Original Research Article

A Holistic Approach to Land Valuation Using Automated Valuation Models (AVMs): A Case Study in Homagama Divisional Secretarial Administrative Boundary, Sri Lanka

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ABSTRACT

Land valuation is a crucial process that involves the comprehensive assessment of specific land parcels to estimate their worth based on market value or predefined value base on valuation standards and regulations. Traditionally, this process has relied on expert involvement, often leading to different value figure for the same land by different valuation officers. While minor variations are considered acceptable, concerns have been raised regarding the lack of transparency, accuracy, and efficiency in the traditional approach. In response to these challenges, this research proposes an innovative system leveraging the potential of automated valuation models (AVMs) and big data applications in the real estate domain to address the limitations of traditional land valuation methods. The objective of the study is to enhance the transparency and accuracy of land valuation through the integration of a holistic data interpretation system, improved information exchange between AVM projects and property valuation, and the automation of specific workflows for property assessment. The study focuses on the Homagama Divisional Secretarial administrative boundary in Sri Lanka as a case study area for implementing the proposed AVM-based valuation model. The methodology adopts a multi-criteria approach with expert validation, considering various causative factors influencing land value, such as access to transportation, proximity to educational institutions, distance from government and commercial establishments, proximity to urban centers, access to medical facilities, slope, land use, population density, size, shape, and road infrastructure. To determine the relative importance of each factor, the Analytical Hierarchical Process (AHP) is utilized, providing a rational and consistent weighting approach. The AVM is developed using ArcGIS software and Weighted Overlay Analysis, effectively capturing the spatial distribution of land values within the study area. The research results in the classification of the Homagama Divisional Secretary area into distinct land value classes, ranging from very low to very high valued areas. In order to ensure the accuracy and validation of the model, the estimated AVM for land lot cadaster data, is reviewed alongside real-world land value data. The valuation map produced presents a graphical representation of the value of each land parcel, thereby facilitating rapid decision-making processes. Additionally, the study highlights the potential for further enriching the model with additional factors beyond those initially considered. In conclusion, this research demonstrates the value of AVMs in revolutionizing land valuation by providing a transparent, accurate, and efficient approach. The proposed model serves as a valuable tool for decision-makers, stakeholders, and property professionals in their efforts to assess land values and make informed real estate investment decisions.

Keywords: Analytic Hierarchy Process, Geographic Information System, Weighted Overlay Analysis, Geographic Information Systems

1. INTRODUCTION

Land valuation is a critical process involving the assessment of a particular parcel of land, relying on expertise and judgment. The primary objective of land valuation is to ascertain its market value or benefit value, predominantly influenced by its legal, physical and geographical location [1]. This process holds significant relevance in various public service transactions, such as expropriation, privatization, urban development planning, land consolidation, urban transformation, registration procedures, and easement procedures [2]. In order to achieve accurate value estimations for a given land, numerous tangible and intangible factors must be considered during the valuation process [1]. The value of a property is determined by its capacity to fulfill specific functions [3].

Functional attributes in commercial real estate, including location-related aspects such as proximity to the market, suppliers of raw materials, and key transportation nodes like railway stations, parking facilities, and open spaces, along with physical characteristics such as size, shape, age, and condition, as well as legal considerations such as lease terms and restrictive covenants, and economic and planning aspects all contribute to the valuation process. The determination of the precise value of a unit of land is a challenging task due to the inherent variability of land values. However, estimating the value of land is feasible by selectively considering relevant land valuation factors and analyzing them spatially through a developed model. Notably, each land valuation factor does not equally affect the overall value, and certain economic and sociological challenges may arise, necessitating an objective approach to land valuation.

In the context of Sri Lanka, professional valuer considers numerous external and internal factors, examine current and recent land values in surrounding areas, and then arrive at a preliminary value for the land. The traditional manual and subjective method employed in has its drawbacks, leading to potential discrepancies in land values determined by different valuer. To address this issue, the study proposes an alternative method for land valuation using Geographical Information Systems (GIS) technology, with a focus on reliability, accuracy, time efficiency, and effort. GIS enables the integration of diverse data sources and spatial analysis, thereby enhancing the reliability and efficiency of the valuation process.

The proposed automated land valuation model utilizing GIS aims to determine the value of land by considering specific factors that influence its valuation, aiming to arrive at a unified figure representing the overall value of the land compared to others. Notably, this approach solely evaluates the land itself and excludes the value of any buildings or property situated on the land. Moreover, the study assumes the land to be freehold, as considering ownership details would introduce complexities and extend the time required for the valuation process. If scenario is different professional valuers' intervention recommended. Thus, the study aims to develop a GIS based automated land valuation model to estimate the land values of Homagama Divisional Secretariat area in Sri Lanka.

While various global case studies have utilized Remote Sensing (RS) and GIS technologies in land valuation, this study's distinctive contribution lies in developing an automated model tailored to the Sri Lankan context, emphasizing objectivity. By leveraging GIS technology, the proposed model can significantly enhance the reliability, accuracy, time efficiency, and effort in the land valuation process in Sri Lanka. Therefore, this study fills an existing research gap and aims to develop GIS based automated land valuation model to estimate the land value map in Sri Lanka, contributing valuable insights to the field of land valuation within the Sri Lankan context.

2. LITERATURE REVIEW

The determination of land prices is a multifaceted process influenced by a myriad of interrelated factors, which can be broadly categorized into several key aspects, including accessibility and land use, physical attributes, location, and surrounding area prices [4]. Among these, the transportation infrastructure assumes a significant role in shaping land value [1]. The seamless connectivity facilitated by well-developed roads, highways, and efficient public transportation systems, such as buses and trains, is paramount for ensuring accessibility within and beyond urban centers. This robust transportation network not only enhances trade and commerce but also fosters tourism and facilitates daily commuting activities [5]. Additionally, the reputation, diversity, and quality of educational institutions within a town are instrumental in attracting residents and contributing to its overall allure [1].

Furthermore, the availability and proximity of essential public services, including police stations, banks, cemeteries, fire stations, post offices, and municipal offices, significantly influence the land value. These indispensable services contribute to the overall infrastructure and livability of a town, rendering it more attractive to potential investors and inhabitants [1]. During the selection of urban centers, a comprehensive assessment of various factors and features is undertaken to determine their suitability and significance. This evaluative process encompasses a wide range of considerations, such as the presence of educational institutions, banking and financial establishments, healthcare facilities, public services, commercial establishments, and the efficiency of transportation and connectivity options [6]. Healthcare facilities play a crucial role in enhancing the well-being and convenience of residents and consequently exert a notable impact on the appeal of a town [5].

Moreover, topographic maps emerge as invaluable tools for identifying optimal locations for diverse construction projects, including residential, commercial, and public developments. The detailed depiction of elevation changes through contour lines allows for a thorough understanding of the terrain and slope of the land, aiding in informed decision-making during development planning [6]. To ensure an accurate valuation of land, certain areas, such as water bodies, tanks, marshy lands, sandy lands, and forested areas, are designated as restricted zones and must be excluded from consideration during the valuation process [1,7].

The population density of an area is another crucial factor profoundly influencing land value, as a positive correlation exists between population growth and land prices [5]. Additionally, well-designed and well-maintained road networks significantly contribute to the appreciation of land value [8,9]. An introduced indicator, the shape index, provides valuable insights into landscape characteristics, serving as a further consideration in the valuation process. The division of land into plots, characterized by irregular shapes and defined based on land-use classification, ownership, and natural or administrative boundaries, aids in assessing land value [6,10]. Furthermore, the presence and quality of facilities on a given parcel of land significantly contribute to its overall value [5]. By examining these multifaceted factors in conjunction with one another, a more comprehensive understanding of land valuation can be attained.

2.1 The Analytic Hierarchy Process and Multi-Criteria Model

The Analytic Hierarchy Process (AHP), a type of multi-criteria decision analysis (MCDA), serves as a valuable tool in real estate valuation by generating coefficients that underpin the assessment process [9, 11,12]. The AHP method was employed to generate weighted criteria, describing the areas targeted for potential purchase, which were subsequently validated.

Furthermore, Geographic Information Systems (GIS) emerge as a more efficient and accurate alternative to traditional spreadsheet formats for mapping and economic analysis of real estate [9]. The utilization of GIS facilitates the digitalization of data, offering improved visualization, and integration of property-related information [13]. This enhanced capability enables users to make informed decisions based on comprehensive and spatially referenced data. Consequently, GIS enhances the accuracy and efficiency of real estate analyses, enabling stakeholders to derive valuable insights from the data.

Overall, the combination of AHP and GIS methodologies presents a comprehensive and sophisticated approach to real estate valuation, empowering stakeholders with the tools necessary to make well-informed and data-driven decisions in the complex real estate market. The validation process further strengthens the applicability of the model, ensuring its accuracy and reliability in estimating property values for various scenarios and locations.

3. MATERIAL AND METHODS

3.1 Study Area

The Homagama Divisional Secretary Division, situated approximately 24 km away from Colombo town in Sri Lanka, boasts an area abundant in diversity and opportunities. Positioned at Latitude 6.8440 and Longitude 80.0024, this region spans 121 sq. km and encompasses 81 Grama Niladhari Divisions (*local administrative division*).

Homagama represents a fascinating area within the western province of Sri Lanka, characterized by ever-evolving land-use patterns. Its landscape showcases a myriad of distinctive features, including a mix of rural and urban elements. This rich variety makes it an ideal candidate for a land valuation model, offering ample potential for exploration and study.

Given its unique attributes and dynamic nature, the Homagama Divisional Secretary Division has been deliberately chosen as the focal point of this study. By focusing on this locale, the research aims to identify and understand the special characteristics essential for developing a comprehensive land valuation model. Refer Fig 1 for map of the study area.

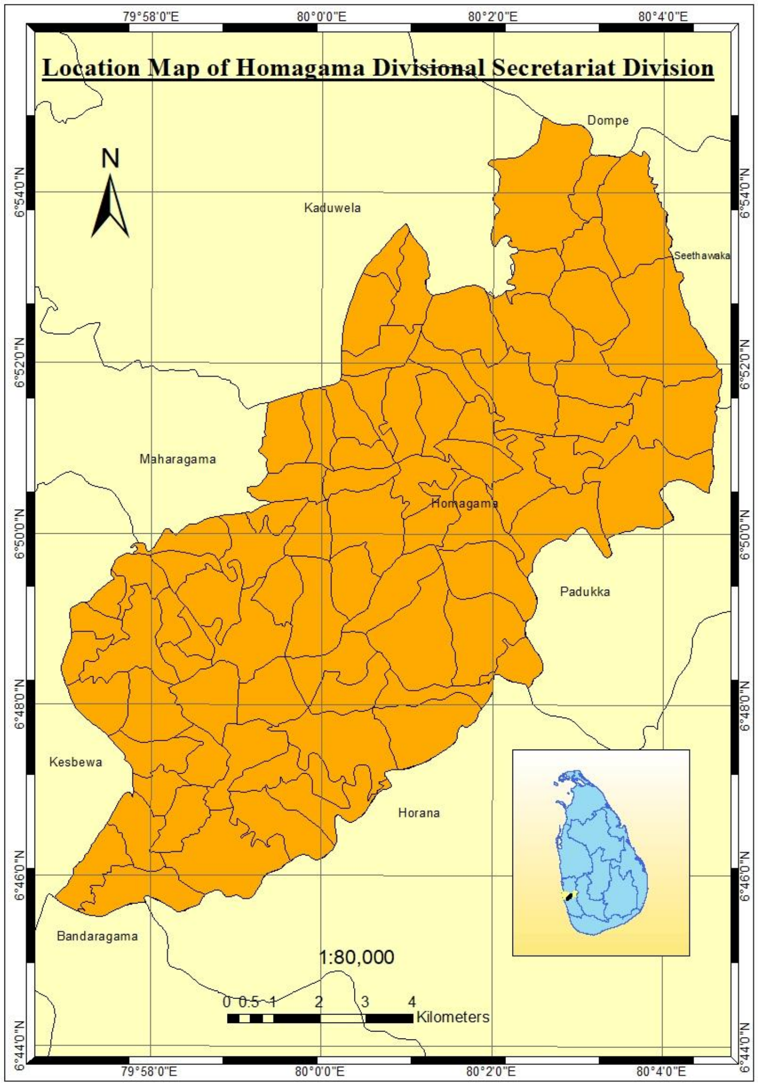


Fig 1. Study Area

3.2 Selection of Criteria

The selection of the main and sub criteria represents the most crucial and fundamental step in susceptibility modeling. This study identified eleven causative factors for land value as the main criteria and sub criteria. These factors were derived from literature review and expert review process, as shown in Table 1. The study primarily relied on both primary and secondary data sources. Primary data for this study were collected through a questionnaire, designed with five-point Likert scale questions to gather perceptions from 20 professionals regarding the sub criteria for each factor. The questionnaire encompassed professionals' insights on the 11 pre-determined factors, treated as independent variables. The dependent variable in this study is 'land value'. Furthermore, secondary data were sourced from institutions including the Survey Department, Inland Revenue Department, and Homagama Divisional Secretariat Office. Data collection methodologies for the factors are detailed in Table 1.

Table 1. Causative Factors on Land Value and Data Collection Methods For Factors

Factors	Data required	Source	Data collection method
Access to transport	Transport data	Survey Department	By using 1:10000 scale topographic data
Proximity to school	Location of Schools	Survey Department	By using 1:10000 scale topographic data
Distance to government & commercial buildings	Location of government & commercial buildings	Survey Department	By using 1:10000 scale topographic data
Distance to urban center	Location of urban centers	Survey Department	By using 1:10000 scale topographic data
Slope	Contour data	Survey Department	By using 1:10000 scale topographic data
Landuse	Landuse data	Survey Department	By using 1:10000 scale topographic data
Proximity to Hospital	Location of health services	Survey Department	By using 1:10000 scale topographic data
Population	Population records	Divisional secretariat office	By using field data
Foot print of road	Cadaster data	Survey Department	By using Cadaster plan(1:1000 scale)
Shape of land	Cadaster data	Survey Department	By using Cadaster plan(1:1000 scale)
Size of land	Cadaster data	Survey Department	By using Cadaster plan(1:1000 scale)

Land value	Land value records	Inland Revenue Department	By using field data

Source: Compiled by authors

3.3 Method of Data Analysis

3.3.1 Preparation of Thematic Data Layers

Thematic data layers were generated for each factor using information gathered from accessible maps and field data. In the initial stage, eight thematic data layers were established. Since the study area did not include any inhabited regions, these areas were excluded from all thematic data layers, considering their potential lack of associated land value. Following this, the eleven raster layers were reclassified into eight. During this process, ranked values were assigned to the respective subgroups, as outlined in Table 2.

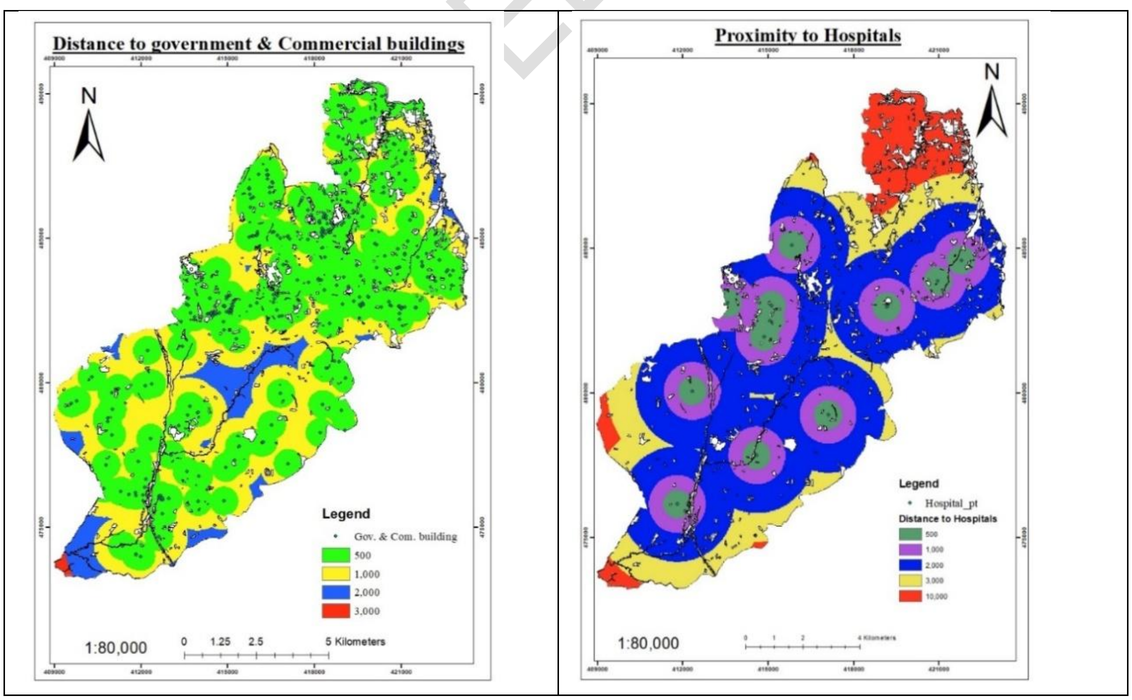
The considered eight causative factors are not equally important to the value of land. Therefore, to identify the areas which considered factors should be combined in accordance with their relative importance to land value. This can be achieved by developing a rating scheme in which the factors and their classes are assigned numerical values. A rating scheme was developed based on the expertise knowledge by questionnaire and the exiting literatures.
It generated a weight for each factor according to the information provided. The AHP is hierarchical because it reduces complex decision-making problems into pair wise comparisons [14,15]. Weights and rank for each factor and their classes are given in Table 2. There are 8 factors then RI is equal to 1.41. Obtained CR value is 0.025 (≤ 0.1) Therefore, comparisons in this study are acceptable. Thematic maps are given in Fig 2

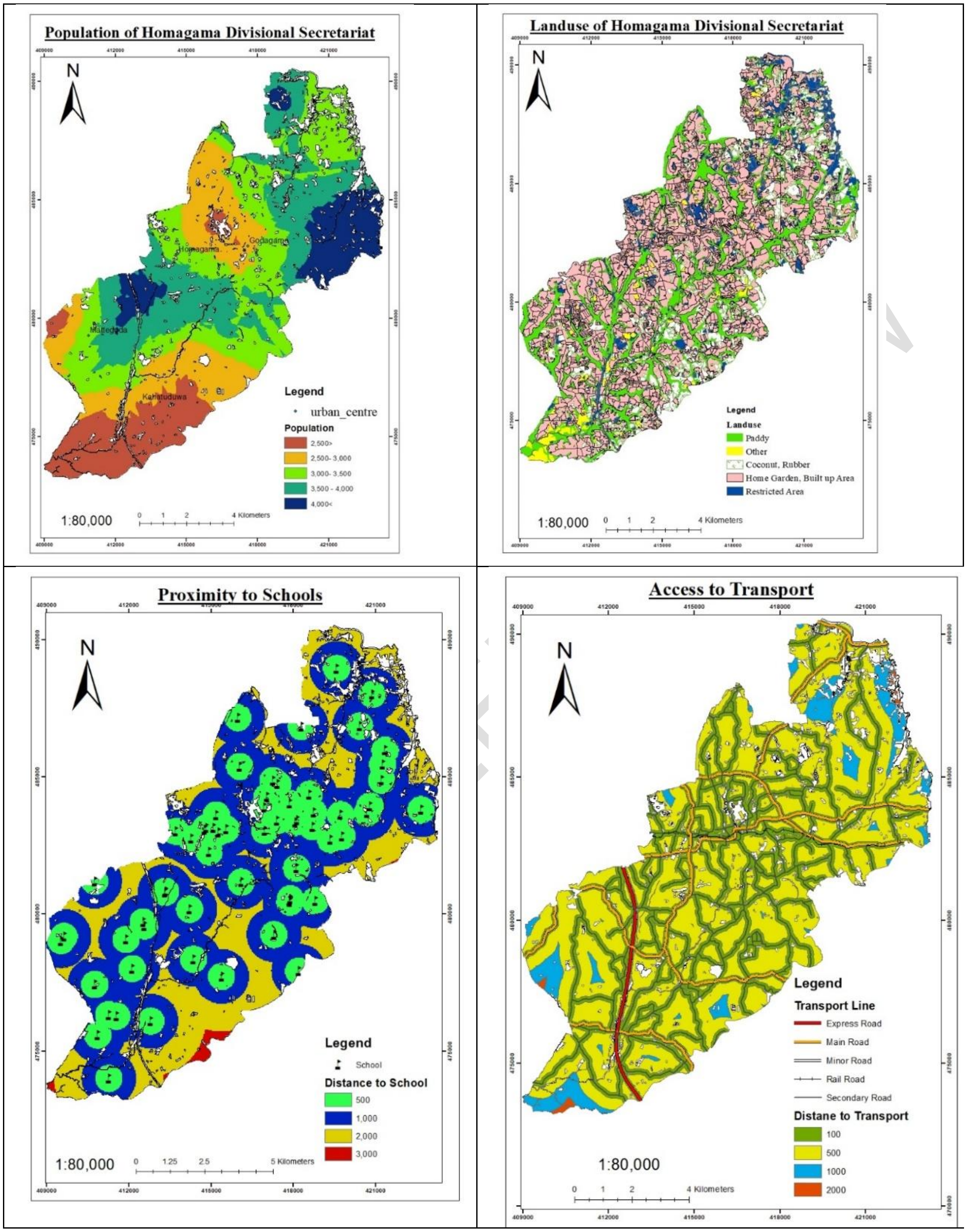
Table 2. Weights and rank for factors and their classes

ID	Main Criteria	weight (%)	Sub Criteria	Score/Rank
1	Access to transport	16.9	<100m	5
			100m -500m	4
			500m – 1000m	3
			1000m – 2000m	2
			>2000m	1
2	Proximity to school	15.7	<500m	5
			500m -1000m	4
			1000m – 2000m	3
			2000m – 3000m	2
			>3000m	1
3	Distance to government &Commercial buildings	14.9	<500m	5
			500m -1000m	4
			1000m – 2000m	3
			2000m – 3000m	2
			>3000m	1
4	Proximity to Hospital	11.4	<500m	5
			500m -1000m	4
			1000m – 2000m	3
			2000m – 3000m	2

			>3000m	1
5	Slope	9	>20	1
			15-20	2
			10-15	3
			5-10	4
			<5	5
6	Land Use	10.7	Home Garden, Built up area	5
			Paddy	1
			Coconut, Rubber	4
			other	2
			Forest, Tank, Water area, Marshy, Sandy, Stream	0
7	Distance to urban centers	12.2	<500m	5
			500m -1000m	4
			1000m – 2000m	3
			2000m – 3000m	2
			>3000m	1
8	Population	9.1	<2500	1
			2500-3000	2
			3000-3500	3
			3500-4000	4

Source: Expert Review Results (2023)





Population of Homagama Divisional Secretariat
Homagama
Godagama
Meegoda
Kahatuduwa
Legend
urban_centre
Population
2,500>
2,500- 3,000
3,000- 3,500
3,500 - 4,000
4,000<
1:80,000
0 1 2 4 Kilometers
Landuse of Homagama Divisional Secretariat
Legend
Landuse
Paddy
Other
Coconut, Rubber
Home Garden, Built up Area
Restricted Area
1:80,000
0 1 2 4 Kilometers
Proximity to Schools
Legend
School
Distance to School
500
1,000
2,000
3,000
1:80,000
0 1.25 2.5 5 Kilometers
Access to Transport
Legend
Transport Line
Express Road
Main Road
Minor Road
Rail Road
Secondary Road
Distane to Transport
100
500
1000
2000
1:80,000
0 1 2 4 Kilometers

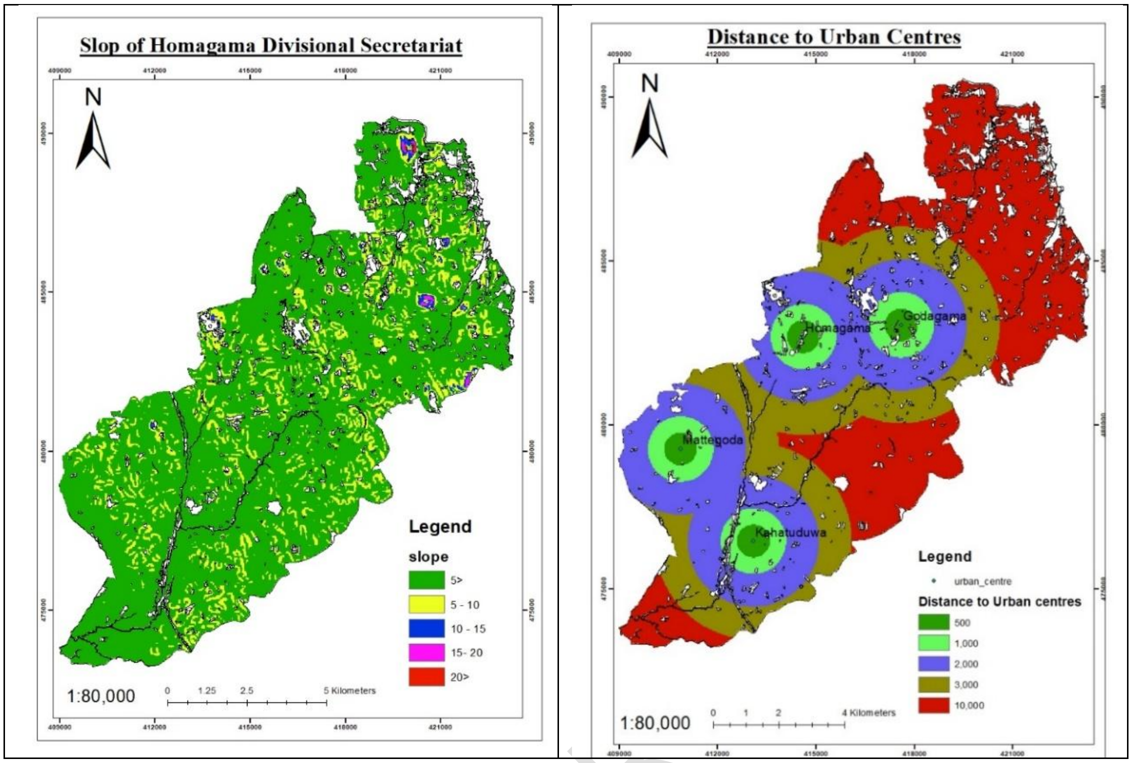


Fig 2. Thematic Maps

The model indicating the value of land was generated using Weighted Overlay Analysis in the ArcGIS software. To create the model, 'Model Builder' was employed, which is a tool designed for creating and managing automated, self-documenting spatial models. In this study, the land valuation map was produced for the Homagama Divisional Secretariat area using GIS and multi-criteria Analytical Hierarchy Process (AHP) techniques, along with a weighted overlay. The factors considered for land valuation included Access to Transport, Proximity to Schools, Distance to Government & Commercial Buildings, Distance to the Urban Center, Proximity to Hospitals, Slope, Land Use, and Population. Refer Fig 3 for Model Builder.

Finally, the land valuation map has been categorized into five classes, illustrating Restricted, Low-Valued, Moderately Valued, High-Valued, and Very High-Valued areas. Utilizing a 1:1,000 scale cadastral plan obtained from the Survey Department of Sri Lanka can indeed offer valuable insights for determining accurate land values. This plan facilitates the identification and assessment of various factors influencing land value, including road layouts, land shapes, and individual lot sizes.

Moreover, the prepared land-valued areas have been integrated into the Land Information System (LIS) of Survey Department of Sri Lanka, primarily focusing on cadastral data. This dataset encompasses information related to land boundaries, ownership, and other spatial details.

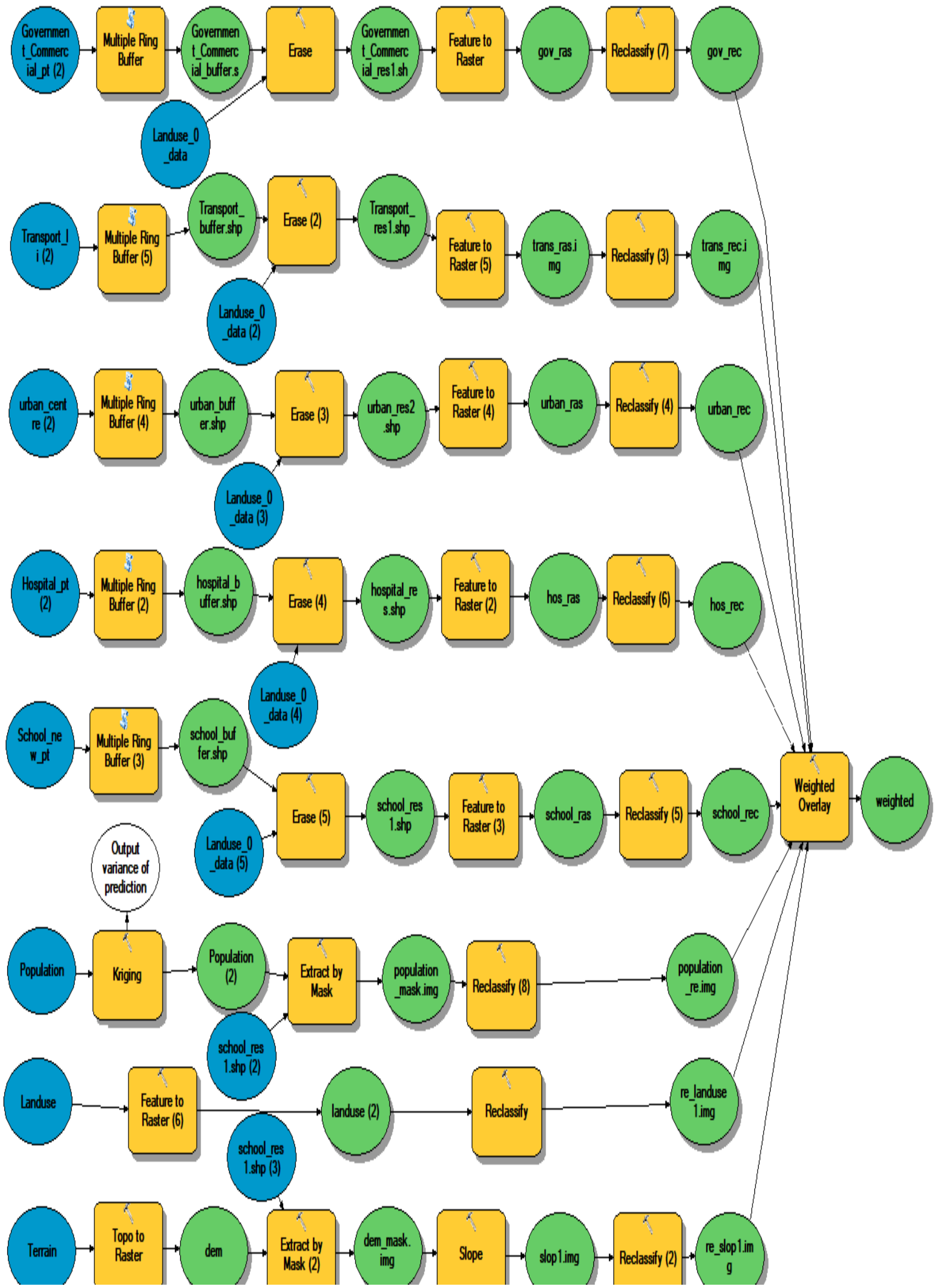


Fig 3: Model for Land Valuation in Homagama Divisional Secretariat

4. RESULTS AND DISCUSSION

Based on the provided information, the land valuation map depicts a diverse range of land values within the study area. Merely 44.43% of the total study area received classification as high or very high-value land zones, suggesting that these zones are relatively scarce in comparison to other parts of the study area. The majority of the study area (45.64%) has been classified as moderately valued, indicating that this category constitutes the most prevalent land valuation in the region. Additionally, a small portion of the study area (1.74%) falls under the classification of very low land value probability, signifying that a significant portion of the area holds some level of value.

However, it's crucial to acknowledge that these classifications are based on specific methodologies and criteria and may not necessarily align with the actual market value of the land. In summary, the data implies that the study area exhibits a spectrum of land values, with moderate value being the prevailing category. This insight could prove valuable for landowners, developers, and other stakeholders seeking to comprehend the potential value of land within the study area. The percentage distribution of land value zones is provided in Table 3. Fig 4 depicted the five land valuation zones identified.

Table 3. Percentage area of Land value zone

Land value zone	Area Sq.Km	Percentage (%)
Restricted	9.87	8.18
low valued	2.10	1.74
Moderately valued	55.03	45.64
High valued	53.50	44.37
Very high valued	0.07	0.06

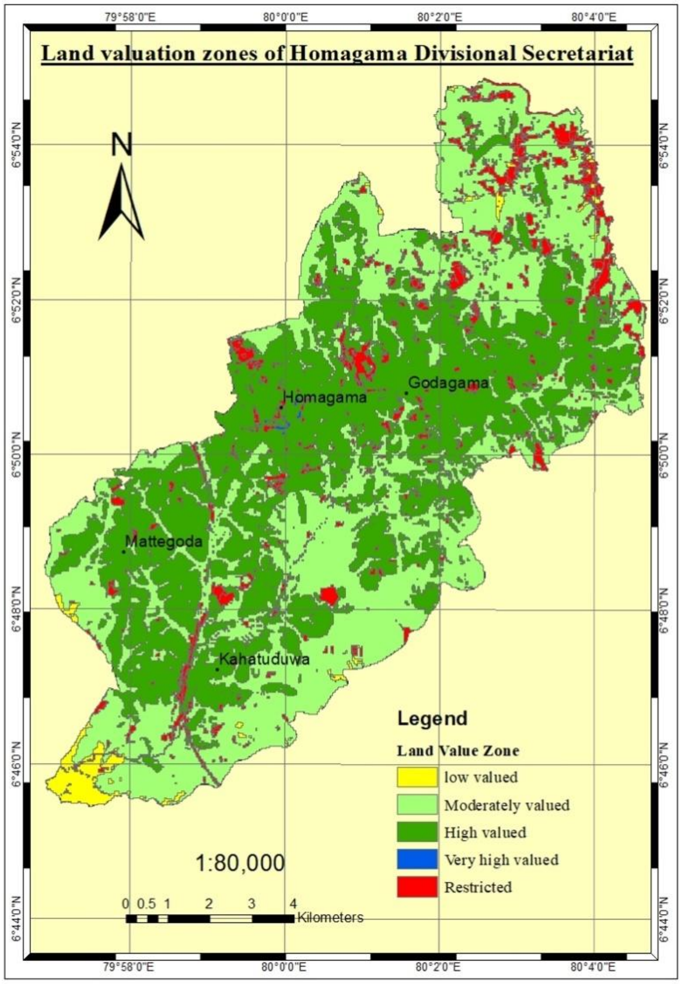


Fig 4. Land Valuation zones of Homagama Divisional Secretariat Area

It seems there are various factors that can influence the valuation of land. Valuers often take these factors into consideration to assess the potential value of a piece of land accurately. Valuers may exclude certain areas from their assessments, such as restricted zones like forests, tanks, water bodies, marshy or sandy areas, and streams. These areas may not be suitable for development or could be subject to environmental regulations or restrictions. Areas that are well-connected with infrastructure and facilities, including urban centers, transportation networks, schools, hospitals, government, and commercial buildings, tend to have higher land values.

Easy accessibility can attract both commercial and residential development, contributing to the increased land value. Land with very steep slopes may have limited development potential, making it less desirable to potential buyers. Steep slopes can also increase construction costs, further reducing the value of the land. Zones with higher population densities often experience higher land values. The availability of services and amenities like public transportation, schools, and healthcare facilities in areas with a higher population creates greater demand, leading to an increased land value.

These factors are indeed important considerations for valuers when determining the value of a piece of land. They help ensure a comprehensive assessment of the land's potential and its attractiveness to potential buyers or developers.

4.1 Map Validation

In this study 220 samples of real land values were collected using the simple convenience sampling method. It is a non-probability sampling method and may not provide a representative sample of the population. The validation of the developed map was done by overlaying the 220 real land value locations on developed map and compare with the different land valuation zones. Table 4 is describing that more than 76% of the Land value locations fall under moderate and high Land valuation zones. Refer Fig 5 estimated zones and actual land value interpolation map.

Table 4. Percentage of land value locations on the land value zone

Land Valuation zone	Number of land value locations	Percentage %
High	89	40
Moderate	79	36
Low	52	24
Total	220	100

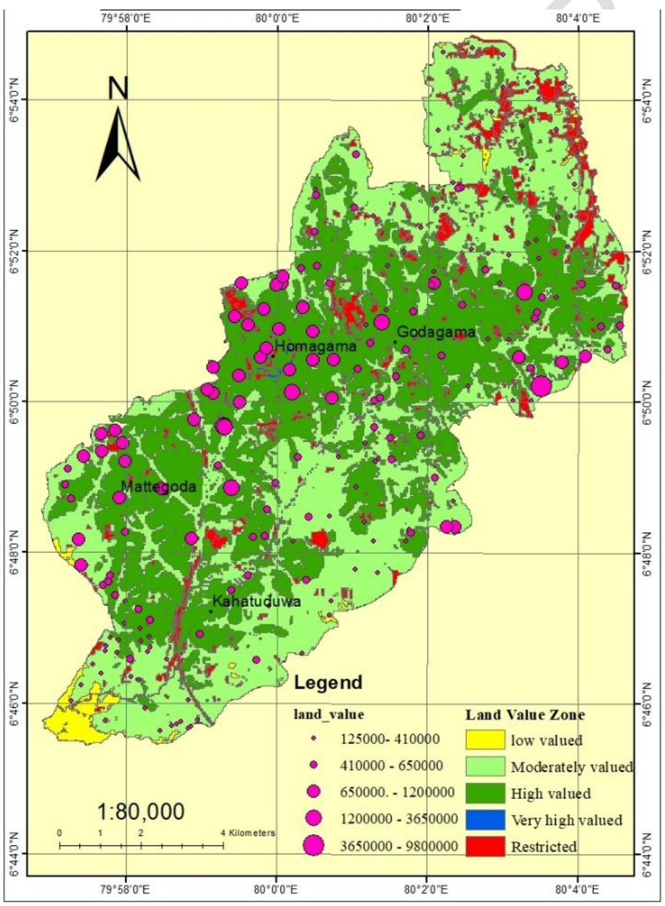


Fig 5. Land Valuation zones and Real Land Value of Homagama Divisional Secretariat Area

5. CONCLUSION

This study introduces an alternative method for land valuation by utilizing an automated land valuation model based on GIS technology. The selected causative factors for land value in the Homagama Divisional Secretariat area are access to transport, proximity to school, distance to government and commercial buildings, distance to the urban center, proximity to the hospital, slope, land use, population, size, shape, and road footprint. The integration of GIS technology with this information provides a powerful tool for accurately producing land valuation maps. The Analytic Hierarchy Process revealed that access to transport, proximity to school, and distance to government and commercial buildings hold the highest preference for land value, while slope and population have the least preference.

It is interesting to note that most of the lands in Homagama Divisional Secretariat area are in the moderate land valuation zone with 45.64% and very high land valuation zone with 0.06%.
Having summarized validating the developed model, more than 76% of the Land value locations fall under moderate and high Land valuation zones. So it can be concluded that the developed model gives a very good result for the land valuation process which is currently conducting using the manual method. The proposed model represents a significant step forward in the land valuation process and has the potential to provide a more accurate and objective approach to determining the value of land.

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