Spatio-Temporal Visualization of Land Price Change in the Greater Yogyakarta City, Java, Indonesia

Rahardjo, N.[1] **and Marhaento, H.**[2*]
[1]Faculty of Geography, Universitas Gadjah Mada, Indonesia
[2]Faculty of Forestry, Universitas Gadjah Mada, Indonesia, E-mail: marhaento@ugm.ac.id
**Correspondence Author*

Abstract
This paper analyses changes in the land distributions, patterns, prices and the causal factors affecting land price in the greater Yogyakarta city, Java, Indonesia in 1996-2011. Field survey in hundreds of sample points with a sample size of 100x100 square meter have been carried out to identify factors affecting changes in land price. In addition, reports from the government offices were used to assist the data analyses. Furthermore, by using combination between visualization model based on isoline symbol combined with isopleth symbol and multiple linear regression analysis, this study was able to visualize the changes in land price of the study area for past and future conditions. The results showed that the distance to city centre and the distance to socio-economic activities were identified as the most significant factors affecting land price. In addition, this study found that the sub-urban in the study area was currently transforming into urban area affecting changes in the land price pattern. It was also observed that in the past an increase trend of land price was toward the north-eastern area, but currently began to shift towards south-western area. Finally, it was predicted that the south-western part of the greater Yogyakarta will be the target for land buyer in the near future for which several measures are required to control an increase in the land price.

1. Introduction

With a population of over than 130 million (in 2010), Java is the most populous and densely island of the world. Over the last century, land use on Java has changed rapidly as following the rapid growth of human population. According to Verburg and Bouma (1999), land use of Java has significantly changed since the early of 20th century when the arable land was growing extensive and expanding to the upland fields followed by a migration from densely populated lowlands of Java to remote mountainous area, which transformed rural area in Java as an agricultural area. Together with continuing population growth and larger demands for housing and its facilities (e.g. roads, industrial buildings, shops and recreational parks), Java start losing its prime agricultural areas (Dyson, 1996) and forests as well (Prasetyo et al., 2009). In the past decade, Java Island has changed into a more urbanized society for which agricultural area expansion has moved to the outer Indonesian islands (Bottema, 1995).

A rapid increase of population growth in Java, Indonesia followed by an increasing demand for land in particular for settlement has increased the pressure on land (Foscue, 1983). Because land is limited, land ownership competition emerges and further affects changes in land function and usage (Ritohardoyo, 1991 and Broomhall, 1995). As a result, values of land vary in time as well as land prices (Chanond, 1987 and Abelson, 1997). Cho (2005) argue that land price in urban areas grows faster than rural areas. Besides economic factors, land prices are also influenced by factors such as non-economic social, governmental, physical, environmental, and location factors (Eckert and Gloudemars, 1990). Han and Basuki (2001) studied the spatial pattern of land value in Jakarta city and argue that the spatial variables in particular distance to the central business district were significant factors to determine the land-value patterns of Jakarta city. Helmi (2005) used satellite imagery (i.e. IKONOS) to analyse the land price patterns in Pontianak city and found that land price increases following an increase in the housing density, accessibility and utility.

Yogyakarta city is one of the most developing areas in Java, Indonesia. With its entire predicate as city of students, tourism city and city of culture, Yogyakarta becomes one of the most visited destinations in Indonesia for tourist, business as well as residence. With a high demand for land for business and residence, land price in Yogyakarta city has doubled in the last decade (pers. comm. with housing developers) giving more pressures on the land availability. Suparmono (2012) argue that land price in Yogyakarta is affected by six variables

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namely the land width, width of the nearest road, width of the nearest main road, distance to the nearest main road, distance to Yogyakarta ring road, and the travel time to Gadjah Mada University campus. However, how those variables interact each other and how the trend of spatial patterns and land price has changed in Yogyakarta city are not fully understood, requiring further study.

The main objective of this research is to analyse the spatial distributions, patterns, trends of land price change and factors affecting land price change in the greater Yogyakarta city. Furthermore, future spatial distribution of land prices in the study area is predicted. While most of researches in this topic mainly used statistical analysis to observe the relationship between variables affecting land prices, this research proposes the use of spatial analysis in combination with statistical analysis to obtain the objective. In this research, changes in the land price are visualized using models with cartographically-appropriate symbols.

2. Materials and Methods

2.1 Study Area

This research is conducted in Yogyakarta city and surroundings (i.e. sub-districts adjacent to Yogyakarta city), which later called as the greater Yogyakarta. Administratively, the study area includes 14 sub-districts and 45 villages with a total area of 213.8 km² consisting 32.5 km² (15.1%) urban area and 181. 3 km² (84.9%) rural area. The greater Yogyakarta is located in zone 49S in the Universal Transverse Mercator (UTM) system, laid between 419,250 meters East and 438,750 meters East, and 9,128,000 meters North and 9,145,500 meters North. Figure 1 shows the administrative map of the greater Yogyakarta city. According to the District Statistical Bureau (BPS), population density in the peri-urban areas of Yogyakarta city has increased from 2,371 person/km^2 in 1990 to 3,889 person/km^2 in 2011 that is higher than the average provincial population density (i.e. 914 person/km^2 and 1,095 person/km^2 in 1990 and 2011, respectively) and is lower than population density in the Yogyakarta city (i.e. 12,678 person/km^2 and 12,017 person/km^2 in 1990 and 2011, respectively).

2.2 Data Acquisitions

In this study, spatial and non-spatial data were used. For the spatial data, IKONOS imageries with a spatial resolution of 80 cm for the year 2008 were available for mapping land parcels at a detail scale. The topographic map contains information related to elevation, roads and locations of public facilities (e.g. hospitals, schools, and offices) and is available from the Geospatial Information Agency of Indonesia at 1:25,000 scale (i.e. sheets 1408 - 223 and 1408-224). For the non-spatial data, time-series of economics data at village level (i.e. PODES) for the study area are available for years 1996, 1998, 2000, 2002, 2004, 2006, 2008 and 2011. Changes in the land price of the study area were collected from field surveys.

This study collected data from both primary and secondary sources. Data collected from primary source included the land price data that was acquired from interviews with land owner and public figures (e.g. village leaders). During the interview, the respondents were asked about changes in land prices based on their own experiences and transactions occurred around their areas. To collect data from primary source, this study used quota sampling technique with sample point distribution as shown in Figure 2. A quota sampling technique acquires representative data from a group consisting representative individuals that are chosen out of a specific subgroup (Yang and Banamah, 2014). For each sample point, this study collected data such as land physical characteristics, factors affecting land price (i.e. area domination for each land plots, land ownership status, accessibilities toward various services like transportation, public services, social services, and health services, and constraint accessibilities like distance from cemeteries, pollution and noisy levels). In order to prevent a bias of land price change perceived by interview respondents, this study provided the respondents questionnaires with choices during personal interviews. With these choices, the respondents gave clear answers within ranges we determined. In addition, this study set up questionnaires that would be finished in a short period of time that was about 20 minute interview. This interview duration was sufficient to obtain desired information and did not burden the respondents. According to Yamarino et al., (1991), length of questionnaire may affect the response rate of respondents where longer questionnaire and interview will reduce the response rate resulting larger bias.

For data obtained from the secondary source, this study used all recorded files and reports from government offices such as District Statistical Bureau (BPS), National Land Administration Office (BPN), and District Plan and Development Bureau (Bappeda).

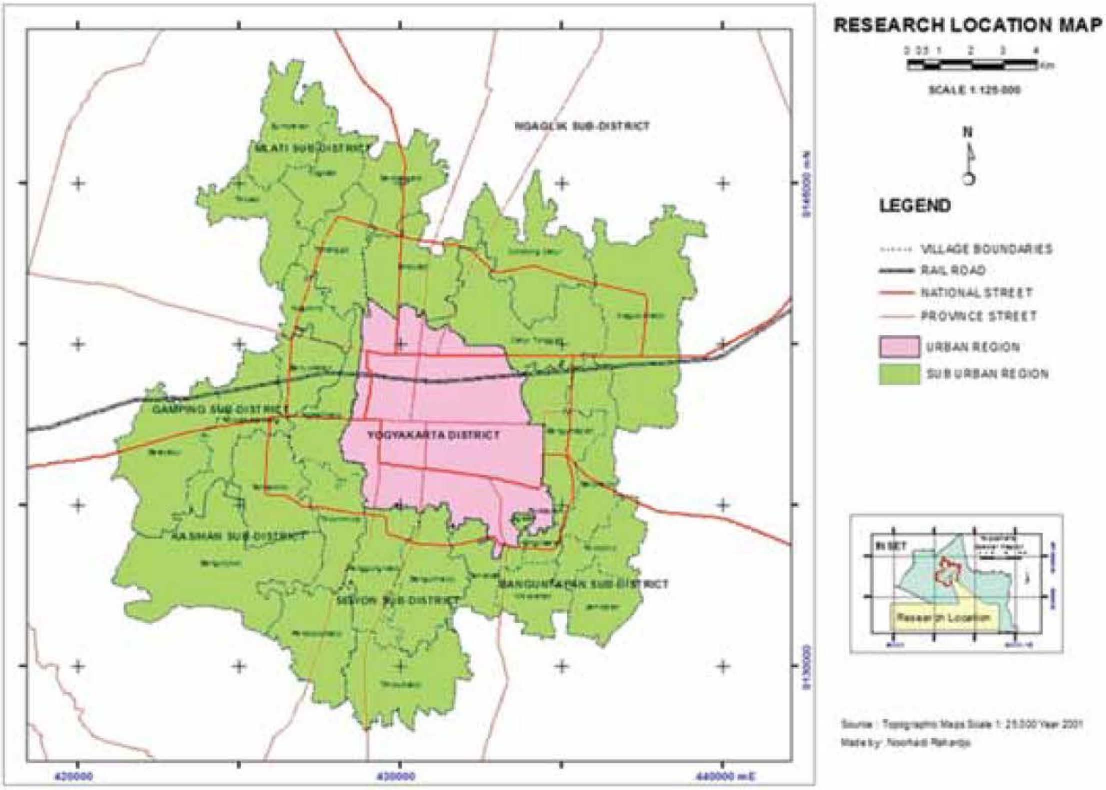

Figure 1: Administrative map of the greater Yogyakarta city

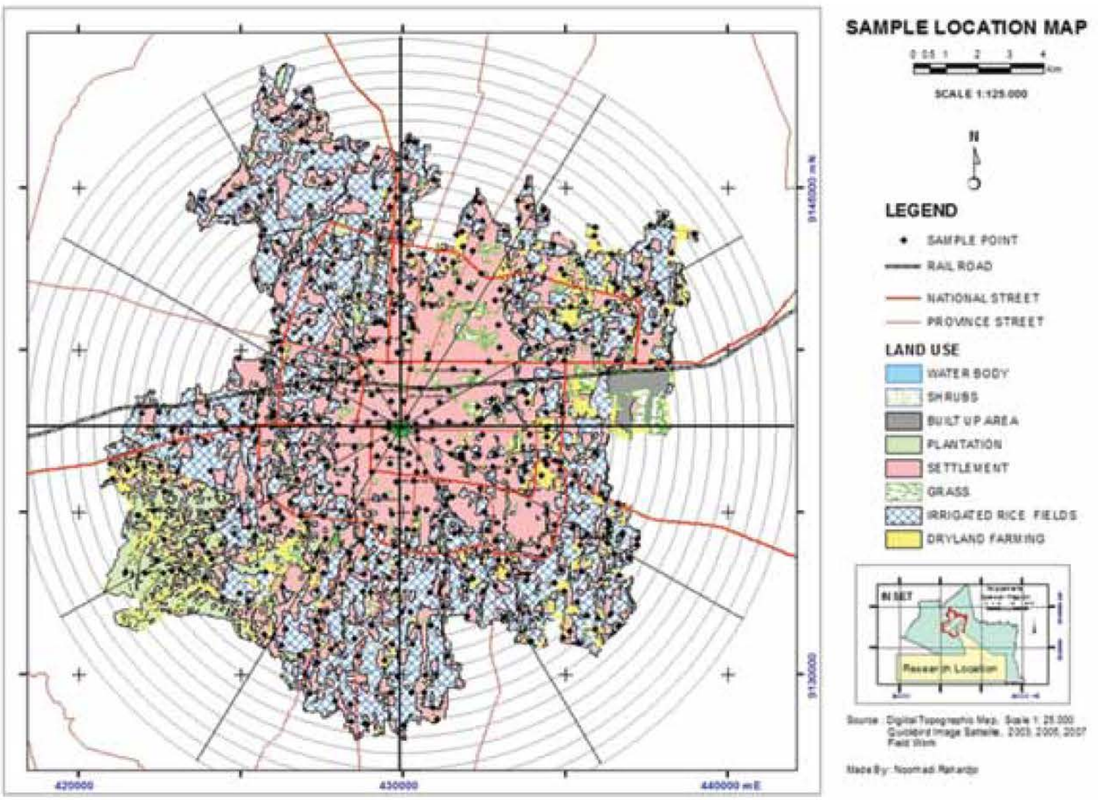

Figure 2: Point sampling distribution in the study area including the quadrant area

2.3 Methods

2.3.1 Land price visualization

As a first step, this study visualized changes in land price in form of maps following cartographic rules. There are three main consideration in visualizing data into maps namely data characteristics, symbol usage and visual variable selection. Guo et al., (2006) argue that visualizing those three aspects in spatio-temporal perspective are challenging due to limited ability to explore complex patterns across all dimensions (i.e., geographic, temporal, and multivariate spaces). The most common method to present data in spatio-temporal map is by using multivariate and temporal mapping (Grinstein et al., 1992, Dibiase et al., 1994 and Carr et al., 2005). In this method, the results of multivariate representation of each map with composite symbols and attributes of color from different point of time are combined so that may present multivariate spatial pattern.

In this study, the three aforementioned aspects were used and applied in three visualization models namely Value Indication Symbol (VIS), Isoline Map combined with Quantitative Line Symbol or Isopleth Map (IM), and Three Dimensional symbol or 3D Map (3DM). Value Indication Symbol (VIS) uses point symbols including their values to show exactly the value of certain point located on the map. Isoline map combined with Isopleth map (IM) uses combinations of two-dimensional cartographic symbolization for showing gradual change over space in order to avoid the abrupt changes in the boundary lines. Three-dimensional map (3DM) uses a digital, mathematical defined, three-dimensional virtual generalised representation of a specific area to illustrate physical features. Furthermore, this study evaluated the performance of these three different visualization models in providing a proper information on land price change based on 7 criteria (7C) namely coverage, completeness, consistency, correctness, currentness, creativity-level, and communicative. To carry out data visualization, this study used ArcGIS 10.2. IKONOS imageries and topographic map of the study area were employed to assist the model performance evaluation.

2.3.2 Changes in Distribution, Pattern, and Trend of Land Price

A time-series land price map from 1996 to 2011 (i.e. includes maps of the years 1996, 1998, 2000, 2002, 2004, 2006, 2008 and 2011) was visualized using the best visualization model selected from previous step. For each land price map, a qualitative descriptive analysis was carried out to investigate the spatial distribution and patterns of land price of the study area. Furthermore, a spatio-temporal analysis of land price change was carried out by means comparing land price maps from different years. In order to investigate the direction of the land price change, this study applied the quadrant analysis method on the geometry. First, the study areas averagely divide into 4 directions, with the geometric centre of Yogyakarta city in 2006 as the origin. Second, the land price map was superimposed with the quadrant orientation diagram to extract the land price change in 4 directions at different years. Finally, changes in land price and its trends were calculated in each block (i.e. Quadrant I, Quadrant II, Quadrant III and Quadrant IV) as can be seen in Figure 2, to analyse the space differentiation of land price change.

2.3.3 Identification of Factors Affecting Land Price

To identify factors affecting changes in land price, we initially determined nine predictors (i.e. independent variables) namely distance to the city centre (DISC), land acreage (LACR), distance to main road network (DISR), distance to public transportation (DISP), distance to settlements (DISS), distance to health facility (DISH), distance to education facility (DISE), distance to communication facility (DISM), and distance to socioeconomic facility (DISN), while land price was regarded as dependent variable. This study selected these nine predictors based on the previous studies by Ritohardoyo (1991), Broomhall (1995), Chanond (1987) and Abelson (1997) who found that these predictors were detected as the most significant factors affecting land price of a city around the world. Furthermore, a multiple linear regression was carried out to identify the relationship between a dependent variable and independent variables following the formula as follow.

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + ... + \beta_n x_n + \varepsilon$$

Equation 1

Where y is the land price variable, β is the parameters of regression line, x is the predictors and ε is the model deviations. The best model was determined based on the least square method (R^2). Furthermore, future land price in the study area was predicted based on the best regression model for the upcoming 5, 10 and 15 years.

3. Results and Discussion

3.1 Visualization Model of Land Price

Figures 3, 4 and 5 show land price map using Value Indication Symbol (VIS), Isoline Map combined with Quantitative Line Symbol or Isopleth Map (IM), and Three Dimensional symbol or 3D Map (3DM), respectively.

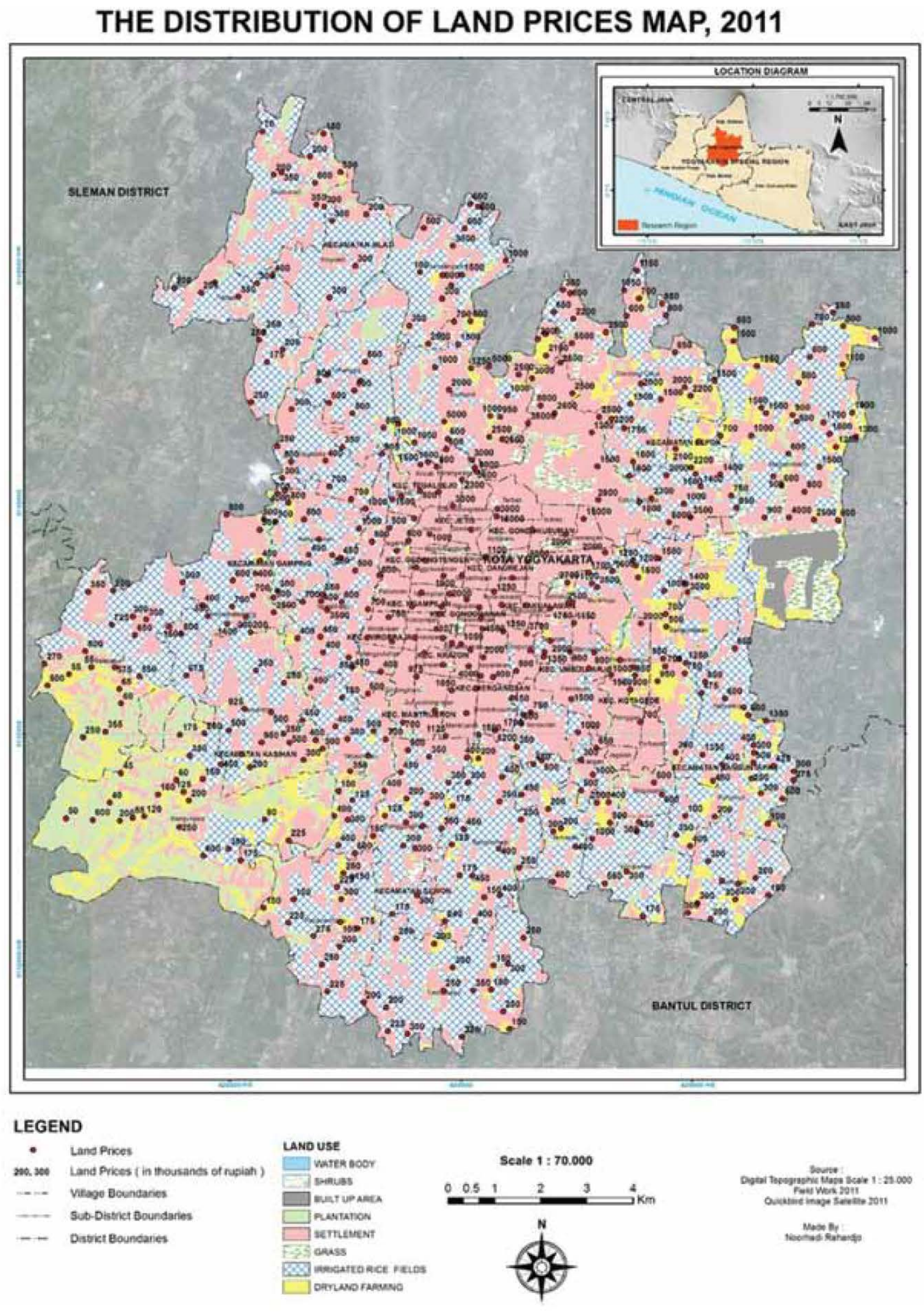

Figure 3: Land prices map using value indication symbol (VIS)

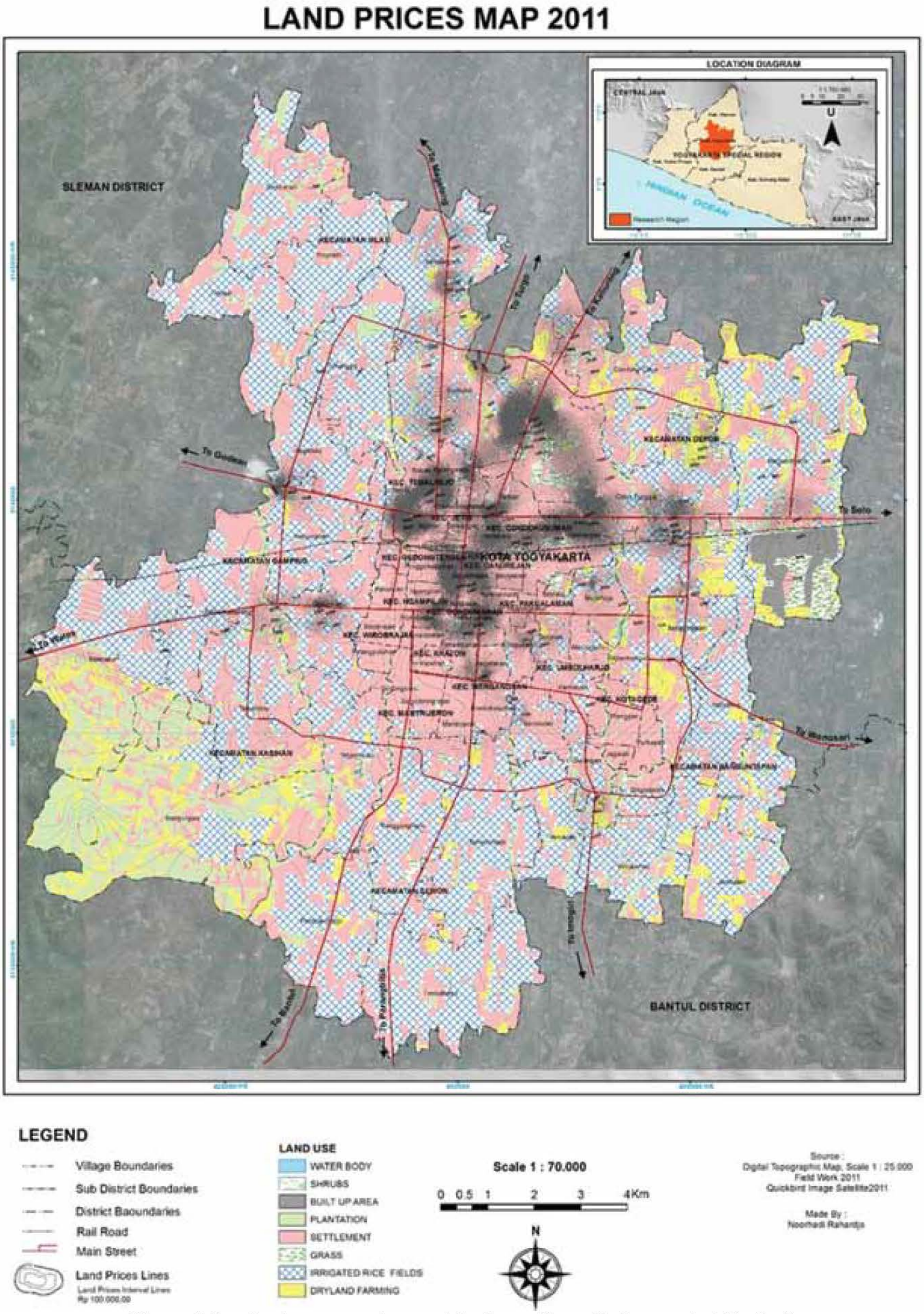

Figure 4: Land prices map using combinations of quantitative symbol (isoline) and quantitative area (isopleth) (IM)

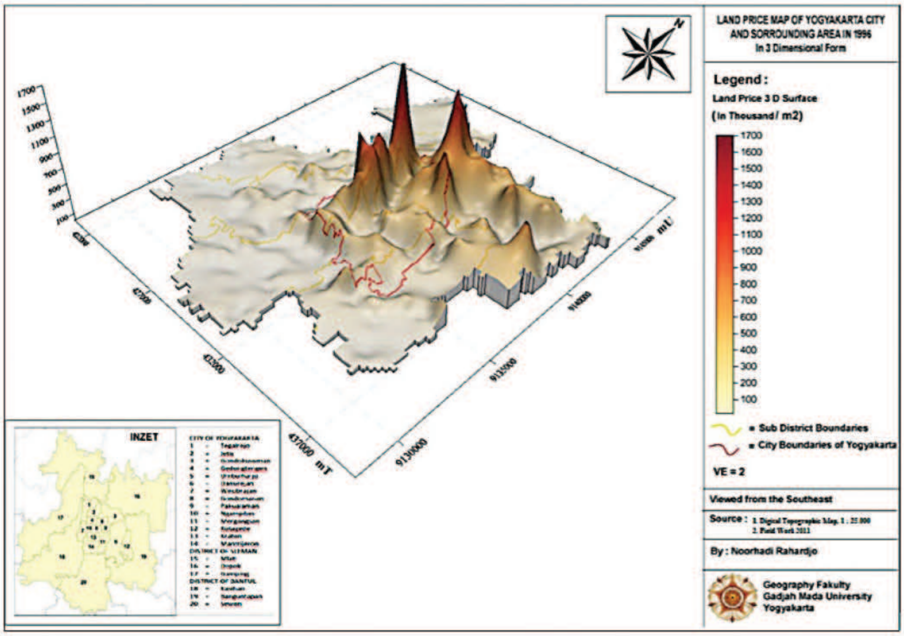

Figure 5: Land prices map using three dimensional symbol (3DM)

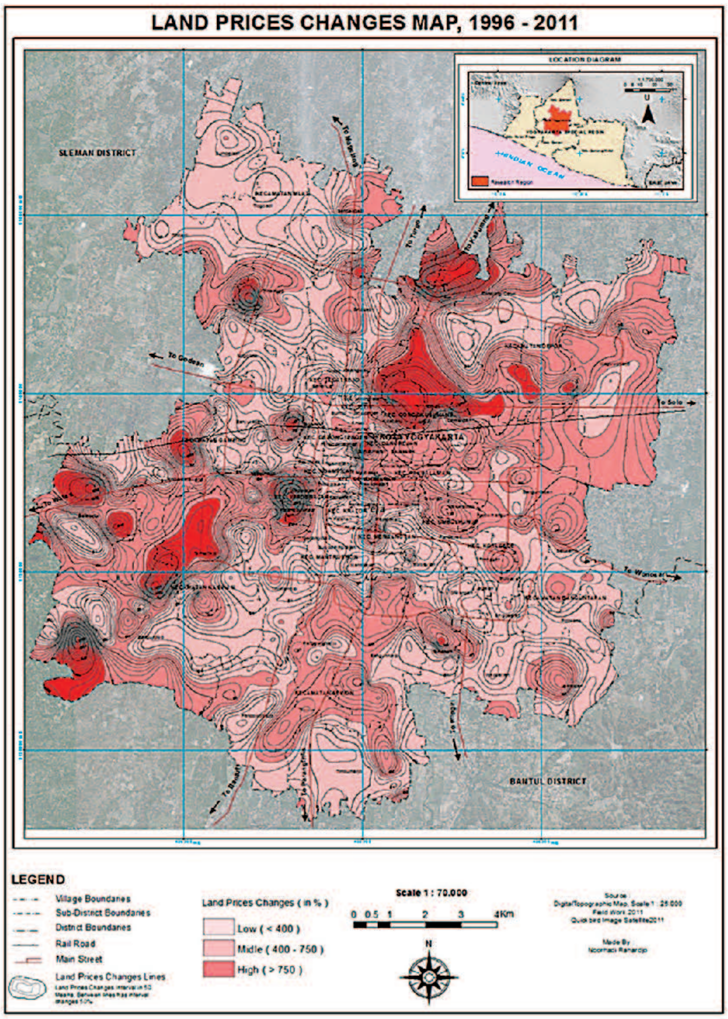

Figure 6: Changes in land prices in 1996-2011 that is visualized using quantitative line symbol (isoline) and quantitative area (isopleth)

Using 7C (i.e. coverage, completeness, consistency, correctness, currentness, creativity-level, and communicative) to evaluate the visualization model performance, the results showed that the IM model performed better than other visualization models. The IM model allows the map reader to understand the absolute (i.e. point values) and categorical changes (i.e. low, middle and high) in land price simultaneously resulting in better coverage, completeness and consistency than other models. By using the IM model, the map can be updated easily as well as the VIS model and therefore met with the currentness category. In addition, through this model, the changes in spatial distribution, patterns, and trend of land price can be better visualized on different years and relatively easy to understand by users (i.e. communicative). For the creativity level, the IM model is better than VIS model, but cannot be compared with 3DM model which allows more design freedom to the cartographer. As can be seen in Figure 4, a high land price was clustered around the city centre and gradually decreased away from the city center. This is similar with the findings of Ritohardoyo (1991), Cadwallader (1985), and Levy (1985) who argue that land price decreases following proximity from the city center.

3.2 Spatial Distribution, Pattern, and Trend of Land Price

Using IM model for visualization changes in the land price in 1996-2011, the spatial distribution and pattern of land price can be identified. In addition, a quadrant analysis provided information about the direction of land price changes. Figure 6 shows changes in land prices in 1996-2011 that is visualized using the best visualization method (i.e. IM method). From Figure 6, it can be observed that changes in land price in the north-eastern area (Quadrant I) is higher than changes in other regions. This can be implied that during 1996-2011 the urban development in the Yogyakarta city is toward north-eastern area (i.e. Depok sub-district). However, it is also detected that ongoing trend of changes in land price is toward south-western area (Quadrant III) and followed by north-western area (Quadrant II) and south-eastern area (Quadrant IV). These results actually similar with the trend of socio-economic development in the greater Yogyakarta. According to the Yogyakarta province Statistical Bureau (BPS, 2010), population growth (people/km^2) of the Yogyakarta province in the period 2002-2009 increased toward Quadrant I and III. In addition, in the last two decades there is an increase trend of housing development as well as market centre toward Quadrant I, III, II and IV, respectively (pers. comm. with housing developers). By using IM model to visualize, the land price change level can be easily read by the isoline, while the level of change (categorical) can be easily observed by isopleth with color gradation.

3.3 Main Factors Affecting Changes in Land Price

Using multiple regression analysis, this study found that DISN is the most important factor affecting changes in land price in the urban and sub-urban area. However, if the analysis is clustered based on the quadrant, it was found that DISC is the strongest predictor. Table 1 shows the regression coefficient of each predictor against the land price in the urban and sub-urban area, while Table 2 shows the regression coefficient of each predictor against the land price in each quadrant area.

These findings showed that land price will be lower following an increase in the distance towards the activity centre where tourism object, city centre, airports, train station, and other activity centre are located. Our findings are similar with Broomhall (1995) and Levy (1985).

Table 1: Regression coefficient of each predictor against the land price in the urban and sub-urban area

Predictors	**ε**	**β**	**t score**	**Sig.**
(Constant)	1350.497		2.893	0.005
DISC	310.382	-0.114	-0.885	0.380
LACR	1.447	-0.128	-0.920	0.361
DISR	1.092	-0.155	-0.935	0.354
DISP	0.669	0.172	1.085	0.283
DISS	6.665	-0.029	-0.208	0.836
DISE	0.948	0.013	0.075	0.941
DISH	0.925	-0.090	-0.650	0.518
DISM	0.609	-0.271	-2.196	0.032
DISN	0.528	-0.358	-2.345	0.023*

Table 2: Regression coefficient of each predictor against the land price in each quadrant area

Quadrant I	ε	β	t score	Sig.
(Constant)	542.992		7.616	0.000
DISC	74.141	-0.431	-5.266	0.000**
LACR	0.386	-0.046	-0.560	0.576
DISR	0.199	0.055	0.431	0.668
DISP	0.127	-0.012	-0.096	0.924
DISS	6.774	-0.127	-1.546	0.125
DISE	0.303	-0.074	-0.889	0.376
DISH	0.157	-0.009	-0.100	0.920
DISM	0.265	-0.015	-0.169	0.866
DISN	0.107	0.151	1.665	0.099
Quadrant II				
(Constant)	1370.966		60.727	0.000
DISC	180.220	-0.361	-30.747	0.000**
LACR	0.060	-0.065	-0.669	0.505
DISR	0.054	-0.091	-0.729	0.468
DISP	0.049	-0.085	-0.586	0.559
DISS	0.864	0.019	0.186	0.853
DISE	0.134	-0.031	-0.297	0.767
DISH	0.101	-0.012	-0.111	0.911
DISM	0.182	0.077	0.576	0.566
DISN	0.100	0.030	0.257	0.798
Quadrant III				
(Constant)	53.040		9.578	0.000
DISC	7.752	-0.459	-5.484	0.000**
LACR	0.040	0.043	0.519	0.605
DISR	0.019	-0.055	-0.435	0.664
DISP	0.012	-0.016	-0.126	0.900
DISS	0.616	0.025	0.307	0.760
DISE	0.029	0.065	0.801	0.424
DISH	0.015	0.185	20.189	0.031*
DISM	0.025	-0.032	-0.352	0.726
DISN	0.010	-0.039	-0.427	0.670
Quadrant IV				
(Constant)	131.517		8.526	0.000
DISC	18.850	-0.517	-60.679	0.000**
LACR	0.019	-0.154	-10.992	0.049*
DISR	0.059	0.089	0.857	0.393
DISP	0.049	0.103	0.985	0.327
DISS	0.794	-0.069	-0.808	0.421
DISE	0.126	-0.187	-20.148	0.034*
DISH	0.131	-0.039	-0.419	0.676
DISM	0.142	-0.043	-0.408	0.684
DISN	0.080	0.195	20.119	0.036*

Using this predictor with the best regression model, a prediction about future land price can be estimated. Figure 7 shows the minimum land price, average land price, and maximum land price in each quadrant. Table 3 shows the prediction of land price in the years 2015, 2020 and 2025 in each quadrant area. From Figure 7 it can be seen that the north-eastern area of the greater Yogyakarta city (quadrant I) has the highest land price in 2025 with an average value of IDR 9,200,000 – 18,000,000 per square meter land, and followed by south-eastern area (quadrant IV), north-western area (quadrant II) and south-western area (quadrant III) with an average value of IDR 7,250,000 – 14,350, 000; 6,900,000 –

13,700,000 and 4,300,000 – 8,500,000 per square meter land, respectively. It is observed that the land price of the quadrant I is doubled compared to the quadrant IV and quadrant II, and tripled compared to the quadrant III. As a result, this study predicted that the direction of future development is in quadrant III (e.g. Gamping sub-district and Kasihan sub-district) where the land price is much lower and land availability is much higher than other regions.

4. Discussions

This study has been successfully analysed changes in the land price distribution, patterns and trend in the greater Yogyakarta city in 1996-2011. It was observed that the spatial distribution of land price in the greater Yogyakarta city varied spatially and temporally in the last fifteen years. However, the trends of land price change in the urban and sub-urban area are relatively similar because land demand in the sub-urban area has increased following limited land availability in the urban area.

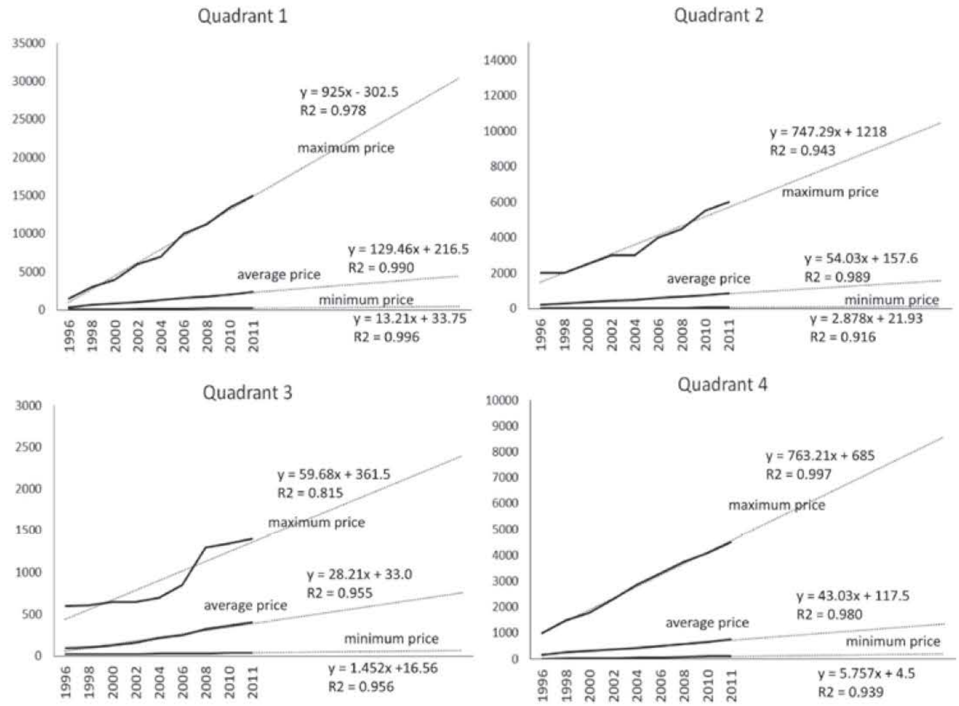

Figure 7: Trend of land price in the study area in each quadrant

Table 3: Predicted land price per square meter in different quadrant areas in years 2015, 2020 and 2025

Quadrant	Predicted year	Land price (in thousands Indonesian Rupiah, IDR)		
		minimum	average	maximum
I	2015	< 6,400	6,400 – 12,500	> 12,500
	2020	< 7,600	7,600 – 15,000	> 15,000
	2025	< 9,200	9,200 – 18,000	> 18,000
II	2015	< 4,400	4,400 – 8,700	> 8,700
	2020	< 5,600	5,600 – 11,000	> 11,000
	2025	< 6,900	6,900 – 13,700	> 13,700
III	2015	< 2,800	2,800 – 5,500	> 5,500
	2020	< 3,500	3,500 – 7,000	> 7,000
	2025	< 4,300	4,300 – 8,500	> 8,500
IV	2015	< 4,700	4,700 – 9,250	> 9,250
	2020	< 6,000	6,000 – 11,800	> 11,800
	2025	< 7,250	7,250 – 14,350	> 14,350

As a result, sub-urban area in the greater Yogyakarta is rapidly transforming into urban area. Our findings in the greater Yogyakarta are similar to those in other Indonesia cities like in Jakarta (Han and Basuki, 2001) and Pontianak (Helmi, 2005), other cities in South-East Asia like in Bangkok, Thailand (Chanond, 1987) and Malaysia (Mariadas et al., 2016), and other cities around the world like in Washington DC, United States (Broomhall, 1995) and Texas, United States (Jennifer et al., 2005).

It was observed that the trends in land price in the greater Yogyakarta have increased in all directions (i.e. quadrant) indicating a significant increase of urbanization in the study area that mostly occupied green spaces such as yards, farmlands, and moors. This conurbation phenomena has linked the Yogyakarta city with its surrounding sub-district cities (e.g. the Depok area in Sleman district) creating into one continuous urban or industrially developed area. Although in economic perspective conurbation has its benefits such as creating local economic growth, it has many negative consequences for residents and the environment such as higher water and air pollution, increased traffic fatalities and jams, loss of agricultural capacity, increased car dependency, higher taxes, increased runoff into rivers and lakes and harmful effects on human health (Levy, 1985). Thus, several measures (e.g. strict regulation in the issuance of building construction permit (IMB) and detail spatial planning) should be done to control the conurbation to prevent the negative effects (e.g. environmental effect) in particular for south-western area of Yogyakarta city where was simulated in this study to be the next developing area.

Land price in the greater Yogyakarta has been predicted to continuously increase. However, it was found that changes in land price were mostly determined by the distance to city centre and the distance to socio-economic facilities. Our findings were similar to those in Ritohardoyo (1991), Levy (1985), Chanond (1987), and Wolcot (1987) who found that location of parcels in terms of distance to public services is the main factor affecting changes in land price. According to Jin (2016), following the urban economic spatial structure theory, the urban centre is the most intensive and prosperous region. Therefore, the most influence factor on changes in the land price distribution is the distance to commercial centre. The results of this study is in line with the western urban spatial structure equilibrium theory where land price spatial distribution gradually decline with the increasing of the distance to the city centre. In addition, this study found that land utilization type also affects the land price where a settlement yard was more valuable than moors and farmlands. This finding is similar with Jun Lo (2004) who argue that land utilizations for settlements, commercial lands and industrial lands are more favorable in the markets compared to other land utilization types.

However, it should be noted that changes in the land prices of the greater Yogyakarta can be also affected by other factors besides the two factors detected by this research. Like in Jakarta, the capitol city of Indonesia, Dowall and Leaf (1991) argue that changes in the land price are mainly controlled by infrastructural provision and tenure (land title) for land prices. They found that land price in Jakarta city increases in suburban areas and in informal-sector plots indicating a conurbation to surrounding cities. Another study by Liu et al., (2013) argues that changes in land price are affected by the macro economy where a recession period may affect to the land price fluctuations. Because of this large variability of factors affecting land prices in different area, disseminating the results of this study to other areas should be done with cautious. Besides practically useful to provide information about the dynamics of land price in the study area, this study also delivers advancement in the field of cartography digital by proposing changes in the mapping paradigm. According to Guptill and Starr (1984), cartography is a process of transferring information based on spatial data, which can be used to compile various visualization models of geographical data in form of maps. Data presentation in form of map has been done for centuries (Kraak and Ormeling, 1999). For land price visualization, this study can be one of few studies in the cartographic research to combine land price dynamics and cartography. The results of this study in terms of land price visualization can provide practical guidelines for geographer and be useful for supporting the authorities to monitor changes in land price in the study area.

5. Conclusions

This study found that the visualization model using combination of isoline and isopleth symbol was able to spatially and temporally show changes in the land price in the greater Yogyakarta city. By using this model, map reader can easily discover the gravity centre of land price and its change. When the study area is divided into four quadrant area, it was observed that land developments in the study area are directed to north-eastern area. However, in the future the land development is predicted to shift toward the south-western area. Factors that significantly affect changes in land price are the distance to the city center and socio-economic facilities, where further the distance to the city center and socio-economic facilities is resulted in a lower land price. In addition, changes in land price have increased for both urban and sub-urban area, which an increase of land price in the sub-urban area is higher than the urban area indicating that rural area is rapidly transforming into urban area. From the prediction of minimum, average and maximum land price, it is found that the highest land price is in the north-eastern area of the greater Yogyakarta city and followed by south-eastern, north-western and south-western areas, respectively. Considering a decreasing trend in land availability at the north-eastern area, it can be predicted that the south-western area of the greater Yogyakarta will be the next target for land buyers. Thus, several measures like strict regulation in the issuance of building construction permit (IMB) and detail spatial planning can be done to control the negative effects (e.g. environmental effect) of land development.

Acknowledgements
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References

Abelson, P., 1997, House and Land Prices in Sydney from 1931 to 1989. *Urban Studies,* Vol. 34(9), 1381-1400.

Bottema, J. W. T., 1995, *Market Formation and Agriculture in Indonesia from the Mid 19th Century to 1990.* Jakarta

BPS. 2010, Yogyakarta Province in Numbers. District Statistical Bureau, Indonesia.

Broomhall, D., 1995, Urban Encroachment, Economic Growth and Land Values in the Urban Fringe: Growth and Change. *A Journal of Urban and Regional Politics,* Vol. 26, No. 2, 191-203.

Cadwallader, M. T., 1985, *Analytical Urban Geography, Spatial Pattern and Theories*, New Jersey: Prentice Hall Inc, Englewood Cliff.

Carr, D. B., White, D. and MacEachren, A. M., 2005, Conditioned Choropleth Maps and Hypothesis Generation. *Annals of the Association of American Geographers*, Vol. *95*(1), 32-53.

Chanond, C., 1987, Recent Change in the Land Market on the Urban Fringe of Bangkok. *ITC Journal*, Vol. 3, 211- 221.

Cho, J., 2005, Urban Planing and Urban Sprawl in Korea. *Urban Policy and Research,* Vol. 23(2), 203-218.

DiBiase, D., Reeves, C., Krygier, J., MacEachren, A. M., von Weiss, M., Sloan, J. and Detweiller, M., 1994, Multivariate Display of Geographic Data: Applications in Earth System Science. *Visualization in Modern Cartography*, Vol. 2, 287-312.

Dowall, D. E. and Leaf, M., 1991, The Price of Land for Housing in Jakarta. *Urban Studies*, Vol. 28(5), 707-722.

Dyson, T., 1996, *Population and Food: Global Trends and Future Prospects*. Routledge. London, New York.

Eckert, J. K. and Gloudemars, R. J., 1990, *Property Appraisal and Assessment Administration.* The International Association of Assessing Officers, Chicago, Illionis, USA.

Foscue, E. J., 1938, Influence of Contrasted Soil Types upon Changing Land Values near Grapevine, Texas. *Annals of the Association of American Geo-graphers,* Vol. 28(2), 137-144.

Guo, D., Chen, J., MacEachren, A. M. and Liao, K. 2006, A Visualization System for Space-Time and Multivariate Patterns (vis-stamp). *IEEE Transactions on Visualization and Computer Graphics,* Vol. 12(6), 1461-1474.

Grinstein, G., Sieg, J. C., Smith, S. and Williams, M. G., 1992, Visualization for Knowledge Discovery. *International Journal of Intelligent Systems*, Vol. 7(7), 637-648.

Guptill, S. C. and Starr, L. E., 1984, *The Future of Cartography in the Information Age*, Washington: ICA.

Han, S. S. and Basuki, A., 2001, The Spatial Pattern of Land Values in Jakarta. *Urban Studies,* Vol. 38(10), 1841-1857.

Helmi, 2005, Zonasi Harga Lahan Permukiman Kota Pontianak dengan Memanfaatkan Citra IKONOS, *Tesis*, Yogyakarta: Sekolah Pascasarjana UGM.

Jennifer, S., Fred, A. F. and Ronald, C. R., 2005, The Effect of Development Impact Fees on Land Values. *Growth and Change*, Vol. 26(1), 191-203.

Jin, J., 2016, Spatial Variation Analysis of Urban Land Price in Central Kunming City. *5th International Conference on Materials Engineering for Advanced Technologies* (ICMEAT). 98-101.

Jun, L., 2004, *Modelling Urban Land Values in a GIS Environment.* Milwauke: Department of Geography, University of Wisconsin.

Kraak, M. J. and Ormeling, F. J., 1999, *Cartography: Visualization of Spatial Data*. London: Longman.

Levy, J. M., 1985, *Urban and Metropolitan Ecocomic*, USA: McGraw-Hill Book Company.

Liu, Z., Wang, P. and Zha, T., 2013, Land□Price Dynamics and Macroeconomic Fluctuations. *Econometrica*, Vol. 81(3), 1147-1184.

Mariadas, P. A., Selvanathan, M. and Hong, T. K., 2016, A Study on Housing Price in Klang Valley, Malaysia. *International Business Research*, Vol. 9(12), 103.

Prasetyo, L. B., Kartodihardjo, H., Adiwibowo, S., Setiawan, Y. and Okarda, B., 2009, Spatial Model Approach on Deforestation of Java Island, Indonesia. *Journal of Integrated Field Science*, Vol. 6, 37-44.

Ritohardoyo, S., 1991, *Agihan Harga Lahan di Sekitar Pusat Kegiatan Wisata Candi Borobudur*, Yogyakarta: Fakultas Geografi UGM.

Suparmono, S., 2012, Accessibility to Center Business District and Land Price. *Economic Journal of Emerging Markets*, Vol. 4(2), 143-152.

Verburg, P. H. and Bouma, J., 1999, Land Use Change under Conditions of High Population Pressure: The Case of Java. *Global Environmental Change*, Vol. 9(4), 303-312.

Wolcot, R. C., 1987, *The Appraisal of Real Estate*, Chicago: Munican Institute of Real Estate Appriser.

Yamarino, F. J., Skinner, S. J. and Childers, T. L., 1991, Understanding Mail Survey Response Behavior a Meta-Analysis. *Public Opinion Quarterly*, Vol. 55(4), 613-639.

Yang, K. and Banamah, A., 2014, Quota Sampling as an Alternative To Probability Sampling? An Experimental Study. *Sociological Research Online*, Vol. 19(1), 1-11.