Analysis of Residential and Industrial Land Development and Its Influencing Factors in Semarang City in 2011 and 2022

Shafa Rifda Syafira Purnomo, Hamim Zaky Hadibasyir(✉), and M. Iqbal Taufiqurrahman Sunariya

Faculty of Geography, Universitas Muhammadiyah Surakarta, Surakarta 57162, Central Java, Indonesia
hamim.zaky.h@ums.ac.id

Abstract. Settlements are part of the environment inhabited by humans, comprising supporting infrastructure facilities in urban and rural areas. Land developments include residential developments and industrial areas. One of the factors that cause the development of built land in urban areas is an increase in the number of people, both naturally (internal) and through population migration (external). Semarang is a city in Central Java province that is the center of government, education, and economy. Due to these factors, Semarang's population has grown, which has led to an increase in the amount of built-up land within the city. Each Semarang City subdistrict's 2011 and 2022 data, as well as Landsat images 5 and 8, were used in this study. This study employed quantitative methods and multiple linear regression, overlay, and maximum likelihood classification analysis as data analysis techniques. The study's findings are the degree of development of the built-up land in each subdistrict of Semarang city in 2022, with a total land development area of 5653.86 ha. The highest levels of development were in Genuk Subdistrict, Mijen Subdistrict, and Ngaliyan Subdistrict. The results of multiple linear regression showed R2 values of 0.821, indicating that topographic averages and free variables (such as population density, population, public facilities, and the difference in population density between 2021 and 2011) had an influence of 82.1% on the development of built-up land in Semarang city in 2022.

Keywords: Settlement · Population · Linear Regression

1 Introduction

Over time, the population will be expanded to fulfill the demand for housing from the surging population and increased socioeconomic activity (Schiavina et al. 2022). Humans will always adapt to their environment as they grow, which includes building homes, establishing communities, and creating jobs to meet basic needs (Haryana, Fikriyah, and Yulianti 2013). Urban is a collection of residential centers, in which each residential center has a role in the development area. Urban areas will forever be associated with rapid development and annual growth in built-up land (Harjanti 2002). The city

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is a settlement with population activities that have administrative boundaries determined by legislation and residential areas that have shown the character and characteristics of urban life (Kemendagri 1987). Over the past few years, Indonesia's built-up land has developed at a breakneck pace. Large cities are typically where these developments are most prevalent. This growth is very normal and inevitable in developing nations because urban development moves dynamically over time (Belal and Moghanm 2011). One of the factors that cause the development of built land in urban areas is an increase in the number of people, both naturally (internal) and through population migration (external) (Catanese, A. J., & Snyder 1989). The increasing number of residents will also affect the activities in it. This population activity can be in the form of trade, industry, services, and so on. Population activity is also another factor that precipitates the development of the city (Dwiyanto, T. A., & Sariffudin 2013). Moreover, improved accessibility conditions, the construction of freeways and arterial roads, and an increase in the number of public facilities also lead to changes in land use in urban areas. The development of the region or city will be related to the availability of natural resources and human resources in the region (Fikriyah et al. 2022).

Along with the development of activities in urban areas, the need for land will simultaneously increase. Urban area is developed and heterogeneous land (Teerarojanarat 2022). The demand for residential land will rise as the population grows, but land supply will remain constant. This increase in residential land needs will encourage changes in land function from paddy field/moorland and green open land to residential and industrial land. These circumstances are also referred to as "changes in land use." (Paul, B. K., & Rasyid 2017). This change in land use is inevitable. This shift takes place as housing demand in the community rises in tandem with population growth. Additionally, one of the factors influencing land use change is the desire for a higher quality of life. This increase in demand provokes the conversion of land from non-built-up to built-up land. Urban areas have certain physical characteristics, and one of those characteristics is the development of built-up land, which is becoming more and more common in urban areas. The development of non-built-up land into Subsequent paragraphs, however, are indented. Poorly controlled built-up land will also cause a loss of land function, which will ensue problems in the environment (Wuryanta, A., Susanti, P. D., Yani, A. J., & Pabelan 2015).

One of Indonesia's major cities, Semarang has experienced extremely rapid growth on both the physical and social fronts. The strategic location of Semarang also supports its rapid development. Semarang, which is the capital as well as the center of government, education, and the economy in Central Java, is a destination for people in search of a higher standard of living. These conditions fuel the flow of urbanization and industrialization in Semarang. The current urbanization is dominated by areas near Semarang, such as Kendal, Demak, Kudus, Purwodadi, and so forth. The population of Semarang city is continuously growing. In 2020, Semarang city had 1,685,909 inhabitants; in 2021, that number rose to 1,687,222 (Statistic Indonesia of Semarang City 2022).

The level of population density in Semarang will change as a result of the increase in population. Based on data from Statistics Indonesia for Semarang city in 2021, the population density of Semarang in 2021 was 4431.92 people per km^2. This increase in population density will have a bad impact in the form of the emergence of slums,

declining environmental quality, increased competition in the world of work, and so on. Semarang's growing population density is a result of the annual flow of urbanization and the large number of immigrants who come for a variety of reasons, including employment or further education. This activity then affects the center of activity in the form of settlements and services that lead to a surge in built-up land. Land used for agriculture is rapidly declining as Semarang's built-up sprawl expands. High population growth and increasing community needs for more land will provide benefits and problems that occur simultaneously. This condition is characterized by an increase in economic activity in urban and surrounding communities that will cause physical changes in the city (Tanjung, Ernan, and Widiatmaka 2021).

The reduction of green open land and agricultural land will have a bad impact on the environment, such as the lack of water storage areas during rainy seasons, decreased oxygen quality, and increased risk of flooding in Semarang city. Monitoring of factors that influence the transformation of undeveloped land into developed land as a result of dynamic population growth is necessary (Yunus 2005). Monitoring land development can also be carried out by observing the direction of development of built-up land in Semarang. Additionally, negotiations between relevant parties, including farmers, governments, and business actors, are required in order to reach a land use change agreement and reduce environmental harm (Munibah et al. 2010). Space control is also possible during the processes of spatial planning and land development designed to restore the function of space, (Fahmi, Sitorus, and Fauzi 2016) it changes when there is a discrepancy between theory and practice (Tranggono, 2021). This study aimed to analyze the development of built-up land in Semarang in 2011 and 2022 and identify factors influencing the development of built-up land in Semarang in 2011 and 2022.

2 Methods

This study examined the Semarang City area, which has 16 subdistricts and 177 villages. Semarang city is situated between 6° 50′ and 7° 10′ south latitude and 109° 35′ and 110° 50′ east longitude. The total area of Semarang City is 373.70 km^2. Semarang city is bordered to the west by Kendal Regency, to the east by Demak Regency, to the south by Semarang Regency, and to the north by the Java Sea, with a long coastline covering 13.6 km (Statistic Indonesia of Semarang City 2022). Below is the Administrative Map of Semarang City in 2022 (Fig. 1).

This study is quantitative research. This study used quantitative methods, in which the data used in the form of Landsat 5 images in 2012 and Landsat 8 in 2022 were processed using devices based on GIS technology, namely ArcGIS, and quantitative data processing was carried out using SPSS software. Spatial data from Landsat images can be processed and analyzed using GIS, along with its development (Fikriyah et al. 2022). This research was conducted in Semarang. This study employed secondary data obtained from relevant agencies.

Data collection was conducted using literature studies and institution studies. The data collection technique was used because the data were secondary. The secondary data used include information on the population density, public services, topographic averages, and average elevation of Semarang City between 2010 and 2021. The secondary

Fig. 1. Semarang Administrative Map 2022

data were obtained from the subdistrict data in figures per subdistrict in Semarang, totaling 16 districts. Following are the data analysis methods used in this study. First, supervised classification, spatial analysis has advantages in digital image processing by classifying images in *training sample area* (Lubis 2020). This analysis required Landsat 5 image data in 2011 and Landsat 8 image in 2021. The classification method used is Maximum Likelihood. This method determines the likelihood that a pixel belongs to a particular class by assuming that each class has a statistic with distributing bands (Hidayah and Suharyo 2018). Second, overlay analysis, this analysis is used to analyze the development of land from non-built-up land to built-up land in Semarang city in 2011–2022. Overlay analysis combines two or more layers of data to produce a picture of a combination of attributes that indicate certain information (Fahmi et al. 2016). This analysis is used to determine the level of development of built-up land in Semarang. According to (Setyaningsih & Pradoto, 2015) the formula used to determine the growth

rate of built land is as follows.

$$\text{Level of Development} = \frac{\text{Difference of Built - Up Area}}{\text{Difference Period of Time}} \quad (1)$$

Factors Influencing the Development of Built-up Land, there are several factors used in the analysis of built-up land development. These developments are influenced by a number of variables, including the population in 2011, the population density in 2011, the difference in population density between 2011 and 2021, the number of public facilities in 2011, and the average topography of the Semarang City region. e). Multiple Linear Regression Analysis, this analysis is used to determine the influence of independent variables on dependent variables based on factors influencing the development of built land (Ghozali 2011). Independent variables used in this analysis consist of the number of residents, population density, public facilities, and average topography of the city of Semarang. The independent variable is a factor that influences the dependent variable, namely, the development of built-up land in 2022. According to Ayu et al. (2021), the equation model used in multiple linear regression analysis is expressed in the following formula (Ayu et al. 2021).

$$Y = a + b1x1 + \ldots + bnxn \quad (2)$$

Y : dependent variable
X_1….Xn : independent variable
a : regression constant
b_1….. bn : regression coefficient

3 Results and Discussion

Land use in Semarang has increased in the last decade. The selling price of land, changes in the workforce brought on by economic changes, and governmental policies that increase demand for specific types of land and encourage land conversion are just a few of the factors that can result in land changes. It will consequently lead to problems with spatial arrangement and a mismatch in land use (Suryantoro & Sutanto, 2002). The general pattern of land changes will have implications for the expansion of one class or category's land use, which will be followed by a contraction of other land classes. Such an increase in built-up land will have an impact on the decline of rice fields, moorland, and green open land. Changes in the use of built-up land in the city, in general, occur when rice fields, moorland, or shrubs are turned into built-up land in the form of land parks and yards (Sunartono, 1995). This study has two discussions, namely, an analysis of built Land Development and factors that influence the development of built land in Semarang city in 2011 and 2022.

3.1 Analysis of Built-Up Land Development

Analysis of the development of built-up land was carried out using the supervised classification and Maximum Likelihood classification on Landsat 5 imagery in 2011 and Landsat 8 imagery in 2022. The results of the classification are in the form of built-up

Table 1. Land Use of Semarang City in 2011 (Statistic Indonesia of Semarang City 2012)

Land Use	Area (Ha)	%
Built-up	15,291.45	40.90
Non Built-up	22,088.55	59.10
Total	37,380	100

and non-built land types. Built-up land includes residential areas and industrial areas, and non-built land includes vegetation, vacant land, and water bodies. The following are the results of the Semarang land cover classification in 2011 and 2022.

Land Cover Analysis in 2011

Based on Landsat image data processing in 2011, which was processed through GIS-based software, ArcGIS, using image classification maximum likelihood and Statistics Indonesia of Semarang city data in 2011, we obtained the area and class of Semarang city land cover, which includes built-up and non-built-up land, as shown in Table 1 and Semarang city land cover classification in 2011 as shown in Fig. 2.

Table 1 describes that the land cover of Semarang city in 2011 was dominated by non-built-up land with a cover area of 22,088.55 ha or 59.10% of the total land area in Semarang, while the built-up land cover had an area of 15,291.45 ha or 40.90% of the total land area. The development of built-up land in the city of Semarang is very likely to occur under these land cover conditions. The findings of the analysis of land use in the form of built-up land show a pattern that concentrates on the city's core, specifically the regions of North Semarang, West Semarang, Central Semarang, South Semarang, Gayamsari, East Semarang, and Gajah Mungkur, and spreads outward. This condition occurs because the city center, which is the center of government and economic activity, will attract people to live in the region, so the built-up land is developing more rapidly. Meanwhile, the land cover in the form of vegetation and vacant land was dominated by the Southern and western parts of Semarang, namely in Gunung Pati Subdistrict, Mijen Subdistrict, and Ngaliyan subdistrict.

Land Cover Analysis in 2022

The results of the processing of Landsat 8 image data in 2022, which were processed using GIS-based software, namely ArcGIS, using image classification, namely Maximum Likelihood, and Statistics Indonesia of Semarang City data in 2022, obtained the results of the area and land cover class of Semarang city, which includes built-up and unbuilt-up land, as in Table 2 and Fig. 3.

According to Table 2, the built-up land cover made up the majority of Semarang City's land area in 2022, accounting for 20,945.31 ha, or 56.03% of the city's total land area, while the non-built-up land cover covered 16,434.69 ha, or 43.97% of the city's total land area. The southern and western parts of Semarang have increasingly experienced an increase in built-up land. The shift of economic and industrial areas in the Semarang suburban area is the driving factor behind land change in the region. There are more bodies of water in Semarang City's northern section or along the north coast of Java.

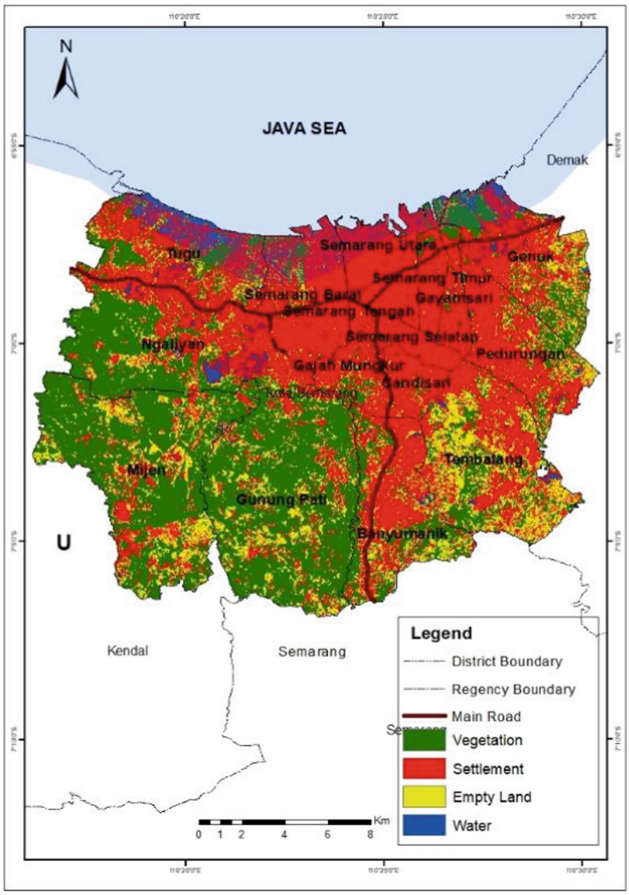

Fig. 2. Map of Land Cover of Semarang City in 2011

Table 2. Land Use of Semarang City in 2022 (Statistic Indonesia of Semarang City 2022)

Land Use	Area (Ha)	%
Built-up	20,945.31	56.03
Non Built-up	16,434.69	43.97
Total	37,380	100

While it is thought that land conversions into ponds are responsible for the increase in water bodies in the Tugu district, "rob floods," or floods brought on by an increase in sea level, are deemed to be the cause of the increase in water bodies in the Genuk district.

Analysis of Built-up Land Development

Comparing land use data from different points in time allows for the analysis of land

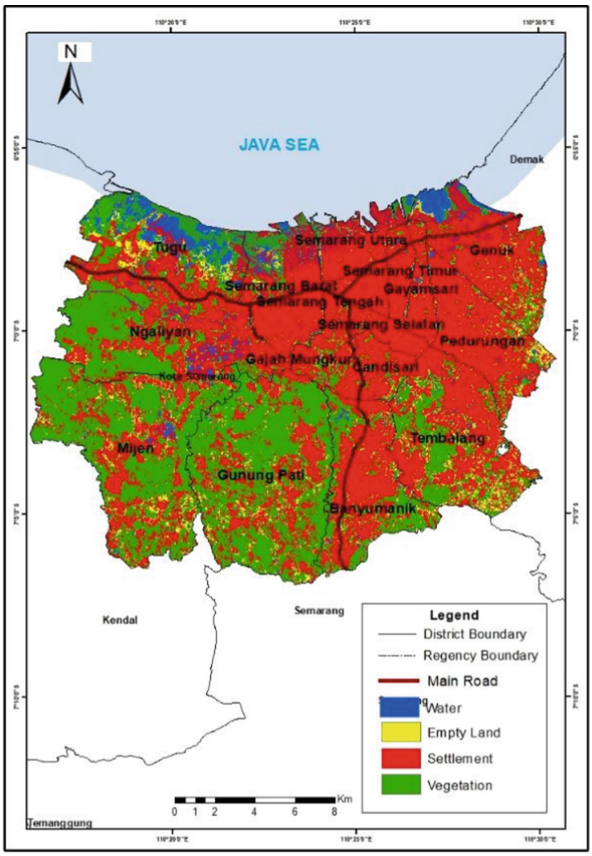

Fig. 3. Map of Land Cover of Semarang City in 2022

use change. The time period used in this study is from 2011–2022. According to data on land use in Semarang between 2011 and 2022, built-up land increased by 15.13 percent, or 5653.86 ha, while non-built-up land decreased. This shows that there was a rather high increase in built-up land. Changes in the use of the city of Semarang occur in every district in Semarang. The following is a graph of land use changes that occurred in the city of Semarang from 2011 to 2022 (Fig. 4).

The changes in land use that occurred in the city of Semarang in 2011–2022 were significant. A total of 5653.86 ha, or 15.13 percent, of the area underwent changes in use over the course of 11 years. Numerous factors can cause this change, one of which is an increase in the population, which led to a rise in the demand for developed and industrial land for a living. Shrinkage that occurs in the area of non-built-up land due to the conversion of land into built-up land as a result of the physical development of the city (Utaya 2008). The following is a map of land change developments that occurred in the city of Semarang from 2011 to 2022 (Fig. 5).

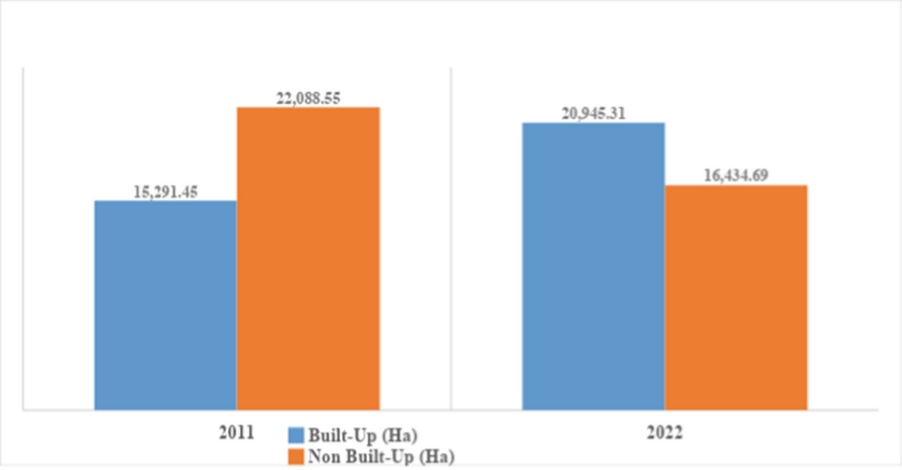

Fig. 4. Land Use Change in Semarang from 2011 to 2022 (Statistic Indonesia of Semarang City 2012, 2022)

Changes in land use from undeveloped land to developed land in Semarang city occurred significantly from 2011–2022. This land cover change was dominated by residential land and industrial areas. One of the factors causing the development of built land are factors of population growth that arise naturally or through migration. Based on Fig. 5, the development of built-up land occurred in the suburbs of Semarang. This is due to the fact that vegetation still predominates in Semarang's suburbs. The development in the Semarang suburb is referred to as a "peri-urban urban area," which is a location where a change in function results in changes to the place (Muladica, Murtini, and Suprapti 2018). Furthermore, because land is still relatively inexpensive in the area, many people are moving into industrial areas and out of residential areas. Rising land sale prices are a result of changes in land function that happen periodically each year and directly affect built land. Changes that occur cause a decrease in vacant land, paddy fields, moorland, and vegetation. The decrease in paddy fields and moorlands will have an impact on reducing the amount of staple production. Changes in land use can also have an impact on climate change in a region (Shatu, Kamruzzaman, and Deilami 2014). Generally speaking, the transformation of land use in Semarang into residential and industrial areas is one of the ways the local community is working to meet basic needs, which include not only the need for housing but also a location where the government can meet needs related to trade, industry, education, and so on (Sari, Ahmad, and Rindarjono 2022). In addition, residential and industrial development are also carried out in order to achieve the set goals both in the short-term and the long term (Maharani and Nurjaman 2022).

Analysis of the Development Level of Built-up Land

An analysis of the level of development of built land is calculated based on the difference in the area of changes in built land divided by the difference in the period of time used.

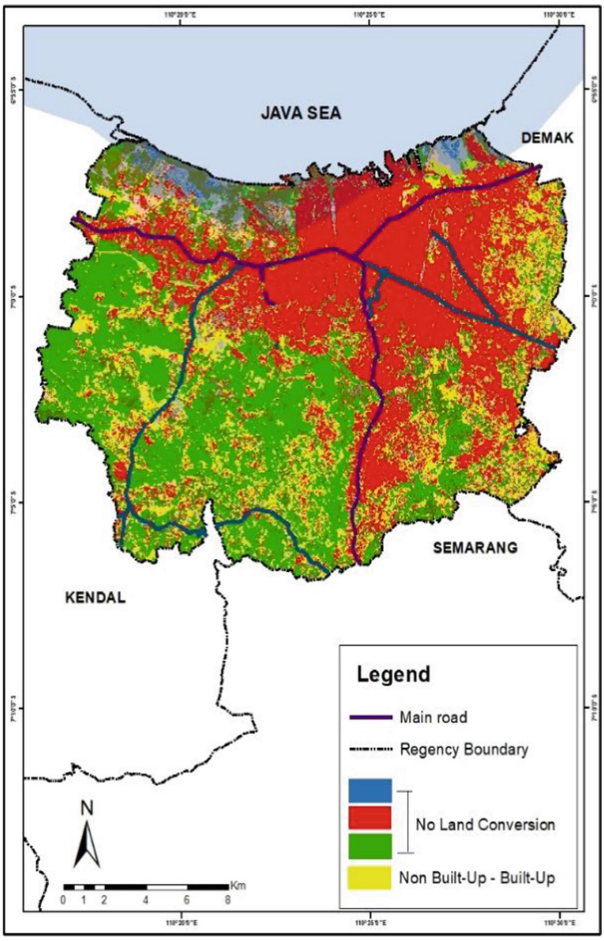

Fig. 5. Map of Land Development Changes in Semarang City in 2011–2022

The results of these calculations indicate the high and low levels of development in each district of the city of Semarang. The level of land development can be seen in Table 3.

The results of the analysis on the level of development of built-up land show that the highest value was located in the Genuk subdistrict with a percentage rate of development of 81.37%, followed by the Mijen subdistrict with a percentage rate of 79.38%. The smallest percentage value was found in the District of Central Semarang with a percentage value of 0.14%. While Mijen subdistrict's level of land development was influenced by the growth of industrial and educational areas, Genuk district's high level of land development was caused by the expansion of residential land in the area where Semarang city and Demak regency met. The development of industrial estates in the Mijen subdistrict was carried out because the area of undeveloped land is still relatively large. Residential neighborhood development is influenced by the presence of industrial areas. Additionally, the growth of educational areas, including Universitas Katolik

Table 3. Development Level of Built-up Land of Semarang City in 2011–2022 (Statistic Indonesia of Semarang City 2012, 2022)

Subdistrict	Built-Up Area (Ha)		Development Level (%)
	2011	2022	
Banyumanik	1,935.56	2,461.56	52.6
Candisari	494.39	585.97	9.1
Gajahmungkur	691,65	715,63	2.39
Gayamsari	421,39	536,92	11.55
Genuk	1,094.148	1,907.89	81.37
Gunungpati	1,070.74	1,673.82	60.3
Mijen	943. 06	1,737.1	79.38
Ngaliyan	418	1,133.34	71.53
Pedurungan	1,506.99	1,873.03	36.6
West Semarang	1,329.25	1,622.1	29.28
South Semarang	440.9	588.57	14.76
Central Semarang	522,17	523.64	0.14
East Semarang	691.56	713.66	2.21
North Semarang	837.38	871.32	3.4
Tembalang	2,386.39	3,072.39	68.6
Tugu	507.73	928.37	42.06

Soegijapranata, was followed by the development of residential areas and commercial or service facilities. Due to the area's altitude, which ranges from 60 to 80 m above sea level, and the still-affordable land prices in the area, many residents migrated to the southern and western regions of Semarang city, specifically Gunung Pati Subdistrict, Mijen Subdistrict, and Ngaliyan Subdistrict, where built-up lands of residential areas occurred. Map of the development level of built-up land is presented in Fig. 6.

3.2 Analysis of Factors Influencing the Development of Built-Up Land

This analysis is used to determine the conversion of built-up land in Semarang by using other driving factors that induce the development. The statistical data processing program SPSS was used for the analysis to determine these factors. There are six independent variables used in this study, namely X1 population density, X2 population, X3 public facilities, and X4 mean topography. The dependent variable is the area of built-up land in 2022. Linear regression analysis performed partial T-test and simultaneous F-test. The results of the regression analysis are shown in Table 4.

Partial T-test was conducted to determine the effect of each independent variable on the development of built-up land that occurs. Partial is the influence of each dependent variable on the dependent variable. Each of the variables (population density, population,

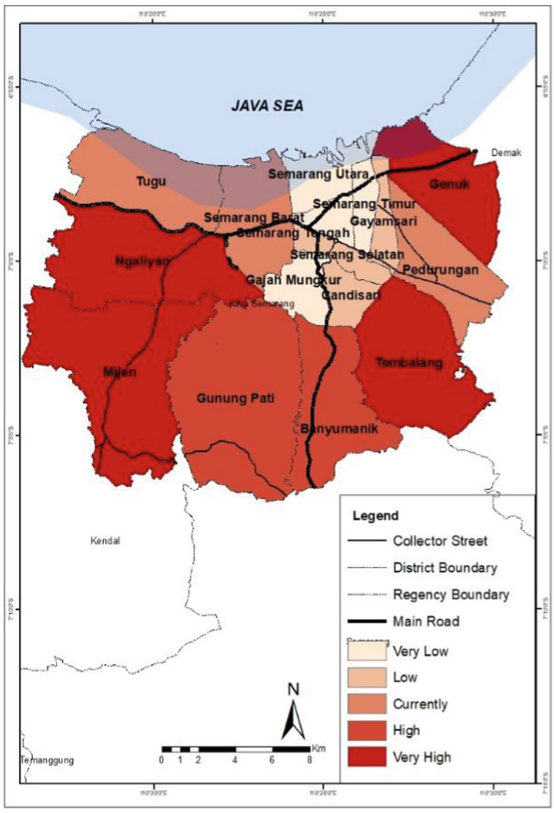

Fig. 6. Map of Land Development Level of Semarang City in 2011–2022

public facilities, and topographic average) achieved a GIS value of 0.05, which indicates that, in part, the number of residents in 2011, the average topography in 2011, the difference in population density between 2021 and 2011, and the number of public facilities in 2011, had no influence on the development of built-up land in 2022, but the population density in 2011 had an impact on it. However, based on the simultaneous F-test and R Square analysis, it had an influence on the development of built-up land in 2022. The following is a simultaneous F-test table that shows that the independent variable had an influence on the dependent variable. Table 5 shows the analysis's findings from the regression analysis ANOVA table.

The results of the analysis based on Table 5 can be analyzed that the significant value in the simultaneous F-test is 0.002, where the significant value of $0.002 < 0.05$. This means that simultaneously or the entire set of independent variables (that is population density (X1), population (X2), public facilities (X3), and average topography (X4)) and the difference in population density between 2021 and 2011 had an influence on the development of built land in Semarang city in 2022. Table 6 shows the analysis that was done to determine how much the independent variable influenced the dependent variable.

Table 4. Regression Analysis: Coefficient Table (T-Test)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	49.517	17.893		2.767	0.020
	Population Density 2011	-0.006	0.001	-.952	-5.139	0.000
	Total Population 2011	0.000	0.000	0.130	0.538	0.602
	Public Facilities 2011	0.035	0.072	0.121	0.486	0.637
	Topographical Average	0.003	0.043	0.011	0.064	0.950
	Difference in Population Density 2021 and 2011	0.009	0.005	0.259	1.658	0.128

a. Dependent Variable: Development of Built-Up Land in 2022

Table 5. ANOVA Table Regression Analysis (Simultaneous F-test)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11,169,786	5	2,233,957	9.196	0.002[a]
	Residual	2,429.358	10	242,936		
	Total	13,599,144	15			

a. Predictors: (Constant), topographic Average, Total Population 2011, Population Density 2011, Public Facilities 2011, Difference in Population Density 2021 and 2011

Table 6. Regression Analysis: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.906[a]	0.821	0.732	15.586

Predictors: (Constant), Topographic Average, Total Population 2011, Population Density 2011, Public Facilities, Difference in Population Density 2021 and 2011.

Based on Table 6, it obtained a value of 0.821 for R squared. The value of R Square will be equal to 82.1% when multiplied by 100%. The partial T-test and concurrent F-test results can be obtained from the regression equation when they are combined with the impact on the built-up land in 2022. Correlation analysis was also performed in this study. The results obtained based on correlation analysis are as follows (Table 7).

Table 7. Correlation Analysis

Model		Population Density 2011	Total Population 2011	Public Facilities 2011	Difference in Population Density 2021 and 2011	Topographical Average	Development of Built-up Land 2022
Population Density 2011	Pearson Correlation	1	0.110	-0.252	0.488	-0.559*	-0.849**
	Sig. (2-tailed)		0.686	0.347	0.055	0.024	0.000
	N	16	16	16	16	16	16
Total Population 2011	Pearson Correlation	0.110	1	0.745**	-0.010	-0.135	0.111
	Sig. (2-tailed)	0.686		0.001	0.972	0.617	0.681
	N	16	16	16	16	16	16
Public Facilities 2011	Pearson Correlation	-0.252	0.745**	1	-0.122	0.243	0.428
	Sig. (2-tailed)	0.347	0.001		0.652	0.365	0.098
	N	16	16	16	16	16	16
Difference in population density 2021 and 2011	Pearson Correlation	0.488	-0.010	-0.122	1	-0.339	-0.226
	Sig. (2-tailed)	0.055	0.972	0.652		0.198	0.400
	N	16	16	16	16	16	16
Topographical Average	Pearson Correlation	-0.559*	-0.135	0.243	-0.339	1	0.467
	Sig. (2-tailed)	0.024	0.617	0.365	0.198		0.068
	N	16	16	16	16	16	16
Development of built-up land 2022	Pearson Correlation	-0.849**	0.111	0.428	-0.226	0.467	1
	Sig. (2-tailed)	0.000	0.681	0.098	0.400	0.068	
	N	16	16	16	16	16	16

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed)

The table of the correlation analysis shows that the significance value in the correlation analysis of the 2011 population density variable had a significance value of 0.000 (<0.05), meaning that the population density variable had a correlation with or influence on the development of built-up land in 2022. Other variables, namely the number

of residents in 2011, public facilities in 2011, topographic averages, and the difference in population density in 2021 and 2011, had a significance value of >0.05, meaning that these variables did not correlate with or affect the development of built-up land in 2022. The direction of the relationship between each bivariate independent variable is positive and negative. The 2011 population density variable (-0,849) and the 2021 and 2011 population density differences (-0,226) were negatively related to the development of built-up land with no correlation. The 2011 population variable (0.111) was positively related to the development of built-up land in 2022 with no correlation degree, while the 2011 public facilities variable (0.428) and the topographic average (0.467) were positively related to the development of built-up land with a moderate degree of correlation relationship. Regression equations that can be made based on free variables are as follows.

$$\begin{aligned} Y = & 49.517 - 0.006(X1) + 0.000(X2) + 0.035(X3) \\ & + 0.003(X4) + 0.009(X5) \end{aligned} \tag{3}$$

The constant value of linear regression analysis is the value of the dependent variable Y when all variables X1 are zero. Based on regression analysis, it obtained a regression equation value of 49,517. The value indicates that if the value of the independent variable is zero or has no effect, then the value of the dependent variable is 49,517.

The value of the regression coefficient variable X1 (population density) was -0.006, meaning that for a decrease of one unit X1, the building area was reduced by 0.006 with other variables fixed. The population variable X2 had a regression coefficient of 0.000, which means that if other variables are held constant, the area of built-up land increases by 0.000 if X2 rises by one unit. The regression coefficient value for variable X3 (public facilities) was 0.035, which means for every increase of one unit of X3, built-up land area increases by 0.035, assuming other variables are considered constant. The regression coefficient value of variable X4 (topographic average) was 0.003, which means that for each increase of one unit of X4, the area of built land increases by 0.003, assuming other variables are considered constant. The value of the regression coefficient of variable X5 (difference in population density in 2021 and 2011) was 0.009, which means for every increase of one unit of X5, the area of built land increases by 0.009, assuming other variables are considered constant.

The influence of the independent variables used was 82.1% at the time of presentation, so the independent variables had a total influence of 82.1% on the development of built-up areas in Semarang city in 2022, while the rest of the percentage was a variable that was not used in this study.

4 Conclusions

In Semarang, built-up land increased from non-built to built during the period of 2011 to 2022, from an initial area of 15,291.454 ha to 20,945.31 ha. The development of built-up land appears to be in sub-districts located in the suburbs of Semarang. The highest level of development is located in the Genuk subdistrict (81.37) (Catanese & Snyder, 1989), Mijen subdistrict (79.38), and Ngaliyan subdistrict (71.53). The development of built-up land in Semarang was dominated by residential and industrial areas.

The lowest level of development was located in the district of Central Semarang (0.14). Based on the results of multiple linear regression analysis, it attained the equation $Y = 49.517 - 0.006(X1) + 0.000(X2) + 0.035(X3) + 0.003(X4) + 0.009(X5)$ with R^2 value of 0.821. This value shows that free variables (population density, population, public facilities, and topographic averages) had an influence of 82.1% on the development of built-up land in Semarang in 2022, while the remaining 17.9% are due to other factors that are not explained in this study.

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