Assessing Geographical Characteristic of Agricultural Land Conversion: A Spatial Analytical Approach

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ABSTRACT
Agricultural land conversion is a global and inevitable phenomenon. On the other hand, agricultural land is a fundamental asset and resource for those who depend on the agricultural sector for their livelihood. Preservation of agricultural land or controlling agricultural land conversion is a must. Therefore, information regarding the conversion of agricultural land and its related aspects is essential to support focused preservation. The main objective of this study is to explore the characteristic of agricultural land conversion. The study was conducted in the vicinity of Yogyakarta City that is the area inside the ring road of Yogyakarta. A spatial analytical approach was applied to obtain information regarding converted agricultural land's spatial distribution between 2000 and 2020 and its locational attributes. The study revealed that converted agricultural land is mainly located near the ring road of Yogyakarta, near main roads, and close to existing built-up or developed areas. In addition, the intensity of agricultural land has a strong relationship with distance to the ring road (R=0.97), main roads (R=0.98), and existing built-up areas (R=0.91). Those three geographical characteristics could be valuable variables for further research, particularly for predicting the location of agricultural conversion in the study area in the future.

Keywords: *Geographical Characteristics, Agricultural Land Conversion, Spatial Analytical Approach, Yogyakarta*

1. INTRODUCTION

Agricultural land conversion is a global phenomenon. Globally, many agricultural lands have been converted to residential, commercial, and urban uses [1,2]. The conversion is driven by multiple factors,e.g., economic, political, biophysical, and culture. Therefore, the phenomenon is considered as a result of multi interactions among those factors [3]. On the other hand, agricultural land is a fundamental asset and resource for those who depend on the agricultural sector for their livelihood. Therefore, preservation of agricultural land or controlling agricultural land conversion is a must. Information regarding the conversion of agricultural land and its related aspects is essential to support focused preservation.

Studies regarding agricultural land and its conversion have been conducted by scholars. They are diverse in terms of spatial extents, approach, methods, and concerns. From a spatial extents perspective, the study area varies from global, regional, and local. At the global level, studies about agricultural land can be seen, among others, in the GFSAD (Global Food Securitysupport Analysis Data) project. Information related to the project has been published and could be widely accessed [4,5]. Studies at the regional or country-level could be found in several publications, including cropland in South Asia [6] and the study of agricultural land conversion in Indonesia [7]. From the aspects related to agricultural land conversion, some research focuses on the social, economic, and cultural [1,3,8]. From the methodological perspective, some research examined the decision-maker or stakeholder perspective through interviewing their opinion. Other research explores certain information by utilizing remote sensing data at different spatial and temporal resolutions [9,10,11].

Studying the phenomenon of agricultural land conversion at a local level or site-specific, particularly from a spatial analytical perspective, will provide different insights. Every agricultural land has its characteristics. The characteristics could be internal (intrinsic) or external (extrinsic). The inherent quality of the soil is an example of internal, while attributes related to the location of agricultural land are considered external or extrinsic. Attributes of land concerning its location could be termed as geographical characteristics. Other

terms may name these characteristics, i.e., locational attribute [2] or spatial factors [12]. The characteristic could be assessed using a combination of mapping and spatial analysis. Remote sensing imagery provides data for mapping. The spatial analysis provides an analytical framework for using a map as a basis for obtaining information. The main objective of this study is to assess agricultural land conversion and its geographical characteristics. Converted and yet unconverted agricultural land may have different locational characteristics. Assessment of these characteristics may provide a valuable contribution in the study of agricultural land conversion, e.g., identification of conversion vulnerability. Further, this information could be used as a basis for predicting the conversion in the future.

2. METHODS

2.1. Study Area

The study area is situated in the vicinity of Yogyakarta City (Figure 1). Instead of using administrative division, a physical object, i.e., the ring road of Yogyakarta, is used to delimit the study area's boundary. In this study, the area inside the ring road of Yogyakarta is termed as Yogyakarta urban area.

Area "inside" the ring road of Yogyakarta administratively consists of the whole area of Yogyakarta City and part of Bantul and Sleman Districts. Despite urban development in the "outside" of the ring road, the inside area is considered mainly influenced by Yogyakarta City's growth. As urban growth or expansion mainly change the land use, agricultural land in this area is highly vulnerable to conversion.

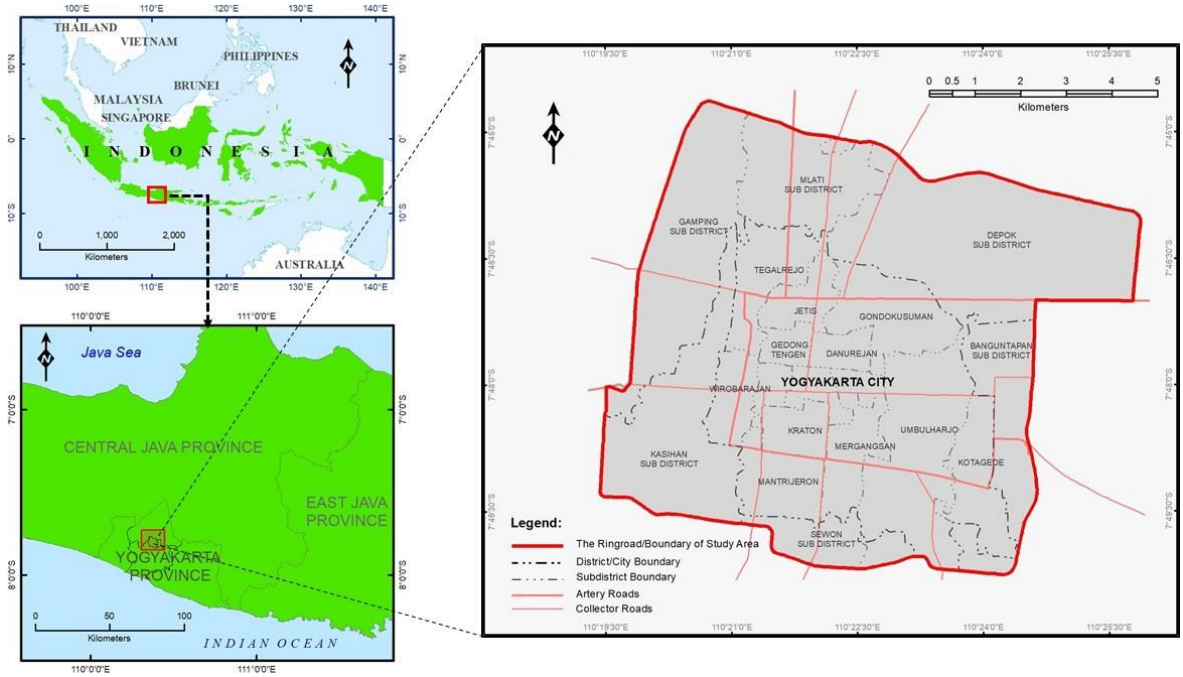

Figure 1 Study area: the area in the vicinity of Yoyakarta City and inside the ring road of Yogyakarta

2.2. Mapping The Agricultural Land Conversion

Multitemporal maps of agricultural land, i.e., 2000 and 2020, were used as a basis for analyzing the conversion. Those maps were obtained from 1: 20.000 aerial photographs and high-resolution remote sensing imagery. Certain land use types, mainly paddy or rice fields and dry fields, were identified from the imageries and classified into agricultural land. Other types of land use are considered non-agricultural land. Identification of agricultural and non-agricultural land was performed by using a visual interpretation technique.

A spatial analysis technique, i.e., map overlay, was performed against maps of agricultural land 2000 and 2020. This analysis produced a new map which termed a map of agricultural land conversion 2000-2020. The map shows the spatial distribution of agricultural land conversion in the study area between 2000 and 2020.

Figure 2 shows the process of mapping the agricultural land conversion 2000-2020 in the study area.

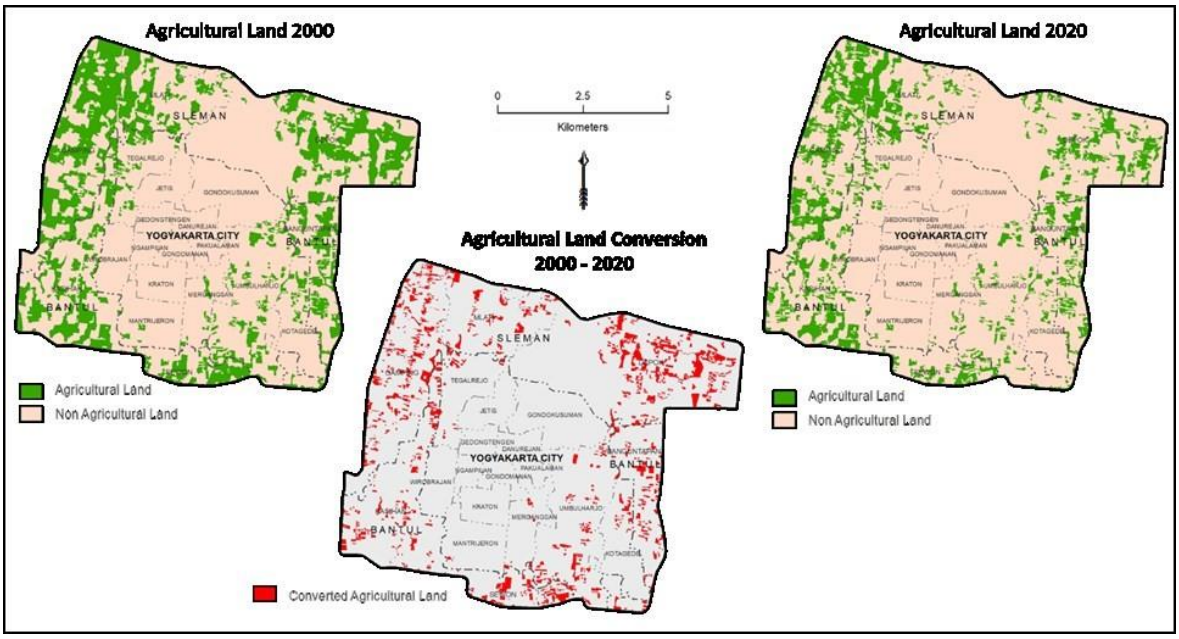

Figure 2 Mapping the agricultural land coversion in the study area between 2000 and 2020

2.3. Mapping The Descriptor of Geographical Characteristic

The term geographical characteristic of agricultural land conversion, in this study, has a similar meaning with spatial pattern characteristic or locational attribute. However, instead of describing the spatial pattern, e.g., random, clustered, or regular, this study describes the converted and yet unconverted agricultural land using some descriptor. Certain spatial aspects were mapped and used as a basis for describing the agricultural land conversion. In this study, five spatial aspects are used as descriptors, i.e., distance to the ring road, distance to the urban center or urban core, distance to the main road, distance to built-up land, and roads density. Maps of those descriptors were created using spatial analysis techniques termed euclidean distance analysis and line density analysis.

Figure 3 shows maps of geographical descriptors. The urban center or urban core was defined based on the smallest administrative unit, i.e., urban village (kelurahan). Urban villages in Yogyakarta City that do not have agricultural land were selected, then merged into a single polygon and termed the urban center or urban core. Main roads consist of artery and collector roads. All road types, i.e., artery, collector, and local roads, were used in analysis to generate a road density map. In addition to those five maps, a map termed a geographical zone was created. This map is considered helpful in describing the spatial distribution of agricultural land conversion.

2.4. Spatial and Statistical Analysis of Geographical Characteristic

Geographical characteristics of agricultural land conversion were analyzed using a combination of spatial and statistical analysis. Analysis was conducted in four main steps. The first step was map overlay. The agricultural land conversion 2000-2020 map was overlayed with administrative and geographical zone maps. This process produced detailed information about the quantitative aspect of agricultural conversion and its spatial distribution. The second step was the generation of a point map. Agricultural land 2000 and agricultural land conversion 2000-2020 maps were converted into a point map (Figure 3). This map contains a number of points where each point represents a portion of the land of 50 m x 50 m in size. Each point falls into one of the two conversion categories, i.e., converted and yet unconverted agricultural land. The third step was map values extraction. Maps of geographical descriptors served as input of this process, and the point map served as extracting features. The values of input maps were extracted and embedded into the attribute table of the

point map. For the purpose of statistical analysis, the attribute table was saved as a spreadsheet file. The fourth or last step was statistical analysis. The spreadsheet containing geographical descriptor values was then analyzed using a statistical analysis technique.

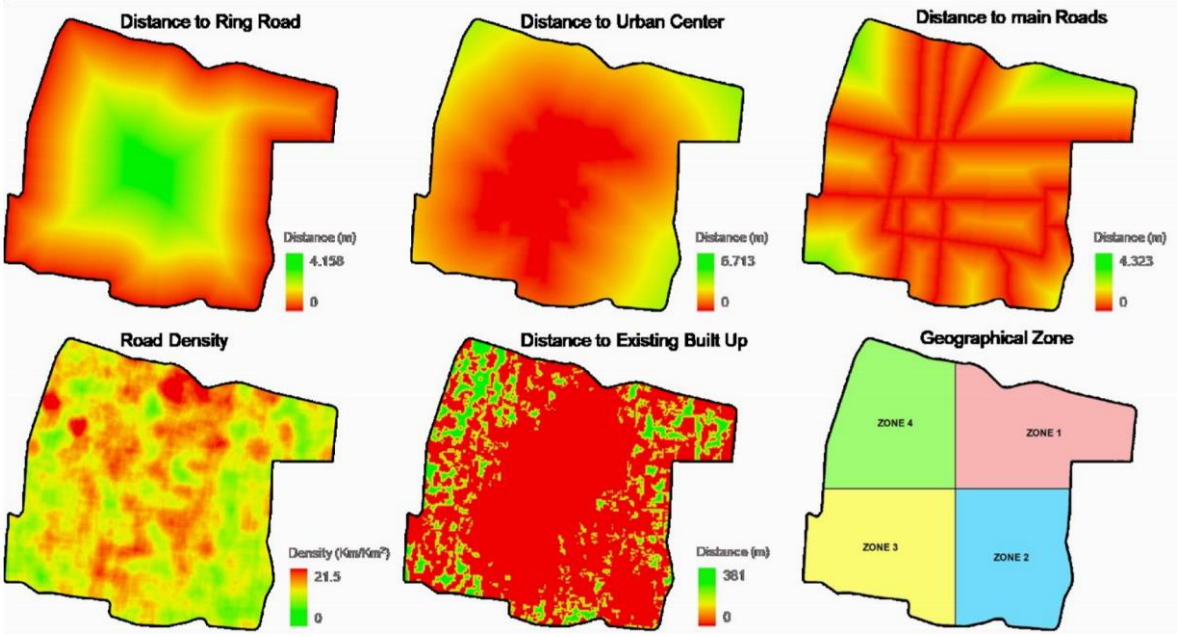

Figure 3 Maps of geographical descriptors of agricultural land conversion

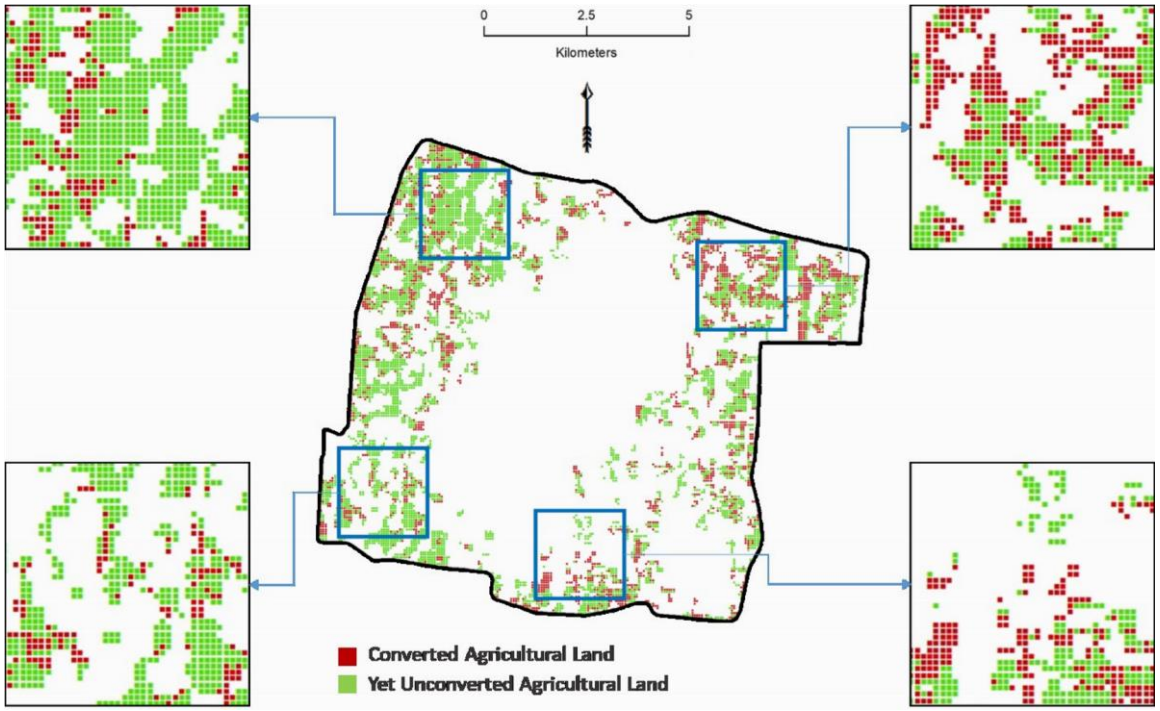

Figure 4 Point maps as a basis for spatial and statistical analysis of the geographical characteristic

3. RESULT AND DISCUSSION

3.1. Agricultural Land Conversion in the Study Area

Between 2000 and 2020, 650.1 hectares of agricultural land in the study area have been converted into nonagricultural land. This conversion was equal to 32% of the total agricultural land in the study area in 2000. Agricultural land in 2000 was primarily located in the northeastern and northwestern parts of the study area. About 60.69% of total agricultural land is situated in this part. A similar pattern applies to the spatial distribution of agricultural land conversion. Approximately 62.25% of total agricultural land conversions have occurred in the northeastern and northwestern parts of the study area. Detailed information about the spatial distributions was described using a particular spatial unit. Table 1 shows the spatial distribution of agricultural land and its conversion according to geographical zone and administrative divisions.

Table 1. Spatial Distribution of Agricultural Land in 2000 and Conversion 2000-2020

Zone	Geographical Position	Administrative Division		Agricultural Land Year 2000		Conversion 2000 - 2020	
		District	Sub District	(Ha)	(%)	(Ha)	(%)
1	Northeast	Bantul	Banguntapan	29.19	1.45	3.33	0.51
		Sleman	Depok	414.87	20.59	189.49	29.15
			Mlati	13.56	0.67	6.02	0.93
			Nganglik	0.46	0.02	0.46	0.07
		Yogyakarta City	Umbulharjo	1.91	0.09	1.29	0,20
		Sub total Zone 1		**459,99**	**22.83**	**200.59**	**30.86**
2	Southeast	Bantul	Banguntapan	212.24	10.53	77.39	11.90
			Sewon	13.63	0.68	7.76	1.19
		Yogyakarta City	Gondokusuman	0.96	0.05	0.00	0.00
			Kotagede	33.03	1.64	11.89	1.83
			Mergangsan	11.99	0.60	3.25	0.50
			Umbulharjo	133.07	6.61	55.12	8.48
		Sub total Zone 2		**404.91**	**20.10**	**155.42**	**23.91**
3	Southwest	Bantul	Kasihan	279.56	13.88	56.62	8.71
			Sewon	52.27	2.59	23.00	3.54
		Sleman	Gamping	45.14	2.24	7.30	1.12
		Yogyakarta City	Mantrijeron	6.83	0.34	1.21	0.19
			Wirobrajan	3.22	0.16	1.89	0.29
		Sub total Zone 3		**387.01**	**19.21**	**90.02**	**13.85**
4	Northwest	Bantul	Kasihan	41.12	2.04	20.39	3.14
		Sleman	Depok	0.57	0,03	0,00	0,00
			Gamping	477.06	23,68	127,43	19,60
			Mlati	191.33	9,50	43,65	6,72
			Ngaglik	0.23	0,01	0,23	0,04
		Yogyakarta City	Tegalrejo	52.42	2,60	12,37	1,90
		Sub total Zone 4		**762.73**	**37.86**	**204,07**	**31,39**
Total Study Area				**2,014.65**	**100.00**	**650.10**	100.00

Source: Primary Data Analysis

3.2. Geographic Characteristic of Agricultural Land Conversion

Following the spatial and statistical analysis procedure using a point map, as previously explained in the methods, there were 8,055 points obtained. Each point falls into one of two categories, i.e., converted and yet unconverted agricultural land. The converted category consists of 2,619 points, while the unconverted consists of 5,436 points. Each point has several values related to particular geographical characteristics, i.e., distance to the ring road, distance to the main road, distance to the urban center, distance to built-up land, and road density. The different characteristics between converted and unconverted agricultural land could be assessed based on the variation of the values. The values were summarized using descriptive statistics, as shown in Table 2, to provide a convenience assessment.

Table 2. Descriptive Statistic of Geographical Characteristic of Agricultural Land Conversion

Geographic Characteristic	Category of Agricultural Land Related to Conversion 2000-2020							
	Converted				yet Uncoverted			
	Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev
Distance to Ring Road (m)	0.0	2,951.7	802.1	606.0	0.0	3,090.7	850.1	628.7
Distance to Main Road (m)	0.0	2,500.0	874.9	616.0	0.0	2,500.0	878.2	562.7
Distance to Urban Center (m)	0.0	4,226.7	2,007.3	976.8	0.0	4,315.7	1,894.0	974.8
Distance to Built-up Land (m)	50.0	364.0	72.0	37.0	50.0	380.8	77.3	40.3
Road Density (km/km^2)	2.9	18.9	8.1	2.6	1.7	19.6	7.8	2.3

Source: Primary Data Analysis

If we compare the mean values in Table 2, we can conclude that converted and unconverted agricultural land have different characteristics. Converted agricultural lands are closer to the ring road, main roads, and built-up land than unconverted agricultural land. Converted agricultural lands are farther to the urban center than unconverted. The road density surrounding the converted agricultural land is higher than unconverted.

Further analysis revealed the relationship between the intensity of agricultural land conversion and the geographical descriptors. A total of 650.1 hectares of converted agricultural land were represented by 2,619 points. Each point has values of distance and density variables. Specific "bins" were used to relate the intensity of agricultural land conversion with the distances and density. The points "inside a bin" were calculated and used to describe the intensity of agricultural land conversion. Correlation diagrams were generated based o this processing technique. Equation and coefficient of determination (R^2) were obtained and displayed as well.

Figure 5 shows the diagrams that portray the relationship between agricultural land conversion and geographical characteristics. The red line depicts the actual relationship, and the dashed grey line shows the trend line of the relationship. Equations and R^2 provide a quantitative indicator of the degree of the relationship. The coefficient of correlation (R)could be obtained by taking the root square of R^2 values. The diagrams revealed the strong relationship between the intensity of agricultural land conversion and the distance to the ring road (R=0.97), distance to main roads (R=0.98), and distance to existing built-up land (R=0.91). The intensity of agricultural land conversion moderately correlates with roads density (R= 0.64) and poor correlation with distance to the urban center (R=0.21).

The relationship between the intensity of agricultural land and the distance to the urban center, in this study, is somehow not in line with other studies. Since the study uses a spatial analytical approach, this probably has some association with the nature of the study area. Agricultural lands in the study area are located mainly at a distance from the urban center. Consequently, almost all the conversion has taken place far from the urban center. The study area, on the other hand, is relatively small. The combination of both situations decreases the influence of the urban center.

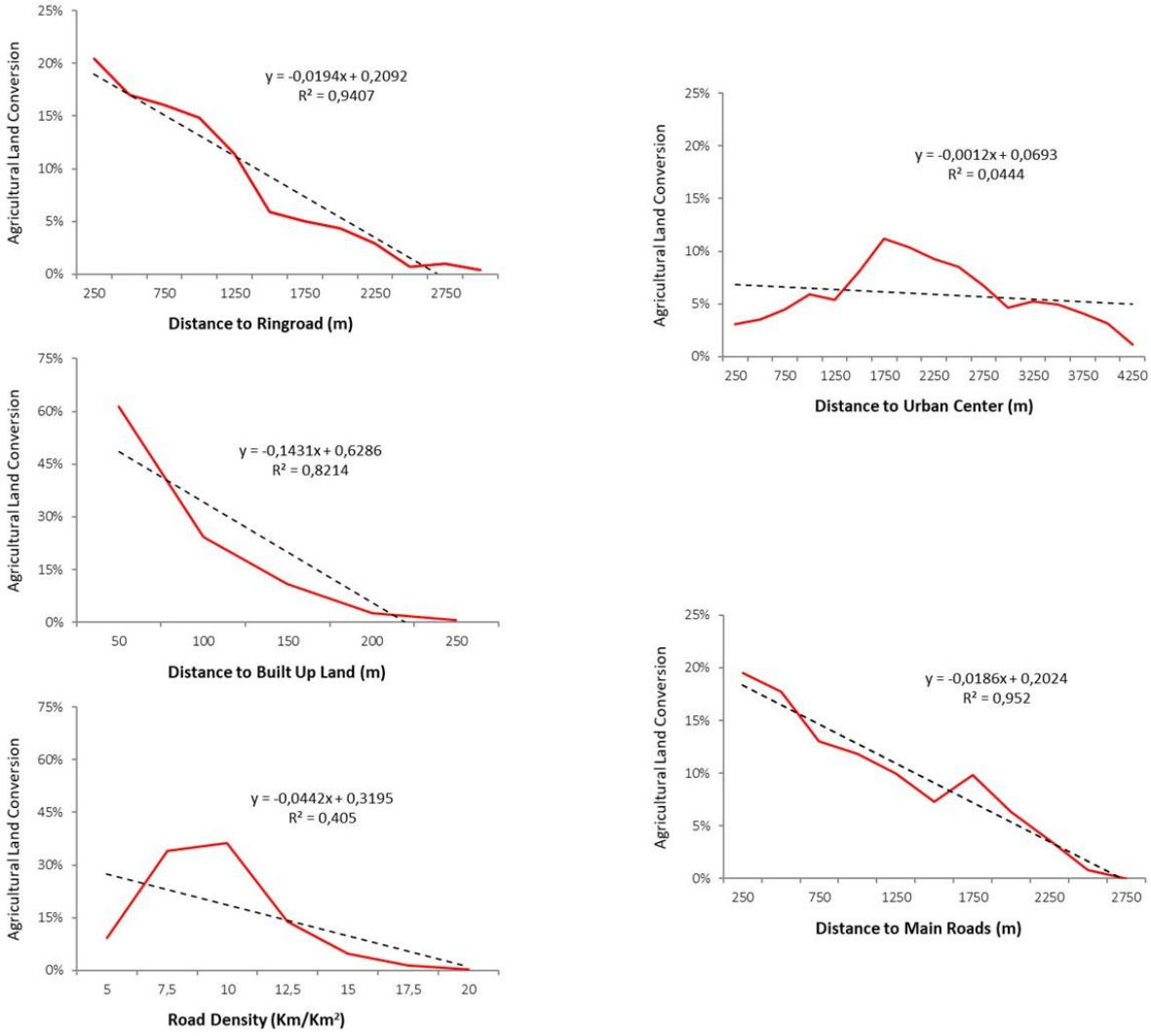

Figure 5. Relationship between agricultural land conversion and the geographical characteristics

4. CONCLUSION

In a certain period, agricultural land conversion occurs in certain locations with a certain intensity. This study employed a spatial analytical approach to assess the intensity and geographical characteristics of agricultural land conversion. This study shows that in the past 20 years, i.e., between 2000 and 2020, approximately 650.1 hectares of agricultural land in the study area had been converted into other land use types. Conversion occurred mainly in the northeastern and northwestern parts of the study area. Converted and unconverted agricultural land differs in several locational characteristics. Converted agricultural lands were located closer to the ring road, main road and developed area. In addition, conversion intensity strongly correlates with distance to the ring road, main roads, and developed area. Authorized agencies or stakeholders could utilize this information as a consideration in the agricultural land management in the study area. Further research could use the geographical characteristic in combination with other factors for predicting the spatial distribution of agricultural land conversion in the study area in the future. Spatial prediction of agricultural land conversion will be useful to support focused preservation and control of the conversion.

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