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Original article

Land value assessment based on an integrated Voronoi-geographically weighted regression approach in Makkah, Saudi Arabia

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ABSTRACT

Objective: Makkah Al-Mukarramah is the holiest city of the Islamic world because of the presence of the Holy Mosque which is also known as Al-Haram. Due to lodging and business activities around the Holy Mosque, Makkah city has experienced a rapid urban growth and an increase in population. Hence, it is necessary to develop an efficient land value assessment method that takes into account the main factors influencing the prices of land in Makkah.
Methods: This study proposed an integrated Voronoï- Geographically Weighted Regression (GWR). Voronoi diagrams were used to subdivide the space into regions which were generated based on the spatial location of land value input data. Then, the GWR regression equation related to each land value input data was applied to the entire corresponding Voronoï region. The proposed approach ensured a continuous estimation of the prices of land in the whole study area.
Results: Based on the results obtained from this research, the property price in Makkah varies between 4000 SAR/m2 and 14050 SAR/m2 according to the location of the property. Because of the holiness of Makkah, the lands nearest to the Holy Mosque have the highest prices. However, comparison with ground value data showed that there is a variation of percentage between −17% and 22%.
Conclusions: The proposed model overestimated the prices of lands around the Holy Mosque, even though the prices remain higher; this was because the Voronoï-GWR model captured the high demand on lands surrounding the Holy Mosque. Nevertheless, the proposed model underestimated the prices of land in the southern region of the study area because of the presence of mountains with new infrastructures under construction not considered.

1. Introduction

Makkah Al-Mukarramah is the holiest city of the Islamic world. It is an important place because this is where the Holy Mosque which is called Al-Haram is located, this Mosque contains the First House of God Kábah built by prophet Ibrahim and his child Ismail. It is situated in the western part of Saudi Arabia, 80 km inland from the Red Sea at the lower regions of the Hijaz mountain extension. Makkah has developed from a little settlement around the Kábah into a major city spread over a region of roughly 1000 km^2 with populace of 1.5 million (Solami et al., 2006). Muslim Pilgrimage to the Kingdom of Saudi Arabia (KSA) is one of the most established and biggest strict religious events on the planet. This is where Muslims from every part of the world gather in KSA each year to perform revere at Al-Haram (Holy Mosques in Makkah and Madinah) and Al-Masha'ir (Mina, Arafat and Muzdalifah). Al-Haram mosque in Makkah has an indoor and open-air outlet; the Mosque is around 356,800 square meters. About 2 million Muslims can worship at once, particularly during the Ramadan (ninth month of the Islamic lunar schedule) and Hajj (twelfth month of the Islamic lunar schedule) (Nizami et al., 2017).

The development of the sacred city of Makkah is an extraordinary model among other urban communities in the world. This city flourishes in a desert region, where there is no water, food or some other human culture. With the consistent development of the city, the territory around the Holy Mosque turns out to be intensely

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populated and there is an increase in building density (Solami et al., 2006). Geographically, Makkah is secured by various kinds of molten, transformative and sedimentary rocks of Precambrian and lower Paleozoic period. Moreover, there are subordinate sedimentary rocks as well as basaltic magma stream of Tertiary and Quaternary age (Solami et al., 2006).

The majority of the urban development that takes place in the city, most especially the lodging and business improvements, is as a result of the presence of the Holy Mosque, this also impacts the neighboring regions as the rocky landscape on the urban rambling of the city spread across the restricted valleys to the level urban edges (Al Jabri and Alhazmi, 2017). The city has experienced an increase in population and development towards its edges, bringing about further expansion of the regions that surrounds it. Significant developments that took place in the City of Makkah in the previous years have led to acceleration in urban changes. The city of Makkah, most especially around the Holy Mosque and the holy locales of pilgrimage was redeveloped into sets of hotels and stores, which can be considered as the travel industry zone in Makkah. Besides, the neighborhoods have extended outside the travel industry zone, accordingly this urban development is influenced by the pilgrims' activities (Ascoura, 2013). The area of Makkah and its religious significance affected the city's populace; the increase in population is as a result of regular increase in immigration.

However, Changes in Land use and land Cover (LULC) is essentially adjusting the common biological system and changing the natural landscape. The increase in land cover modification has affected biodiversity and other ecological components (Alqurashi and Kumar, 2019) and it has socio-economic impact on land.

Due to rapid increase in population, urban growth and land cover modifications in Makkah, there is need for land value assessment in Makkah. Indeed, land value assessment is essential to ensure stability in the sales of land, reduce fight speculation and promote the value of land in the city. This process should be based on scientific methods to avoid randomness and enhance realistic valuation. In addition, the expansion of the Holy Mosque in Makkah and improvement of the city infrastructure has caused expropriation of the surrounding lands which requires a fair method for land value assessment. This expropriation has limited the available land around Al-Haram where the price of land has increased due to increase in demand. Therefore, the main objective of this research is to develop an approach for the assessment of the land value in Makkah city using an integrated Voronoï- Geographically Weighted Regression.

2. Land Value Assessment Methods

2.1. Conventional method of land value assessment

The conventional method for land value assessment is the onsite visual assessment technique adopted by local government. This method is time consuming, unreliable, and is not effective in terms of transparency and accuracy (Demetriou, 2017). These deficiencies have inimical effects on planning land valuation, as there is need for some research in order to examine land valuation factors and the quality of this traditional process. To address deficiencies in conventional land valuation process, there is need for the development of a new framework based on advanced spatial analysis techniques such as Multiple Regression Analysis (MRA) and Geographically Weighted Regression (GWR) within GIS environment (Demetriou, 2017). Shortcomings in the conventional method of mass appraisal can be solved by the use of Automated Valuation Models (AVMs) with Geographical Information System (GIS) (Demetriou, 2018). The conventional model depends on some key factors such as physical features, locational characteristics and economic conditions. Analytic Hierarchy Process can be used to produce criteria relative weights according to their influence on the discussed problem (Issa et al., 2019).

Land rent theory shows that unimproved land value is a result of the lands inaccessibility to goods, facilities, transportation, medical assistance, education and other services. In theory therefore, public transport provision which increases accessibility to services should in turn increase land values (Mulley et al., 2018). In land consolidation scheme, two components should be considered; these include the reallocation of land and the provision of rural infrastructure such as roads and irrigation networks.

Valuation is based on consumers' behavior, which means how they want to spend their money based on their individual preference (Hamilton and Morgan, 2010) according to the principle of supply and demand, it also depends on buyers who are in competition with each other to ensure good utility as much as possible (Demetriou, 2017).

Land value assessment is a very important and risky process around the world, as it involves many aspects of socio-economic life in both the developing and developed countries, this is because it affects the value of real estate property each year which revolves around 1,000 billion euros (Weber, 2004). In land value assessment process, knowledge of neighborhood land and buildings plays a significant role in determining the value of a specific land. Due to incorrect neighborhood breakdown and incorrect land value accredited to neighborhood, there might be bias in the assessment of land value (Ruddock, 2014).

Although the drawbacks of standard valuation process have been pinpointed by some researchers (Jahanshiri et al., 2011), in the case of land consolidation, there are little or no research on land valuation (Yomralioglu et al., 2007) hence, there is need for relevant assessment studies which is focused on land valuation based on the spatial statistical analysis of a real full-scale project (Demetriou, 2017).

2.2. GIS and Hedonic methods

Hedonic model for property pricing was introduced by Rosen in 1974. Since it is based on the actual real behavior rather than intended one, it is considered as the revealed preference method. It does not require previous judgments, comparative prices, or income information as in the conventional methods, it needs some reasonable amount of pricing data in order to determine the value of property (Aladwan and Ahamad, 2019). Generally, the common procedure of hedonic model started with the selection of variables, which is usually a dependent variable and one or more independent variables, this is followed by applying statistical regression method to study property multiple parameters effects on its final price, or in other words the effects of each parameter on the final price, and finally, building the model which is needed to fit the sample data for further value estimations (Li et al., 2013).

There are two main hedonic methods used for regression analysis and estimating the relationships between variables namely: The Ordinary Least Square (OLS) and Geographic Weighted Regression (GWR). OLS is the dominant method in the implementation of regression analysis (Cebula, 2010; Kong et al., 2007; Lozano-gracia and Anselin, 2012; Ottensmann et al., 2008). OLS is considered as a global method that produces constant coefficient over the whole study area and does not take into account the autocorrelation and geospatial effects while, GWR is a local regression method enhances variation of coefficients in a given study area (Bujanda and Fullerton, 2017; Kinabalu et al., 2015; Radoslaw Cellmer, 2011). GWR has the potential of being implemented fully in a GIS environment (Lu et al., 2014). Wang and Li (2020) provide a systematic review of mass appraisal models for nearly two decades and identify a 3I-trend, namely AI-based, GIS-based and MIX-based models (Wang et al., 2020).

Different functional specifications of hedonic equations were found in literatures. The simplest mathematical linear regression was employed by (Kong et al., 2007; Lozano-gracia and Anselin, 2012; Bujanda and Fullerton, 2017, and Zhang et al., 2015). The semi log regression was used by (Cebula, 2010; Kong et al., 2007; Ottensmann et al., 2008; Lehner, 2011, and Randeniya et al., 2017). Alternatively, studies by (Lehner, 2011), and (Paper and Paper, 2013) used the log-log regression. Among these methods, the semi log regression is commonly used in building the computerized hedonic model because of its simplicity in interpreting results, as well as its ability to accept categorical variables (Cebula, 2010; Kong et al., 2007; Ottensmann et al., 2008; Lehner, 2011, and Randeniya et al., 2017).

Some researchers have established the use of Hedonic price method for pricing houses. Zhang et al. (2004), Armstrong and Guez (2006) examined the relationship between different traffic convenient degree and house price (Armstrong and Guez, 2006; Zhang et al., 2004) while, (Wang and Zheng, 2007) analyzed the degrees at which urban public service accessibility influences housing price (Wang and Zheng, 2007). Visser et al. (2008) employed Hedonic price modelling to derive different models of pricing property from which the contribution of the characteristics of the residential environment were estimated (Visser et al., 2008). Meanwhile, city economics researchers mainly focused on the application of Hedonic method to study the external environment influence in pricing houses (Liu et al., 2010). Also, GIS spatial interpolation method was used to get spatial distribution map and contour map of housing price (Mei and Li, 2008). Cellmer et al., (2019) developed an application of Hierarchical Spatial Autoregressive Models for Land Value Maps in Urbanized Areas. (Cellmer et al., 2019). According to

The use of GIS along with the Hedonic approach appeared in work presented by (Schaerer et al., 2008). They employed the Zurich and Geneva Geographic Information System in valuing natural land uses in urban areas of Geneva and Zurich (Schaerer et al., 2008). In the study carried out by Cavailhès et al. (2009), hedonic price models was combined with a GIS-based geographic model to evaluate the price of landscapes of houses in the urban fringe of Dijon, France (Cavailhès et al., 2009). Li et al. (2013) used GIS and Hedonic in the modelling of spatial variation of housing price in Xiamen city, China. They discovered that location characteristic, neighborhood characteristic and building characteristics had significant influence on housing price (Li et al., 2013). Korea et al. (2015) presented a framework that combines Geographic information System (GIS) with Hedonic pricing method in order to improve analysis and determining the value of green spaces with price of houses in Subang Jaya, Malaysia (Korea et al., 2015).

The use of hedonic approaches with GIS has been proved effective for land value assessment. More specifically, the use of the GWR method in a GIS environment enhances the consideration of spatial variations of phenomena that influence prices of land. The GWR method provides only a discrete and local regression equation that corresponds to each input data. However, in order to estimate the price of land in an area of interest, there is need to find a method to apply alongside with local regression equations continuously in the whole area. The selection of GWR method compared with other common methods is due to the advantage of GWR in the perception of the spatial variability of the independent variables.

3. Voronoi-GWR based approach for Land Value Assessment

This paper presents an approach for Land Value Assessment based on the integration of the GWR method with Voronoi diagrams in a GIS environment. Voronoi diagrams are used to subdivide the space into regions that are generated based on the spatial location of each input with its corresponding land price. Thereafter, the regression equation related to the value of each land input data will be applied to the entire corresponding Voronoï region. In this section, the proposed methodology for integrating Voronoi diagrams with GWR for land value assessment is presented in more detail.

3.1. Recall on GWR and Voronoï Diagrams

- *Geographically Weighted Regression (GWR)*

Spatial nonstationary is a condition where a basic 'worldwide" model cannot clarify the connections between certain arrangements of factors. The idea of the model must change over space to mirror the structure contained in the information. Geographically weighted regression attempts to capture this variety by aligning a numerous regression model which permits various connections to exist at various spaces focused (Brunsdon et al., 1996). Geographically weighted regression (GWR) has been broadly used in comprehending the spatially varied connections between socio-economic results and policy investment (Wang and Chen, 2017).

The utilization of Geographically Weighted Regression (GWR) philosophy with prices of land as the dependent variable is clarified by spatially characterized independent variables used in determining the value of land.

Based on geographically weighted regression, parameter evaluation can be made for all the geographical data input characterised

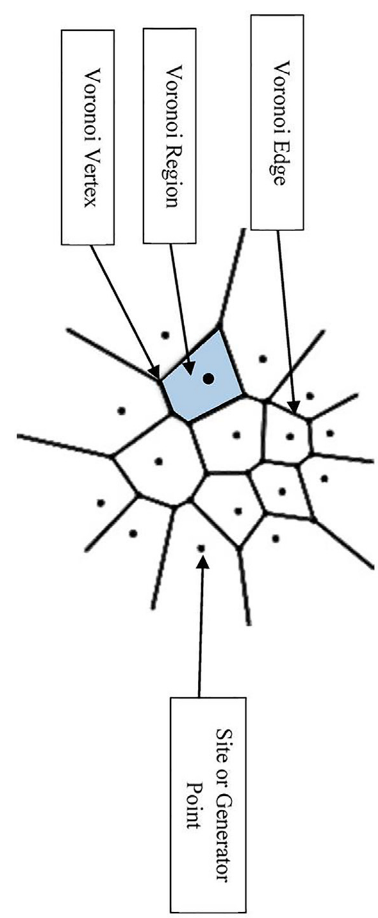

Fig. 1. Illustration of A Voronoi Diagram (Yaagoubi et al., 2015)

by its coordinates, independent variables and dependent variable as shown in the formula below.

$$y = \beta_0 \sum_{i=1}^{n} (\beta_i * X_i) + \varepsilon \quad (1)$$

where: - y: The independent variable. X_i: The independent variable (the input or observation data). n: The number of dependent variables. β_0: The intercept that corresponds with zero value for all dependent variables. β_i: The weight coefficient for each dependent variable. ε: The residual variable.

With the GWR method, every observation is treated as an individual input at a particular geographic location as required in spatial analysis (Du and Mulley, 2012). A key advantage of GWR modeling is the perception of the spatial variability of the independent variables. Indeed, ordinary regression models (such as Ordinary Least Square) do not take the spatial variability of independent variables into consideration, which may lead to ineffective models (Densmore and Mulley, 2012).

- *Voronoi Diagram:*

Voronoi diagram is a data structure which portrays spatial contiguous relations, it was proposed by Russian mathematician Georgy Feodosevich Voronoi in 1908 (Zhang and Li, 2009).

Voronoi diagram (Fig. 1) is originally defined for a set of sites which divides a plane surface into a number of regional planes where each site corresponds to one region (Yaagoubi et al., 2015). These sites may be points, lines or polygons, with (or without) a corresponding weight (Yaagoubi et al., 2015). Voronoi diagram represents the geometric spatial arrangement, the unpredictable spatial distribution of socio-economic variables (for example focal city, rancher's market, stockroom, street limit, Land centroid) may be considered as sites distribution inside Voronoi diagram (Zhang and Li, 2009). Each point on a Voronoi edge is equidistant from the two sites whose corresponding regions share the same boundary. Also, each vertex is equidistant from the nearest three sites that generate Voronoi regions.

3.2. Factors influencing the value of land in Makkah

There are several factors that may influence the value of land in Makkah. These factors are classified into socio-economic factors, land policy factors and natural factors. Based on an exhaustive literature review and interviews with experts in land valuation in Makkah, a list of 28 factors were determined. Then, a questionnaire was designed in order to choose the most critical criteria based on the experience of 30 participants (professionals working in the area of Land Valuation in Makkah). The analysis of the questionnaire highlighted 20 factors that appear relevant for land valuation in Makkah as shown in Table 1. A value of 5 corresponds to a strong positive effect on land value, a value of 0 is neutral, a value of −5 corresponds to a strong negative effect. After that, an OLS analysis was carried out based on these 20 factors as independent variables and land price for each input data (11 locations with the corresponding land price) as the dependent variable. OLS is considered as global method that produces constant coefficient over a study area and does not consider the problems of autocorrelation and spatial effects. Through OLS analysis, a detailed report can be gotten on the strength of each factor and the possibility of it being a main factor. Also, all factors that have similar influence are to be considered. Based on the OLS analysis, five factors were considered as statistically significant, these are: Distance from the Holy Mosque, Distance from Masha'er Mina, Distance from sewage network, Distance from main roads, and Distance from shopping centers.

Table 1
Factors influence the value of land in Makkah

Factors	Mean value	Standard Deviation
Distance from the Holy Mosque	5.00	0.00
Type usage of the property	4.07	0.99
The existence within the boundaries of the Holy Mosque	3.80	1.32
limitation of the number of floors permitted for building.	3.73	1.31
Distance from main roads	3.53	0.88
Distance to the commercial roads	3.40	1.30
Distance from Masha'er Mina	3.33	1.64
Property's location in a regular scheme	3.20	1.07
Distance from electricity service	3.20	1.19
Distance from train station	2.97	1.58
Presence within the urban space	2.90	1.62
Distance from the mosques	2.43	1.58
Number of streets that serve the property	2.33	1.46
Distance to a grocery center	2.27	1.56
Width of roads surrounding the property	2.27	1.65
Distance to the gardens	2.03	1.27
Distance to the schools	1.90	1.79
Distance to shopping centers	1.80	1.68
The impact of distance from water service	1.67	1.44
Distance to sanitation service	1.57	1.35
Distance to the government departments	1.00	1.12
Distance to the hotels	0.67	2.28
Distance from Projects under implementation	0.53	1.58
Distance from gas stations	0.00	2.11
Distance to the government departments	−0.20	1.85
Distance from railway	−2.50	1.62
Presence of the property in a mountainous area	−2.60	1.08
Property's location in an unplanned area	−2.87	1.68

3.3. Implementation of the Voronoi-GWR approach

The importance of the GWR method was presented in section III.a (Recall on GWR and Voronoï Diagrams). This method takes into accounts the spatial distribution of input data, where each input will have its own regression equation. In order to apply these equations for land value assessment over the entire study area, the area should be subdivided based on Voronoï regions defined by each input data (Fig. 2). The regression equation corresponding

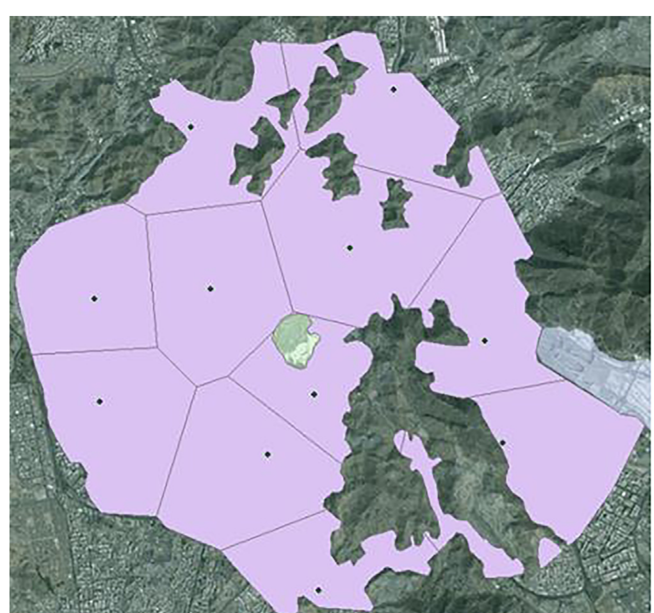

Fig. 2. Voronoï regions generated from land value input data in the study area.

Table 2
The intercept, the residual, and the weight of the five criteria for each land value input data.

FID	Shape *	Intercept	Weight_C1	Weight_C2	Weight_C3	Weight_C4	Weight_C5	Residual
0	Point	128214.517745	−21.298214	−4.603225	10.232631	25.595068	7.590018	−5842.1618620
1	Point	128213.070613	−21.299184	−4.603226	10.243444	25.592332	7.593133	−9503.7763490
2	Point	128219.456622	−21.297613	−4.604245	10.216723	25.604374	7.587298	7757.6551700
3	Point	128221.809634	−21.296835	−4.604546	10.205338	25.608818	7.584568	−5563.4993740
4	Point	128224.675180	−21.295608	−4.604812	10.189310	25.614255	7.580434	−4293.0361620
5	Point	128220.392134	−21.296634	−4.604115	10.207012	25.606166	7.584262	−18831.514867
6	Point	128223.457833	−21.295476	−4.604457	10.191043	25.611986	7.580287	8660.1203340
7	Point	128216.617573	−21.298127	−4.603723	10.227177	25.599022	7.589353	−15666.286591
8	Point	128216.970807	−21.297434	−4.603551	10.220995	25.599706	7.587262	2972.4548640
9	Point	128220.876108	−21.296842	−4.604314	10.207525	25.607064	7.584773	−5507.6903310
10	Point	128217.487231	−21.297712	−4.603786	10.221981	25.600667	7.587972	33950.248787

to each input data will be applied to the corresponding Voronoï region.

Based on the OLS analysis that was used to determine the main factors influencing the price of land in Makkah section 3.2 (Factors influencing the value of land in Makkah), the GWR method was applied on all input data considering only the selected criteria, these include:

- Criterion 1: Distance from the Holy Mosque.
- Criterion 2: Distance from Masha'er Mina.
- Criterion 3: Distance from sewage network.
- Criterion 4: Distance from main roads.
- Criterion 5: Distance from shopping centers.

The information in Table 2 summarized the intercept, residual, and the weight of the five criteria for each land value input data.

The equation calculated by the GWR method for each land value input data was applied to the corresponding Voronoi region as shown in Fig. 3.

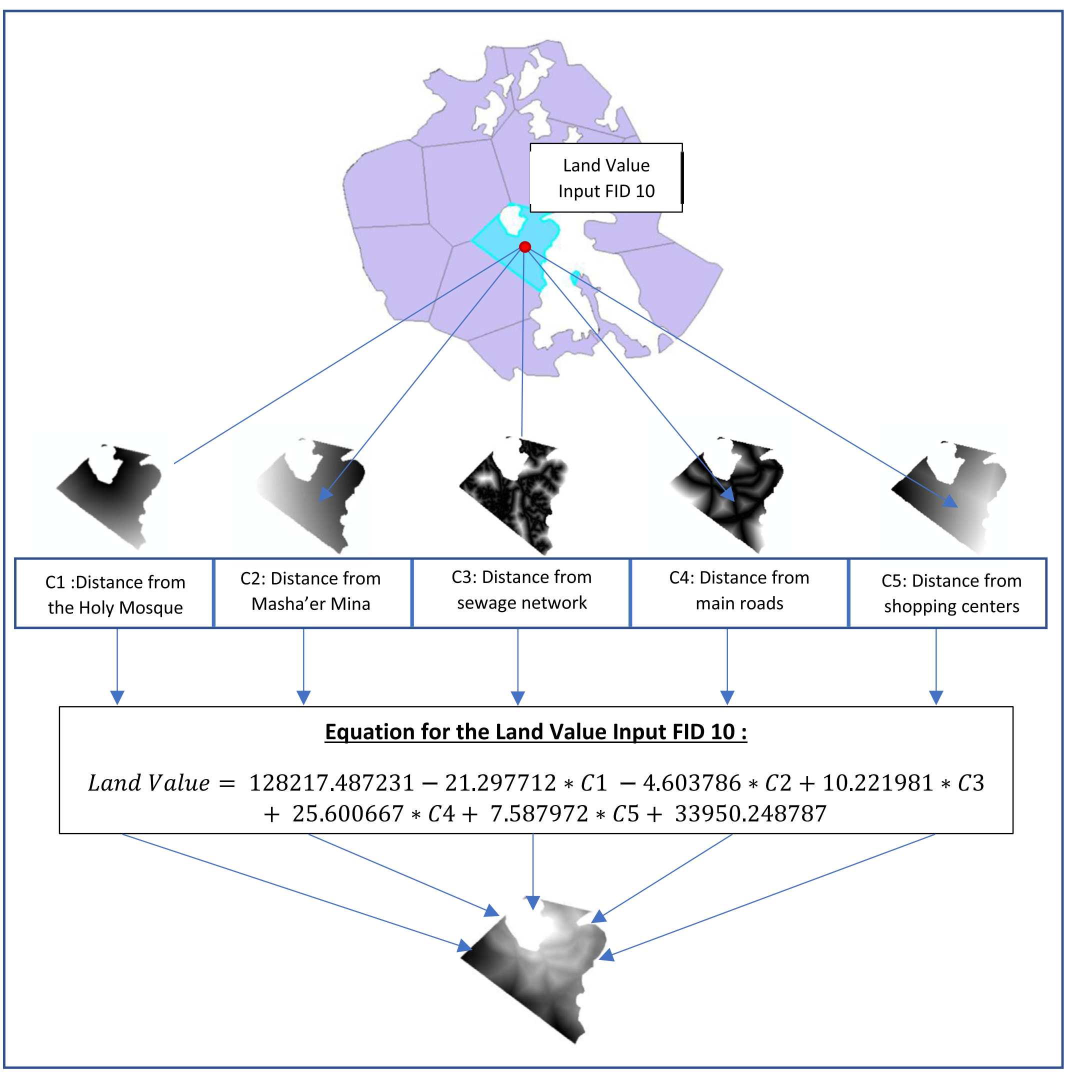

Fig. 3. Land Value assessment within a Voronoï region.

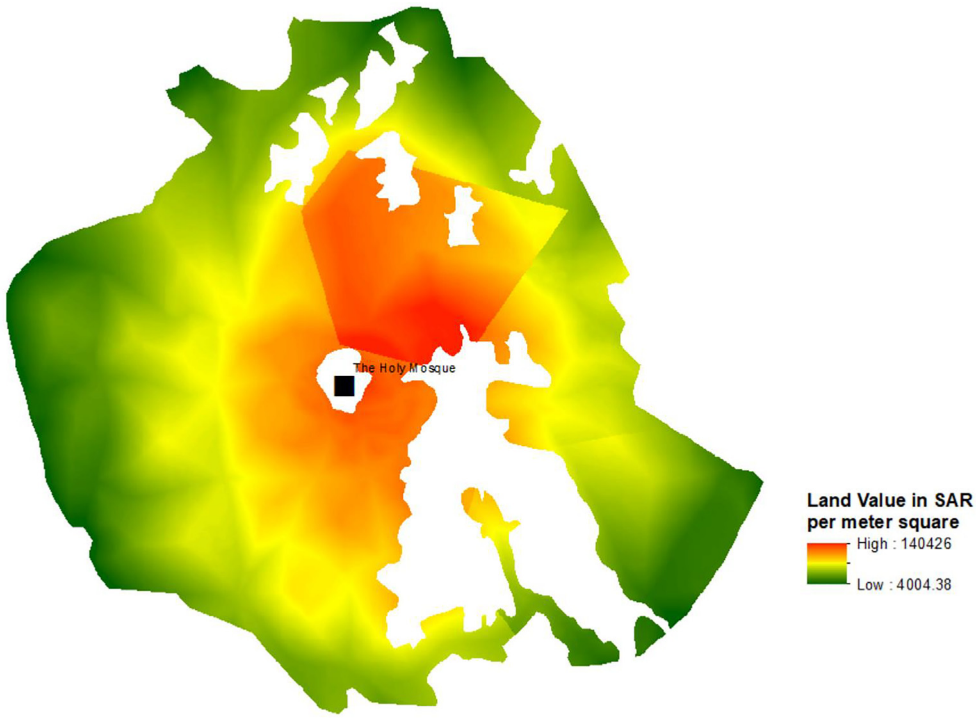

Fig. 4. Land Value assessment in Saudi Riyal (SAR) per meter square within the study area.

After estimating the value of land in each region of Voronoï, these regions were aggregated in order to obtain a global estimate of the price of land in Saudi Ryals (SAR) per meter square over the entire study area as shown in Fig. 4.

4. Discussion

Based on the results shown in Fig. 4, lands nearest to the Holy Mosque have the highest prices, especially in the North-North-East region. These prices are justified by the holiness of Makkah. Also, it was noticed that the prices are decreasing as we move away from the Holy Mosque. In addition, the lands that are close to the main roads have a higher value compared to the lands that are not closer to the main roads.

To objectively validate the approach proposed in this study, 10 Land price values were used as validation data. These data were distributed homogeneously across the study area as shown in Fig. 5. The results of the comparison between real prices and those estimated by the Voronoi-GWR approach were summarized in Table 3. The difference is calculated by subtracting the real value from the estimated value. While the percentage is equal to the difference divided by the real value.

The geographic distribution of the percentage of differences shown in Fig. 6 revealed that the value of land in the areas closer to the Holy Mosque (except for the far northeast) was overestimated by the proposed model compared to the actual reality, despite the high price of land in these areas. This could be justified by the fact that the model captured the high demand of lands that surrounds the Holy Mosque in Makkah. In fact, the City of Makkah is surrounded by the legitimate boundaries of the Holy Mosque in addition to the natural mountains in the City, which occupy more than 70% of the total land mass. This means only 30% of land is meant for residential buildings to keep up with demand. The absence of a regulation to control the number of floors in the buildings within the City also increases the land values.

The absence of new housing plans that meet the needs of middle and low-income groups also influences the real estate market. Moreover, the demand for housing from Makkah's residents had increased by 54% due to the millions of Muslims flying into Makkah yearly. The decrease in the volume of supply does not correspond with the volume of demand, especially with the establishment of several developmental projects which contributes to the expropriation of more than 20 thousand real estates.

However, it was observed in the southern region that the prices were underestimated by the model. More particularly, In Al Rusayfah region, the recent establishment of train station for the Haramain Train may increase real estate value in this area. This fact was not considered in the model. Moreover, land valuation experts consider Al Rusayfah region and its surroundings as areas that attracts new investments and developmental project. Thus, it was evaluated at higher price than that which was obtained from the proposed model. For Alazizia Al Janoubya 2 region, the location is relatively far from the Holy Mosque, main roads and shopping centers. Also, the existence of Thowr mountain serves as demarcation that prevents the extension of residential buildings towards the Holy Mosque. That could justify the reason for underestimating the values of land in this area by the proposed model.

5. Conclusion and areas for future or further study

In this study, an approach was developed for estimating prices of land by combining Voronoi diagrams with the local regression method GWR. This approach ensured a continuous estimation of the prices of land by applying the GWR local regression equations on the corresponding Voronoi region. The application of this approach to the city of Makkah was revealed to have the potential of Voronoi-GWR integration in Land value assessment. The results obtained indicated that price varies between 4000 SAR/m^2 and 14050 SAR/m^2. Nearest lands to the Holy Mosque have the highest prices because of the holiness of Makkah.

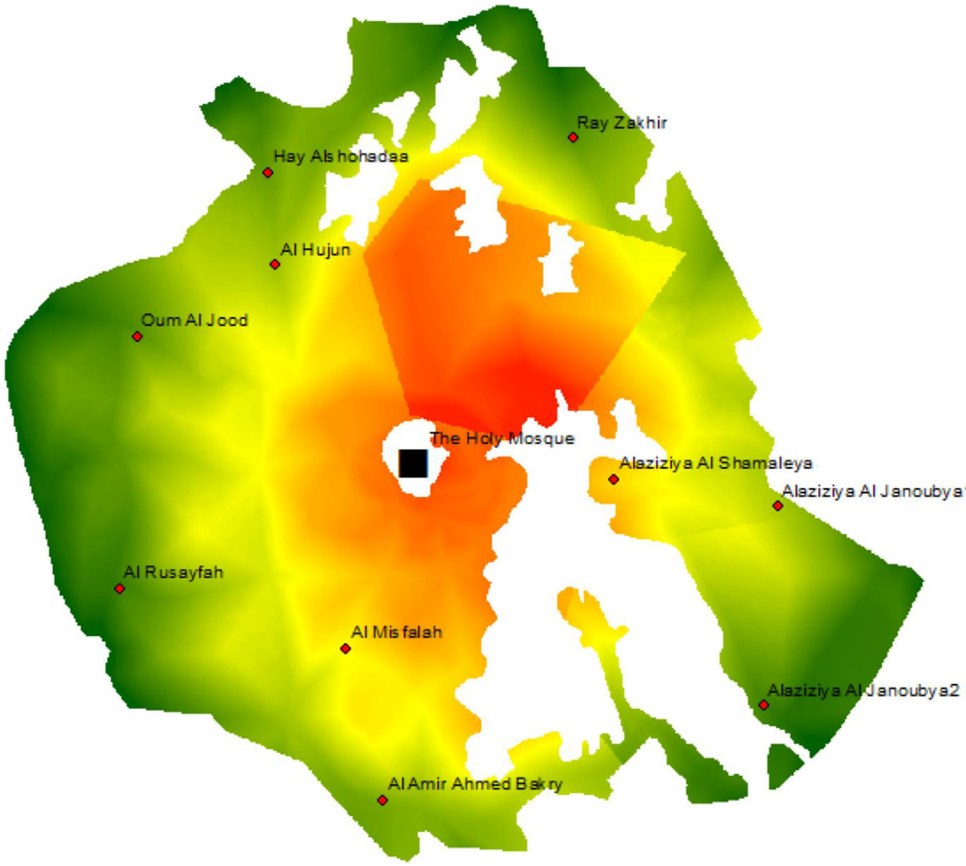

Fig. 5. Geographical distribution of validation data in the study area.

Table 3
Comparison between real and estimated prices for validation data per meter square.

OBJECT ID	Real Price	District	Estimated Price	Difference	Percentage
1	76000	Alaziziya Al Janoubya 1	89997	13997	18
2	32000	Alaziziya Al Janoubya 2	26521	−5479	−17
3	67000	Al Misfalah	72493	5493	8
4	24000	Al Amir Ahmed Bakry	20757	−3243	−14
5	34000	Al Rusayfah	38267	4267	13
6	45000	Alaziziya Al Shamaleya	52476	7476	17
7	25000	Oum Al Jood	29503	4503	18
8	44500	Al Hujun	53184	8684	20
9	31000	Hay Alshohadaa	37720	6720	22
10	29500	Ray Zakhir	31373	1873	6

However, in comparison with ground value data, there is a variation of percentage between -17% and 22%. More particularly, the proposed model overestimated the prices of land around the Holy Mosque, even though the prices remain higher. Hence, it can therefore be concluded that the Voronoï-GWR model captured the high demand of lands surrounding the Holy Mosque in Makkah. Nevertheless, prices of land were underestimated by the proposed model in the southern region of the study area. This was as a result of the presence of mountains with new infrastructures under construction not considered.

It is important to emphasize that the Voronoi-GWR approach was based on the geographic distribution of factors influencing the prices of land as well as a sample of discrete input data that represent the real prices of land. However, the proposed model did not consider the tacit knowledge of real estate appraisers as well as their expertise. Therefore, future studies should develop the use of fuzzy logic and Analytic Hierarchy Process (AHP) for land value assessment in the same study area. Then, a comparison should be made with the results obtained from the use of Voronoi-GWR method.

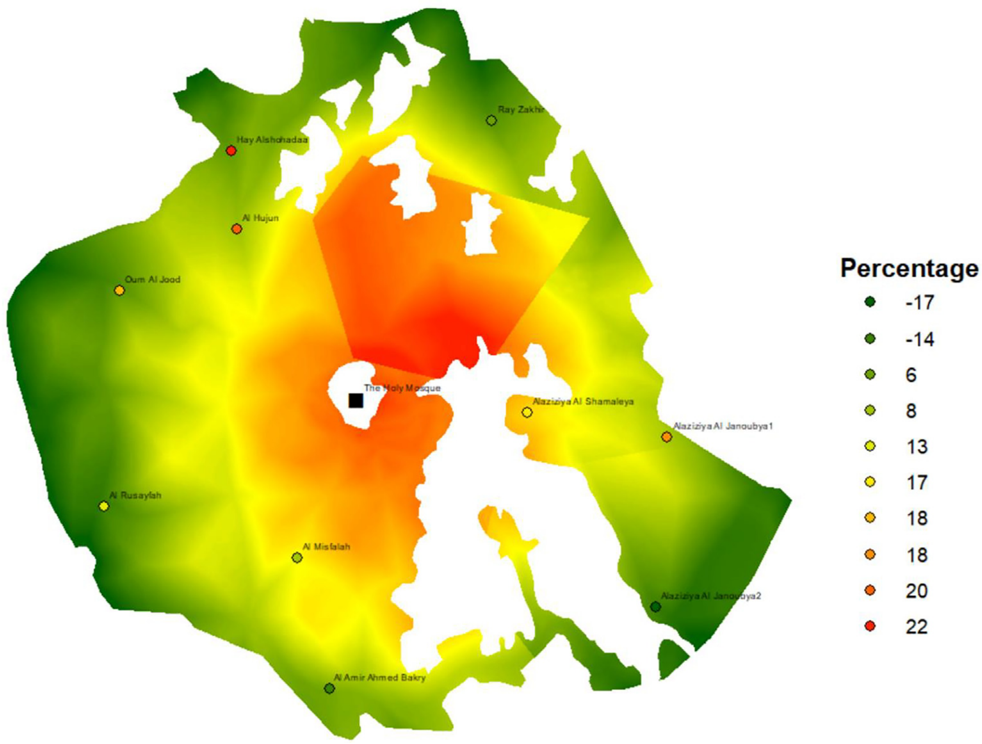

Fig. 6. Geographical distribution of the percentage differences between real and estimated prices for validation data.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could influence the work reported in this paper.

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