MAKERERE UNIVERSITY

COLLEGE OF ENGINEERING, DESIGN, ART AND TECHNOLOGY

SCHOOL OF THE BUILT ENVIRONMENT DEPARTMENT OF GEOMATICS AND LAND MANAGEMENT

A GIS BASED MULTICRITERIA DECISION ANALYSIS METHODOLOGY FOR PROPERTY VALUATIONS. CASE STUDY OF KIIRA MUNICIPALITY

FINAL YEAR PROJECT REPORT

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A Final Year Project Submitted to the Department of Geomatics and Land Management in partial fulfillment of the requirements leading to the Award of a Master's Degree in Geo-Information Science and Technology of Makerere University

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DECLARATION

I **ICODIO ARTHUR PAUL** declare that the work presented in this report is my own and has been generated by me as a result of my original research except where acknowledged.

Sign.....

ICODIO ARTHUR PAUL

Date.....28/01/2022.....

APPROVAL

The project report titled; a GIS based multicriteria decision analysis methodology for property valuations. Case Study of Kiira Municipality prepared by **ICODIO ARTHUR PAUL, 2019/HD08/23508U** under the supervision of **Dr. ANTHONY GIDUDU** for the partial fulfillment of the requirements leading to the award of a Master's Degree in Geo-Information Science and Technology of Makerere University. It has been examined and approved for submission.

SIGN: .....

Dr. ANTHONY GIDUDU

DATE: .....28/01/2022.....

Dedication

I would like to dedicate this report to my late mother, Ms. Flora Okumu for her love and unending support through my time at University and to my dad Mr. Alex Oluka for support and encouragement he gave me throughout the journey

Acknowledgement

I owe a lot to friends and members of my family who have helped me in the project work, and who, through their support, have encouraged and educated me.

I am extremely thankful to, my supervisor Dr. Anthony Gidudu, for his supervision and guidance

Table of Contents

Index of tables

Table of figures

List of Abbreviation

AHP	Analytic Hierarchy Process
CR	Consistency Ratio
CI	Consistency index
GIS	Geographic Information System
MCDA	Multiple-Criteria Decision Analysis
PAPs	Project Affected Persons

P

Abstract

Traditional valuation approaches used by valuers in Uganda are highly dependent on subjective judgment in the returned values. This has been cited as a major cause of value variability and disparities among valuers. In this study the traditional valuation methods mainly; Cost approach, Income approach and Market approach have been examined. Their strengths and weaknesses have been highlighted. The study attempts to offer solution through application of a GIS-based MCDA methodology. The advantage of using a GIS-based MCDA method is that it can model the relationship between the property market value and the value attributes.

Due to the fact that property value factors are subjective, the study utilized the AHP method of MCDA in the analysis. Among advanced real estate valuation methods, AHP is different because it can assign points to each other and assess criteria groups (location, physical, and legal) affecting the value within themselves. As the structures, units, importance, and values of sub criteria within criteria groups are different from each other, weight points calculated by AHP provide homogeneity with respect to units and their effect on value. An analysis of the data was done in ArcGIS 10.7 software, better visualize the values using maps

It was concluded that land values were more affected by their proximity to roads, schools and hospitals and, the values decrease with distance from these services

A methodology was designed which involved firstly, determining the factors, weighting them, and using these weighted values to determine land values as opposed to traditional valuation methods which take block figures for particular areas and do not consider property attributes

1.0 Background

Valuation of real estate in is the process of assessing the characteristics of a given piece of land. Real estate properties are spatial goods of which the value is expected to depend upon their unique spatial and non-spatial attributes. In definition, valuation is the art or science of estimating the value for as specific purpose or particular interest in property at a particular moment in time, considering all the features of the property and also considering all the underlying economic factors of the market including the range of alternative investments ((Millington, 2000). Accurate estimates of property values are important not only for sellers and buyers, but also for financial institutions managing underwriting risk related to housing finance. Nevertheless, the estimation of market value for residential real estate is a relatively complex endeavor, because residential housing usually contains unique packages of attributes that are potentially conflicting and interfering with market value predictions (Fernando , Ronald , & Mark , 2016)

In determining the value of a particular property, all value attributing factors must be considered. A multi Criteria Decision Analysis (MCDA) model can be utilized here. Multi Criteria Decision Analysis is a criterion that explicitly evaluates multiple conflicting criteria in decision making (Mahdi, 2011). It is a methodology for appraising alternatives on individual, often conflicting criteria, and combining them into one overall appraisal. (Fernando , Ronald , & Mark , 2016) note that each criterion considered in MCDA has a relative weight within the final evaluation reflecting its relative importance within the decision context. The subject of the valuation is scored according to how it performs within each criterion. The aggregation of the scores received for each criterion multiplied by their relative weights results in a composite score. In order for one to fully utilize an MCDA, a GIS system can be used. A geographic information system is a conceptualized framework that provides the ability to capture and analyze spatial and geographic data. It is an information system capable of integrating, storing, editing and displaying geographically referenced information.

Kiira municipality is a developing suburb with a booming real estate sector, well planned with roads and different value affecting factors like schools, hospitals, supermarkets, and road. However, the spatial distribution of these services and amenities in relation to the plots differs for the plots. Some have all the amenities within near reach and some barely have any yet, traditional

valuation methods take the value for plots in kiira as a block figure irregardless of location of the plots.

Decision making is an essential part of our private and professional life. The consequences of our decisions are sometimes very simple, but very often our decisions affect our life and future significantly. (Andras Inotai, et al., 2018). This cuts across in valuation too and the use of a GIS based MCDA comes in handy.

1.1 Problem Statement.

Property valuers often have appraised real estate based on their intuition or experiences. They base on recent comparable sales data to determine the value of the subject property and often they do not consider the peculiar features of the property to be valued vis a vie the peculiar features of the comparable property.

Now that the concern with securitization of real estate is brought to attention, the technique of appraising the real estate more logically, quantitatively and accurately is required. This calls for the need to use GIS based Multi Criteria Decision Analysis technics to appropriately value properties.

1.2 Objectives.

1.2.1 Main objective

To develop a GIS based multicriteria decision analysis methodology for property valuations

1.2.2 Specific objectives

- To identify the factors that affect property value
- To design a multicriteria weighting methodology to assist in determining property values
- To implement the methodology and compare values obtained using the model and traditional property valuation approaches

1.3 Scope

The scope of the research Will be threefold covering the content, geographical and time aspects of the research.

1.3.1 Geographical Scope

The research will be based in Kiira municipality, Wakiso district. Kiira is 17.1 kilometers from the central business district of Kampala

1.3.2 Content Scope

The research will look at developing a GIS based MCDA model to assist in assesing property values in Kiira municipality.it will weight a variety of property value determining attributes and use them to determine property values and in process it will compare the output with values from traditional valuation methods

1.3.3 Time Scope

The research will be time bound in order to achieve its main objective and specific objectives. It will be carried out between the period of November 2021 to December 2021, a time period in which the researcher will carry out field surveys, analyze primary data in relation to secondary data in order to produce the results.

1.4 Justification.

The determination of property values is a fundamental aspect of finance because most times, these values are used for secured lending purposes, government compensation rates, property taxes. If property values are not well determined, it can lead to losses and this can affect the economy. Occasionally, property valuers have difficulty in value determination, cases which have seen banks having non-performing loans, government over compensating for properties in compulsory acquisitions and local councils collecting low revenues from properties. The project will develop a more concise and clear approach to assist in determining the value of property

1.5 Dissertation outline

This dissertation is made up of five chapters focused on realizing the purpose of the study and answering its aims. A summary of the chapters is provided below.

2.0 Literature Review.

2.1 The Concept of property valuation.

Considerable literature exists regarding the complexity of the residential real estate appraisal process and the methods employed to determine the market values. Deviations in residential real estate intrinsic values occur due to a multiplicity of attributes and explanatory factors requiring consideration. The aim of valuation is to achieve the best estimate of the transaction price of property. The market of specialized properties is very diverse as property does not transact sufficiently often to allow the establishment of price by comparison with previously sold assets. Real estate valuation is premised on the approaches to property valuation which are majorly three approaches, the income approach, the cost approach and market approach. (RICS, 2020). In the market approach method, the value of real estate is determined by reference to the market activity for example transactions involving identical or similar assets while making quantum adjustments and allowances for the differences between the properties for instance, two identical properties with the same accommodation but one may be close to schools and hospitals while the other may be close to the mall though far from the main road. In practice, the two properties may be given the same value yet there is a need to weight these value options. In selection of this criteria, a universal model for sorting real estates is not possible because of the unique nature of the weights and value functions. Therefore, it would be more appropriate to execute the model constructing process with the case investor (Otto , 2012). Different investors have different traits they look for in property and these determine how much weight each criterion has.

2.2 Traditional Valuation Methods

The red book, a document that lays out "Valuation Professional Standards" recognises three approaches to value, the market approach, the income approach and the cost approach. (RICS, 2020).

2.2.1 The market approach

The market approach to value, also known as the sales comparison approach determines the value of an asset based on the selling price of comparable assets. The method entails using valuation metrics from properties that have traded publicly which are considered to be rightly similar to the subject entity. (Ireneusz , Marta , & Paweł , 2020) This method though simple and straight forward,

it is difficult to identify sufficient comparable data. It raises questions on how much data is available and how good the data is. Heinrich & Mathia, (2015) while assessing data quality note that for better accuracy assesements data should be recent, accurate, reliable complete and comprehensive.

2.2.2 The income Approach

Marshall , (2020) defines the income approach to property valuation as a methodology used by appraisers to estimate the market value of a property based on the income of the property. With the income approach, a property's value today is the present value of the future cash flows the owner can expect to receive. The income approach to property valuation is suitable for income producing real estate. It weighs the potential income of the property to the purchase price and captures cashflows that investors care about however, it requires a lot of information projections and any small variations in assumptions can lead to significant impact on value.

2.2.3 The cost Approach

Under the cost approach, property value is derived by adding the value of land to the current replacement cost of a new building less adjustments for estimated depreciation and obsolescence. (Onyejiaka, Emoh, & Oladejo, 2015). The cost approach is less reliable for old properties as it is difficult to estimate the depreciation of old properties, and valuers face challenges due to the a, unavailability of up to date data on construction costs; inadequate data for calculation of depreciation leading to numerous assumptions which can render a value opinion inaccurate and unreliable.

In conclusion, the three approaches to valuation all have advantages and disadvantages. (Musili, 2013) in his study asserts that, traditional valuation methods used by valuers are highly dependent on subjective judgement which has been cited as a major cause of value variability and disparity among valuers. He further affirms that the hedonic method for valuation can offer better solutions to this problem since the method can model the relationship between sale price of a house and housing attributes. His findings resonate with studies from Zubeida & Mohd , (2019) who note that the hedonic model which which makes use of a classical linear regression model by weighting attributes of a property to determine its value is by far a great solution in determining property values.

2.2.4 The hedonic method of property valuation

The hedonic pricing model is used to estimate the extent to which each factor affects the market price of the property. (Stanisław & Damian , 2017). In the hedonic price method, the valuation process consists in decomposition of the price of the asset into combinations of the specific characteristics, which reflect the importance when it comes to pricing. In fact, only the specific features of the asset are valuated, and not the asset itself. The hedonic pricing model ideally weights property attributes however, it does not always incorporate external factors or regulations, such as taxes and interest rates, which could also have a significant impact on prices.

2.3 Geographic Information System (GIS)

GIS is a tool that combines spatial and non–spatial data sets to create thematic maps illustrating a variety of demographic information relating to population, housing and economic activities (Cheng et al., 2007). Over the years, GIS Has evolved and it has been used in various aspects of life to solve problems. It's ability to be used to create, manage, analyze, various types of spatial data have made it a go to tool for everyday problem solving. In addition, GIS integrates a lot of other technologies like databases, python and this helps to illuminate spatial issues. It has been argued that GIS-MCDA systems can potentially provide a flexible problem-solving framework where participants can explore, understand and redefine a decision problem (Kyem, 2004). The use of MCDA with GIS has become one of the sought of research areas in various fields. Many of the problems we are facing today are complicated, with a lot of conflicting interests and solutions. Using cognitive maps and multiple criteria decision analysis (MCDA), to address valuation limitations, may prove effective by incorporating multiple perceptions and decision makers into a framework for residential real estate valuation. However, groups need to be able to work together and compromise to find a solution that is the most feasible. There is often a spatial or geographic nature to these problems, and thus, by using GIS with different frameworks or analyses, can aid the decision-making process.

Studies have shown that the use of GIS technology alone cannot provide suitable decision making. According to (Boroushakin & Malczewski , 2010), arguments have arisen over the use of GIS technologies alone for making better decisions.

2.4 Need for GIS-Based Multi-Criteria Decision Analysis in Real Estate Valuation.

GIS-based multi-criteria decision analysis (GIS-MCDA) can be defined as a process that transforms and combine geographical data (map criteria) and value judgment (decision makers preference and uncertainties) to obtain appropriate and useful information for decision making (Boroushaki & Malczewki, 2010). Multiple criteria decision-making has grown as an important part of modern decision science and operations research, and supported by computational and mathematical tools allows the subjective evaluation of performance criteria and alternatives by decisionmakers (Zavadskas, Ustinovichius, & Stasiulionis, 2004). There are multiple conflicting and incommensurable criteria involved in MCDA that cause a challenging decision situation for the decision maker. A Multi-Criteria Decision Analysis (MCDA) framework could support the decision-making process by aggregating multiple policy objectives. The logic behind MCDA is described as "divide and conquer" whereby a complex problem is decomposed into simpler problems and each individual problem is analyzed separately before all analyses are connected together, resulting in a program of action for the complex problem. MCDA is a methodology for appraising alternatives on individual, often conflicting criteria, and combining them into one overall appraisal. Each criterion considered in MCDA has a relative weight within the final evaluation reflecting its relative importance within the decision context. The precise choice of scoring, weighting and aggregating techniques will ultimately depend on a number of characteristics of the decision-making problem under consideration, in relation to theoretical relevance, level of precision required in the evaluation of the options and cognitive burden posed to stakeholders and decision-makers. (Valerie & Theodor, 2002). Otto , (2012) notes that one of the advantages of using MCDA is decision maker's ability to learn and understand both his own and others' values and judgments. These benefits are received by actions such as taking the decision maker's preferences into account and concerning the decision problem explicitly by structuring and synthesizing the information. Joerin & Musy (2000) stated that integration of analytical techniques designed to work with MCDA problems within a GIS context could offer more functionality to users and improve the decision-making process in spatial contexts and land suitability assessments. Therefore, MCDA can be used to allow evaluation of different options according to many criteria, often conflicting in order to guide the decision maker towards judicious choices

2.5 The Analytic Hierarchy Process (AHP)

One of the most eminent MCDM methods, in terms of application in decision models and publications, is the Analytic Hierarchy Process (AHP). Almost one-third of MCDM applications have been done with the use of AHP, and this is because it is simple to use and able to break down the components of the problem in a hierarchical structure. In addition, Vasileios & Fotios , (2020) notes that the AHP is the most suitable method to structure a decision problem with a large number of criteria and sub-criteria and a relatively small number of alternatives. AHP is a method of measurement through pairwise comparisons that incorporates the judgments of experts in deriving priority scales. To decide in an organized way necessitates generating priorities; we need to deconstruct the decision into the following steps. (Saaty, 2008)

1. Define the problem and determine the kind of knowledge needed. In this study: Determining and weighing the value-affecting criteria for parcel value estimation.
2. Structure the decision hierarchically from the highest level (goal of the decision and objectives from a broad perspective) to the intermediate level (criteria on which the top elements depend) and finally the lowest level (usually a set of alternatives). In the intermediate level of this study: the major categories of the criteria are Location, physical, and legal features. In addition, there are also sub criteria of the features.
3. Construct a set of pairwise comparison matrices (Equations 1 and 2). Each criterion is compared with the other criterion within its group

$$A=\left[a_{ij}\right]=\begin{bmatrix} 1 & a_{12} & a_{13} & \dots & a_{1n} \\ 1/a_{12} & 1 & a_{23} & \dots & a_{2n} \\ 1/a_{13} & 1/a_{23} & 1 & \dots & a_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ 1/a_{1n} & 1/a_{2n} & 1/a_{3n} & \dots & 1 \end{bmatrix}_{nxn} ; \quad (1)$$

$$a_{ij}^{*}=\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}. \quad (2)$$

4. Use the priorities obtained from the comparisons to weight the priorities in the level immediately below it for each element. Then, for each element, add its weighted values

and obtain its overall priority. Continue this process of weighting and adding until the final priorities of the alternatives in the bottommost level are obtained.

$$w_i = \frac{\sum_{j=1}^{n} a_{ij}^{*}}{n}, \qquad (3)$$

The processes described above should be applied and criteria that are taken into consideration should be assigned scale values in accordance with their degree of importance (Table 1). This decision is made either by an expert or in accordance with the results of the questionary. In this study, the decisions were given by experts who have been working as real estate appraisers in public institutions, professional organizations and private sector.

Table 1The fundamental scale of absolute numbers (Saaty, 2008)

Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

2.6 Consistency ratio of AHP

With the pairwise comparison method, criteria and alternatives are paired with one or more referees (i.e. experts or decision makers). It is necessary to evaluate individual alternatives, derive

weights for the criteria, construct the overall rating of the alternatives, and then identify the best one. The matrix of pairwise comparisons represents the intensities of the expert's preferences between individual pairs of alternatives. (Alonso & Lamata, 2006). The consistency ratio (CR) is determined in order to test the consistency of the comparison matrices. If the CR $\leq$ 0.10, the assessment is consistent; otherwise, it must be refreshed

2.7 Summary of the literature

Gap 1: There is a lack of national a streamlined appropriate valuation methodology in Uganda despite there being a regulatory body. Most of the legislations are not well implemented in addition to being contradictory to each other

Gap 2: due to the poorly implemented laws, the valuation fraternity is being shadowed by the Institute of certified public accountants of Uganda (ICPAU). Accountants are seeming to be more organized and taking over business valuations and valuations for taxation. This calls for a firm grip on property valuations by valuers which entails revising valuation methodologies

3.0 Methodology

This chapter explains the project design and the methods used to operationalize the specific objectives of the research.

3.1 Description of the Study Area

The study area kiira municipality is located in wakiso district, the study area can be found between latitude and longitude 60˚ 38.487'N, 17˚ 09.258'E and 60˚ 38.318'N, 17˚ 09.352' E. Kira Municipality is bordered by Gayaza to the north, Mukono to the east, Lake Victoria to the south, Kampala to the west, and Kasangati to the north-west. The town is approximately 15 kilometers north-east of the central business district of Kampala, Uganda's capital and largest city. The study area covers 98.83 km^2 of land. It is characterized by a steadily growing real estate sector

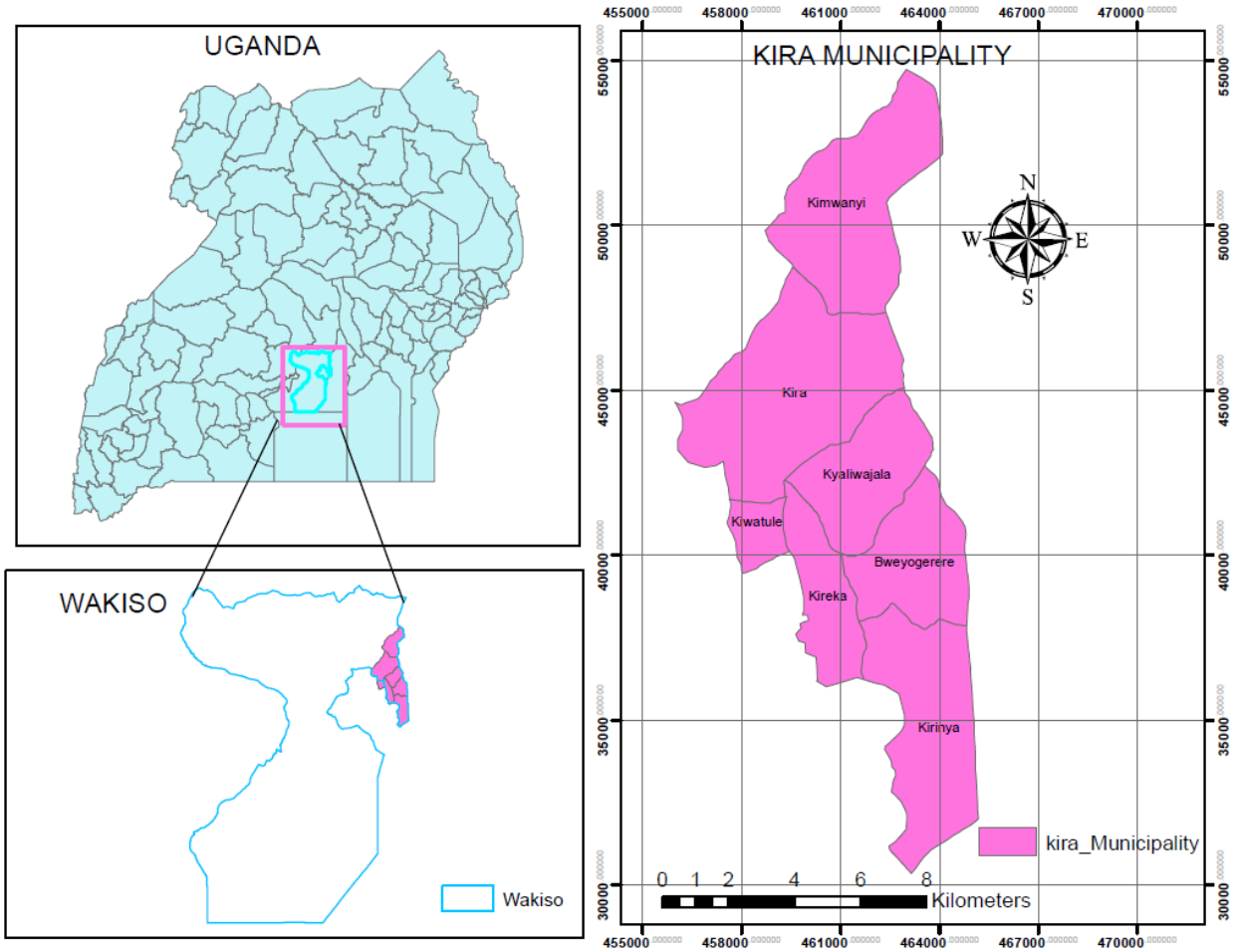

Figure 1 a map of kiira municipality

3.2. Data Sources

Both primary and secondary data were collected and analyzed during the study.

3.2.1 Primary Data

Primary data was collected through delphi method by purposively sampling valuers.

3.2.2 Secondary Data Collection

Secondary data was acquired from books, journals, and reports related to land and property valuation. This data will give an insight into the current methods of property valuation, application of MCDA and GIS in valuation which will be used for prudent judgment. The purpose of a literature review is three-fold: (1) to survey the current state of knowledge in the area of inquiry, (2) to identify key authors, articles, theories, and findings in that area, and (3) to identify gaps in knowledge in that research area.

3.3 The Methodology Design and Workflow

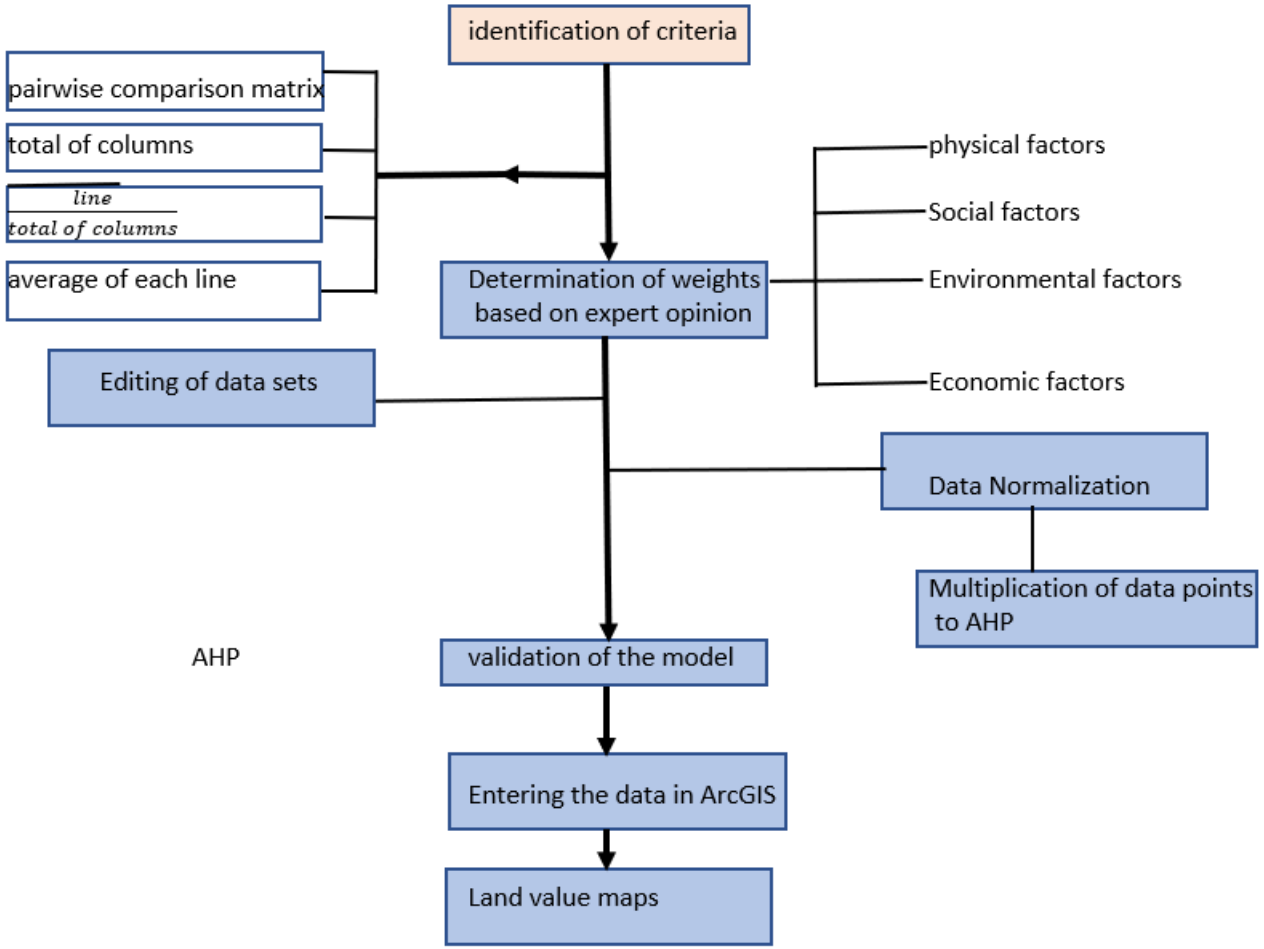

Figure 2: a workflow of the methodology

The research process will start with a data collection phase through a 3-round Delphi, then modeling of the property value attributes and finally, an analysis of the data with the Analytic Hierarchy Process (AHP) to develop an MCDA model.

3.3.1 Identifying the value attributes.

Without exception, all multicriteria methods call for the identification of the key factors which will form the basis of an evaluation. These are referred to variously as: values, (fundamental) objectives, criteria, (fundamental) points of view. The methodology involved identification and screening of alternatives that affect value of real estate. This was done through explanatory research methods and a group of 5 property valuers were tasked with this. There are many factors that affect property values. They can be grouped as subjective and objective factors

3.3.2 Assigning weights

This stage involved assigning weights for each attribute to reflect their relative importance to the decision. The attribute considered most important was assigned the weight 100%. A higher percentage indicates better performance, with 100% being the full score that was awarded to any particular criterion, while 0% represents the worst score for performance of any criterion. Stakeholders then decided which attribute they thought is the least important one and judged how much less important it was to the decision compared to the most important one. For the other attributes the weighting was chosen in between, according to their relative importance Very poor performance in some key criteria resulted in their exclusion from the assessment (exclusion category). In the end, the weights are scaled down so that their sum equals to 100%.

A pairwise comparison table was designed using Microsoft excel. To void ambiguity and too many pair outcomes, only the relevant 8 set of factors was used, the ones whose data could be acquired.

$\frac{n(n-1)}{2}$ where n is the number of elements to pair

$=\frac{8(7)}{2} = 28$

3.3.3 Calculate the Weighted Total Score

Next step was to combine the weights and scores to derive the overall value of each option. This was done by multiplying scores by weights for each attribute and summing the products up for each option. Each stakeholder generated different total values according to their weighting. The values were reviewed and a final table of weights was produced

3.3.4 Compare the Results and Evaluate the Alternatives

The options were then be ranked according to their total values (the highest value corresponds to the best option). Different stakeholders generated different rankings. There was a comparison and discussion of the ranking of options by stakeholders and their different weightings, and an analysis of how sensitive the rankings are to scores and weights assigned to each of the attributes and options was done

3.5 GIS based MCDA implementation

This stage focused on the integration of multicriteria decision analysis (MCDA) and geographical information systems (GIS) and introduced a tool, GIS–AHP, written in visual basic in ArcGIS for GIS-based MCDA. The GIS–AHP deals with raster-based data sets and includes standardization, weighting and decision analysis methods, and sensitivity analysis. Simple additive weighting, weighted product method, technique for order preference by similarity to ideal solution, compromise programming, analytic hierarchy process, and ordered weighted average for decision analysis; ranking, rating, and pairwise comparison for weighting and linear scale transformation for standardization was applied by using this tool.

4.0 Results and discussion

4.1 Geospatial Land Valuation factors

The 8 Geospatial Land Valuation factors were selected for this study basing on expert opinion review of existing literature. They were then grouped as Physical, Social, Economic and Environmental accordingly to a developed hierarchical structure.

The Physical factors refer to the physical attributes of land in which case land cover was considered for this study. Environmental factors describe the susceptibility of land to hazards such as flood (proximity to wetland, river) and forests (insect outbreaks and attacks from wild animals). The Economic factors are economic benefits of land due to its nearness to major trading centers or towns.

Table 2 table showing a breakdown of factors that affect land values

Land Value			
Physical Factors	Social Factors	Economic Factors	Environmental Factors
• Land Cover • Plot shape and size • Developments on land	Proximity from: • Schools • Health Centers • Roads (Highways, Major roads and Other access roads)	Proximity from • Major Trading Centers • Demand and supply • Interest rates	Proximity from • Wetlands • Lakes • Forests

4.2 Hierarchical Modelling

Having identified the above factors and categorized them as shown above assigning of relative weights of the first hierarchy (i.e., physical, social, economic and environmental) was then performed. In a similar manner, the relative weights of the second hierarchy (i.e., 8 subfactors) in each factor-category were also computed. In both processes, the AHP was used to derive the relative weights of each factor-category and subfactor.

Each sub-factor was classified and assigned score of 0 to 5 with 5 being highest effect on land value and 0 meaning no effect.

4.3 Weights of Main Factors and Sub-factors

These factors were grouped into four categories and each category was assigned weights using the AHP method with the aid of expert advice. Further, sub-factor of each category was weighted also with the AHP. The pair-wise comparison and weights of the main factors and sub-factors (are shown along with the respective consistency ratio (CR) value. In all cases, CR value is less than 0.10; this implies judgements are consistent and hence weights are acceptable.

4.4 Calculations of AHP

The social, physical, economic, and environmental features of the land values, and the weights of the sub criteria were calculated as described below.

I. Process: in the first step, weights of the social, physical, economic, and environmental were calculated. So as to create a Pairwise Comparison Matrix in accordance with the criteria as seen in Table 2. Points were determined by considering the scale dimensions of Saaty in Table 1. Scores of the diagonals of comparison matrices (3×3) are one and the values above the diagonal are given points by considering scale values in accordance with the experts' opinions. The downside of the diagonal is found by taking the reciprocals of upward values

Table 3 Pair-wise comparison of the Main factors

1. Comparison Matrix				
Main Factor	**Social Factors**	**Physical Factors**	**Economic Factors**	**Environmental Factors**
Social Factors	1.00	3.00	2.00	5.00
Physical Factors	0.33	1.00	1.00	5.00
Economic Factors	0.50	1.00	1.00	3.00
Environmental Factors	0.20	0.20	0.33	1.00
Total	**2.03**	**5.20**	**4.33**	**14.00**

Columns are summed in comparison matrix and each line is divided into sum of the column (Equation 2) and line processes are done (Table 3). This is done to standardize the weights.

The average of the first three columns was used in Equation 3 and calculated weights of Legal, Location and Physical Features are indicated in the last column of the table

Table 4: Weights of Main factors

2. Normalized Matrix							
Factor	**Social Factors**	**Physical Factors**	**Economic Factors**	**Environmental Factors**	**Total**	**Criteria Weights**	**Consistency Measure**
Social Factors	0.49	0.58	0.46	0.36	1.89	**0.4719**	4.19
Physical Factors	0.16	0.19	0.23	0.36	0.94	**0.2360**	4.11
Economic Factors	0.25	0.19	0.23	0.21	0.88	**0.2208**	4.11
Environmental Factors	0.10	0.04	0.08	0.07	0.29	**0.0713**	4.02
Total	**1.00**	**1.00**	**1.00**	**1.00**		**CI =**	0.04
						RI =	1.12
						C.Ratio =	**0.03**

Table 5: Pair wise comparison of Environmental Factors

1. Comparison Matrix			
Factor	**Wetlands**	**Lake**	**Forest**
Wetlands	1.00	1.00	5.00
Lake	1.00	1.00	9.00
Forest	0.20	0.11	1.00
Total	**2.20**	**2.11**	**15.00**

2. Normalized Matrix						
Factor	**Wetlands**	**Lake**	**Forest**	**Total**	**Criteria Weights**	**Consistency Measure**
Wetlands	0.45	0.47	0.33	1.26	**0.4205**	3.04
Lake	0.45	0.47	0.60	1.53	**0.5094**	3.06
Forest	0.09	0.05	0.07	0.21	**0.0701**	3.01
Total	**1.00**	**1.00**	**1.00**		**CI =**	0.02
					RI =	0.58
					C.Ratio =	**0.03**

Table 6: Derivation of weights of Environmental factors

Table 7: Pair-wise comparison of Social factors

1. Comparison Matrix					
Factor	**Distance to Schools**	**Distance to Health Center**	**Distance to Residential Roads**	**Distance to Major Roads**	**Distance to Highways**
Distance to Schools	1.00	0.20	0.33	0.20	0.33
Distance to Health Center	5.00	1.00	3.00	2.00	0.33
Distance to Residential Roads	3.00	0.33	1.00	0.20	0.11
Distance to Major Roads	5.00	0.50	5.00	1.00	0.33
Distance to Highways	3.00	3.00	9.00	3.00	1.00
Total	**17.00**	**5.03**	**18.33**	**6.40**	**2.11**

Table 8: Derivation of Weights of Social Factors

2. Normalized Matrix

Factor	Distance to Schools	Distance to Health Center	Distance to Residential Roads	Distance to Major Roads	Distance to Highways	Total	Criteria Weights	Consistency Measure
Distance to Schools	0.06	0.04	0.02	0.03	0.16	0.31	**0.06**	5.20
Distance to Health Center	0.29	0.20	0.16	0.31	0.16	1.13	**0.23**	5.76
Distance to Residential Roads	0.18	0.07	0.05	0.03	0.05	0.38	**0.08**	5.55
Distance to Major Roads	0.29	0.10	0.27	0.16	0.16	0.98	**0.20**	5.83
Distance to Highways	0.18	0.60	0.49	0.47	0.47	2.21	**0.44**	5.84
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**		**CI =**	0.16
							RI =	1.12
							C.Ratio =	**0.1**

From table 6 and 7, we can observe that plot values are higher and influenced more by their proximity to schools, and residential roads and in all tables, to ensure validity of the results I made sure the consistency ration was below 0.1 (Saaty, 1980)

Land value map of kiira municipality

In this study, GIS was used in order to generate a value map. The base map of the study area, was transferred into GIS software (ArcGIS, 10.7) as a base layer. The layer for roads, schools, health then added and then different prediction maps were generated for market value, and AHP outputs. Thus, all the parcel values were positionally distributed on the value maps. The maps were utilized for information on land values (Figure 2,3 and 4). A lot of information was drawn on the maps

From the map, we can see that land values are higher along the major roads and high way and the further you move away from roads, the prices drop. Ideally if a plot of land in kiira trading centre is one hundred and twenty million, a plot 500 metres from the center will be approximately eighty million shillings. Further more in figure 3 we analyzed land values based on the proximity to major trading centers of Bweyogerere, Najjera, Kyaliwajala and Kiira and it was observed that land values keep tapering as one moves away from the centres.

Areas in bukasa and nakwero at the extremes are observed to be with low land values. This is because nakwero is just a developing neighborhood with great future prospects. The same applies

to bukasa but in addition it is close to the lake shores which are swampy and settlement around the shores is prohibited

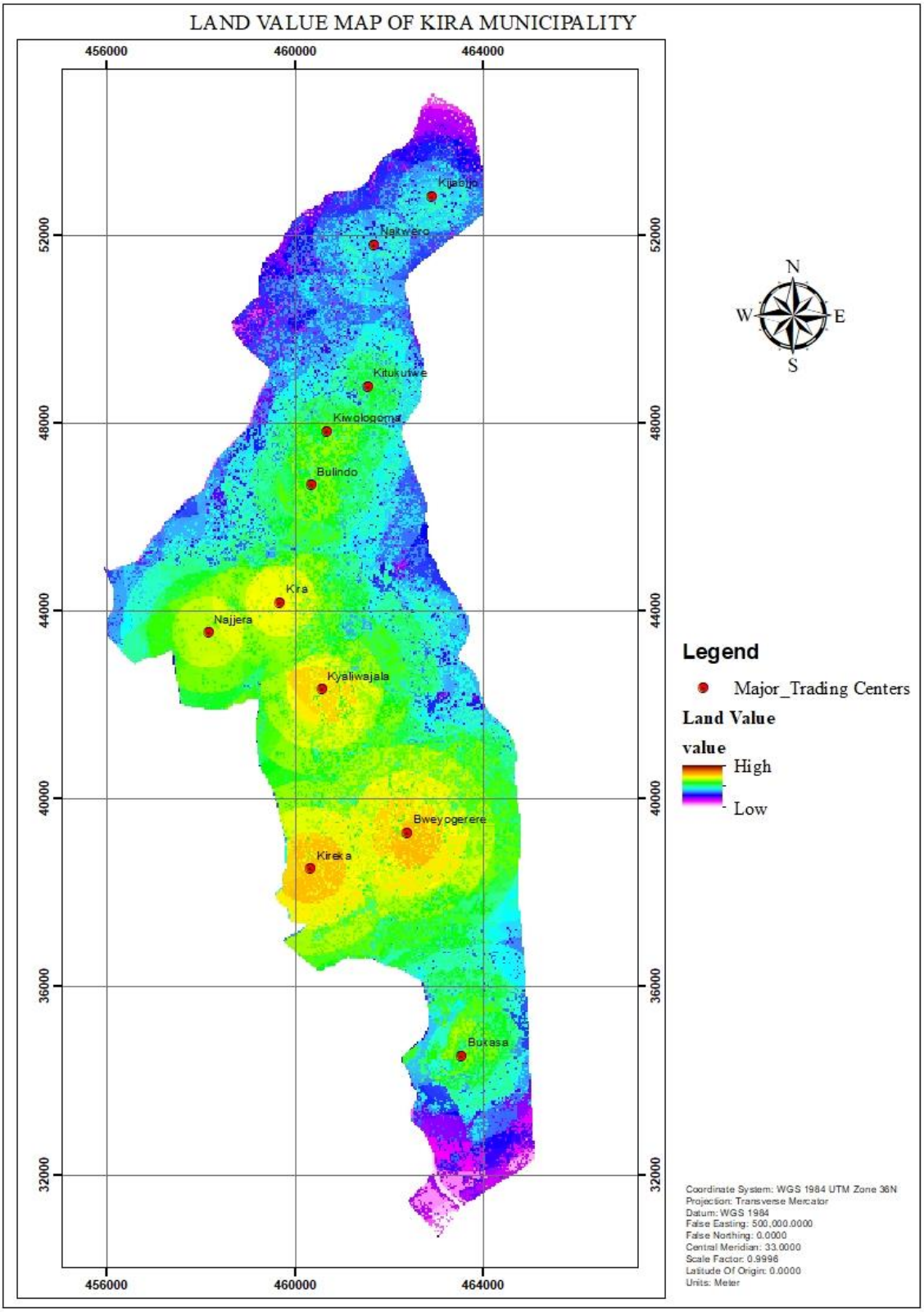

Figure 3: a map showing how land values are affected with proximity to major towns

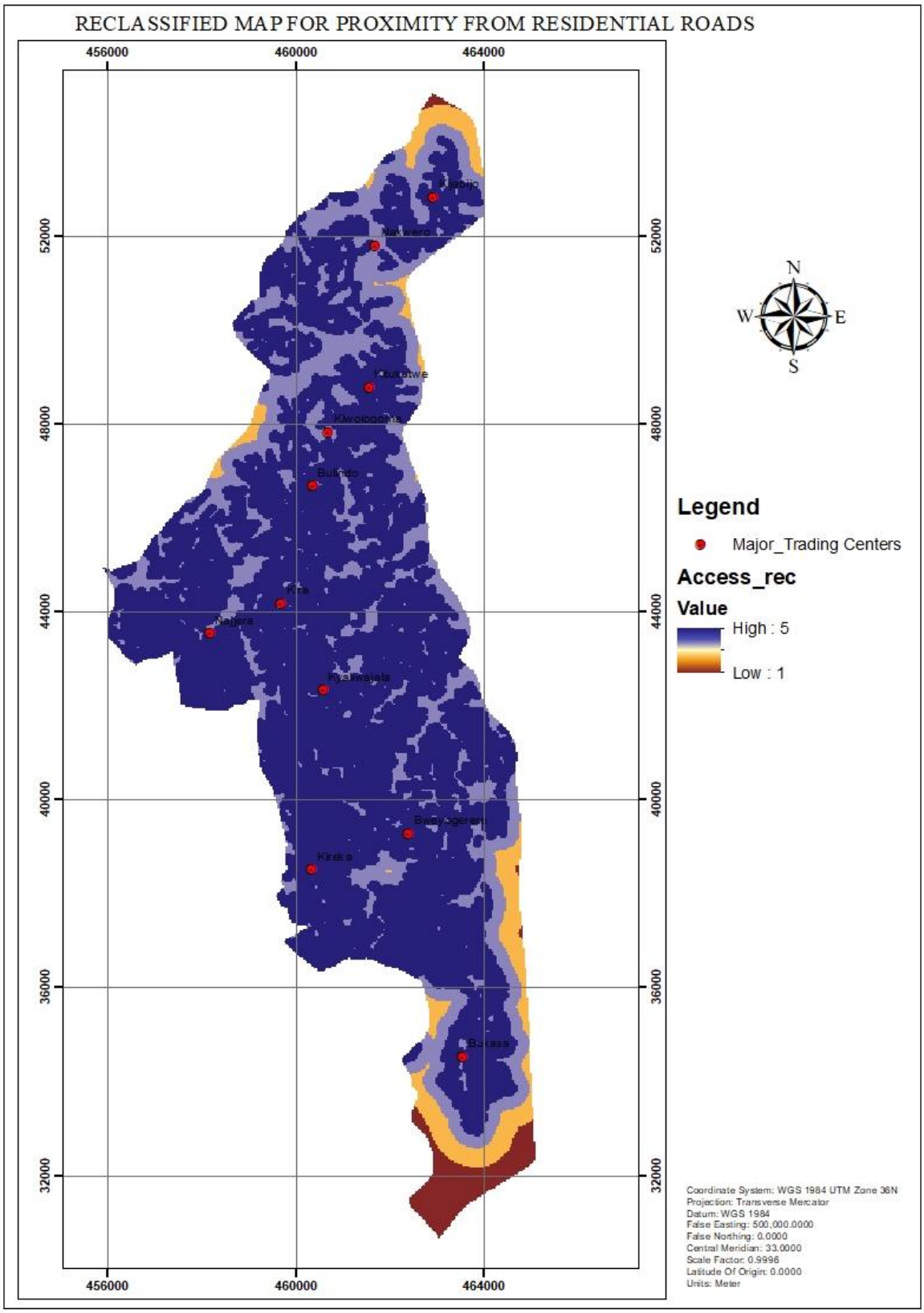

Figure 4: a land value map showing how values are affected by proximity to roads

An assessment of how property values are affected by proximity to roads was done. Figure 4 shows how land values are affected by roads and kiira municipality has a road network. Almost 90% of the plots in kiira have access roads, in addition to major roads. This explains why land in kiira municipality is high compared to other municipalities like nansana. Ideally a 13 decimalplot of land within a radius of ten kilometres from kampala CBD is in the range of 35-150 million. On a comparison scale, plots in kiira municipality that are 17 kilometres from the CBD account for the high figures as compared to localities like nsangi and nansana which are almost the same distance as Kiira.

Social Factors

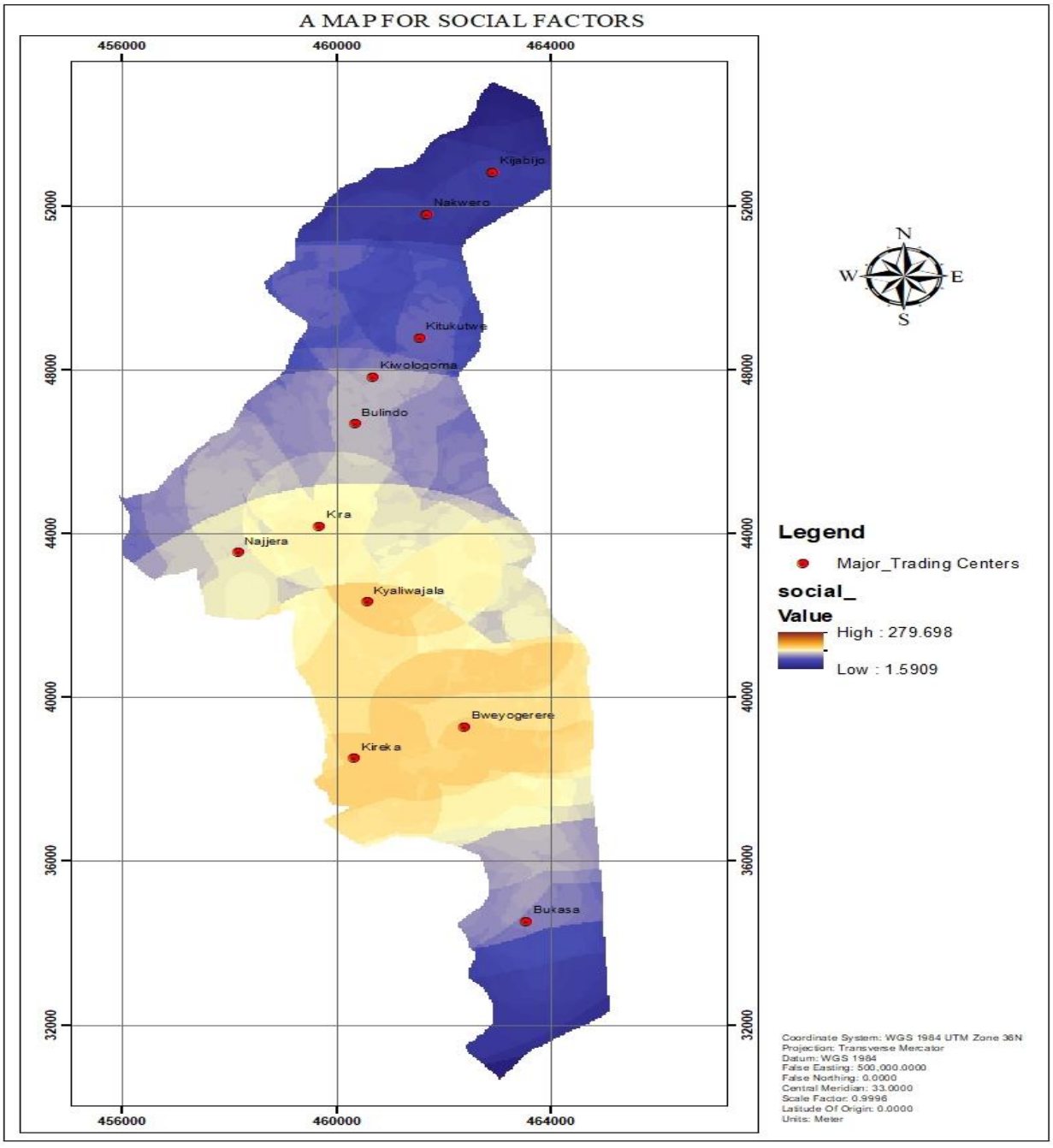

Figure 5: a map showing how values of land are affected by social factors of roads, schools, hospitals and trading centres

Real estate values are largely dependent on location hence the popular adage location, location, location. The location creates desirability, desirability creates demand, and demand raises real estate prices consequently, location to hospitals, schools, major trading centers etc is a bonus for real estate. Figure 5 shows how location is affected by the proximity factors. Figure 6 shows the

major schools, hospitals, major high ways, and major trading centers. From the map, it is quite evident that areas of Kireka, bweyogerere and kyaliwajala have the most developments. This further explains the map (figure 5), the land value discrepancy between these areas and areas of bulindo, kiwologoma, nakwero and kibabijo.

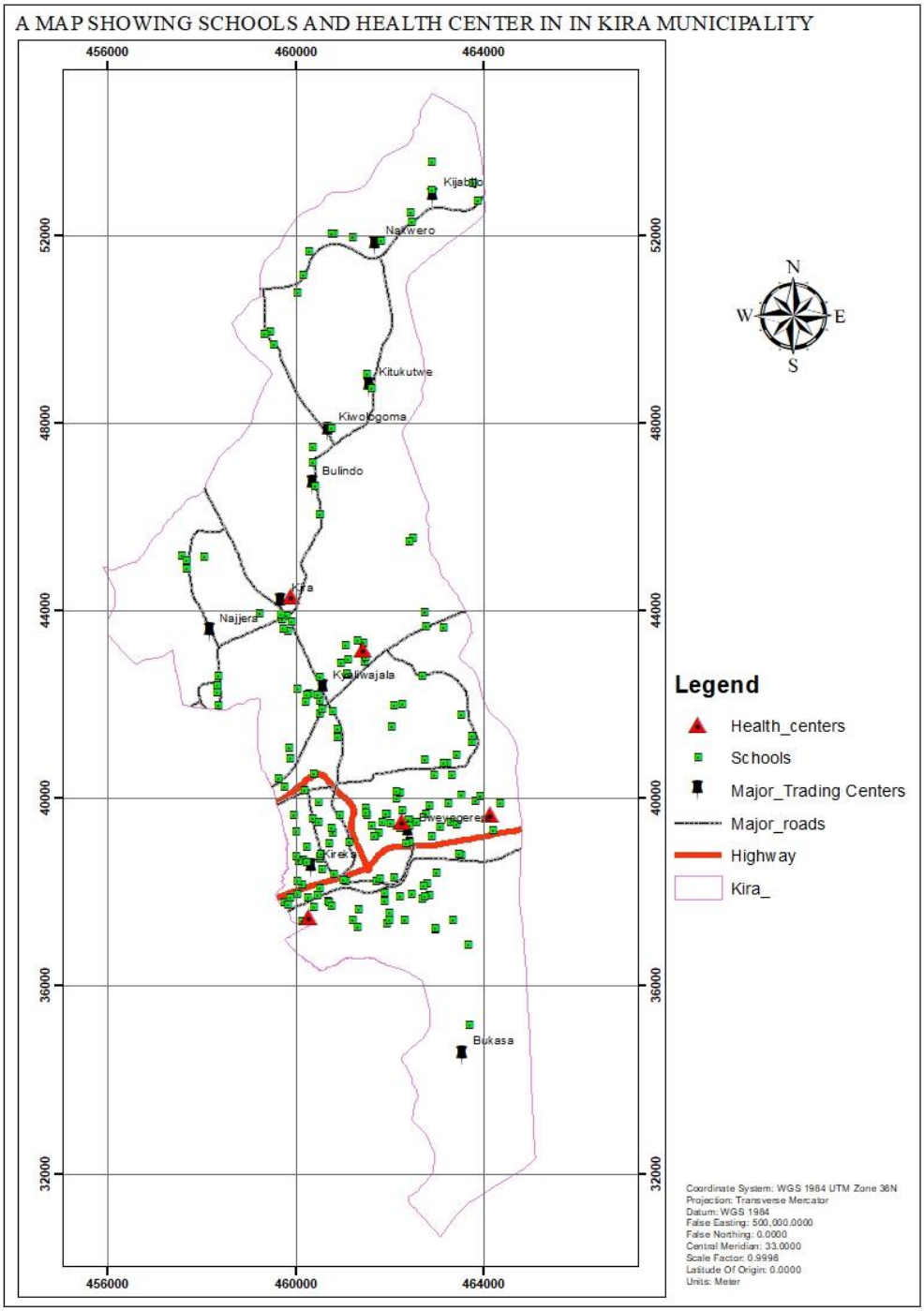

Figure 6: a map showing the spatial distribution of amenities in kiira municipality

5 Conclusion and recommendations

5.1 conclusion

Property valuation has been evolving over time to improve on value assessment and mitigate financial losses caused by valuation. The importance of real estate valuation increases daily. While some of the developed countries have a base that can be considered as a value map, these studies are lacking for developing countries such as Uganda. The value of real estate is affected by many criteria; therefore, it is difficult to determine important criteria and weight them. The criteria vary from country to country, from region to region and from person to person. The study was carried out to identify and come up with an appropriate methodology that considers all these factors and weighs them. In AHP, the process of real estate valuation started with comparison of criteria and then obtained the mathematical model. It was determined that the criteria become different between experts in the survey applied for weight of AHP. Pairwise comparisons matrices were applied by experts who are from different branches of different professions. AHP weights become a homogeneous state by blending survey data because of the fact that the experts are in different opinion on real estate valuation. In beginning of valuation process, AHP method may be an exhaustive process, but this process will only be performed once.

This study revealed that the AHP method is a good assistive method for creating a model of real estate valuation.

GIS has an important role of relating location to value in mass appraisal.

5.2 Limitation of study

The study was limited to a number of factors. Firstly, it is difficult to weight subjective data and overlay them in ArcGIS. Data for the, economy, interest rates and supply and demand could not be quantified

There is no established land values database in Uganda and different valuation firms and government rely on their own values. This was hard to sort out to come with one comprehensive database to in cooperate in the analysis. Besides, real estate values are constantly changing so a map showing land numerical land values for particular places could not be made

5.3 Recommendations

In Uganda, valuation is carried out on traditional valuation methods. I recommend that valuers could explore the GIS Technologies in property valuation. Valuation is premised on location and GIS is a framework for applying science to almost everything, the Science of Where is applying a data-driven approach that uses geography to unlock the understanding. For example, GIS technics like the AHP method can be used in modelling methodologies to property taxation, property insurance, compulsory land acquisition in relocating project affected persons (PAPs) and creating a property geodatabase

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