Application Of Geographic Information System In Property Valuation

Stephen Wakaba Gatheru, David Nyika

ABSTRACT: The purpose of this study was to investigate the application of Geographic Information System (GIS) in property valuation. The study adopted descriptive research design to investigate the relationship between value of land and the factors influencing it. A population of 400 land parcels was used with a sample size of 100 parcels of land. Data collection was done by use of questionnaires. A multivariate regression model was used to link the independent variables to the dependent variable. The resultant Hedonic Pricing Model (HPM) indicated that the value of land can be predicted by using the following key attributes; land size, accessibility to bypass, accessibility to primary school. Results also showed that Hedonic Pricing Model is objective and verifiable and hence an ideal method of valuation.GIS technique has proved to be a powerful tool in ensuring that a geodatabase of all the attributes of each parcel of land is stored and retrievable at the clique of a button. The valuation map that was produced enables quick decision making, as all the values of each parcel are displayed graphically. It is recommended that the HRM and GIS be used to do property valuation.

Keywords: accessibility to bypass, accessibility to primary school, Geographic Information System, Hedonic Pricing Model, land size, valuation

I. INTRODUCTION

Hedonic Pricing Model is a valuation model that measures the influencing effects of particular characteristics of a property on overall transaction price, while regression analysis is used to determine correlation of each characteristic to the transaction value. Regression analysis is a statistical technique used to determine correlation between different data points (Matt Monsoon, Cornell university,2009).The Hedonic pricing method places emphasis on the relationship between selling price and attributes for estimating values of properties. It is useful to determine the intrinsic value of each attribute, as well as to predict transaction prices. Geographic information system (GIS) is a computerized data management system used to capture, store, manage, retrieve, analyze, and display spatial information. GIS is a marriage between computerized mapping and database management system (DBMS). GIS entails creating database for both geometric and attribute data. Database as “a unified computer based collection of data showed authorized users with the capability for controlled definition to access, retrieval, manipulation and presentation of data within it. It is a combination of spatial and none spatial data which is georeferenced to the coordinates of a particular projection system. This allows precise placement of features on the earth’s surface and maintains the spatial relationships between mapped features. As a result, commonly referenced data can be overlaid to determine relationships between data elements. This study helped in identifying parcels of land and prepares a database of parcels of land and their attributes. The value of the plots was determined by Hedonic pricing method of valuation while Geographic information system (GIS) was employed to manage, organize, analyze and display the data. The property valuation process has been carried out manually since the profession was introduced in this country and the profession has not escaped criticism sometimes for producing poor quality valuation. A valuation is said to be of poor quality when it is inaccurate, inconsistent, inefficient, illogical, unconvincing, unacceptable and unreliable. Cases of valuation being re-done by property owners and cases reported to the Thika district Land Valuer, where property owners request for to re-valuation before paying stamp duty to remove doubt, were evidenced during data collection. Banks rely on property valuations to lend money to the clients against the collaterals that have been valued. It is therefore important that the values returned are accurate and reliable; otherwise in the event that the borrower defaults to pay the loan and the actual value of the security is below that reported by the valuer, then the bank would not be in a position to recover its money. Quality valuation service is an asset for the government sector since it has ensured accurate calculation of taxes and financial institutions have also benefited when securities deposited bare correct value. Property valuations done by The Department of Property Valuation at the Ministry of Lands are referenced by other sectors for, the purposes of rating, taxation, development and economic planning. Quality property valuation can help a decision maker to do their work efficiently, accurately and convincingly which is seen as an important contribution for the development of a country. One of the reasons for poor quality valuation is lack of proper tools to manage, maintain, explain, view, analyze and make optimal decisions on the massive amount of data involved. GIS is a viable tool to solve this problem. The purpose of the study was to investigate the application of geographic information system in property valuation. Zhao, (2011) conducted a study on design and implementation of an object-oriented space-time GIS Data Model. In his study he stated that Geographic data are closely related to both spatial and temporal domains. Geographic information systems (GIS) can capture, manage, analyze, and display spatial data. However, they are not suitable for handling temporal data. Models exhibit weaknesses in various aspects. He also argues that geodatabase data model can be used to store instantiated space-time objects. Tweddale, (2011) in his report on expansion of the Illinois Department of Natural Resources’ Owned, Managed, and Leased Properties (OMLP) Database demonstrated how effective GIS was used to

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create a geodatabase. He showed that geodatabase created for the OMLP project contained property boundaries at the parcel level and had been designed with the capability of mapping outer extent property boundaries, interior parcel lines, easement boundaries, lease boundaries, and land use information. According to Chicoine (1981) the attributes that influencing farmland prices are classified as location, agricultural factors, and nonagricultural factors. Location reflects the proximity of the farmland *vis a vis* metropolitan areas. Agricultural factors include characteristics related to the productivity of a specific farmland parcel as well as attributes of the agricultural economy.

II METHODOLOGY

The study adopted the descriptive research design to investigate the relationship between value of land and the factors influencing it. The information was not well documented as revealed by the literature search done by the researcher. The researcher was therefore required to conduct a field study to collect the relevant information by enquiring directly from the players in the valuation framework.The population of the study was 40 registered offices each with 10 land valuers, making a total of 400 target population.). A sample size of 25% of 400 parcels of land (100 parcels) was selected using random sampling. This is based on Mugenda and Mugenda (2003) recommendations that a sample size of 10% or more is acceptable for a survey study. Primary data was collected or obtained from the original sources. Primary data was obtained from questionnaires. The information gathered from these interviewees and the literature search assisted the researcher in developing a questionnaire which was completed by valuers, property managers and developers. The researcher sought to establish the perspective of these professionals towards value of parcels in Ruiru Kiu. Registry index maps (RIMs) for Ruiru Kiu block 2 was acquired from survey of Kenya. The registration block is covered by 5 sheets of Registry index maps numbered sheet 1 up to 5. Due to the large size and numerous numbers of parcels in the entire registration section, only part of sheet 5 of the RIM was used containing 400 parcels. After data was collected through questionnaires, it was prepared in readiness for analysis by editing, handling blank responses, coding, categorizing and keying into statistical package for social sciences (SPSS) computer software for analysis. SPSS was used to produce frequencies, descriptive and inferential statistics which was used to derive conclusions and generalizations regarding the population. The particular descriptive statistics was frequencies, mean scores and standard deviation. The particular inferential statistic was regression and correlation analysis. The analysis of variance (ANOVA) was checked to reveal the overall model significance. In particular, the calculated f statistic was compared with the tabulated f statistic. A critical p value of 0.05 was also used to determine whether the overall model was significant or not. The individual regression coefficients were checked to see whether the independent variables significantly affected the value of land. A critical p value of 0.05 was used to determine whether the individual variables were significant or not. A multivariate regression model was used to link the independent variables to the dependent variable as follows;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_{5+} \mu$$

Where;
Y =Value of land (price)
X_1 = Zone (location)
X_2 = Size
X_3 = Accessibility to infrastructure
X_4 = Accessibility to other amenities
X_5= physical characteristics
Source: Gundimeda, (2005): Hedonic price method

In the model, β_0 = the constant term while the coefficient β_ii = 1….5 was used to measure the sensitivity of the dependent variable (Y) to unit change in the predictor variables X_1, X_2, X_3 and X_4. μ is the error term which captured the unexplained variations in the model.

VI. RESULTS AND DISCUSSION

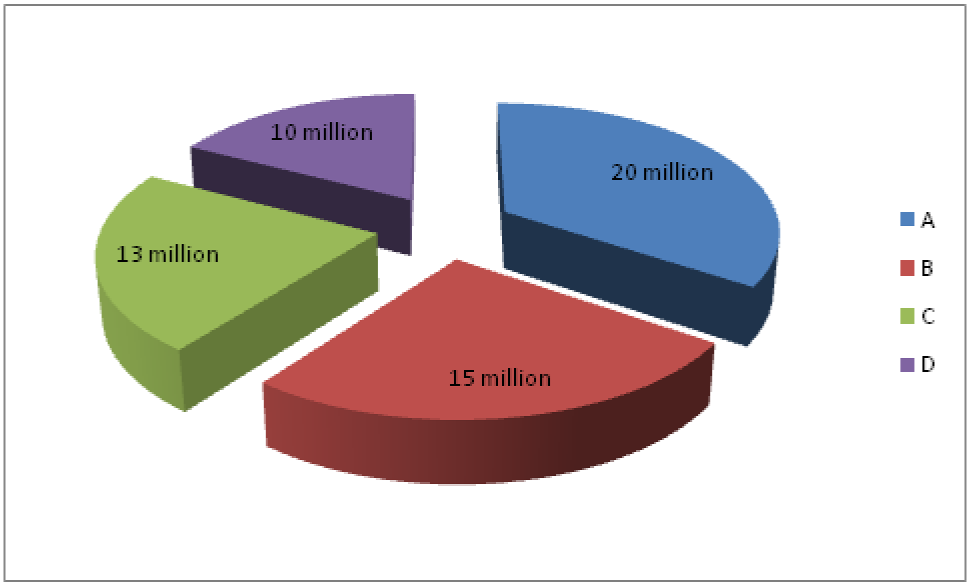
4.1 Descriptive Statistics

Descriptive Statistics was used in transforming the raw data into a form that can be easily understood and interpreted. Descriptive analysis involved the use of frequencies in their absolute and relative forms (percentage). Mean and standard deviations were also used as measures of central tendencies and dispersion respectively. For data presentation, the study employed the use of tables, graphs and charts for clear presentation and description of the data.

4.1.1 Zones

The study covered Ruiru Kiu area, in Ruiru sub County of Kiambu County. This area falls between Thika road and The Eastern bypass, and is covered by Ruiru Kiu block 2 registration section. The study aimed to identify these parcels of land and prepare a database of the plots and their attributes. The value of the plots was determined by Hedonic pricing method of valuation. The area was first divided into five zones namely 'A', ' B1', 'B2',' C1', 'C2', and 'D'. The plots in Zone 'A' borders eastern by pass. Plots in zone 'B1' borders the proposed by pass. Parcels in Zone 'B2' have some close proximity to Thika road while zones 'C1',' C2' and 'D' have minimal proximity to infrastructure .Random sampling was used to sample 100 parcels of land by the land valuers and in some cases by some property owners. 10 were picked from zone 'A'. This parcels had higher prices with an average of Ksh.20 million per 0.5 hectare of land .This was due to the fact that they border the bypass. 41 parcels were picked from B1 and B2 and also had a high price with an average of Ksh.15 million per 0.5 hectare. This is because they border the proposed bypass and proximity to Thika road respectively. 34 parcels were picked from zone 'C1' and 'C2'. The parcels had an average price of Ksh.13 million. While 15 parcels were picked from zone 'D' and it had the lowest average price of Ksh.10 million. This is because they had no proximity to infrastructure.

Figure 4.1: *Average value for 1 Ha .per Zone*



Source: *Author (2015)*

Figure 4.1 shows the average values of 1 hectare parcels of land for each zone. A standard unit of a hectare was chosen so as to make it comparable to all attributes. It was expected that a favorable attributed will be attributed to a higher value, holding size constant. An average of 1 hectare was used as a standard, since different parcels had different acreages. Apart from the location (zone) and land size, other factors which are deemed to influence the value of land in this area of study are Accessibility to bypass, Distance to railway track, Distance to shopping centre, Nearness to police station, Accessibility to primary school, marshy land (Physical 1), rocky land (Physical 2) and parcels with perimeter fence (Physical 3).

Table 4.1: *Land size*

Variable	N	Minimum (Ha.)	Maximum (Ha.)	Mean	Std. Deviation
Size (hectares)	100	0.15	1	0.429	0.1673

Source: Author (2015)

4.1.2 Land Size

The respondents were asked to indicate the size of land. From the hundred (100) parcels of lands the maximum size was 1 hectare while the minimum size was 0.15 as indicated by the table above.

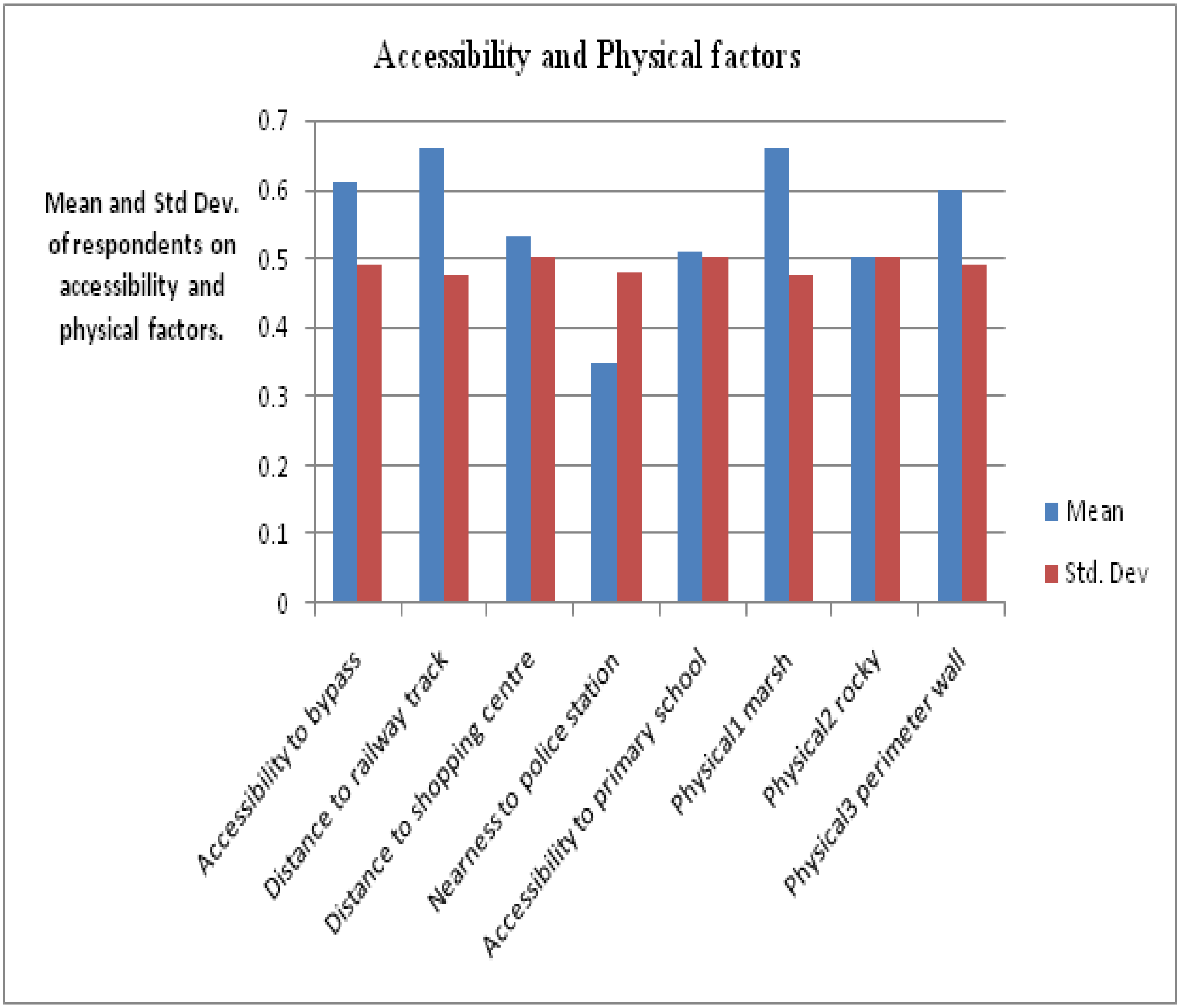
Table 4.2: *Accessibility and Physical Factors*

Variables	Mean	Std. Dev
Accessibility to bypass	0.61	0.49
Distance to railway track	0.66	0.476
Distance to shopping centre	0.53	0.502
Nearness to police station	0.35	0.479
Accessibility to primary school	0.51	0.502
Physical1 marsh	0.66	0.476

Physical2 rocky	0.5	0.503
Physical3 perimeter fence	0.6	0.492

Source: Author (2015)

Figure 4.2: *Accessibility and Physical Factors*



Source: *Author (2015)*

4.1.3 Accessibility and Physical Factors

Results in table 4.2 indicate the descriptive statistics of the parcels of land; Accessibility to bypass, Distance to railway track, Distance to shopping centre, Nearness to police station, Accessibility to primary school, Physical 1 marsh ,Physical 2 rocky and Physical 3 perimeter wall. As indicated in the table below the percentage of respondents who have parcels of land accessible to bypass for the period is 61%, while those who have lands close to the railway track is 66%. Fifty three percent have lands close to the shopping centre while 35% have lands close to the police station. Fifty one percent are accessible to primary school while 66% have lands in the marshy areas. Fifty percent are rocky while 60% have their lands fenced with a perimeter wall or live fence as shown in the table 4.2 and Figure 4.2.

4.2 Inferential Statistics

Inferential analysis was conducted to generate correlation results, model of fitness, and analysis of the variance and regression coefficients.

Table 4.3: *Correlation Matrix*

		Value acre	**Size acres**	**Size acres squared**	**Accessibility to bypass**	**Distance to railway track**	**Distance to shopping centre**	**Nearness to police station**	**Accessibility to primary school**	**Physical1_marsh**	**Physical2_rocky**	**Physical3_perimeter_wall**
Value acre	Pearson Correlation	1										
	Sig. (2-tailed)											
Size acres	Pearson Correlation	.463**	1									
	Sig. (2-tailed)	0.000										
Size acres squared	Pearson Correlation	.360**	.897**	1								
	Sig. (2-tailed)	0.000	0									
Accessibility to bypass	Pearson Correlation	.582**	.232*	0.131	1							
	Sig. (2-tailed)	0.000	0.02	0.195								
Distance to railway track	Pearson Correlation	.289**	.290**	0.192	0.162	1						
	Sig. (2-tailed)	0.004	0.003	0.055	0.108							
Distance to shopping centre	Pearson Correlation	.394**	.308**	.286**	.397**	.382**	1					
	Sig. (2-tailed)	0.000	0.002	0.004	0	0						
Nearness to police station	Pearson Correlation	0.027	0.074	0.108	.200*	0.04	0.145	1				
	Sig. (2-tailed)	0.786	0.466	0.286	0.046	0.694	0.15					
Accessibility to primary school	Pearson Correlation	.412**	.357**	.282**	.201*	.394**	.319**	0.132	1			

	Sig. (2-tailed)	0.000	0	0.005	0.045	0	0.001	0.19				
Physical1_marsh	Pearson Correlation	-.358**	-.274**	-0.139	-.357**	-.248*	-.422**	-0.004	-.239*	1		
	Sig. (2-tailed)	0.000	0.006	0.168	0	0.013	0	0.965	0.017			
Physical2_rocky	Pearson Correlation	-.283**	0.18	0.079	.267**	.338**	.341**	0.021	.220*	-.253*	1	
	Sig. (2-tailed)	0.004	0.073	0.436	0.007	0.001	0.001	0.836	0.028	0.011		
Physical3_perimeter_wall	Pearson Correlation	.247*	0.112	-0.012	.268**	.276**	.213*	0.171	.220*	-.327**	.367**	1
	Sig. (2-tailed)	0.013	0.269	0.909	0.007	0.005	0.034	0.089	0.027	0.001	0	

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

Source: *Author (2015)*

4.2.1 Correlation Analysis

The Table 4.3 above presents the results of the correlation analysis. The results presented in this table shows that the value of land and the size of land are positively related (r=0.463, p=0.000). The table further indicates that the value of land and accessibility to bypass are positively and significantly related (r=0. 582, p=0.000). It was further established that the value of land were positively and significantly related to accessibility to primary school (r=0.412, p=0.000).). Similarly, results showed that the value of land was positively related to distance to the shopping centre (r=0. 394, p=0.000) and distance to the to railway track (r=0.289, p=.004). The results showed that the value of land was negatively related to marshy areas (r=-0.358, p=0.000), to rocky areas (r=-0.283, p=0.000) and also to the perimeter wall (r=-0.247, p=0.013) as shown in table 4.3.

Table 4.4: *Model Fitness*

Indicator	Coefficient
R	0.719
R Square	0.517
Adjusted R Square	0.469
Std. Error of the Estimate	0.519

Source: *Author (2015)*

4.2.2 Regression Analysis

The results presented in table 4.4 present the fitness of model used of the regression model in explaining the study phenomena. Land size, Accessibility to bypass, Distance to railway track, Distance to shopping centre, Nearness to police station, Accessibility to primary school, Physical1 marsh ,Physical2 rocky and Physical3 perimeter wall were found to be satisfactory variables in explaining the value of land. This is supported by coefficient of determination also known as the R square of 51.7%. This means that Land size, Accessibility to bypass; Distance to railway track, Distance to shopping centre, Nearness to police station, Accessibility to primary school, Physical1 marsh, Physical2 rocky and Physical3 perimeter wall explain 51.7 % of the variations in the dependent variable which is the value of land. This results further means that the model applied to link the relationship of the variables was satisfactory. In statistics significance testing the p-value indicates the level of relation of the independent variable to the dependent variable. If the significance number found is less than the critical value also known as the probability value (p) which is statistically set at 0.05, then the conclusion would be that the model is significant in explaining the relationship; else the model would be regarded as non-significant.

Table 4.6: *Analysis of Variance*

Indicator	Sum of Squares	df	Mean Square	F	Sig.
Regression	2594.364	9	288.263	10.698	0.000
Residual	2425.045	90	26.945		
Total	5019.409	99			

Source: *Author (2015)*

Table 4.6 provides the results on the analysis of the variance (ANOVA). The results indicate that the overall model was statistically significant. Further, the results imply that the independent variables; Land size, Accessibility to bypass, Distance to railway track, Distance to shopping centre, Nearness to police station, Accessibility to primary school, Physical1 marsh ,Physical2 rocky and Physical3 perimeter wall, are good predictors of the value of land. This was supported by an F statistic of 10.698 and the reported p value (0.000) which was less than the conventional probability of 0.05 significance level.

Table 4.7: *Regression of Coefficients*

Variable	B	Std. Error	t	sig.
(Constant)	17.722	2.176	8.143	0.000
Size acres	10.915	3.497	3.121	0.002
Accessibility to bypass	6.621	1.233	5.37	0.000
Distance to railway track	0.313	1.299	0.241	0.810
Distance to shopping centre	0.688	1.3	0.529	0.598
Nearness to police station	-1.837	1.142	-1.609	0.111
Accessibility to primary school	2.827	1.201	2.354	0.021
Physical1_marsh	-0.495	1.303	-0.38	0.705
Physical2_rocky	0.401	1.198	0.335	0.738
Physical3_perimeter_wall	0.521	1.223	0.426	0.671

Source: Author (2015)

The objective of this study was to identify the attributes affecting land values. From the regression analysis results in table 4.7 shows that there is a positive and significant relationship between the value of land and size of land ((r=10.915, p=0.002). In addition, the results revealed that accessibility to bypass and value of land has a positive and significant relationship (r=6.621, p=0.000), while accessibility to primary school and value of land has a positive and significant relationship (r=2.827, p=0.021) respectively. These results show that an increase in the unit change of size of land, accessibility to bypass, and accessibility to primary school would result to an increase in the value of land.

4.3 Hedonic Pricing Model (HPM)

From the regression analysis in table 4.7 above, it was possible to derive a hedonic pricing model. The factors that were not significant were; Distance to railway track(r=0.313, p=0.810), Distance to shopping centre(r=0.688, p=0.598), Nearness to police station(r=-1.837, p=0.111), Physical1 marsh(r=-0.495, p=0.705) ,Physical2 rocky (r=0.401, p=0.738) and Physical3 perimeter wall(r=0.521, p=0.671).These factors were insignificant because there p-values were less than the critical value(0.05). These factors were dropped out to remain with land size, accessibility to bypass and accessibility to primary school which was significant. Therefore the hedonic pricing model for this study was: Market price of land (value of land) =f (land size, accessibility to bypass, accessibility to primary school)

Table 4.8: *Hedonic pricing model*

Variable	B	Std. Error	t	Sig.
(Constant)	17.187	1.463	11.744	0.000
Size of land	11.724	3.36	3.489	0.001
Accessibility to bypass	6.894	1.093	6.305	0.000
Accessibility to primary school	3.095	1.111	2.786	0.006

Source*: Author (2015)*

Table 4.8 shows the regression analysis of the three factors. Therefore the specific hedonic pricing model is shown below Market price of land (value of land) = *17.187* **+** *11.724 land size + 6.894 Accessibility to bypass +* ***3.095*** *Accessibility to primary school*

Table 4.9: *Robustness for HPM*

	Minimum	Maximum	Mean of value	Std. Deviation
Hedonic price per hectare	19.53	38.90	28.0004	5.00431
Actual values	20.000	60.000	27.99969	7.120470
Value difference	**-29.89**	**9.08**	**.0007**	**5.06552**

Source: *Author (2015)*

4.4 Testing the Robustness of the HPM

Table 4.9 shows the difference of hedonic price per hectare and value per hectare. The mean for hedonic price per hectare and value per hectare is 28.0004 and that of value per hectare is 27.99969 .The results shows that the two price values difference is 0.0007 thus implying that the two values are statistically significantly the same.

VII. CONCLUSIONS

The study found that; The appropriate Hedonic Pricing Model is Market price of land (value of land) = *17.187* **+** *11.724 land size + 6.894 Accessibility to bypass + 3.095 Accessibility to primary school***.** This was arrived at after eliminating insignificant factors in the pricing model. Hedonic Pricing Method (HPM) is a more objective and consistent .It is not influenced by personal feelings and self appraisal, hence free from individual bias. It reduces subjectivity involved in Sales comparison approach by providing a scientific approach in analysis of the property variables. GIS is a superior tool that enables production of a value map where colour symbology is used to differentiate different colour ranges.

VIII RECCOMENDATIONS OF THE STUDY

From the findings and conclusions that have been made, the following measures are recommended. HRM should be used in Valuation of Property because it has the ability to quantify scientifically the factors affecting Property values. It can also rank them in order of importance. Using the Hedonic Pricing Model, it can help a valuer predict the values of subsequent Property as long as the attributes are known. A lot of data is required in application of HRM. The study therefore recommends that a centralized data bank be created capturing sales data and property characteristics. This information will then be made accessible to property valuers, financiers and property agents. A GIS database will be an ideal data bank. Use of GIS in property valuation should be encouraged and introduced to all valuers since it has been proven in the research that it has many advantages that make decision making easier and faster. Querying capabilities will reduce having to value so many properties in search for a particular property with particular characteristics. A value map will provide information at just a glance, making decision making fast. This method of valuation should be applied in other areas other than Ruiru Kiu Other agents should be encouraged to use the HRM model and GIS. Due to their objectivity and verifiability, Banks can use the model since the outcomes are consistent. The government can adopt the method when it comes to compensation during displacement of disaster victims or whenever there is need for compulsory acquisition of land, to minimize on public complaints occasioned by claims of unfair valuations.

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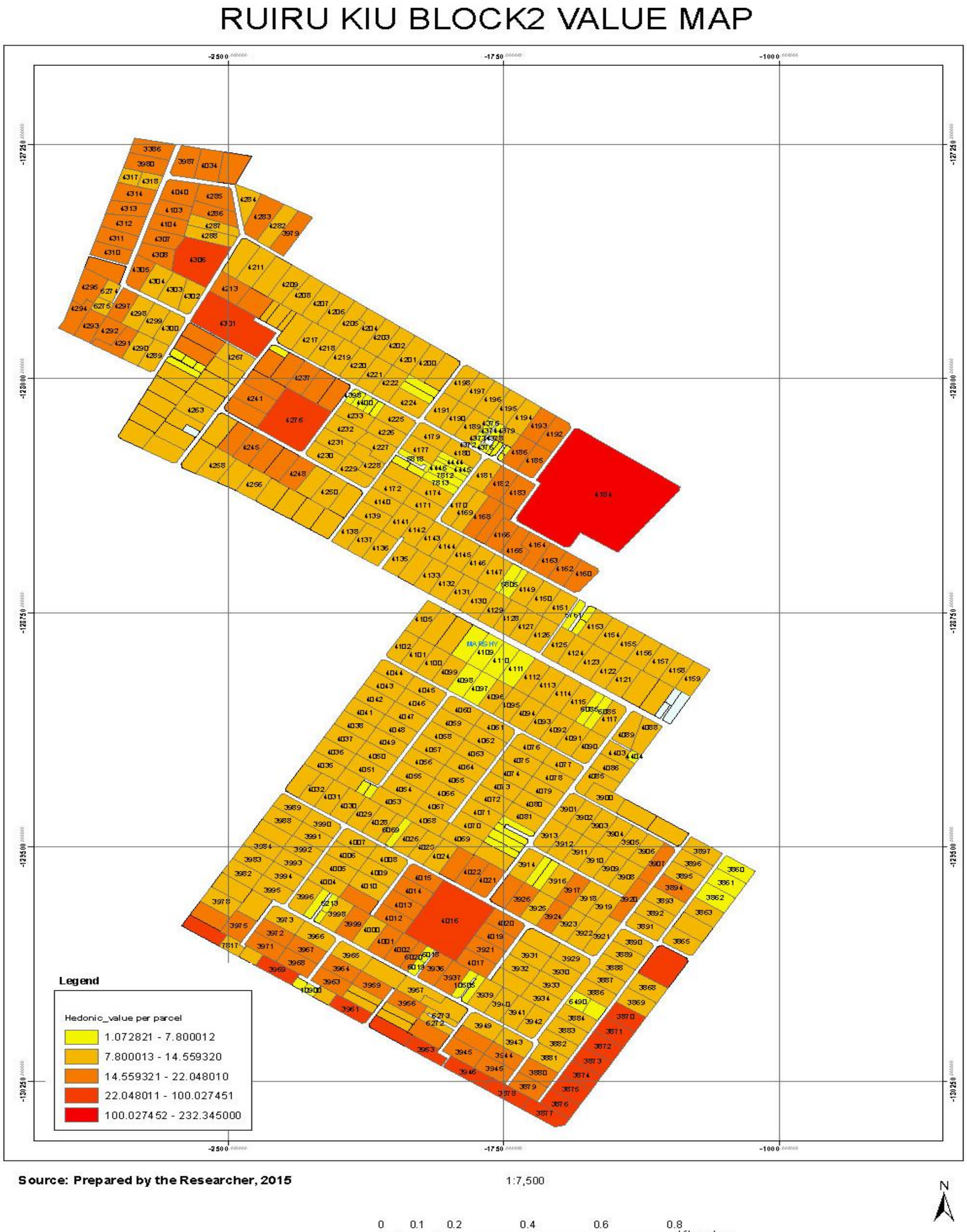
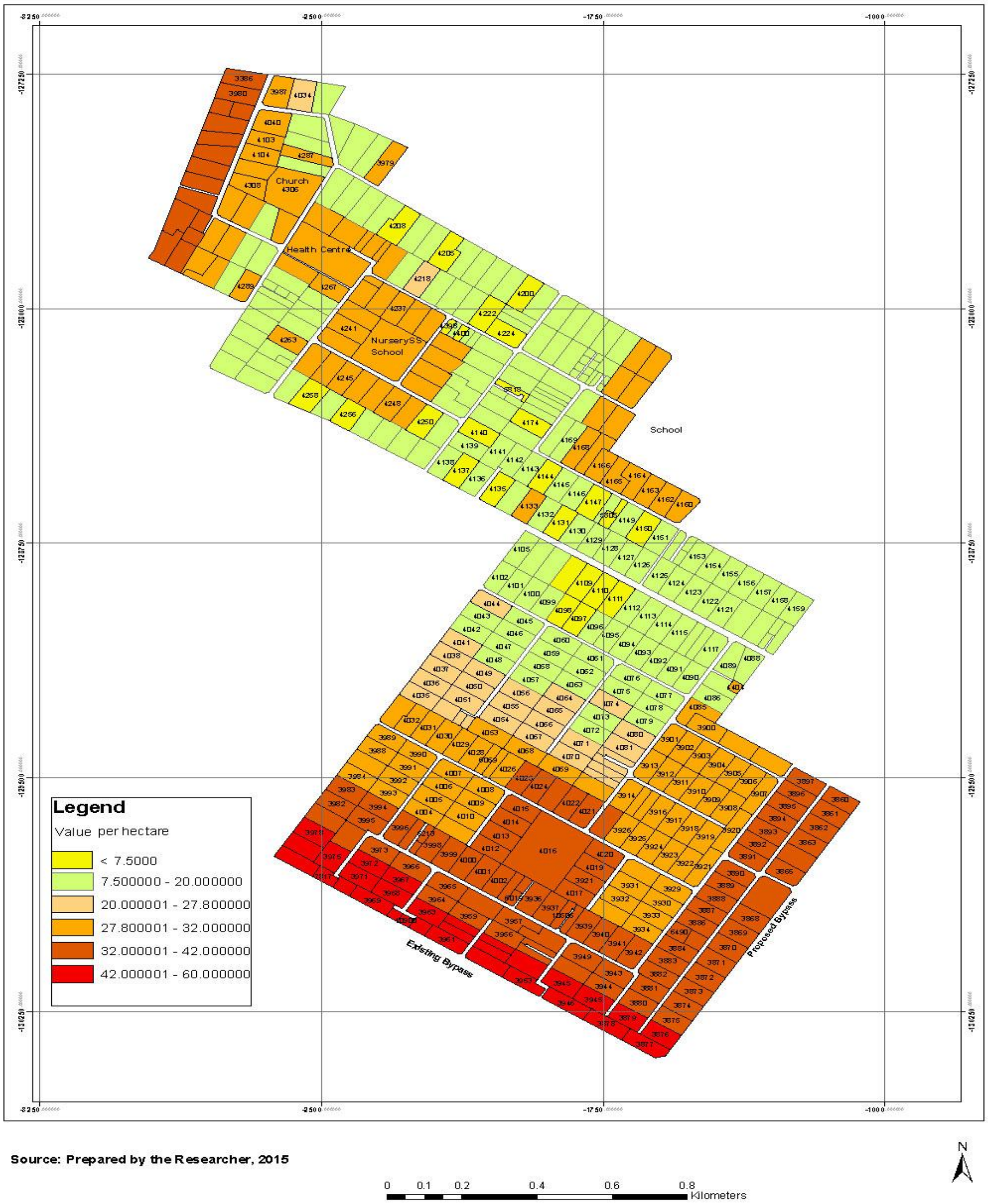
Appendix I: *Value Map per Parcel (in million kshs.)*



Source: *Author, 2015*

Appendix II: *Value Map per Hactare (in million kshs.)*

RUIRU KIU BLOCK2 VALUE MAP



Source: Prepared by the Researcher, 2015