemblong	17.78	-	Cigemblong	93.77	-	75.99
Cihara	40.77	-	Cihara	98.16	97.58	154.97
Cijaku	44.02	-	Cijaku	175.72	-	131.70
Cikulur	153.57	-	Cikulur	296.76	74.10	217.29
Cileles	96.75	-	Cileles	287.74	72.70	263.70
Cilograng	200.00	-	Cilograng	286.76	116.81	203.58
Cimarga	293.53	-	Cimarga	256.40	201.91	164.79
Cipanas	183.93	54.18	Cipanas	129.38	208.10	99.36
Cirinten	55.66	-	Cirinten	110.61	22.23	77.18
Curugbitung	137.64	-	Curugbitung	347.59	39.87	249.82
Gunung Kencana	136.05	-	Gunung Kencana	241.03	38.08	143.05
Kalanganyar	105.81	43.04	Kalanganyar	-	272.74	123.89
Lebakgedong	83.70	-	Lebakgedong	88.96	38.40	43.67
Leuwidamar	180.52	-	Leuwidamar	256.47	24.27	100.21
Maja	131.07	27.46	Maja	208.31	412.01	461.79
Malingping	89.76	57.08	Malingping	43.73	403.39	300.29
Muncang	143.26	-	Muncang	122.61	81.00	60.35
Panggarangan	64.11	-	Panggarangan	268.94	-	204.84
Rangkasbitung	153.20	446.20	Rangkasbitung	-	1,157.50	558.09
Sajira	220.27	-	Sajira	214.76	195.76	190.25
Sobang	104.75	-	Sobang	123.79	14.98	34.03
Wanasalam	101.49	-	Wanasalam	227.83	101.22	227.56
Warunggunung	272.13	104.85	Warunggunung	86.41	557.99	267.43
Total	**3,846.52**	**861.45**		**5,109.01**	**5,158.06**	**5,559.10**

Source: Landsat-8 (2020) and Landsat-5 (2010) image data, processed by the author 2021

Table 2. Number of Lebak District Population Based on Area Status in 2010 and 2020

2010				2020			
Sub-districts	Status		Total 2010	Sub-districts	Status		Total 2020
	Rural	Urban			Rural	Urban	
Banjarsari	57,384	-	57,384	Banjarsari	45,746	19,704	65,450
Bayah	33,625	7,091	40,716	Bayah	25,821	19,614	45,435
Bojongmanik	21,206	-	21,206	Bojongmanik	24,565	-	24,565
Cibadak	41,576	16,481	58,057	Cibadak	1,781	69,058	70,839
Cibeber	54,228	-	54,228	Cibeber	47,904	8,818	56,722
Cigemblong	19,527	-	19,527	Cigemblong	21,591	-	21,591
Cihara	29,530	-	29,530	Cihara	19,641	13,533	33,174
Cijaku	26,876	-	26,876	Cijaku	30,615	-	30,615
Cikulur	46,627	-	46,627	Cikulur	46,172	12,109	58,281
Cileles	46,684	-	46,684	Cileles	43,762	10,674	54,436
Cilograng	31,689	-	31,689	Cilograng	23,286	11,934	35,220
Cimarga	60,968	-	60,968	Cimarga	42,626	31,581	74,207
Cipanas	36,400	8,988	45,388	Cipanas	21,575	29,464	51,039
Cirinten	24,765	-	24,765	Cirinten	25,741	3,414	29,155
Curugbitung	30,036	-	30,036	Curugbitung	30,879	5,655	36,534

2010				2020			
Sub-districts	Status		Total 2010	Sub-districts	Status		Total 2020
	Rural	Urban			Rural	Urban	
Gunung Kencana	32,663	-	32,663	Gunung Kencana	34,502	3,825	38,327
Kalanganyar	23,500	8,482	31,982	Kalanganyar	-	38,828	38,828
Lebakgedong	21,537	-	21,537	Lebakgedong	15,857	6,007	21,864
Leuwidamar	50,430	-	50,430	Leuwidamar	50,114	4,348	54,462
Maja	41,813	8,713	50,526	Maja	26,470	33,235	59,705
Malingping	44,402	17,098	61,500	Malingping	12,122	58,962	71,084
Muncang	31,615	-	31,615	Muncang	23,294	13,985	37,279
Panggarangan	35,242	-	35,242	Panggarangan	38,538	-	38,538
Rangkasbitung	33,485	83,174	116,659	Rangkasbitung	-	134,945	134,945
Sajira	46,366	-	46,366	Sajira	34,036	21,796	55,832
Sobang	28,467	-	28,467	Sobang	29,107	2,156	31,263
Wanasalam	51,233	-	51,233	Wanasalam	46,367	11,763	58,130
Warunggunung	35,697	16,605	52,302	Warunggunung	10,009	51,991	62,000
Total	**1,037,571**	**166,632**	**1,204,203**		**772,121**	**617,399**	**1,389,520**

Source: 2010 and 2020 Population Census, processed by the author 2022

Table 3. Number of Lebak District Workers Per Sector in 2010 and 2020

Total Workforce 2010				Total Workforce 2020			
Sub-districts	Primary Sector	Secondary Sector	Tertiary Sector	Sub-districts	Primary Sector	Secondary Sector	Tertiary Sector
Banjarsari	16,268	1,256	13,171	Banjarsari	10,858	-	9,685
Bayah	8,824	755	5,908	Bayah	5,539	-	8,310
Bojongmanik	8,141	217	1,548	Bojongmanik	7,052	142	1,510
Cibadak	8,369	55	1,893	Cibadak	8,906	212	10,702
Cibeber	25,203	358	3,059	Cibeber	12,058	-	8,051
Cigemblong	10,387	-	562	Cigemblong	6,276	-	1,804
Cihara	7,913	294	2,833	Cihara	10,977	264	2,892
Cijaku	10,110	743	1,921	Cijaku	9,023	355	2,928
Cikulur	12,858	2,797	4,083	Cikulur	10,464	-	7,019
Cileles	12,294	201	3,227	Cileles	7,914	86	2,196
Cilograng	13,826	253	1,007	Cilograng	14,191	305	1,057
Cimarga	33,238	545	4,430	Cimarga	15,201	-	6,059
Cipanas	25,124	1,062	3,844	Cipanas	7,187	-	7,409
Cirinten	8,124	1,476	3,842	Cirinten	5,805	-	3,734
Curugbitung	7,261	417	3,076	Curugbitung	6,473	-	3,943
Gunung Kencana	11,839	252	3,360	Gunung Kencana	12,732	201	3,763
Kalanganyar	2,063	1,222	3,786	Kalanganyar	3,898	-	1,770
Lebakgedong	4,830	648	3,069	Lebakgedong	6,265	596	2,231
Leuwidamar	18,263	911	5,865	Leuwidamar	18,263	911	5,865
Maja	11,840	6	11,763	Maja	12,128	6	11,833
Malingping	8,248	-	8,247	Malingping	11,228	757	9,904
Muncang	7,706	67	2,033	Muncang	7,286	-	3,589
Panggarangan	12,476	1,085	4,810	Panggarangan	7,531	-	5,881
Rangkasbitung	10,514	1,500	21,174	Rangkasbitung	7,529	1,120	24,057
Sajira	22,585	265	6,757	Sajira	24,124	265	6,960
Sobang	8,469	1	421	Sobang	7,985	-	2,861
Wanasalam	13,268	342	4,538	Wanasalam	15,658	307	4,507
Warunggunung	12,777	540	3,377	Warunggunung	12,488	429	7,295
Total	**352,818**	**17,268**	**133,604**		**285,039**	**5,956**	**167,815**

Source: Central Bureau of Statistics (BPS) Kecamatan Dalam Angka 2010, 2011, 2012, 2020 and Civil Registration Agency (Disdukcapil) 2014, 2020, processed by the author 2022

2.2. Method

2.2.1. Rural-urban transformation

The analytical technique used to measure the rate of rural-urban transformation uses the evaluation method of rural-urban transformation indicators based on three main aspects of transformation, namely physical, social, and economic. The calculation method for the evaluation of this transformation indicator can be seen in **Table 4**.

Table 4. Transformation Index Evaluation Calculation Formula

Aspects	Indicators	Definition	Calculation formula
Land	Land urbanization rate (Li)	The proportion of urban built-up land area to total built-up land area	$\left(\frac{ULi}{TLi}\right) x\ Si$
Population	Rate of urbanization of the population (Pi)	The proportion of the population to the total population	$\left(\frac{UPi}{TPi}\right) x\ Si$
Economics	Level of economic urbanization (Ei)	The proportion of secondary and tertiary sector workforce to total workforce	$\left(\frac{UEi}{TEi}\right) x\ Si$

Source: Y. Yang et al., (2018)*, modified.*

The calculation of each aspect of transformation is carried out for each sub-district administrative area with data units using data units for each village per sub-district area. The calculation of the rural-urban transformation rate based on these three aspects of transformation is formulated as follows:

$$TD = \frac{\left(\frac{Li2010+Pi2010+Ei2010}{3}\right)+\left(\frac{Li2020+Pi2020+Ei2020}{3}\right)}{2}$$

Equation 1 Rural-Urban Transformation Rate Based on Aspects of Transformation

2.2.2. Urban growth scenario

This analysis aims to see land use development using several variables, including population density, proximity to roads, distance to toll gates, and the direction of the Regional Spatial Plan (RTRW) of Lebak District. This Modelling scenario uses multiple scenarios (see **Figure 1**). The first scenario employs the direction of industrial estate and toll road development; the second scenario simply uses toll road development. This analysis uses the cellular automata method to examine the land use change scenario in Lebak District, aiming at seeing the land change trend using historical data. The urban development model must also be configured spatially and temporally [23]. The distance between the start and end time is equal to the distance for projections of urban development to obtain more accurate findings.

Figure 1. Framework Urban Growth Scenario (Tripathy and Kumar (2019)*, modified*)

3. Result and Discussion

3.1. Rural-Urban Transformation Level Based on Physical Aspects

Analysis of the level of rural-urban transformation based on physical aspects was carried out to see how the level of urbanization level of physical aspects in Lebak District. This analysis was carried out by calculating the level of land urbanization that occurred in 2010 and 2020. The analysis of physical aspects from 2010 to 2020 showed an increase in urban built-up land by 2.712 Ha (see **Table 1**). This significant change in built-up land occurred especially at the nodes of activity in Lebak District, especially in the urban area of Rangkasbitung District, which experienced an increase in built-up land of more than 500 Ha in 10 years. In addition, at other growth points, there are also quite exciting developments, including in the coastal area of Lebak District, which is one of the large fishing centers and a reasonably popular tourism area. The development of constructed land in coastal areas is also relatively rapid, whereas, in urban areas, there has been a change in the land of at least 500 hectares in the last ten years. In addition, massive development is also seen in the Kota Baru Maja area, one of the ten new cities planned by the government. This area became the new growth center in Lebak District that experienced at least an increase in built-up land of more than 400 Ha.

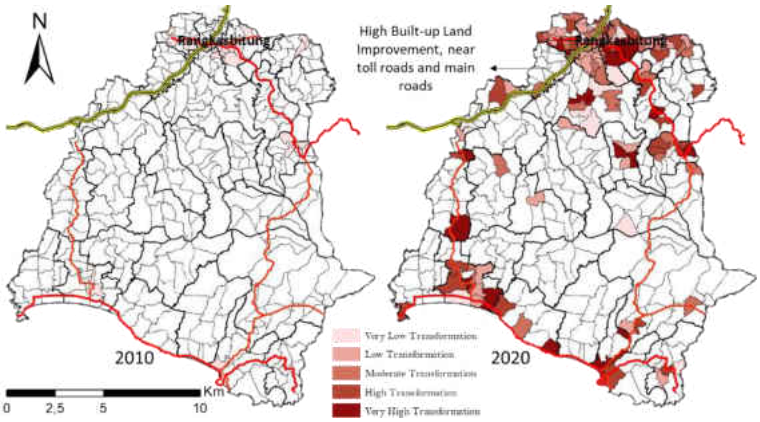


Figure 2. Map of Physical Transformation Lebak District 2010 and 2020 (Analysis, 2022)

Based on the results of this analysis, the growth of built-up land in urban areas is developing quite massively, in which urban agglomeration area of Rangkasbitung Sub-district is undergoing very high transformation, especially in its urban center area (see **Figure 2**). This occurred because of the many developments in the Lebak District and the emergence of various new businesses in the Lebak District, especially in the Rangkasbitung area. In addition to the urban area of Rangkasbitung Sub-district, other activity centers have undergone a high transformation. Among them is the Kota Baru Maja area, the center of new independent settlements on the border between Lebak District and Greater Jakarta. Also, in the southern area of Lebak District, namely in the coastal area, it has experienced considerable development. This coastal area serves as a significant center of fishery activities in the Lebak District and a tourism area.

3.2. Rural-Urban Transformation Level Based on Demographic Aspects

Analysis of the level of rural-urban transformation based on demographic aspects was carried out to see the level of urbanization of demographic aspects or urban levels from demographic aspects in Lebak District. This analysis was carried out by calculating the level of population urbanization that occurred in 2010 and 2020. Based on data from the population census results in 2010 and 2020, the population living in the urban area of Lebak District increased more than three times from 2010, or the overall proportion of the population of urban areas in 2020 increased by around 30% from 2010 (see **Table 2**).

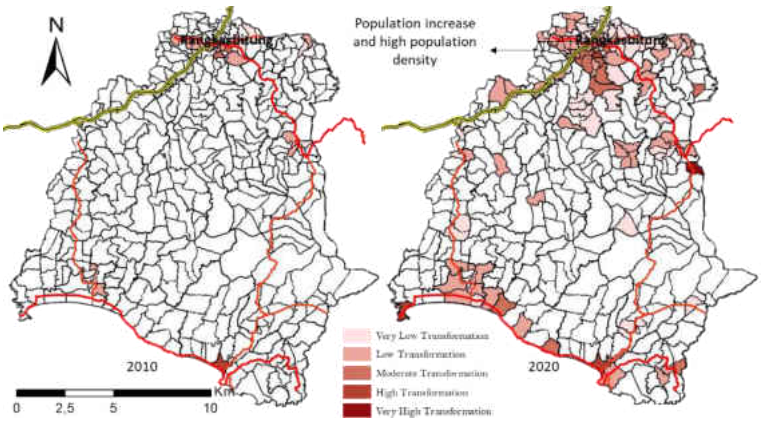


Figure 3. Map of Demographic Transformation Lebak District 2010 and 2020 (Analysis, 2022)

In the demographic aspect as seen in **Figure 3**, Rangkasbitung area as the main center of activity of the Lebak District, has the highest population density compared to other regions. Besides that, it has also undergone a high demographic transformation. In this regard, this region will develop and change faster than other regions. Areas that have experienced a high level of transformation are the center of activity, such as the Rangkasbitung area, which is the administrative and economic center, then the Maja area, which is a new growth area with the existence of Kota Baru Maja, then in coastal areas that are growing quite rapidly with good tourism and fisheries activities.

The level of transformation from the demographic aspect can be observed in Lebak District, especially in the Rangkasbitung area, which has increased quite significantly and showed a high level of transformation. This is also encouraged by various facilities in the Rangkasbitung area so that the increase in population is centralized in the Rangkasbitung area. This is reflected in the high growth of physical aspect. It can also be concluded that the level of population density and the level of social transformation in the region is considerable.

3.3. Rural-Urban Transformation Level Based on Economic Aspects

Analysis of the level of rural-urban transformation based on demographic aspects was carried out to see how the level of urbanization of economic aspects or urban level from economic aspects in Lebak District (Figure 4). This analysis was carried out by calculating the level of economic urbanization that occurred in 2010 and 2020. Based on data from the Central Statistics Agency and the Population and Civil Registration Office in Lebak District (see Table 3), there was an increase in the tertiary sector workforce and a decrease in the primary and secondary sectors. The number of workers in the tertiary sector has increased quite rapidly, especially in the Cibadak Sub-district, which has experienced an increase in the labor force of more than 8 thousand people. In line with the increase in the population of Cibadak Sub-district, which counts more than 12 thousand people. In addition to the Cibadak Sub-district area, several other sub-districts also experienced an increase in tertiary sector workers, namely Rangkasbitung Sub-district and Warunggunung Sub-district, which experienced an increase of more than 2 thousand people. This happens in line with the amount of land turned into commercial land.

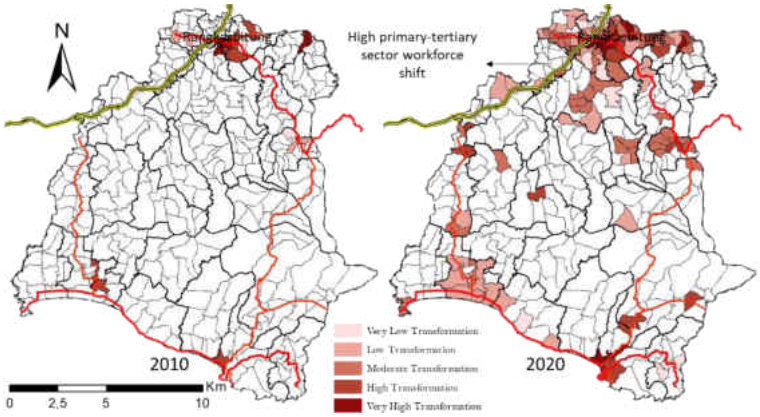


Figure 4. Map of Economic Transformation Lebak District 2010 and 2020 (Analysis, 2022)

In line with the previous analysis, a high transformation occurred in the primary activity nodes in Lebak District (see **Figure 3**). Among them are the Rangkasbitung Sub-district area, which is the primary node of activities in Lebak District; the Kota Baru Maja area, which is also a new growth center in Lebak District, as well as in coastal areas, which is the center of tourism and fisheries activities, experiencing a high level of transformation. An exciting transition is observed in economic transformation analysis, where economic changes do not pass through the industrialization phase as usually occurs in many regions. In Lebak District, most people immediately move towards the tertiary sector, which is dominated by workers engaged in services and trade.

This presents an interesting case, considering that an industrialization phase is quite prominent in various regions. There is also a considerable possibility that the industrialization phase in Lebak District will only begin when the industrial estate development plan is implemented. Meanwhile, from 2018 until present in Lebak District, especially in the primary node area of activities of Rangkasbitung District, many changes in people's lifestyles toward modernity are dominated by the emergence of many new commercial areas.

3.4. Rural-Urban Transformation Level in Lebak District

In order to determine the total degree of transformation in Lebak District, calculations were made using the outcomes of the earlier examination of the level of change of each aspect (see **Equation 1**). The results of this analysis will illustrate how the level of development of urban areas in Lebak District is based on the transformation of physical, demographic, and economic aspects.

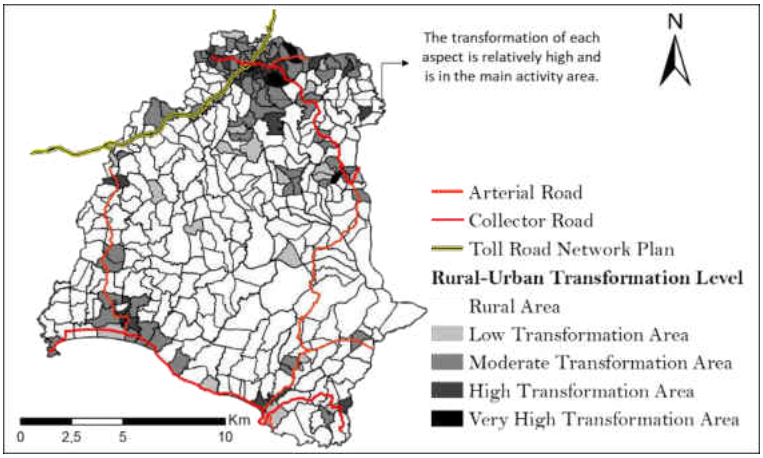


Figure 5. Map of Rural-Urban Transformation Level in Lebak District (Analysis, 2022)

The results of the analysis of the rural-urban transformation level that has been carried out show harmonious results where a high level of transformation occurs at the nodes of activity in the Lebak District. **Figure 5** shows that almost all urban villages that have undergone high transformation are in areas traversed by major transportation routes. This shows that besides the central activity area undergoing high transformation, areas with accessibility to infrastructure are essential aspects of this transformation process. The fastest transformation in Lebak District is in centers of activity that have high attractiveness and are along transportation routes. This is in line with what is explained in article [8] that areas that have high attractiveness will more quickly change to urban areas. As explained in articles [10,11], transportation infrastructure is closely related to the economic development of a city. It is evident in Lebak District that urban development occurs along transportation routes.

3.5. Urban Growth Scenario

The urban growth scenario is carried out because the development of toll roads and industrial designation areas can significantly drive urban growth in Lebak District, provided policymakers respond to it well. However, if the reaction to this growth is unfavorable, the development plan for toll highways and industrial zones might also not have an impact on urban development in Lebak District. In order to present a general overview of how urban expansion in the Lebak District would take place with the construction of toll highways and industrial designation areas, an analysis of the urban growth scenario has been conducted. In this regard, the results of this scenario can be used as a consideration in developing areas in Lebak District, especially in responding to the development of toll roads and industrial designation area plans.

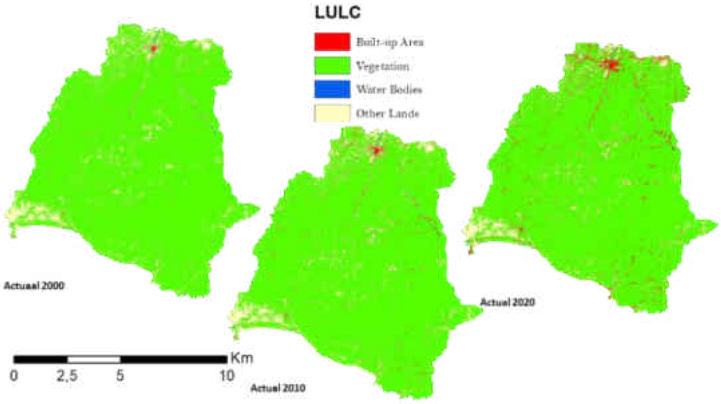
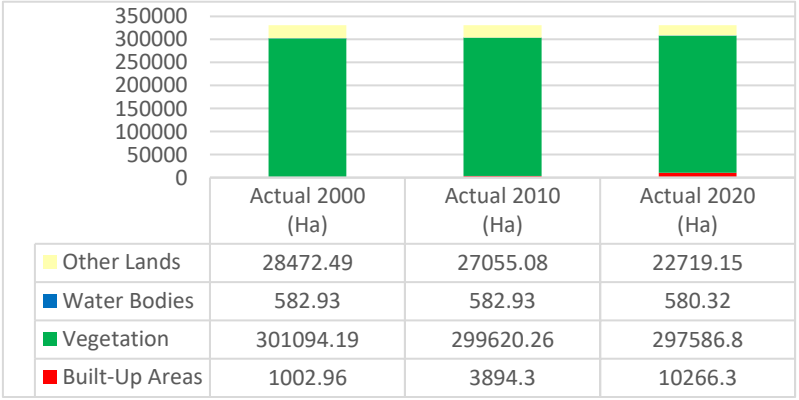


Figure 6. Map Land Use Land Cover (LULC) Lebak District 2000, 2010, and 2020 (Landsat 5 images in 2000 and 2010 and landsat 8 in 2020, processed by the author)



	Actual 2000 (Ha)	Actual 2010 (Ha)	Actual 2020 (Ha)
Other Lands	28472.49	27055.08	22719.15
Water Bodies	582.93	582.93	580.32
Vegetation	301094.19	299620.26	297586.8
Built-Up Areas	1002.96	3894.3	10266.3

Figure 7. Land Use Change Graph of Lebak District in 2000, 2010, and 2020 (landsat 5 images in 2000 and 2010 and landsat 8 in 2020, processed by the author)

Since 2000 there has been at least ± 9000 Ha of built-up land growth (see **Figure 7**). As previously explained, the growth of built-up land occurs in activity centers in Lebak District, especially in the Rangkasbitung area, which has a pattern of expansion to the periphery and further strengthens the urban core of Rangkasbitung (see **Figure 6**). The first stage of the analysis of the urban growth scenario is carried out by calibrating the *cellular automata* model that will be used for projections in 2030. This calibration is carried out by projecting a land use change in 2020 (see **Figure 8**) using data from 2000 and 2010 which is then validated using actual data in 2020.

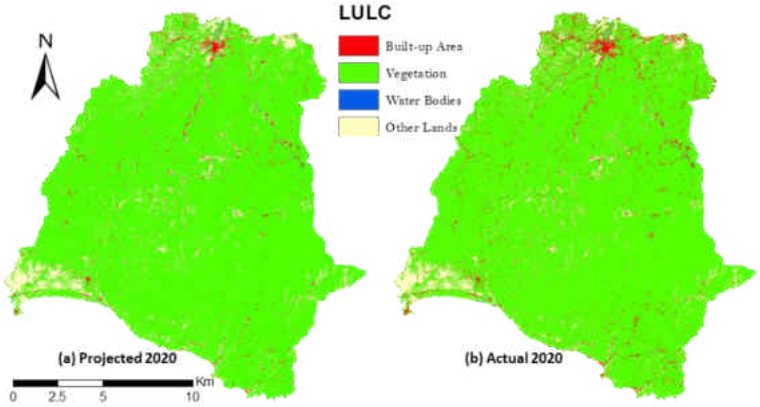


Figure 8. (a) 2020 Projected Land Use Map &; (b) 2020 Actual Land Use Map (Analysis, 2022)

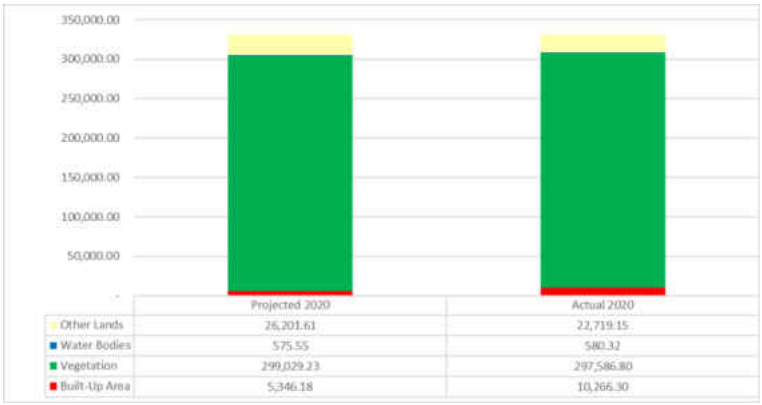


Figure 9. Comparison Graph of Actual Land Use and Projected Results in 2020 (Analysis, 2022)

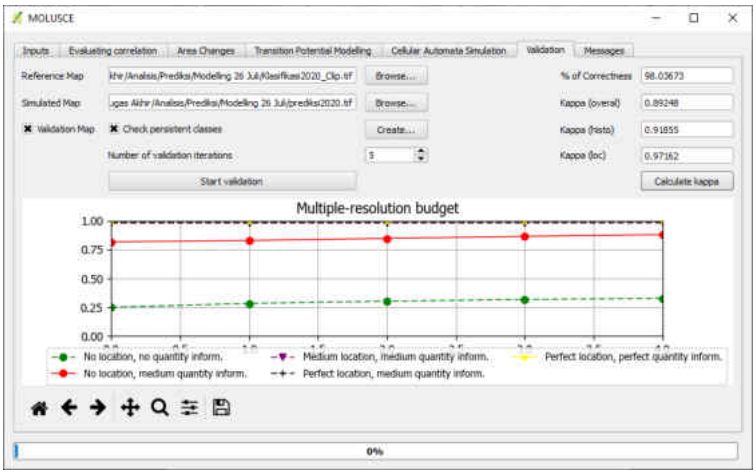


Figure 10. Model Calibration Validation Results (Analysis, 2022)

The comparison between actual land use in 2020 and projections in 2020 is not too different (see **Figure 9**). The results of the validation of the projection model that has been carried out obtained the best model with a kappa index value of 0.89248 (see **Figure 10**), which means that this model can be used for urban development projections in 2030. This projection model is used to estimate urban growth in 2030 utilizing two scenarios since it is considered to be reliable with a kappa value level of more than 0.5. The first scenario is urban development without responding to toll road development policies and industrial estate development. The second urban development scenario responds to toll road development policies and industrial estate development.

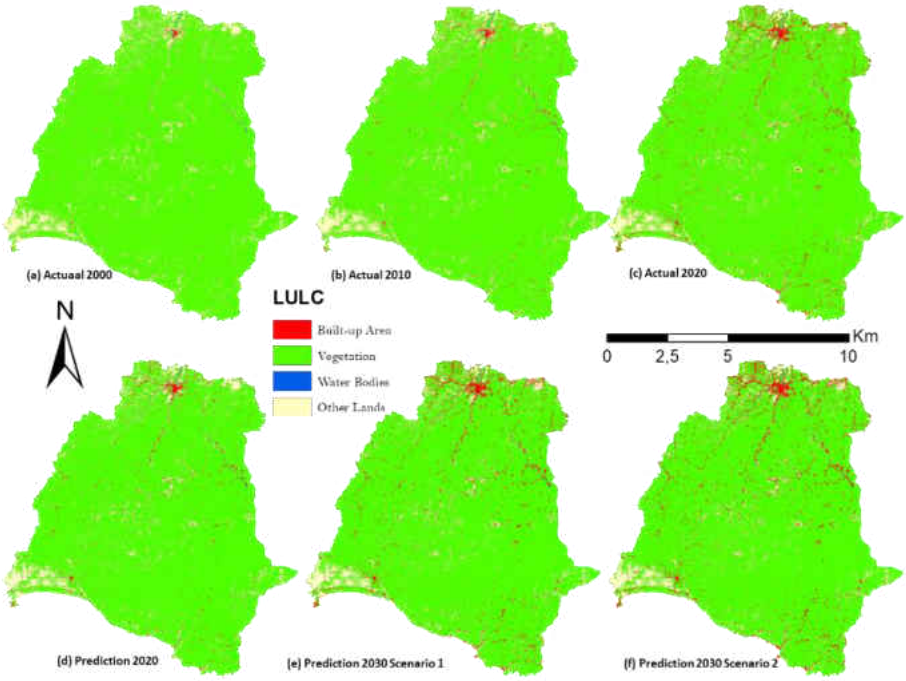


Figure 11. Actual Land Use (a) 2000, (b) 2010, (c) 2020, (d) projected land use 2020, (e) Projected 2030 Scenario 1, (f) Projected 2030 Scenario 2 (Analysis, 2022)

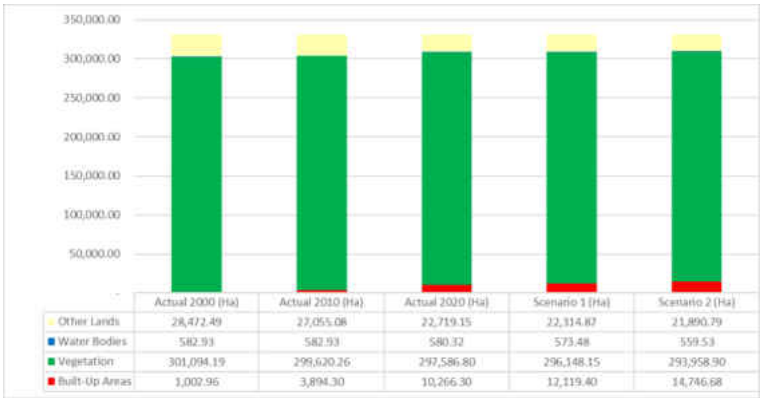


Figure 12. Land Use Development Graph in Lebak District in 2000, 2010, 2020, and 2030 Scenario (Analysis, 2022)

Based on the analysis, from 2000 to 2020, there continued to be an increase in built-up land; a very rapid increase occurred in the period 2010 to 2020, which increased to more than 6.000 hectares (see **Figure 12**). The projection results obtained in the first scenario (see **Figure 11** e), considered urban

growth, do not respond to the policy of toll road development and industrial estate development policy. There is an increase in built-up land of almost 2.000 hectares, with the development of built-up land spreading from urban centers to peripheral areas. In this first scenario, the urban center area of Rangkasbitung strengthened quite rapidly, and the leading road network traversed several areas.

In the second scenario (see **Figure 11** f), the development of developed land strengthened very rapidly in the Central area of Rangkasbitung District and its surroundings because it was influenced by excellent accessibility due to the existence of toll roads and also traversed by the leading road network that had existed from the beginning. In addition, the area around Rangkasbitung Sub-district is included in the industrial development plan, so it is a strong enough driver for developing developed land in the Rangkasbitung area. So that the Urban area of Rangkasbitung Sub-district, which has become the center of activity from the beginning, has become increasingly dense with built-up land. The development of developed land develops faster in the urban area of Rangkasbitung District because it is the center of various activities and is an area that has the highest level of accessibility.

Based on the projected results of urban development scenarios using scenarios one and two, urban development or the development of built land, the change is not as significant as that from 2010 to 2020, when the development of built land from 2010 to 2020 reached more than 6.000 Ha. On the other hand, the projection results using scenario 1 are only 2.000 Ha, and in scenario two, it is only 4000 Ha. Although the development is not as significant as before, the development in Lebak District based on the results of projection analysis shows the occurrence of inequality in urban development. The projection results of both scenarios show that urban development in Lebak District is more focused on the northern region. As for the central and southern regions, urban development is not too large. So, this further strengthens that in Lebak District, there is inequality or disparity in urban development.

3.6. Study findings

The results of the analysis that has been carried out on urban development in Lebak District can be divided into four zones. The division of this zone is carried out by looking at several aspects, including existing strategic policies, the level of physical transformation, the level of social transformation, the level of economic transformation, and the projection of urban development. The division of this zone shows how developments have occurred in several areas in Lebak District (see **Figure 13**).

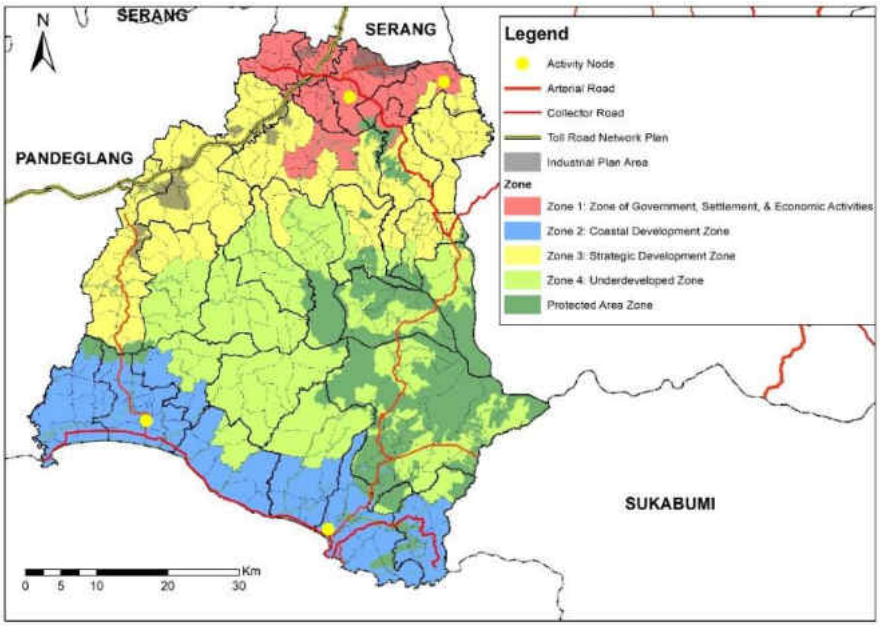


Figure 13. Map of Urban Development Zones in Lebak District (Analysis, 2022)

First is the central activity zone (zone 1), which includes the Rangkasbitung District and surrounding areas, then the Maja New Town Area. This area also intersects with the development zone where in this zone there are many strategic policies in the regional spatial plan (RTRW) of Lebak District, including the development of toll roads, industrial estate development plans, and the development of "Kota Baru Maja". So that in this zone, urban development is very massive because of various strategic policies in the zone.

Then zone 2 consists of an urban development zone in the coastal area of Lebak District, precisely in the southern region. This zone develops by relying on local potential, namely beach tourism, which attracts many tourists, especially for the tourist areas "Bagedur Beach" and "Sawarna Beach," which will be crowded with visitors yearly. Zone 3 has several strategic development plans, including developing the Serang-Panimbang toll road connecting Jakarta to the Tanjung Lesung tourism area. Then there is also a plan to allocate industrial estates along the toll road corridor to help the development of areas in the Lebak District. Lastly, Zone 4 is the zone with the slowest development, even stagnant. This is because the zone is in a mountainous area dominated by protected functions, so the development is not as fast as in other zones with flatter soil contours with cultivation functions.

The analysis of the level of transformation to the division of development zones shows results that lead to urban development in Lebak District experiencing disparities between the northern region, the urban center, and the mountainous area, which is a protected function area. This is not good for the development of an area. If only one area develops, all activities will be concentrated on the area, which will cause various urban problems in the future. So, it is necessary to develop strategic plans for areas far from urban centers by utilizing the local potential of each region.

The rural-urban transformation in Lebak Regency showed different stages, compared with the previous studies [12,14] The transformation in general, started with the industrial activities which attracted people to come and to stay, then increasing built-up land. However, in case in Lebak Regency, the transformation occurred without facing the industrialization phase, it directly jumped into the third phase. As shown in **Table 3**, labor changes in the secondary sector actually decreased from 2010 to 2020, and labor in the tertiary increased significantly. The rural-urban transformation in Lebak District is driven by various strategic policies such as constructing electric railways, toll roads, "Kota Baru Maja" development policies, and industrial estate plans. It can be concluded that urban development in Lebak Regency is strongly encouraged by various existing strategic policies without going through the industrialization phase.

4. Conclusion

Urban development in Lebak District, based on the results of the analysis conducted from 2010 to 2020, continues to rely on the central area of economic and government activities in the north. At the same time, other areas far from the center of economic and government activities can be said to develop slowly. Urban development in Lebak District showed disparities or gaps. In those areas, far from the center of development, activities are very static and tend not to develop, especially in rural areas. This disparity will be apparent, especially in the western area dominated by the Protected Zone. Such developments, if continued, will cause even more significant gaps, coupled with the current strategic policies focusing on the Rangkasbitung area, so that development in this area is predicted to be faster. On the other hand, other areas will not receive adequate regional growth because they are located distant from the hub of activity and development zones.

5. Acknowledgement

We would like to acknowledge research group on Regional Development and Environmental Management, Universitas Diponegoro for facilitating this research.

6. References

[1] Henderson J V and Wang H G 2005 Aspects of the rural-urban transformation of countries *J Econ Geogr* **5** 23–42
[2] Jiang L and O'Neill B C 2017 Global urbanization projections for the Shared Socioeconomic Pathways *Global Environmental Change* **42** 193–9
[3] Zhu J, Zhu M and Xiao Y 2019 Urbanization for rural development: Spatial paradigm shifts toward inclusive urban-rural integrated development in China *J Rural Stud* **71** 94–103
[4] Wineman A, Alia D Y and Anderson C L 2020 Definitions of "rural" and "urban" and understandings of economic transformation: Evidence from Tanzania *J Rural Stud* **79** 254–68
[5] Christiaensen L and Todo Y 2013 Poverty reduction during the rural-urban transformation - The role of the missing middle *World Dev* **63** 43–58
[6] Liu T Y and Su C W 2021 Is transportation improving urbanization in China? *Socioecon Plann Sci* **77**
[7] Ge D, Long H, Qiao W, Wang Z, Sun D and Yang R 2020 Effects of rural–urban migration on agricultural transformation: A case of Yucheng City, China *J Rural Stud* **76** 85–95
[8] Lazaro E, Agergaard J, Larsen M N, Jeremia M and Birch-Thomsen T 2018 *Rural Transformation and the Emergence of Urban Centres in Tanzania*
[9] Li C, Song Y and Chen Y 2017 Infrastructure Development and Urbanization in China *China's Urbanization and Socioeconomic Impact* ed Z Tang (Singapore: Springer Singapore) pp 91–107
[10] Maparu T S and Mazumder T N 2017 Transport infrastructure, economic development and urbanization in India (1990–2011): Is there any causal relationship? *Transp Res Part A Policy Pract* **100** 319–36
[11] Ayazli I E, Kilic F, Lauf S, Demir H and Kleinschmit B 2015 Simulating urban growth driven by transportation networks: A case study of the Istanbul third bridge *Land use policy* **49** 332–40
[12] Yang Y, Liu Y, Li Y and Li J 2018 Measure of urban-rural transformation in Beijing-Tianjin-Hebei region in the new millennium: Population-land-industry perspective *Land use policy* **79** 595–608
[13] Patra S, Sahoo S, Mishra P and Mahapatra S C 2018 Impacts of urbanization on land use /cover changes and its probable implications on local climate and groundwater level *Journal of Urban Management* **7** 70–84
[14] Ma L, Chen M, Fang F and Che X 2019 Research on the spatiotemporal variation of rural-urban transformation and its driving mechanisms in underdeveloped regions: Gansu Province in western China as an example *Sustain Cities Soc* **50** 101675
[15] Liu T-Y, Su C-W, Qin M and Zhang X-Y 2019 What Came First, Transportation or Urbanization? *The Singapore Economic Review* 1–16
[16] Jayne T S, Chamberlin J and Benfica R 2018 Africa's Unfolding Economic Transformation *J Dev Stud* **54** 777–87
[17] Butsch C, Kumar S, Wagner P, Kroll M, Kantakumar L, Bharucha E, Schneider K and Kraas F 2017 Growing 'Smart'? Urbanization Processes in the Pune Urban Agglomeration *Sustainability* **9** 2335
[18] Yang R, Zhang J, Xu Q and Luo X 2020 Urban-rural spatial transformation process and influences from the perspective of land use: A case study of the Pearl River Delta Region *Habitat Int* **104** 102234
[19] Liu Y, Hu Z and Li Y 2014 Process and cause of urban-rural development transformation in the Bohai Rim Region, China *Journal of Geographical Sciences* **24** 1147–60
[20] Hu Z, Wang Y, Liu Y, Long H and Peng J 2016 Spatio-temporal patterns of urban-rural development and transformation in east of the "Hu Huanyong Line", China *ISPRS Int J Geoinf* **5** 1–18
[21] Yang Y, Liu Y, Li Y and Du G 2018 Quantifying spatio-temporal patterns of urban expansion in Beijing during 1985–2013 with rural-urban development transformation *Land use policy* **74** 220–30

[22] Tripathy P and Kumar A 2019 Monitoring and modelling spatio-temporal urban growth of Delhi using Cellular Automata and geoinformatics *Cities* **90** 52–63
[23] Liu Y 2009 *Modelling Urban Development with Geographical Information Systems and Cellular Automata*