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Measuring the changes of peri-urban areas in Bogor Regency by multivariate analysis

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Measuring the changes of peri-urban areas in Bogor Regency by multivariate analysis

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Abstract. Bogor Regency borders several cities on the outskirts of Jakarta and Bogor City. This location explains the rapid developments that Bogor is experiencing. Notably, in line with the development of Jakarta and Bogor, people search for alternative locations to live in this regency. As a consequence,the conversion of land from agricultural into residential areas is taking place at an alarming rate. This is an issue the local government must consider. This research determined the changes inperi-urban areas in Bogor Regency by using multivariate analysis. This method was selected because of the availability of a large data set in Bogor Regency, mainly village potential data (PODES). Multivariate analysis can be used in determiningthe changes of peri-urban areas through factor analysis, principal component analysis, cluster analysis, and the mapping of peri-urban areas usingvillage potential data from 2011 and 2014. The study used 12out of 34 available variables to identify peri-urban areas in Bogor Regency. From a total of434 villages in Bogor Regency 82 villages were categorized as peri-urban in 2011, whereas by 2014, there were 288 peri-urban villages. Consequently, the number of villages categorized as rural decreased from 332 to125. These results indicatedthat the method is successful inshowing the development of a region. As such,itcan be used for drafting policies for rapidly developing areas.

1. Introduction

Currently, the rapid conversion of rural areasinto peri-urban regions is caused by population growth. One of the indications of this is the higher rate of population growth in urban areas; this pattern is also evident in Indonesia. The number of urban dwellers in Indonesia is on the rise as shown by the increasing share of the population living in urban areas and the growing total population in Indonesia. In 1971, the urban share of the population was 17.42%, whereas in 2010 this percentage increased to 42.15%. This condition has resulted in a high demand for residential areas to accommodate the growing population.

The limited amount of land in urban areas forces people to look for alternative areas for living, e.g., the areas surrounding the cities. As a result, these urban areas expand toward their periphery. This phenomenon also leads to the conversion of productive agricultural areas. The continuous conversion of land has created mixed areas in the peri-urban areas around the cities. In fact, areas of this type continue to increase. As Woltjer [1] said, the extension of urban activities has formed peri-urban areas beyond existing administrative boundaries in urban regions. Governments must pay attention to peri-

urban areasbecause, in time, these will develop into urban areas. On the other hand, the amount of land for agriculture reduces and the new town that is formed may not be well-planned.

Bogor Regency shares a border with several cities on the outskirts of Jakarta and Bogor City. A significant part ofthe Bogor Regency is made up of agricultural areas but the regency is experiencing rapid developments. In line with the development of Jakarta and Bogor City, some of the population from these cities are looking for alternative areas to live in Bogor Regency. Consequently, the rapid conversion of agricultural land use in residential areas is taking place at an alarming rate. The government must draft policies to anticipate the problems that may arise caused by this phenomenon. The first step in developing such a policy is to determine which areas are categorized as peri-urban.

There is an abundance of data available on the Bogor Regency that can be used to determine the extent of peri-urban areas. The question is what kind of method is suitable for determining peri-urban areas by bundling data, which can be used as the basis for policy in this regency. This research aims to identify peri-urban areas in the Bogor Regency and the dimension of peri-urban space by using multivariate analysis.The result of the research is the determination of the peri-urban areas of Bogor Regency. This information may be used for formulating development policies for areas that are experiencing rapid development such as Bogor Regency.

2. Literature review

There are three generic dimensions to peri-urban development, i.e., peri-urban space (the spatial expression of peri-urban development), peri-urban life (the functional appearance of land uses, activities and peri-urban innovation), and peri-urban change (a more causal and temporal perspective featuring flows and drivers of change) [1].

Schwartz and Hecking [2] used multivariate statistical analysisfor determining the geographic origins of agricultural products. It is an analytical instrument that can determine more than one component at a time in a sample. Moreover, there has been a great increase in recent years in the information available for decision making. Much of it requires multivariate statistical techniques to convert the data into knowledge [3]. Supranto [4] argued that each problem has more than one causal factor.

Dependency analysis is used to explain the impact of the causal factor onthe problem. Whereas, interdependence methods can cluster great amounts of data through factor analysis and cluster analysis. Usually, multivariate data analysis isused by businesses that face great amounts of data in decision-making. Nowadays, planners use the method to determine the structure of regions. For instance, Kasikoen[5] demonstrated that multivariate data analysis can be used for the identification of rural-urban areas in West Java Province, Indonesia. The results of this statistical analysis were compared with the land use in West Java Province and showed a very similar pattern. Furthermore, SPSS can be used for multivariate analysis [6].

3. Conceptual framework

3.1. The process

This research aims to determine the changes in peri-urban areas in the dimensions of peri-urban space in Bogor Regency using quantitative methods. The selection of this method is based on village potential data (PODES). Moreover, multivariate analysis is used to determine the peri-urban area through factor analysis, principal component analysis, cluster analysis, and mapping of peri-urban areas. Figure 1 presents the research design.

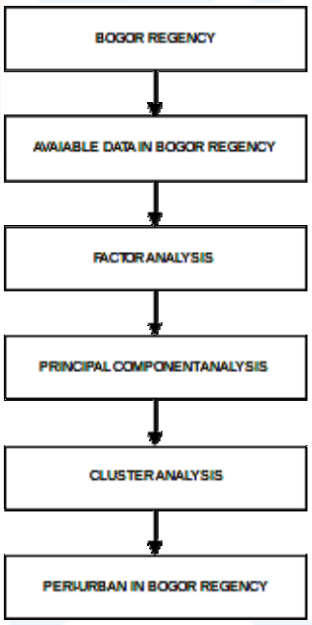


Figure 1. Research design.

3.2. Factor analysis and principal component analysis

Multivariate analysis is the analysis of multiple variables in a single relationship or set of relationships. Whereas, factor analysis is a statistical approach that can be used to analyze the interrelationships among a large number of variables. It can explain these variables in terms of their common underlying dimensions [3]. Factor analysis is based on a process of extraction, to obtain one or more factor.The principal component analysis is an example of a factor extraction method[7]. The basic concept of PCA is transforming a group of original variables into smaller groups of variables through alinear combination that considers the greatest variance from the original data. The PC_1 or the first factor is defined as follows: [8]

$$PC_1 = W_{i1}X_1 + W_{i2}X_2 + \ldots + W_{ip}X_p$$

Where:

PC_1 = prediction of1st factor (based on the value of variable X with W1 coefficient)

W_i = weighted or coefficient of factor i

p = the amount of variable

PCA allows the selection of the weight or factor score coefficients in such a way that the first factor explains for the majority of all variance or absorbs the majority of the variance of the whole variables. Subsequently, the second set may be chosen so that the second factor may absorb most of the remaining variance with the condition that the second factor has a correlation (orthogonal) with the first factor. The subsequent selection of factors follows the same pattern[4].

3.3. Cluster analysis

Cluster analysis is a technique to classify objects or respondent cases into a relatively homogenous group called a cluster. Objects within a group tend to be similar, while they are different from other objects or clusters [4]. Cluster analysis is the process ofcombining variables with similar attributes into groups in such a way that the degree of association between two variables is highest if they belong to the same group,whereas, the degree of association is minimal if they are in other groups[9]. In regional planning, an area can be determined as rural, peri-urban and urbanby using cluster analysis.

4. Results and data analysis

4.1. Overview of the region

Bogor Regency is one of 18 regencies and 9 cities in West Java Province. Bogor Regency borders several cities on the outskirts of Jakarta and Bogor City. In the north, Bogor Regency borders Depok City; in the west Lebak Regency; in the east Purwakarta Regency; in the south Sukabumi Regency; in the northwest Tangerang Regency and South Tangerang City; in the northeast Bekasi Regency; and in the southeast Cianjur Regency. The orientation of the Bogor Regency can be seen in Figure 2.

Figure 2. Orientation and the borders of Bogor Regency.

In 2014, Bogor Regency comprised 40 districts that were made up of434 villages/*kelurahan,* covering an area of 2301.95 km^2. Figure 3 shows the administrative borders of each village.

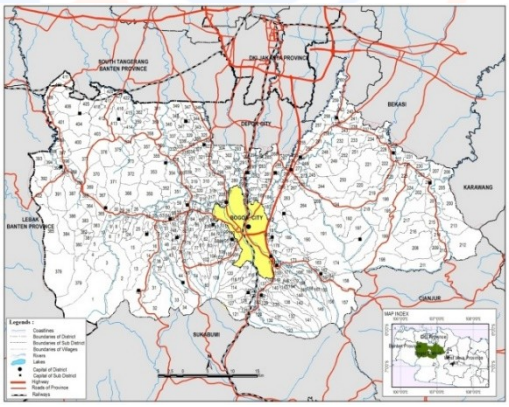


Figure 3. Administrative map of Bogor Regency.

The total population of Bogor Regency in 2017 was 5,715,009 with a density of 2,482 people per km^2. The average population growth per year was 2.86% between 2007 and 2017. The highest density is found in the Bojonggede Sub-District which is located in the south of the regency along the arterial road to Jakarta andBogor City with a density of 11,389 people per km^2. The lowest density is found in Tanjungsari Sub-District which lies in the southeast of the regency bordering with the Cianjur Regency. This sub-district has a density of 5,069 people per km^2.

In the year 2012, the land use for paddy fields was 18% of the total area of the regency. In 2015, the percentage as paddy field has declined to 6.60% of the area. This indicates a conversion from rural to built-up land, especially in peri-urban areas. In 2017, the manufacturing sector had the largest contribution to the GRDP of Bogor Regency at 54.07%, whereas the agriculture sector only contributes 5.33%. The trends in total population, land use, and economic activity indicate that Bogor Regency is experiencing a conversion from rural areas into peri-urban areas.

4.2. Analysis

The first step of the research is to select data from more than one hundred available variables of village potential data (PODES) in the years 2011 and 2014. There are 34 data variables that can be used for the determination of peri-urban areas. The second step is the selection of the dominant variables which explains high variance by factor analysis. The variable can replace the bundle of data without reducing information. The factor analysis reduces the 34 available variables down to 12 variables that are suitable for determining the peri-urban area in Bogor Regency, as shown in Table 1.

Table 1. The selected relevant variables out of original variable. Data processing from PODES 2011 and PODES 2014.

Variables	Name	Code
X1	Total population	PENDUDUK
X2	Total number of family units per village with access to electricity from the State Electricity Company	KEL_PLN
X3	Total number of kindergartens/or similar per village	TK
X4	Total number of elementary schools/or similar per village	SD
X5	Total number of secondary schools/or similar per village	SLTP
X6	Total number of High Schools/or similar per village	SLTA
X7	Total number of universities per village	PT
X8	Totalnumber of policlinics per village	POLINDES
X9	Total number of centers for pre- and postnatal healthcare information for women and children under five (*Posyandu*) per village	POSYANDU
X10	Total number of pharmacies per village	APOTEK
X11	Total number of mosques per village	MESJID
X12	Total number of Islamic secondary schools per village	MAD_DIN

The next step is the principal component analysis. It is a method for data extraction that has been selected by factor analysis, that forms one or more factors. PCA results in four factors that have eigen values greater than one from a total of twelve factors. These factors are: (1) the total number of family units per village with access to electricity from the State Electricity Company; (2) the total number of kindergartens/or similar per village; (3) the total number of elementary schools/or similar per village; and (4) the total number of secondary schools/or similar per village. The total explained variance is presented in Table 2 and Table 3.

Table 2. Total explained variance in 2011.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.231	43.588	43.588	5.231	43.588	43.588
2	1.318	10.981	54.569	1.318	10.981	54.569
3	1.186	9.884	64.452	1.186	9.884	64.452
4	1.015	8.459	72.911	1.015	8.459	72.911
5	0.76	6.337	79.248			
6	0.636	5.304	84.551			
7	0.528	4.402	88.953			
8	0.388	3.229	92.183			
9	0.337	2.81	94.993			
10	0.278	2.318	97.311			
11	0.232	1.934	99.245			

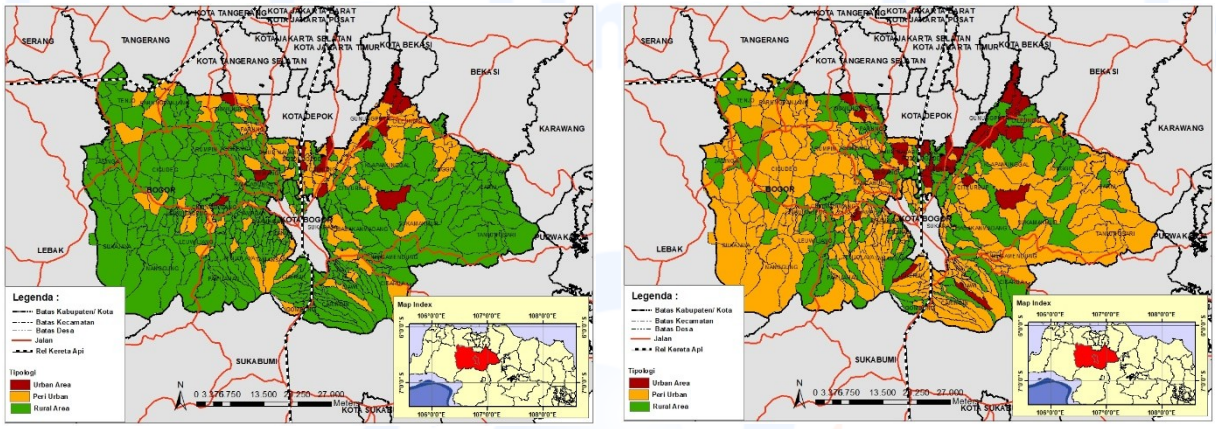
Table 3. Total explained variance in 2014.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.612	38.433	38.433	4.612	38.433	38.433
2	1.324	11.036	49.468	1.324	11.036	49.468
3	1.145	9.543	59.012	1.145	9.543	59.012
4	1.131	9.425	68.437	1.131	9.425	68.437
5	0.972	8.102	76.539			
6	0.813	6.773	83.312			
7	0.593	4.941	88.253			
8	0.44	3.67	91.923			
9	0.403	3.36	95.284			
10	0.287	2.391	97.675			
11	0.209	1.742	99.417			

Using data from the four factors above, the last step of cluster analysis is processing. The villages in Bogor Regency are divided into three clusters which are urban, peri-urban and rural areas. The results of this analysis show that in 2011, 12 villages werelocated in urban areas, 82 villages were located in peri-urban areas and the remaining 332 villages were located in rural areas. In 2014, 21 villages were found in urban areas, 288 villages in peri-urban areas and the other 125 villages were areas. Table 4 shows the results of the cluster analysis in 2011 and 2014, whereas Figure 4 illustrates the geographical implications of the results. All multivariate data analysis uses SPSS ver. 22.

Table 4. Peri-urban area in Bogor Regency using multivariate analysis in 2011 and 2014.

Area	2011	2014
Urban	12	21
Peri-Urban	82	288
Rural	332	125



The Determination of Peri-urban Areas in 2011. The Determination of Peri-urban Areas in 2014.

Figure 4. The determination of peri-urban areas in 2011 and 2014.

5. Conclusion

- It is possible to determine peri-urban areas based on a large data set by analyzing the data using multivariate analysis.
- There have been significant changes from rural areas to peri-urban areas between 2011 and 2014 in Bogor Regency. The location of the Bogor Regency can explain this conversion as it is a buffer zone for large cities such as Jakarta and Bogor. The change to peri-urban areas has an impact on the reduction of agricultural land, which, in turn, reduces water infiltration in the area.
- The very rapid land use change from agricultural areas to residential areas has many spatial implications. Therefore, it is important to determinethe peri-urban areas in Bogor Regency as input for the drafting of development policies in Bogor Regency.

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