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Geospatial Modelling of Land Valuation in Adenta Municipal Assembly, Ghana

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Abstract

This study focuses on land valuation in the Adenta Municipal Assembly, Ghana, addressing a critical knowledge gap of creating a standard model for factors that determined value for land. The study seeks to identify and analyze the factors influencing land value and generate a geospatial model for accurate land valuation. Socioeconomic data were obtained by administering 400 copies of a structured questionnaire and utility maps such as (electricity line map, Road Map, educational facility map, fire station, police centers, financial institution and recreational area maps) were obtained. Descriptive Statistical analysis was performed using SPSS software, Geographic Information System (GIS) techniques was used to produce the factor maps, Multi-Criteria Analysis (MCA) was used to buffer around the factor maps and carried out comparison and normalized matrix, and ArcGIS Model builder in generating geospatial model. The results revealed eleven key factors determinants of land value. These include access to electricity, transport, educational centers, health services, land use type, police stations, city centers, financial institutions, fire stations, recreation centers, parks, and government buildings. The study also established correlations between these factors and variations in land value, resulting in a geospatial and mathematical model for value zones in monetary terms, producing a mathematical model adaptable for diverse valuation categories. The mathematical model produces new values for land value in the municipality range from ₵52,947.00 to ₵92,890.00 as restricted area to very high area. In conclusion, the research highlights the importance of Geospatial modelling in land valuation, providing practical tools for stakeholders, planners, valuers, and policymakers in decision-making related to land use development and taxation in the Adenta Municipal Assembly and beyond.

Keywords: *Geospatial model, Land value, Value zone, Multi-Criteria Analysis (MCA), GIS*

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I. INTRODUCTION

Land constitutes a fundamental resource indispensable for human existence, as virtually all human endeavors are interconnected with it. It serves as a unifying element that supports various livelihoods, encompassing agricultural, forestry, grazing, and aquatic habitats such as rivers, lakes, and coastal marine environments [1]. Recognized as a vital asset in the generation of wealth, land stands as one of the primary factors of production [2]. Land and property transactions play substantial roles in governments' revenues and financial institutions' banking policies, which is particularly the case for developing countries with rapid urbanization and heavy reliance on land-based finance as land is a special kind of commodity, which cannot be moved from place to place [3].

Land valuation involves a meticulous assessment of the characteristics of a given piece of land, often described as a careful estimation of its worth based on expertise and judgment [4]. Nevertheless, the primary objective of land valuation is to

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ascertain its value, typically specified as market value or benefit value [5]. Central to the valuation process is the recognition that the value and potential of a property depend greatly on its location, with land value denoting the monetary worth of land expressed either as a capital value or an annual economic rent. Land valuation holds considerable significance for societies and governments, particularly in contexts such as taxation, expropriation, market capitalization, and economic activities [4, 6-8]. Achieving accurate land valuation necessitates the adoption of practical and standardized methods, leveraging data models that inspire confidence and efficacy [9, 10].

Various methods are employed for land valuation, including the investment method, sales comparison, cost method, residual method, and profits approach according to [11-15], but with the first three being the most commonly utilized in contexts like Ghana, particularly for urban and rural residential land parcels often held under leaseholds[16]. Valuation, according to the Royal Institution of Chartered Surveyors (RICS), entails forming an opinion regarding the value of an asset or liability at a specified date and under specified conditions.

Typically, this valuation is conducted following an inspection, with additional inquiries made as necessary, considering the nature of the asset and the purpose of the valuation, unless otherwise agreed upon in the terms of engagement [17]. Land valuation, on the other hand, involves examining the characteristics of land comprehensively, taking into account economic factors and developments, and estimating its unit value in accordance with prevailing market conditions [18].

Many land valuation factors are changeable. However, the precise value for a land unit cannot be determined easily. To determine the significance of these factors for a land parcel, they need to be expressed mathematically so that the effect of each valuation factor can be determined for the complete land parcel [7]. To estimate the value, some land valuation factors which can affect the total perceived value of a land parcel have been selected and spatially examined with the developed model [19].

In practice, the Adenta Municipal Assembly lacks clear factors that influence land value and has no established, effective land valuation models. These knowledge gaps prevents people, investors, and local government agencies from making well-informed decisions and underscores the need for the development and validation of a robust, context-specific land valuation model for the study area [20, 21]. Such a model would provide stakeholders with a reliable framework to assess land value, facilitating fair taxation, transparent property transactions, and informed land use decision-making.

Modeling involves the representation of something in a scaled-down from Haan and Delft [22]. As described by Adhvaryu [23], a model serves as a simplified version of reality, intended either to enhance understanding of a real system or to forecast its behavior. Models can take various forms, ranging from physical objects to mathematical equations, depending on their nature and the context in which they are used [24].

Geospatial modeling uses GIS to analyze spatial relationships and patterns of geographic features [25, 26]. Spatial modeling is an important instrument to conduct geospatial analysis, design and implement workflows of geospatial analysis and can represent a digital replica of the world, allowing users to understand the mechanisms of natural and human systems [27].

According to Droj and Droj [6], Yomralioglu and Nisanci [7], [19], and Wyatt [28], there are three main methods of property valuation techniques depending on the property type and the purpose of valuation. These includes comparative method, income method, and cost method. The comparative method uses recent comparable transactions to estimate property value, while the income method evaluates an asset's future income based on gross income minus overhead costs. The cost method, also known as contractor's method, values an asset based on replacement cost adjusted for depreciation.

Oud [29] utilized spatial approaches, integrating GIS with regression modeling, to enhance automated valuation by addressing spatial dependencies in property values and improving predictions, particularly evident in assessing the value of views in a residential urban housing market in the Netherlands.

Balaji and Muthukannan [30] used statistical techniques and GIS, particularly the Voronoi Polygon Method, to determine market value in Madurai Corporation, India, demonstrating that GIS, when combined with reliable data and predictive tools, can provide robust solutions for forecasting real estate trends and assessing land assets effectively.

Li and Pgrni [4] evaluated the land market value in the Matara Urban Council Area, China, using the Analytical Hierarchical Process (AHP) technique in GIS. They included seven parameter factors and created shape files from data from the Survey Department, which produced a map that classified the land into value classes. Their model is crucial for land valuation because it has benefits like thorough factor consideration and value suggestion even for bare land without field visits.

However, GIS as a tool can now use spatial analysis techniques as 'modules' which can be used to examine data that has been recorded in a geographically referenced database and can only be relied upon when the data are more accurate, timely, and comprehensive [31, 32]. Analyzing spatial property data within a city improves a valuer's understanding of how location affects land value [28]. This paper identified the factors that determine the value of land, examined the influence of the factors on the value of land and generate a model to manage land valuation in Adenta Municipal assembly, Accra, Ghana. This was with a view of assessing the applicability of Geographic Information Systems (GIS) multi-objective land use planning as an effective procedure for achieving complex planning and preservation objectives. It allows for outcomes based on quality data and sound analysis while minimizing compromise and conflict between land valuation, social and cultural values [33].

II. STUDY AREA

Adenta Municipal Assembly (Ad.M.A) is one of the districts in the Greater Accra Region of Ghana. It was inaugurated on 29th February 2008 as a new municipal assembly. The Adentan Municipality has a current population of 237,546 with 117,841 males and 119,705 females according to Ghana Statistical Service (GSS) in 2021 and is one of the 29 districts in the Greater Accra Region and part of 261 Metropolitan, Municipal, and District Assemblies (MMDAs) in Ghana. The municipality has had an annual population change of 11% from 2010 to 2021. Adentan is unique for its hosting of the elite population in the nation's capital and is also noted for its well-planned physical layout, which has attracted many Real Estates Companies such as Trassaco Ghana Ltd, Regimanuel Gray, and Edlorm Estate to the municipality. The municipal assembly has a total land size of 928.4km2 Area (92,840 hectares). The Adentan Municipal Assembly (with Adentan as its Central Business District) lies 10 kilometers to the Northeast of Accra and is located between latitude 5' 40" north and longitude 3' 09" West and Latitude 5' 48" N and longitude 11' 43" West. The Municipality has few manufacturing, processing industries and quiet a number of estate development companies and others that produce various commodities and services which contribute to internal generated revenue in terms of business operating licenses and property rate.

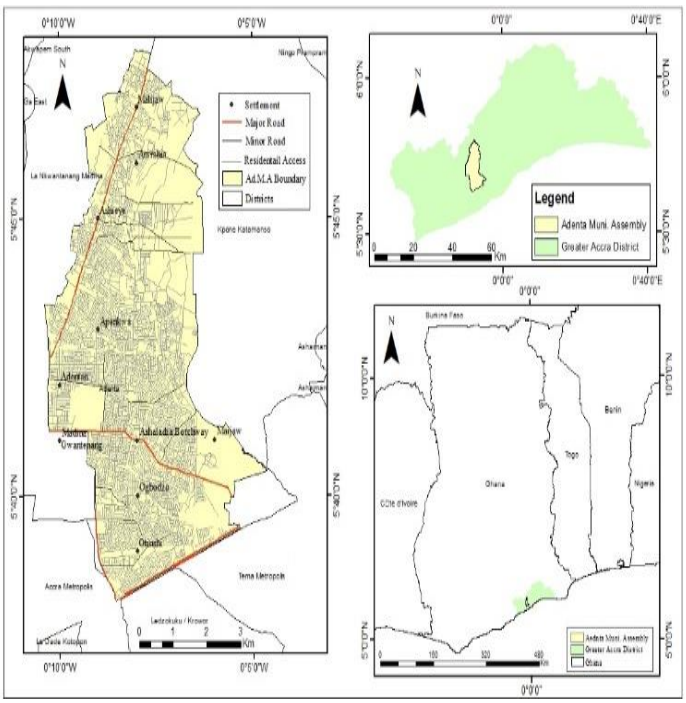

Fig. 1. Study Area Map

III. Methods

The geospatial modelling of land valuation in the Adenta Municipal Assembly, Ghana, necessitates a comprehensive and rigorous methodology to achieve the research objectives effectively. This section outlines the approach adopted to identify the factors influencing land value, examine their impact, and develop a robust model for pre-sale land valuation and management. The methodology employed in this research integrates data collection, analysis, and modelling techniques to provide reliable insights into the complexities of the land valuation in the study area.

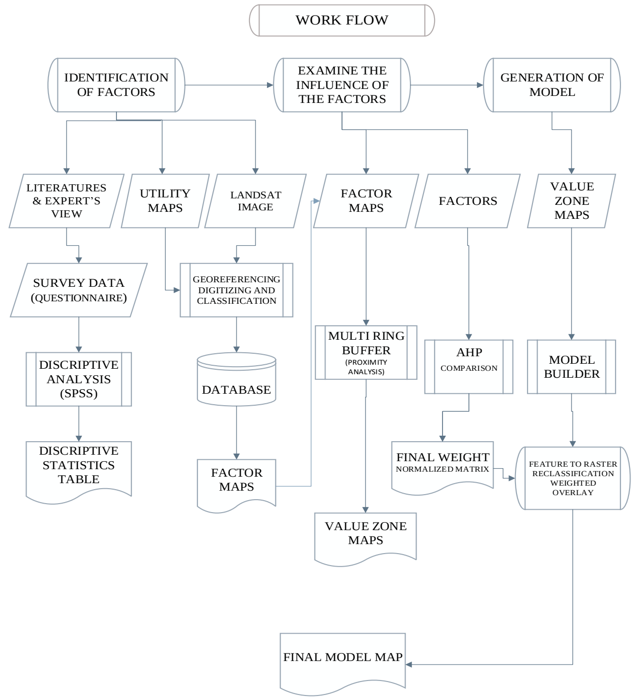

Fig. 2. Work Flow showing the methodology steps.

A. Datasets

- Data Collection and source: Primary and secondary data were used for this work. The primary data collected were data from some experts of Survey and Mapping Division, Land Valuation Division of the land Commission and Estates developer through interviews. Field survey data were also collected through the use of likert scale questionnaires and GPS points were collected for each respondents' location. The secondary data collected for this research are existing literature reviews, Utility maps of the study area from the Municipal Assembly consisting of (transport, educational centers, health services, police stations, city centers, financial institutions, fire stations, recreation centers and parks, and government buildings maps). Electricity line map were also collected from the electricity corporation of Ghana, and Landsat imagery for land-Use type in the study Area.
- Data Preprocessing: To preprocess the data for analysis, there is a need to follow a series of steps to clean, integrate, and prepare the primary and secondary data for use in your research.
- Field Survey Data (Likert Scale Quesionnaires): Data from the questionnaires were entered into a digital format in a spreadsheet. Checks were done for missing or inconsistent responses to complete entries. In terms of normalizing the data, it is ensured that all responses were within the expected range (1-5 for Likert scale). Coding was done in SPSS to convert categorical responses into numerical values for analysis. The GPS points of the respondents picked on the ground were downloaded and converted to CSV format for spatial

analysis. The utility maps and electricity map used in this study were imported into ArcGIS software and projected into spatial reference system WGS84 UTM zone 30N coordinate system to help integrate all the data layers together.

- Data Processing: The factors that determine land value in the Study Area were identified by using a Primary data source from field survey through likert scale questionnaires with a sample population size of 399 using Taro Yamane Formula

$$n = N/1 + N(e)2 \qquad (1)$$

Where n = sample size

N = population size = 151382

e = error (0.05) Reliability level of 95%

So when applied to the study population of 151382 people, we get $n = 399$.

The secondary data were collected from existing literature reviews and expert's view. The method used in carrying out analysis is Descriptive Statistics from SPSS software which descriptive table and bar chart was presented as the final result.

The influence of the factors on the value of land in the study area were examined by using secondary data comprising utility maps, land use map and Landsat imagery of the Study Area. The methodology employed is Multi Criteria Analysis (MCA) method. Factor maps were produced, proximity analysis was carried out where multiple ring buffer method was used to buffer around the factor maps with distance ranges in meters to each factors using ArcGIS software, and outcome of this method were Value Zone Maps.

Analytical Hierarchical Process (AHP) introduced by Thomas Saaty in 1980 is a widely studied multi-criteria decision-making approach. Researchers are attracted to AHP due to its solid mathematical foundations and the ease of obtaining necessary input data [34]. AHP is a tool for ranking both tangible and intangible criteria, enabling the selection of priorities through explicit comparisons [35]. It structures problems hierarchically from primary objectives to secondary criteria and alternatives, using pairwise comparison matrices for each level [34]. AHP is particularly useful in evaluating the impact of infrastructure development on land value in Adenta Municipal Assembly because it systematically handles complex decisions by leveraging expert knowledge and ensuring consistency, thereby improving the accuracy and transparency of land valuations. AHP was adapted and use in constructing a pair wise comparison matrix of each factor using scale of importance. Normalized matrix was used calculate for the final weighted criteria.

The generation of a model to manage land value in the study area was determined by using data from objective two results which are factor maps, value zone maps and the final weighted criteria. ArcGIS 10.8 model builder was used as software in developing the model. The geospatial analytical methods that was employed in the generation of the model are Feature to Raster where all vector data were converted to raster, Reclassify where value of raster would be change to specific classes, and Weighted Overlay analysis, where the final weighted criteria calculated in objective two were used to assign to each layer to produce a suitability land valuation result. In the management aspect of this objective, a mathematical model (formula) will be developed using data from final weighted criteria from AHP and a Purchase price from the questionnaire responses. The method used in calculation of the average purchase price from questionnaire responses plus assign weights to different criteria present, to establish a pricing formula.

IV. Results and Discussions

A. *Descriptive Statistics of Values Added Factors*

The descriptive statistics in Table I provides an overview of the variables included in the analysis, along with their corresponding measures of central tendency and dispersion. The table admits eleven variables related to different aspects of access and distance to various amenities and services and land use type. These variables are the criteria used in the analysis. The number of observations (N) is the sample size of 399 for each variable used were shown in Table I. Each variable has a range of value from 1.00 to 5.00, indicating the Likert scale range from very low to very high as the minimum and maximum values from the responses within each variable. The mean value represents the average rating for each variable. A higher mean value represents higher levels of access or proximity to the corresponding amenity or service. In this research, “access to electricity” has a mean of 4.16, indicating a relatively high level, while “Distance to Government Building” has a mean of 2.70 as the lowest level average of all the variables as shown in Table I.

The standard deviation provides a measure of variability or spread around the mean. The larger the standard deviation indicates greater variability in the responses. According to Guskey [36], if the spread is small, then the average is a fairly accurate representation of the group of scores, but if the spread is large, then the scores vary widely from that average score. In this research, “Access to Transport" has a standard deviation of 1.12, indicating moderate variability in the data whiles "Access to Recreational Area and Parks" has a higher standard deviation (1.30), implying a wider range of access levels compared to other variables.

Some advantages of using Likert scale is that, it provide numerical data that can be analyzed statistically. This allows for easy computation of descriptive statistics like mean and standard deviation, facilitating comparisons across variables and it also produce reliable and consistent results, particularly when multiple items are used to measure the same construct.

The use of a Likert scale (1–5) to measure accessibility and proximity involves subjectivity. Thus, respondents' impressions may vary widely, and these perceptions may not precisely reflect the real accessibility or proximity, which is one important drawback.

In summary, the findings from the Table I Highlight variations in the mean, standard deviation, and range among the variables related to accessibility, distance, and land-use type. These statistics provide insights into the average levels, variability, and distribution of the analyzed factors, which can inform decision-making and planning processes related to the studied area.

TABLE I. DESCRIPTIVE STATISTICS

Factors/Criteria	N	Min.	Max.	Mean	Std. Deviation
Access to Electricity (AE)	339	1.00	5.00	4.16	1.14
Access to Transport (AT)	339	1.00	5.00	4.02	1.12
Distance to Educational Center (DEC)	339	1.00	5.00	3.68	1.15
Distance to Health Service (DHS)	339	1.00	5.00	3.66	1.17
Land-Use type (LU)	339	1.00	5.00	3.66	1.11
Distance to Police Station (DPS)	339	1.00	5.00	3.44	1.19
Distance to City Center (DCC)	339	1.00	5.00	3.36	1.10
Access to Financial Institution (AF)	339	1.00	5.00	3.11	1.19
Distance to Fire Station (DFS)	339	1.00	5.00	3.07	1.28
Access to Recreational Area and Parks (ARP)	339	1.00	5.00	3.01	1.30
Distance to Government Building (DGB)	339	1.00	5.00	2.70	1.22
Valid N (list wise)	339				

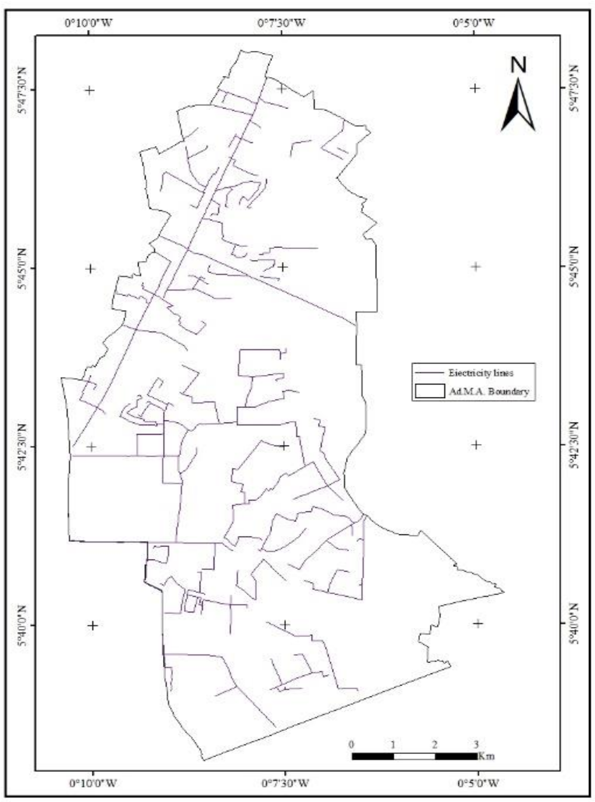

Fig. 3. Electricity map

B. Determinants of Land Value in the Study Area

In this study, various maps were utilized to assess the impact of different factors on land value in the Adenta Municipal Assembly. Each figure represents a specific variable considered as a determinant factor for land value. The analysis was conducted systematically, incorporating a range of factors to provide a comprehensive understanding of the land valuation scenario.

Electricity Line Distribution (Fig. 3): The distribution of electricity lines was examined as the first variable influencing land value. This infrastructure plays a crucial role in determining the development potential and attractiveness of specific areas within the Adenta municipality. Other scholars who study about the regional differences in electricity distribution and their consequences for yardstick regulation of access prices observe that electricity access is a contributing factor for land value and purchase [37, 38].

Road Network (Fig. 4): This illustrates the road map of the study area, highlighting highways and major roads. The accessibility and connectivity provided by road networks are fundamental factors influencing land value. Areas with well-developed road infrastructure tend to have higher land values due to enhanced accessibility than the areas with low concentration of roads. To support this observation, scholars note that land accessibility and road network is a value adding factor for individuals who want to secure or purchase land [39, 40].

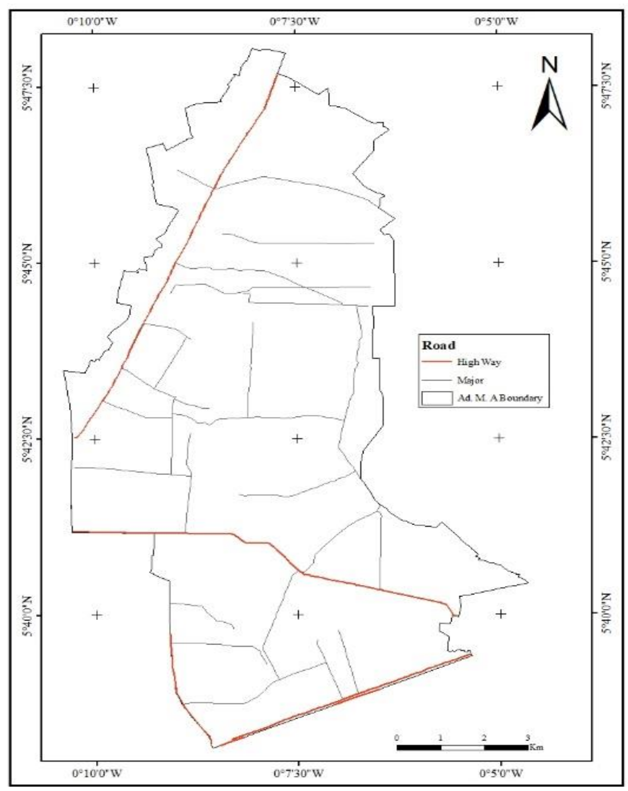

Fig. 4. Road map

Educational Centers (Fig. 5): The third variable considered was the distribution of educational centers, ranging from crèches to universities. Proximity to educational institutions is a significant factor influencing land value, as it reflects the attractiveness of an area for families seeking quality education for their children. It is reported by [41, 42] that a prominent location for school setup can increase visibility and attraction for potential students and stakeholders.

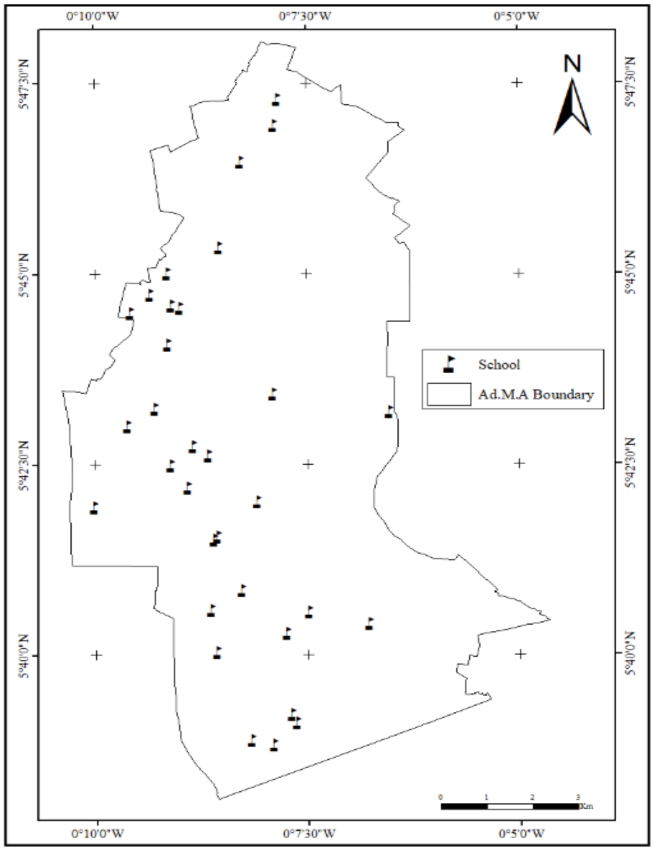

Fig. 5. School map

Health Centers (Fig. 6): this displays the locations of health centers in the Adenta Municipal Assembly. This means that the closeness to health facilities, such as hospitals and clinics, significantly influences the value of land. This is because access to health services enhances the overall quality of life for residents, making the location more attractive and desirable to potential buyers or investors, thereby increasing its value. To support this observation, it has been reported by other studies that women for instance are particular about distance from their homes to community healthcare Centre [43, 44].

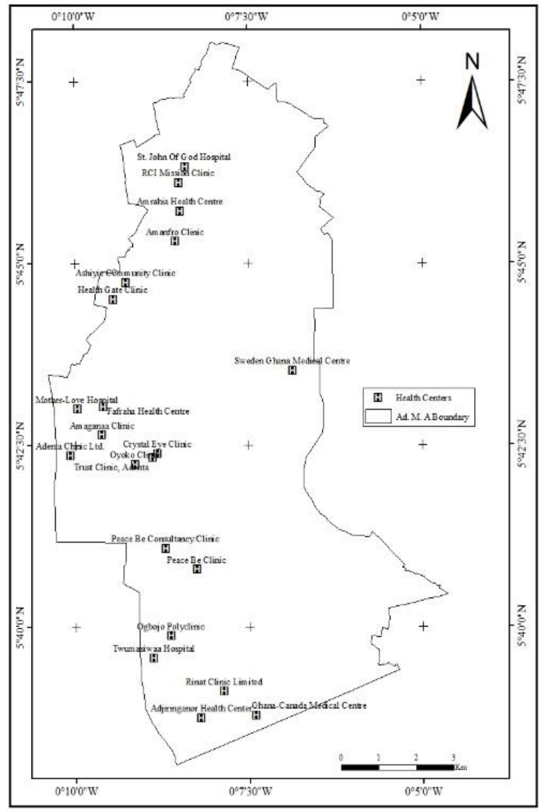

Fig. 6. Health center map

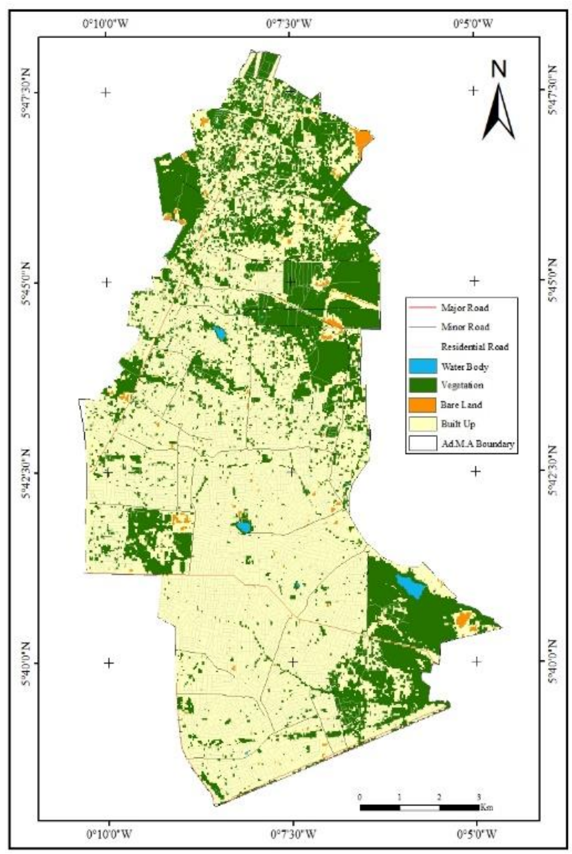

Fig. 7. Land use map

Land Use Type (Fig. 7): The land use map categorizes areas into water bodies, vegetation, bare land, and built-up areas. Understanding land use is essential in assessing its value, as different uses have varying impacts on property values. Scholars also report that land use such as those for school or for banking consider suitable factors for such projects or businesses [41, 45].

Police Station Distribution (Fig. 8): The distribution of police stations, is considered the sixth factor in land valuation. The presence of law enforcement facilities contributes to the security of an area, influencing the perceived safety and, consequently, land value. Quite ironically to this observation, scholars find out that many people may not want to secure or purchase land near or close to police station because of their preference for quiet and privacy [46, 47].

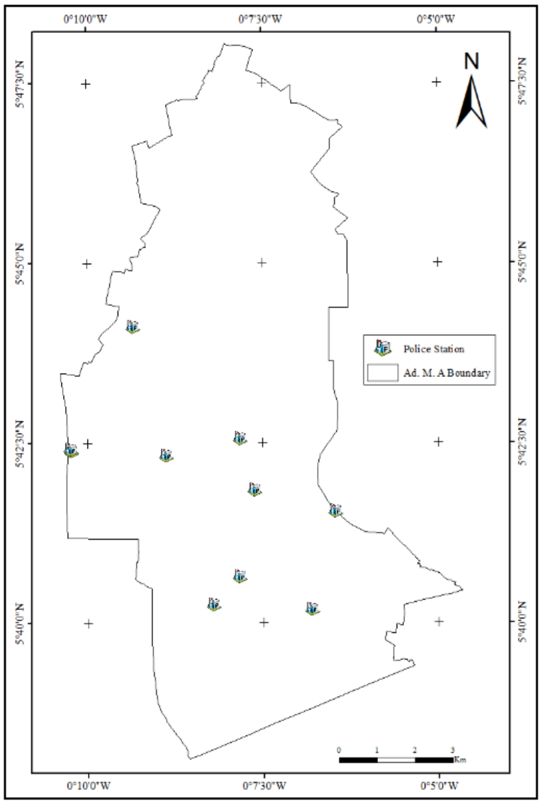

Fig. 8. Police station map

Central Business District (CBD) (Fig. 9): This represents the CBD of the Adenta Municipal Assembly, serving as the seventh factor influencing land value. The CBD is often a focal point for business activities, and its proximity can significantly impact the value of surrounding land. Visibility, prestige, and economic growth were also mentioned by scholar as very important reasons for land sales and purchase that are close to CBDs [48-50].

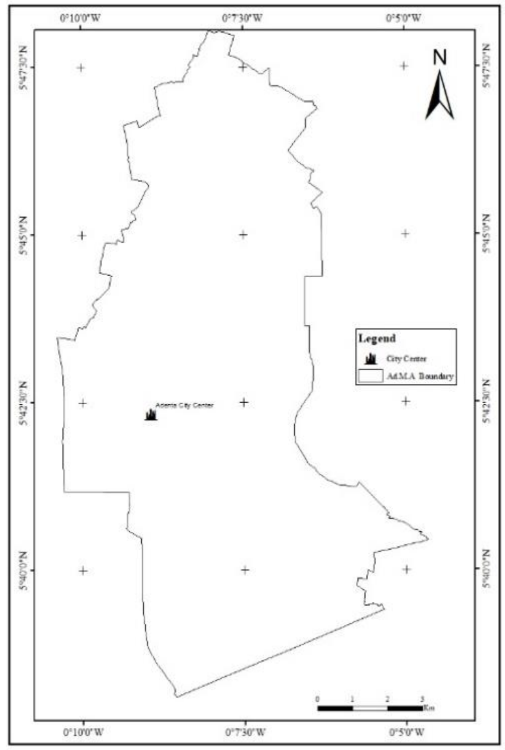

Fig. 9. City center map.

Financial Institutions (Fig. 10): The distribution of financial institutions is the eighth factor considered in land valuation for this research. The presence of banks and financial services enhances the economic vitality of an area, positively affecting land values. Juxtaposing this finding to that of the literature, scholars observe that access to facilities of Financial Institution is not part of the highest priority of clients [51, 52].

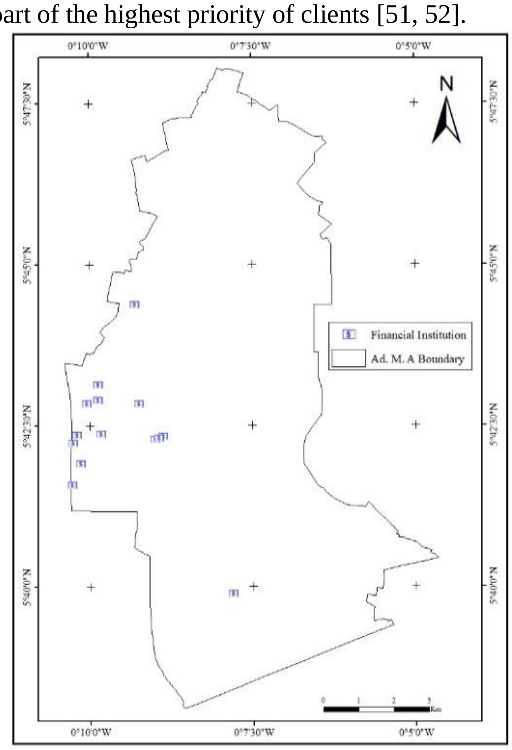

Fig. 10. Financial Institution Map

Fire Station Location (Fig. 11): this depicts the distribution of fire stations in the study area. While there is only one identified fire service station, its location is a crucial factor in assessing the safety and risk profile of a given location. It is noted fro0m the literature that the selection of fire station location and visibility also affect land cost [53, 54].

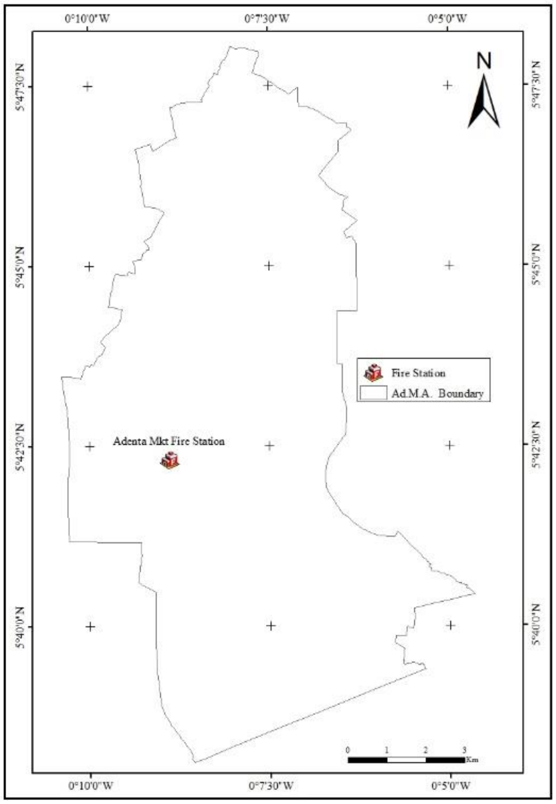

Fig. 11. Fire stations map.

Parks and Recreational Areas (Fig. 12): The tenth factor influencing land value is the distribution of parks and recreational areas, as shown in Fig. 12. Access to green spaces contributes to the overall livability of an area, affecting land values. There is no evidence from the literature that individuals have special interest in land purchase putting recreational areas or parks as determining factors. Rather, they turn to consider other factors such as schools, hospitals, and business center to be better priorities [39, 41, 47, 48].

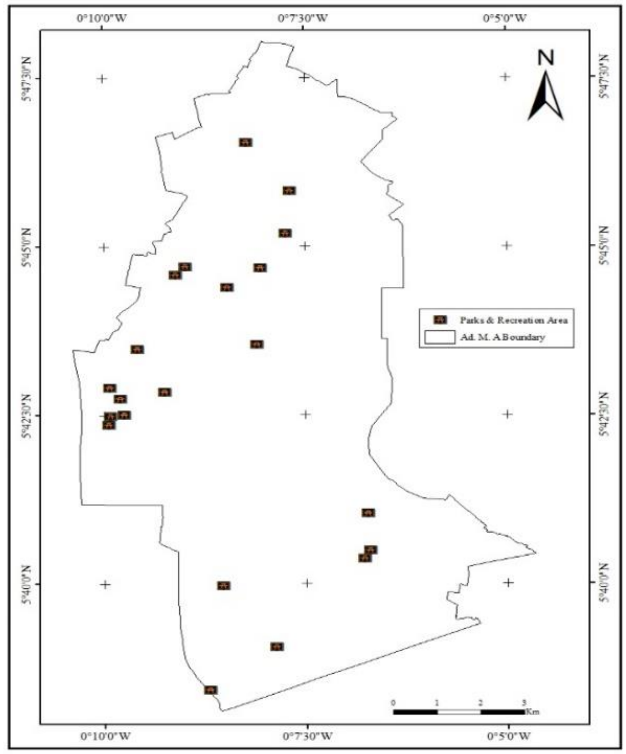

Fig. 12. Recreational & Parks map.

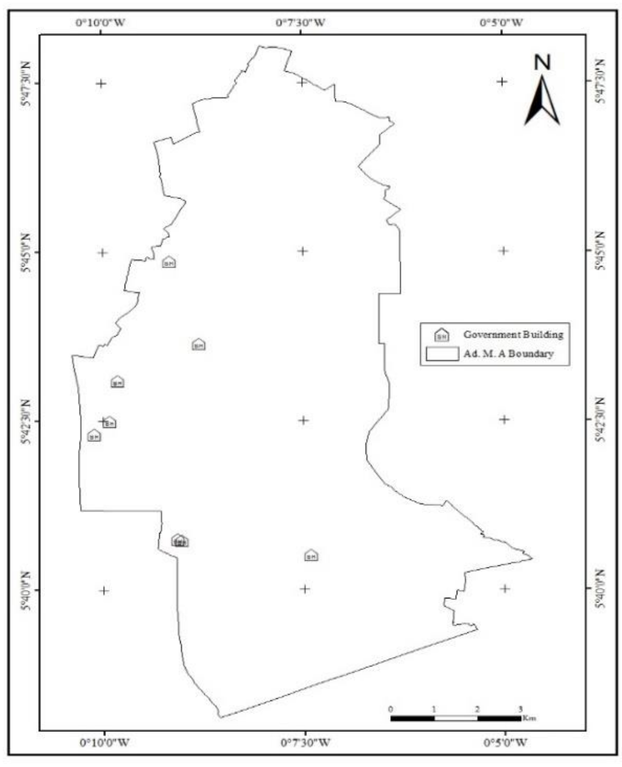

Fig. 13. Gov't Building map

Government Buildings (Fig. 13): The final factor considered in this study is the distribution of government buildings as in figure 13. The presence of government facilities can impact the administrative and institutional character of an area, influencing land values. Scholars such as Munasinghe [55], and Gamal [56] support this observation that government building is a restriction for land purchase by individuals. This is because government lands are enshrined by rules and regulations that legalize the development of those land in the future.

In conclusion, this systematic analysis of various factors provides a comprehensive understanding of the complex dynamics influencing land value in the Adenta Municipal Assembly. The combination of infrastructure, services, and amenities contributes to the overall attractiveness and desirability of specific locations, ultimately influencing their respective land values.

Table II below illustrates the initial classification of the data layers based on recommendations and opinions from experts. Proximity analysis was carried out on the various factor maps that determine value for land in the study area. Multiple ring buffer method was employed under the Arc toolbox, analysis tools and proximity with different distances in maters and its initial weights.

TABLE II. DATA LAYERS WITH THEIR CRITERIA AND INITIAL WEIGHT

Data Layer/criteria	Factors	Initial weights
Access to electricity	100mm	05
	100m – 500m	04
	500m – 1000m	03
	1000m – 2000m	02
	2000m – 3500m	01
Access to Transport	< 100m	05
	100m – 500m	04
	500m – 1000m	03
	1000m – 2000m	02
	2000m – 4000m	01
Distance to Educational center	< 500m	05
	500m – 1000m	04
	1000m – 2000m	03
	2000m – 4000m	02
	4000m – 7500m	01
Distance to Health Centers	< 1000m	05
	1000m – 2000m	04
	2000m – 3000m	03
	3000m – 4000m	02
	4000m – 7500m	01
Land Use Type	Built up	05
	Bear land	04
	Vegetation	03
	Water body	00
Police Station	< 1000m	05
	1000m – 2000m	04
	2000m – 3500m	03
	3500m – 5000m	02
	5000m – 7500m	01
Distance to City Center	1000	05
	1000 - 2000	04
	2000 – 4000	03
	4000 - 8000	02
	8000 - 12000	01
Access to Financial Institution	< 1000m	05
	1000m – 2000m	04
	2000m – 3500m	03
	3500m – 5000m	02
	5000m – 7500m	01
Distance to Fire Station	< 1000m	05
	1000m – 2000m	04
	2000m – 4000m	03
	4000m – 8000m	02
	8000m – 12000m	01
Access to \recreational Areas and Parks	< 800m	05
	500m – 1500m	04
	1500m – 2000m	03
	2000m – 3000m	02
	3000m – 4000m	01
Access to Government Buildings.	< 1000m	05
	1000m – 2000m	04
	2000m – 3500m	03
	3500m – 5000m	02
	5000m – 7500m	01

Results of the influencing factors of the value of land in the study area are shown in Fig.s 14 – 24.

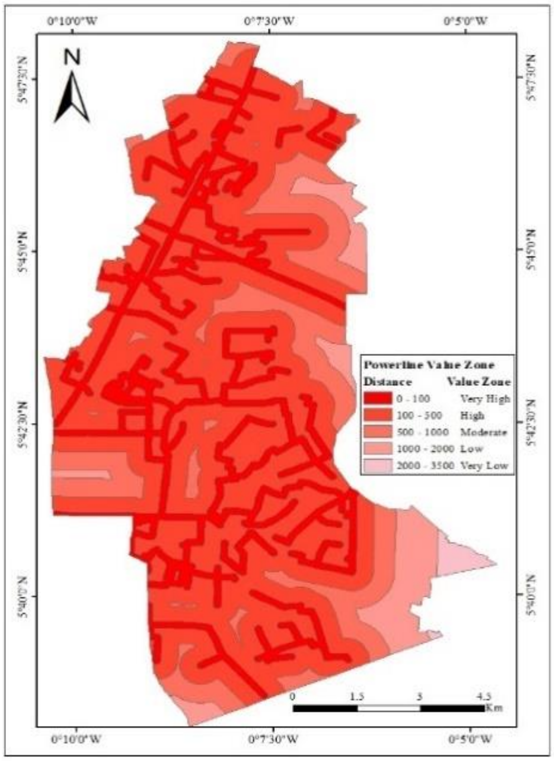

Fig. 14. Electricity Line Zone

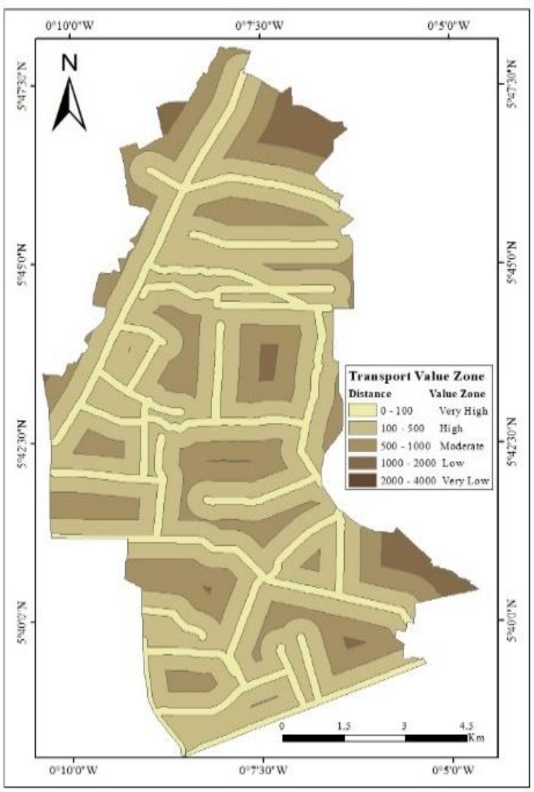

Fig. 15. Transport Zone

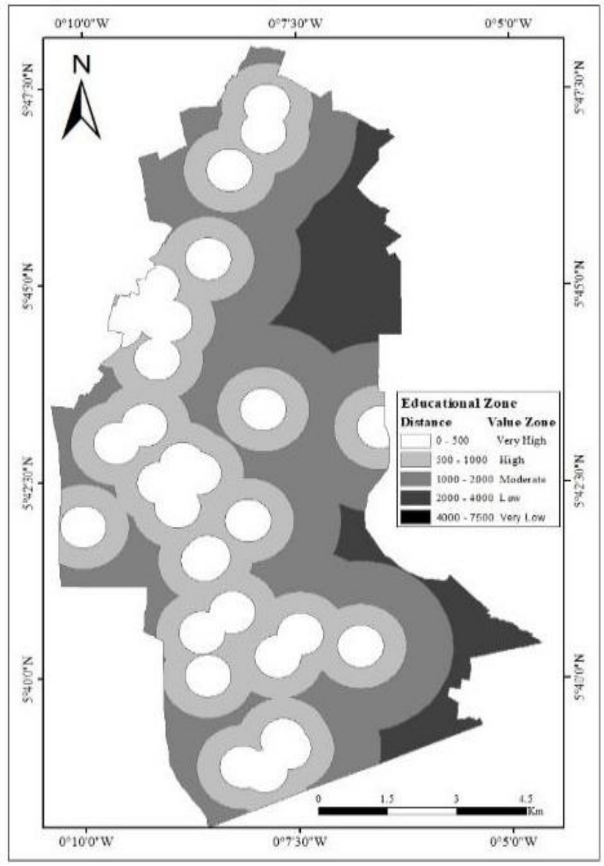

Fig. 16. School Zone

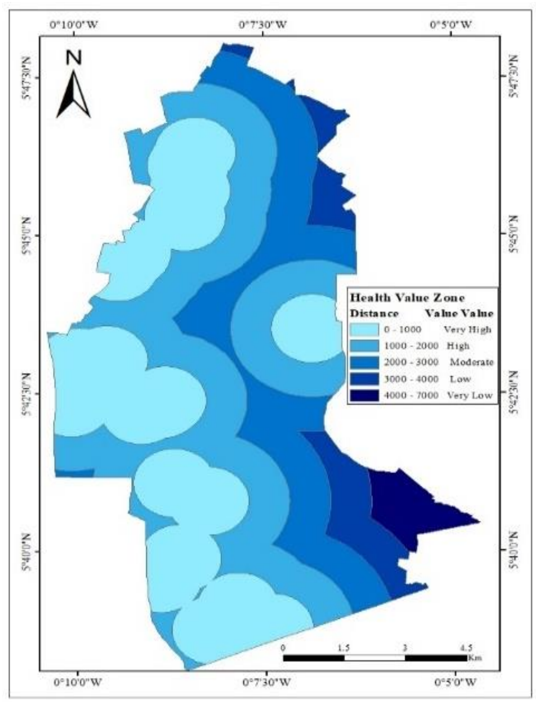

Fig. 17. Health Center Zone

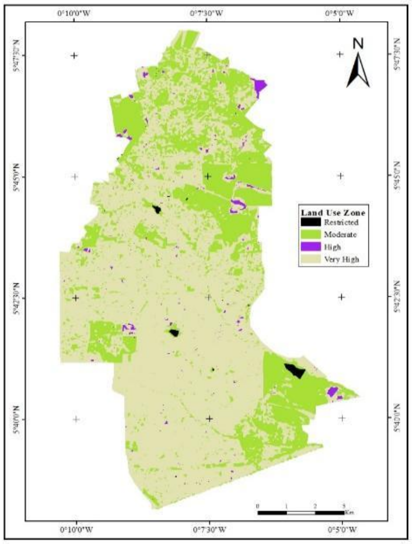

Fig. 18. Land Use Zone

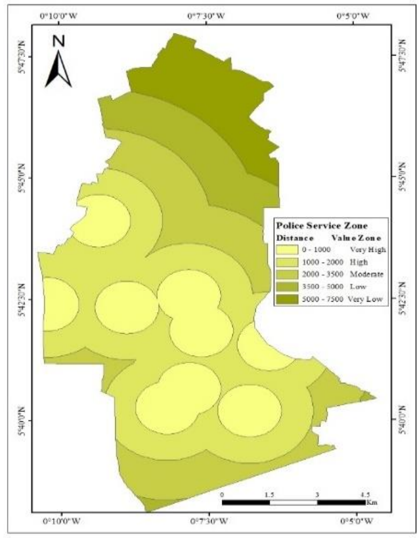

Fig. 19. Police Station Zone

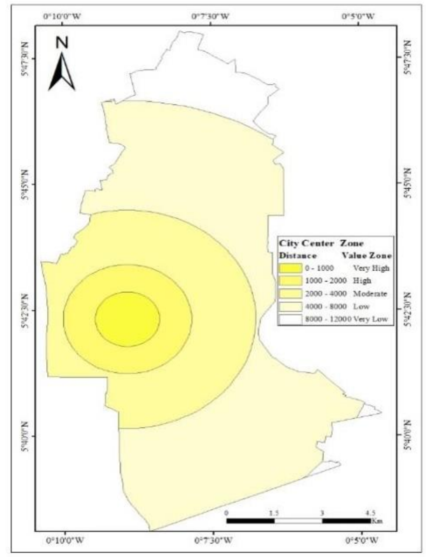

Fig. 20. City Center Zone

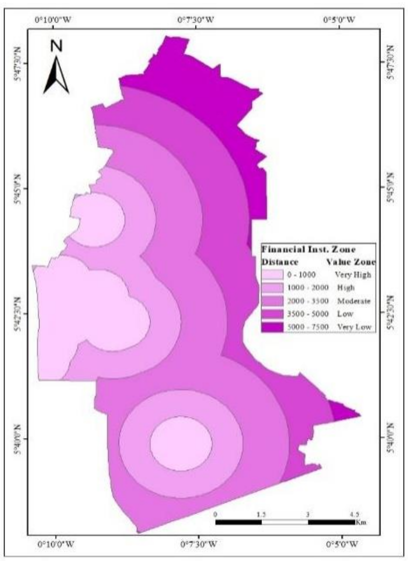

Fig. 21. Financial Inst. Zone

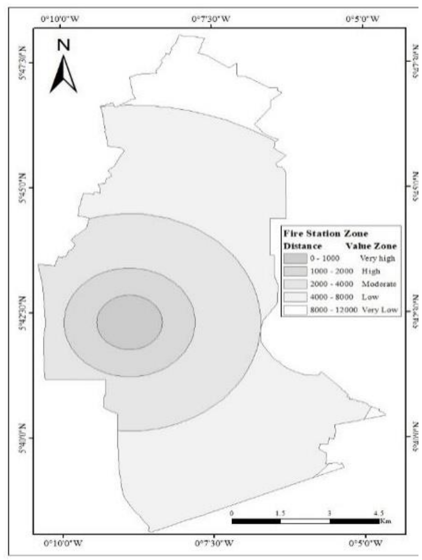

Fig. 22. Fire Station Zone

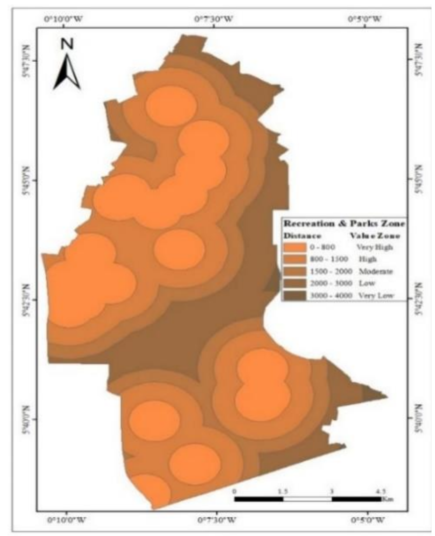

Fig. 23. Recreational & Parks Zone

C. Pairwise Comparison Matrix and Normalized Matrix.

A pairwise comparison matrix is a tool for making decisions that evaluates items in pairs and indicates the relative importance of each pair by assigning a number value. The matrix in table 3 compares different criteria using a numerical scale from 1 to 5, using the rule of "the minority should obey the majority". according to Li and Pgrni [4], and Mustafa [57]. The values represent the relative importance of one criterion over another. The diagonal elements have a value of 1, and the sum of each column indicates the overall preference or importance of each criterion. The highest sum value of "DGB" is 46.00, while "AE" has the lowest value of 4.23. Even though this study presented distance to government building (DGB) as the highest preference, other findings in the literature take contradictory position. For instance, Claessens [58], and Ellis and Lemma [59] observe that economic and market other than DGB is preferred by clients.

The values were derived from a scale reflecting the importance of each factor against the other. The normalized matrix was constructed using all values assigned to each cell in the pairwise comparison matrix dividing them by the sum of columns in the pairwise comparison matrix. The values range from 0.02 to 0.36, with the final weight for each criterion calculated by dividing the sum of the criterion's values by 11. The highest weight is AE (Access to Electricity), followed by AT (Access to Transport) and DEC (Distance to Educational Center) to the lowest weight as DGB (Distance to Government Building). The weights can guide decision-making processes and prioritize factors with greater impact on land value. The consistency ratio (CR) is approximately 0.007, indicating a very high consistency of the matrix and this was calculated using python script. In summary, AHP ranks criteria based on their relative importance, helping to identify which factors have the greatest impact on land value and should be prioritized in decision-making and AHP provides a clear and structured methodology to break down complex decision-making processes into manageable parts, making it easier to analyze each criterion systematically. One key drawback of AHP is that the process of making pairwise comparisons can be subjective and may introduce bias, especially if the experts involved have differing opinions.

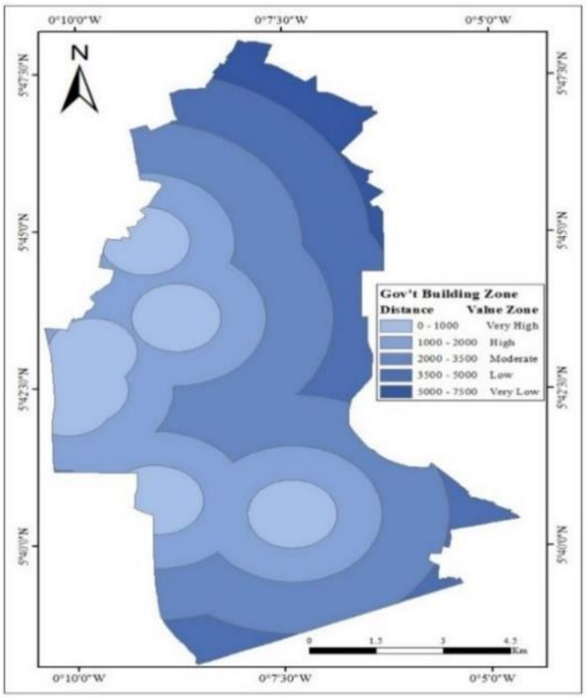

Fig. 24. Government Building Zone

TABLE III. PAIRWISE COMPARISON MATRIX

Criteria	AE	AT	DEC	DHS	LU	DPS	DCC	AF	DFS	ARP	DGB
AE	1	2	3	4	4	3	3	3	5	4	5
AT	1/2	1	2	3	1	3	2	3	2	3	4
DEC	1/3	1/3	1	3	3	2	3	4	4	3	4
DHS	1/4	1/4	1/3	1	3	3	5	3	5	3	5
LU	1/4	1	1/3	1/3	1	3	2	3	3	4	5
DPS	1/3	1/3	1/2	1/3	1/3	1	3	2	3	3	5
DCC	1/3	1/2	1/3	1/5	1/2	1/3	1	3	2	3	5
AF	1/3	1/3	1/4	1/3	1/3	1/2	1/3	1	3	5	4
DFS	1/5	1/2	1/4	1/5	1/3	1/3	1/2	1/3	1	3	5
ARP	1/2	1/5	1/5	1/3	1/6	1/3	1/3	1/2	1/3	1	3
DGB	1/5	1/4	1/4	1/5	1/5	1/5	1/5	1/4	1/5	1/3	1
SUM	4.23	6.70	8.45	12.93	13.87	16.70	20.37	23.08	28.53	32.33	46.00

TABLE IV. NORMALIZED MATRIX

Criteria	AE	AT	DEC	DHS	LU	DPS	DCC	AF	DFS	ARP	DGB	SUM	FINAL WEIGHT
AE	0.24	0.30	0.36	0.31	0.29	0.18	0.15	0.13	0.18	0.12	0.11	2.35	2.35/11=0.21
AT	0.12	0.15	0.24	0.23	0.07	0.18	0.10	0.13	0.07	0.09	0.09	1.47	1.47/11=0.13
DEC	0.08	0.05	0.12	0.23	0.22	0.12	0.15	0.17	0.14	0.09	0.09	1.46	1.46/11=0.13
DHS	0.06	0.04	0.04	0.08	0.22	0.18	0.25	0.13	0.18	0.09	0.11	1.36	1.36/11=0.12
LU	0.06	0.15	0.04	0.03	0.07	0.18	0.10	0.13	0.11	0.12	0.11	1.09	1.09/11=0.10
DPS	0.08	0.05	0.06	0.03	0.02	0.06	0.15	0.09	0.11	0.09	0.11	0.84	0.84/11=0.08
DCC	0.08	0.07	0.04	0.02	0.04	0.02	0.05	0.13	0.07	0.09	0.11	0.71	0.71/11=0.06
AF	0.08	0.05	0.03	0.03	0.02	0.03	0.02	0.04	0.11	0.15	0.09	0.64	0.64/11=0.06
DFS	0.05	0.07	0.03	0.02	0.02	0.02	0.02	0.01	0.04	0.09	0.11	0.49	0.49/11=0.04

ARP	0.13	0.03	0.02	0.03	0.01	0.02	0.02	0.02	0.01	0.03	0.07	0.39	0.39/11=0.04
DGB	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.22	0.22/11=0.02
SUM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	11.00	1.00

D. Development of the Model

The model builder in ArcGIS software was used by the research to generate valuation models for a range of spatial issues (Fig. 26). Layers including electricity lines, transportation routes, health and education centers, land use types, police and city center, fire station, recreational area, parks, and government buildings were incorporated in the model. Proximity analysis, multiple ring buffering, clipping, raster conversion, categorization, and weighted overlay analysis were among the analytical procedures performed. Equal importance was given to both the evaluation scale and the model's development. The Adenta municipal Assembly's final map classifies the study area into five value zone classes: restricted, low, moderate, high, and very high as shown in Fig. 25. This provides a better solution for valuation officers to make decisions without field verification. The map clearly shows each class with colour identity, ranging from lighter brown to deeper brown.

The Table 5 below presents a breakdown of different zones in the study area, based on their total area and percentage representation. The restricted zone covers 0.36% of the total area, which is where water covers. However, Agyemang, et al. [60] observe that water area in Accra is 4.5%. So is likely that the presented breakdown of different zones may vary in different geographical areas. This zone is ignored during valuation, as it is where water covers the study area. The low valued zone covers 5.14% of the total area, with a lower market value. The moderately valued zone covers 26.89% of the total area, with moderate land value. The high valued zone covers 62.28% of the total area and is the highest zone, accounting for 5.33% of the total area. This zone has higher market value and is connected to all factors determining land value in the study area. It is the center of Adenta municipal Assembly with high values zones.

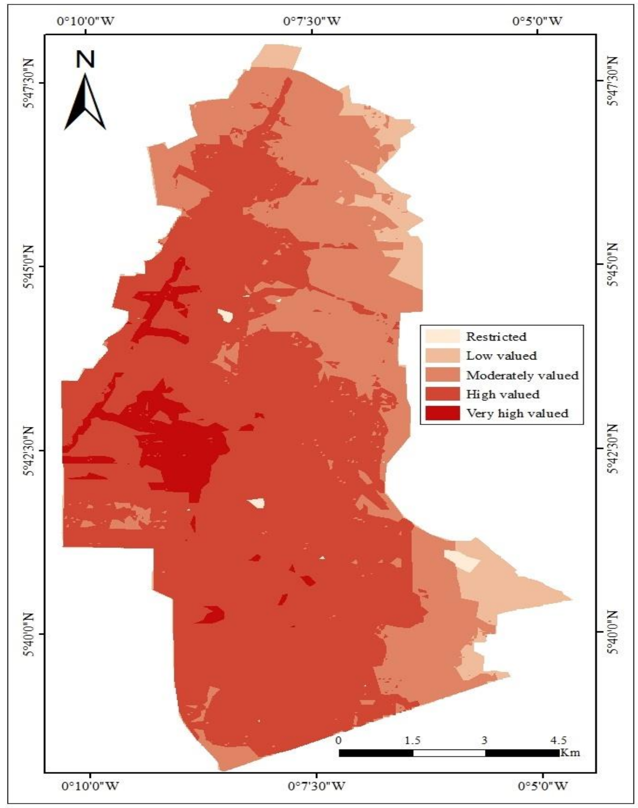

Fig. 25. Final Land Value Zone Map

TABLE V. DIFFERENT ZONES AND AREA

Zones	Total Area Covered (km²)	Area in Percentage (%)
Restricted	0.35	0.36%
Low valued	5.11	5.14%
Moderately valued	26.70	26.89%
High valued	61.84	62.28%
Very high valued	5.29	5.33%
Sum		100.00%

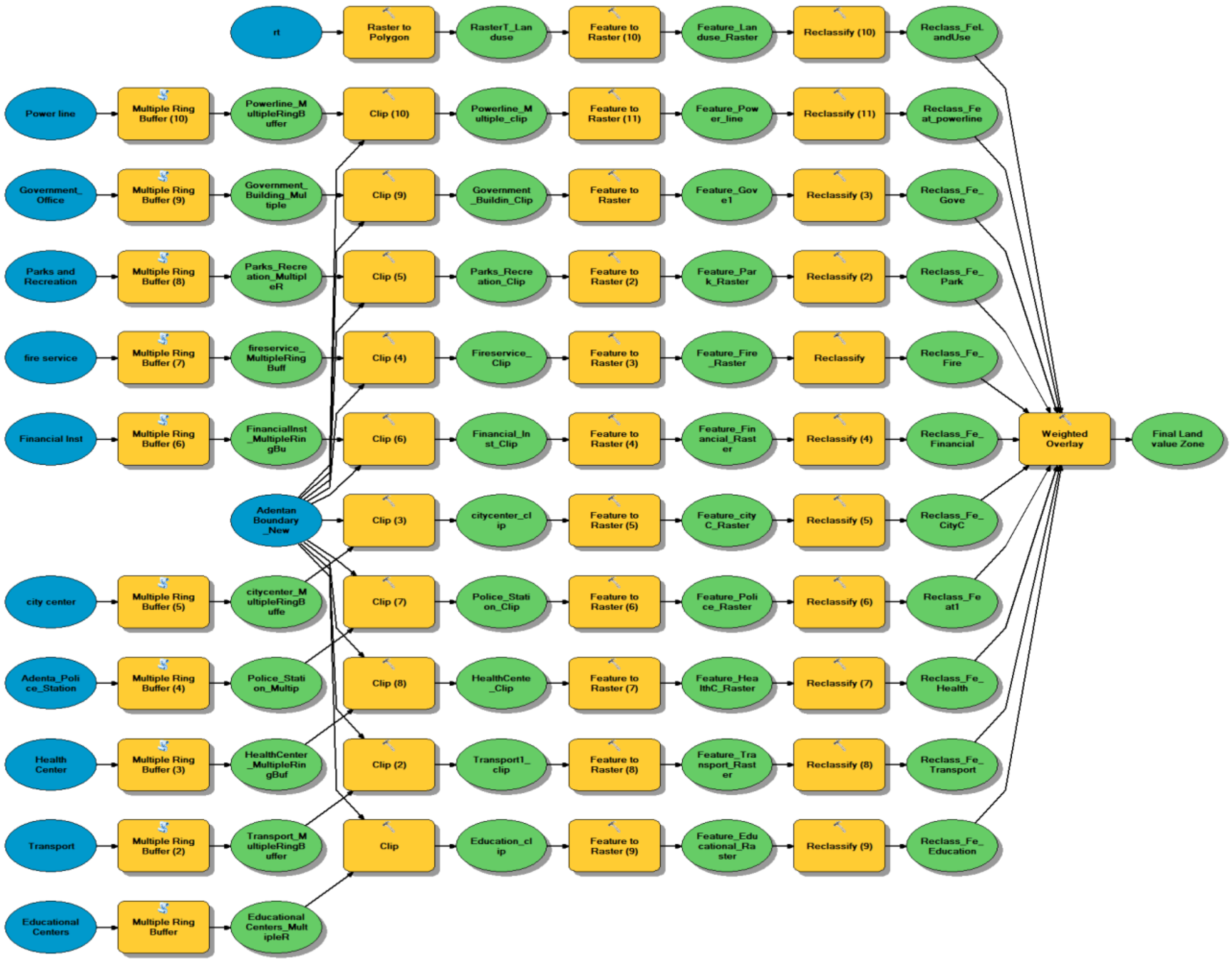

Fig. 26. Elikplim Kodzo Akudeka Valuation (EKAVAL) Model.

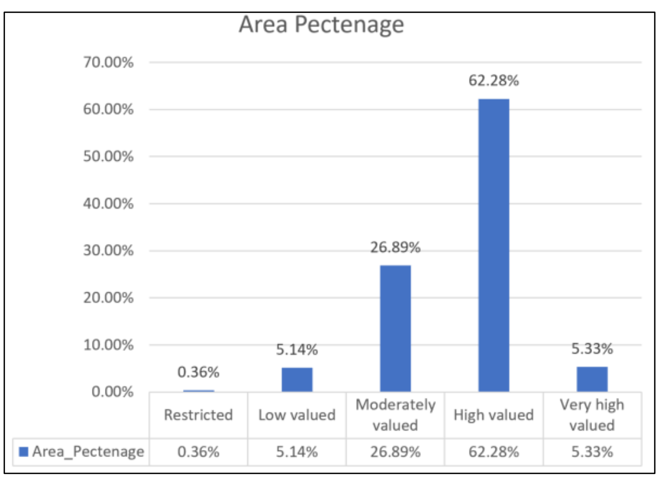

Fig. 27. Area shown in Percentage

E. Development of Mathematical Formula for Management of the Model.

Considering the model generated above in figure 3.24, a mathematical formula has been developed to help in pricing land in the Study Area in monetary terms.

$$P = A + Aw1 + Aw2 + Aw3 + \ldots Awn \qquad (1)$$

Where P = New Prize,

A = Constant Average Purchase Prize

(w1, w2, w3….. to wn) is the weight of criteria or factor or variable involved.

The Average purchase price was calculated from the questionnaire respondent where all the purchase price given were summed and divided by the total respondent of 339 people.

That is 15744694.6/339 = 46445.53. This value is ruined to 46445.00.

In classifying the study area according to the final output of the model, the Very High Zones have all the weight of the criteria from (AE, AT, DEC, DHS, LU, DPS, DCC, AF, DFS, ARP and DGB).

High Zones have the weight of this criteria (AE, AT, DEC, DHS, LU, DPS, AF, ARP and DGB).

The Moderate Zones have the weight of this criteria (AE, AT, DEC, LU, DPS, AF, and ARP).

For the low Zones, criteria weight of (AE, AT, LU, and ARP) are involved.

In the Restricted Zones, the weight of criterion LU and criterion DRP can be applied.

These weights will be applied to the formula to get the new prize for land in the Adenta municipal Assembly.

Therefore from the initial formula;

P = A + Aw1 + Aw2 + Aw3 + … Awn, the value zones price from very high to restricted area formula was deduced.

VHZP = A + Aw1 + Aw2 + Aw3 + Aw4 +Aw5 +Aw6 +Aw7 +Aw8 + Aw9 +Aw10 +Aw11

HZP = A+ Aw1 + Aw2 + Aw3 + Aw4 + Aw5 + Aw6 + Aw8 + Aw10 + Aw11

MZP = A + Aw1 + Aw2+ Aw3 + Aw5 + Aw6 + Aw8 + Aw10

LZP = A + Aw1 + Aw2 + Aw5 + Aw10

RZP = A + Aw5 + Aw10

Where VHZP is Very High Zone Price, HZP is High Zone Price, MZP represents Moderate Zone Price, LZP representing Low Zone Price and RZP Restricted Area Zone Price.

TABLE VI. RESULT FOR VALUE ESTIMATION.

Zones	Average Initial Cost	AE	AT	DEC	DHS	LU	DPS	DCC	AF	DFS	ARP	DGB	Price in Cedis per plot	Price in Dollars per plot
Very high	46445	0.21	0.13	0.13	0.12	0.10	0.08	0.07	0.06	0.04	0.04	0.02	92890.00	8184.00
High	46445	0.21	0.13	0.13	0.12	0.10	0.08	0.00	0.06	0.00	0.04	0.02	87781.05	7734.00
Moderate	46445	0.21	0.13	0.13	0.00	0.10	0.08	0.00	0.06	0.00	0.04	0.00	81278.75	7161.00
Low	46445	0.21	0.13	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.04	0.00	68738.60	6056.00
Restricted	46445	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.04	0.00	52947.30	4665.00

TABLE VII. AMOUNT IN CEDIS AND DOLLAR EQUIVALENT FOR THE ZONES PER PLOT.

ZONE	Amount Cedis ₵ per plot equivalent	Dollars $ per plot
Very High value	₵ 92,890.00	$ 8184.00
High	₵ 87,781.00	$ 7734.00
Moderate	₵ 81,279.00	$ 7161.00
Low	₵ 68,739.00	$ 6056.00
Restricted	₵ 52,947.00	$ 4665.00

V. CONCLUSION

In conclusion, this research focused on geospatial modeling of land valuation in the Adenta Municipal Assembly, Ghana, aiming to enhance property assessment, taxation, and urban development decision-making. The study identified eleven key factors influencing land value, analyzed their impact, and successfully developed a geospatial model integrating various data layers. The model, accompanied by a formula, proved effective in providing accurate and reliable land valuations, addressing challenges in manual valuation methods. The research not only contributes to Adenta but also holds broader implications for similar regions, promoting transparency and efficiency in land markets.

In light of these findings, it is recommended that relevant authorities, such as the Land Valuation Division of the Lands Commission and private valuers, integrate the geospatial model into their processes for fair and sustainable land transactions. Regular updates and improvements should be undertaken to align the model with changing market dynamics. Capacity-building programs for professionals involved in land valuation and real estate management are essential to ensure effective use of the model. Public awareness campaigns about the importance of land valuation factors can lead to more informed decision-making, reducing disputes and promoting fair transactions. Ongoing research and data collection are encouraged to refine the model's precision, and for future studies, the development of predictive models using machine learning techniques is recommended to forecast future land prices and provide insights for long-term investors and regulators.

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