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A GIS-Based Approach for Assessing Urban Development Potential in Federal Capital Territory Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Urban development potential assessment is essential for guiding the spatial expansion of cities, optimizing land use, and ensuring sustainable urban growth. In the context of rapidly urbanizing regions, such as Nigeria, understanding development potential helps mitigate the challenges of urban sprawl, infrastructure strain, and environmental degradation, hence, this study is aimed at a GIS based approach for assessing urban development potential in federal capital territory Nigeria. The objectives of the study are to: identify and categorize the key factors influencing urban development in the Federal Capital Territory, Nigeria; assess the reliability of the identified factors using consistency index and sensitivity analysis; determine the potential areas for urban development in the Federal Capital Territory, Nigeria using analytical hierarchical process; and produce an urban development potential map defining the extent of urban development potential

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across the urban landscape of the Federal Capital Territory, Nigeria. The study employed the assessment of relative priorities in modelling and mapping urban development potential in Federal Capital Territory Nigeria. This assessment was based on a comprehensive set of criteria, including slope, elevation, proximity to road network, population density and proximity to developed areas. The Analytical Hierarchical Process was utilized to compare and establish the relative importance of these criteria by means of matrix comparisons. Subsequently, these criteria were assigned relative weights. Weighted Overlay technique was applied to generate the final development potential map. The study revealed that Abuja Municipal Area had the highest potential development area, covering an area 851.40 km^2, with Bwari and Kuje Area Councils as having the second and third highest development potential with an area coverage of 312.40 km^2 and 279.69 km^2 respectively. Gwagwalada and Kwali Area Councils were ranked fourth and fifth with a developable area coverage of 180.20 km^2 and 127.60 km^2 respectively, while Abaji Area Council was ranked the least with developable area coverage of 40.27 km^2. The study successfully integrated an approach to investigate development potential within the Federal Capital Territory. This evaluation approach, is hereby recommended to be used as tool for planning and decision making in urban development in the study area.

Keywords: Analytical Hierarchy Process (AHP); Federal Capital Territory (FCT); Geographic Information Systems (GIS); Multi-Criteria Decision Analysis (MCDA); spatial analysis; sustainable urban development.

1. INTRODUCTION

Urban development is a dynamic process influenced by various socio-economic, environmental, and infrastructural factors. The assessment of urban development potential is crucial for effective urban planning, sustainable growth, and resource allocation. Geographic Information Systems (GIS) provide a powerful tool for analyzing spatial data and evaluating urban development potential [1,2]. This study aims to assess the urban development potential in the Federal Capital Territory (FCT), Nigeria, using a GIS-based approach.

Urban development potential assessment is essential for guiding the spatial expansion of cities, optimizing land use, and ensuring sustainable urban growth. In the context of rapidly urbanizing regions, such as Nigeria, understanding development potential helps mitigate the challenges of urban sprawl, infrastructure strain, and environmental degradation [3,4] Effective assessment facilitates strategic planning and investment, enhancing the quality of urban life and supporting economic development [5].

Geographic Information Systems (GIS) have revolutionized urban planning by enabling the integration, analysis, and visualization of spatial data. GIS supports multi-criteria decision analysis (MCDA) methods, such as the Analytical Hierarchy Process (AHP), for evaluating urban development potential [6,7]. These tools help planners analyze diverse factors, including land use, infrastructure, topography, and socio-economic conditions, to identify areas suitable for development [8,9].

Nigeria has experienced rapid urbanization in recent decades, driven by population growth and economic activities. The urban population has increased significantly, leading to challenges in managing urban sprawl, infrastructure development, and environmental sustainability [10,11]. In the Federal Capital Territory (FCT), Abuja's emergence as a major urban center has amplified the need for effective urban planning and development assessment [12,13].

The Federal Capital Territory (FCT) of Nigeria, home to Abuja, is characterized by diverse topography, land use patterns, and varying levels of infrastructure development [14]. Assessing urban development potential in this region requires comprehensive analysis of multiple spatial and socio-economic factors. A GIS-based approach enables the integration of these factors, providing a holistic view of development potential [15].

The Analytical Hierarchy Process (AHP) is a widely used multi-criteria decision analysis method for urban development assessment. AHP allows for the evaluation of multiple factors by assigning weights based on their relative importance, facilitating a structured decision-making process [7]. Combining AHP with GIS enables spatially explicit assessment, allowing for the visualization of development potential across different areas [16,17].

Several factors influence urban development potential, including land use, topography, infrastructure, and population density. Land use patterns provide insights into the suitability of areas for different types of development [18]. Topography affects the feasibility of construction and infrastructure development, with flat or gently sloping areas being more suitable. Infrastructure, such as roads and utilities, is crucial for supporting urban growth and enhancing accessibility [19]. Population density reflects the demand for urban development and services, influencing the allocation of resources [20,21].

Several studies have applied GIS and AHP for assessing urban development potential. Malczewski [6] and Luan et al. [22] demonstrated the effectiveness of GIS-based multi-criteria analysis in urban planning. Jat et al. [3] and Mishra et al. [15] utilized GIS to evaluate land suitability for urban development. Feizizadeh et al. [17] integrated AHP with GIS for urban development assessment, highlighting its utility in identifying suitable areas for expansion.

The FCT, particularly Abuja, has experienced accelerated urbanization driven by economic opportunities and population growth [23,24]. However, this rapid expansion has resulted in unplanned urban sprawl, straining existing infrastructure and services [25,13,3]. Uncoordinated urban growth has led to inefficient land use, increased traffic congestion, and the proliferation of informal settlements [11,10]

The rapid expansion of urban areas has outpaced the development of essential infrastructure, including roads, water supply, and sanitation systems [12,25]. This deficit hampers economic development and affects the quality of life for residents. Inadequate infrastructure exacerbates issues such as traffic congestion, poor waste management, and limited access to basic services [19].

The FCT's diverse topography, including hills, valleys, and water bodies, presents challenges for urban development [14]. Uncontrolled development in environmentally sensitive areas increases the risk of flooding, erosion, and habitat destruction [2].

Addressing these challenges requires a robust, data-driven approach that leverages Geographic Information Systems (GIS) for spatial analysis and integrates multiple criteria to assess urban development potential comprehensively [1,8]. A GIS-based approach can facilitate the identification of suitable areas for development, optimize land use, and enhance infrastructure planning by: Incorporating various datasets, including land use, topography, infrastructure, and population density, to provide a holistic view of development potential [22,15] utilizing the Analytical Hierarchy Process (AHP) to assign weights to different factors and evaluate their relative importance in urban development [2] and producing spatially explicit maps that highlight areas with high, moderate, and low development potential, supporting informed decision-making [2].

Despite the critical need for effective urban planning in the FCT, there is a notable gap in the application of advanced GIS-based approaches to assess urban development potential [15,17]. Existing planning frameworks often fail to comprehensively integrate spatial data and multi-criteria analysis, leading to fragmented and inefficient urban development strategies. This research seeks to address this gap by developing a GIS-based methodology that combines spatial analysis with AHP to assess urban development potential in the FCT.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is the Federal Capital Territory. The FCT covers approximately 8,000 square kilometres. The FCT is located at latitude 7°25’N and 9°20’N and longitude 5°45’E and 7°39’E. It shares borders with Kaduna to the north, Niger to the west, Plateau to the east, and Kogi to the south-west. Figs. 1 and 2 show the geographic location of Abuja. It consists of six local councils: Abaji, Bwari, Kuje, Gwagwalada, Kwali, and the Abuja Municipal Area Council (AMAC), which serves the metropolitan city of Abuja.

There are three distinct weather patterns in the FCT each year. There is a scorching dry season and a warm, muggy rainy season. The northeast trade wind causes a brief harmattan interlude between the two, with the main characteristics being dust haze, increased coldness, and dryness. April through October is considered the rainy season. During this time, daytime highs range from 28 to 30 degrees Celsius (82.4 to 30.6 °F), while nighttime lows are between 22 and 23 degrees Celsius (71.6 to 33.4 °F). During the dry season, daytime highs of up to 40 °C (104.0 °F) and nighttime lows of up to 12 °C (53.6 °F) are common.

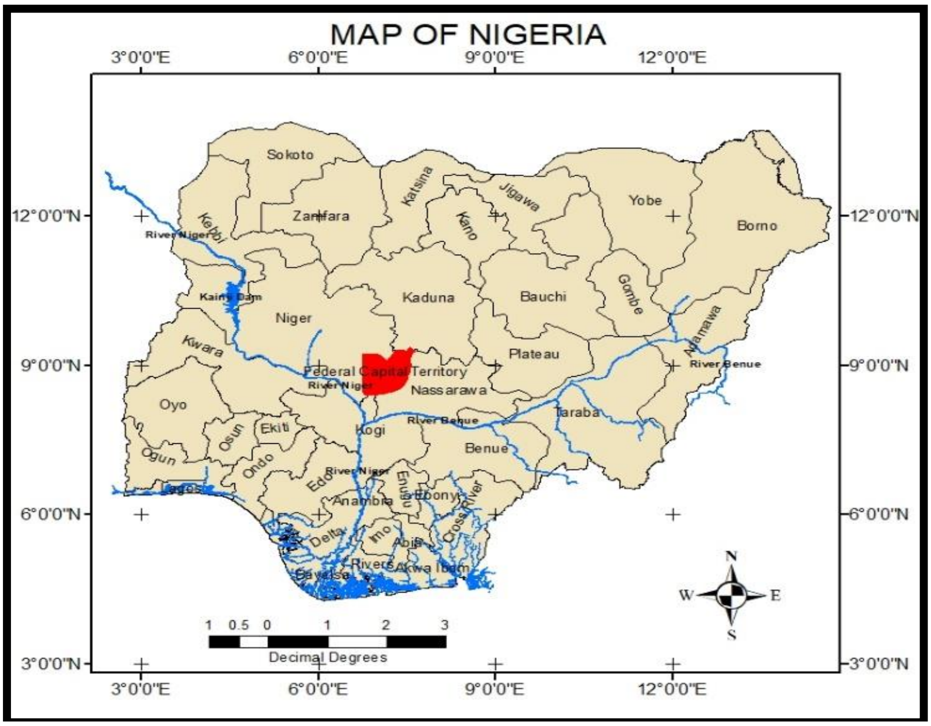

Fig. 1. Map of Nigeria showing FCT

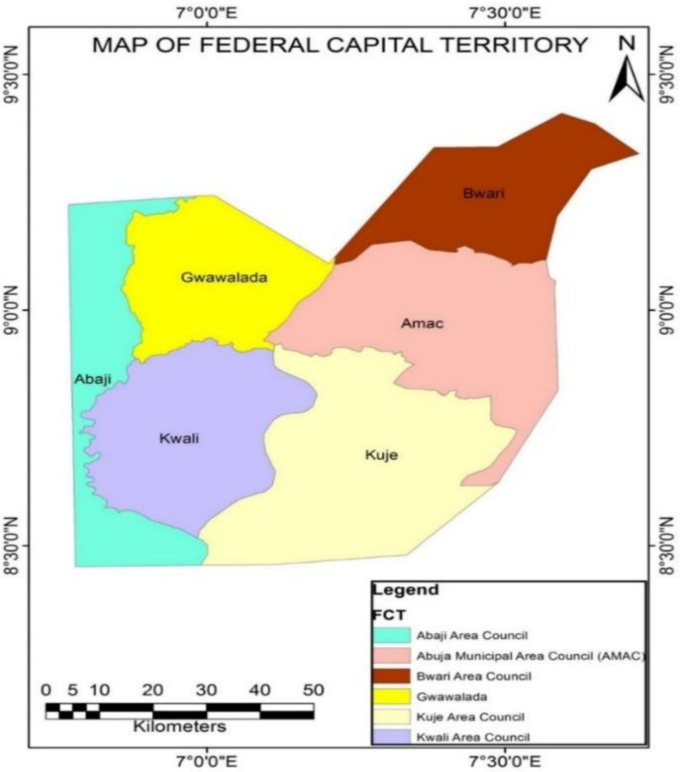

Fig. 2. Map of FCT, Nigeria (Study Area)

It is possible for daytime temperatures to rise well above 30 °C (86.0 °F) even on the coldest evenings. The weather in the Federal Capital Territory is moderated by its high elevations and undulating terrain.

The FCT is located in the West African subregion's Guinean forest-savannah mosaic zone. However, there are pockets of rain forest in the Gwagwa plains, particularly in the rough terrain to the southeast of the area, where gullies and rough terrain can be found. These sections of Nigeria's Federal Capital Territory (FCT) comprise one of the few remaining examples of the country's mature forest vegetation.

2.2 Methods

2.2.1 Data requirement

The datasets utilized in this research include Sentinel-2, ALOS PALSAR, road data, developed area data, and population density data. Secondary datasets were obtained from existing sources. The map of the administrative boundary of FCT, Nigeria, as well as road and population density data, were acquired from the Federal Capital Development Agency (FCDA). Sentinel-2 data and ALOS PALSAR data were obtained from the Open Access Hub (copernicus.eu).

2.2.2 Image pre-processing

Prior to any analysis, initial processing of the collected data was conducted to ensure accuracy. This step corrects any inaccuracies caused by the imaging system and environmental conditions during image acquisition. Although standard corrections were applied by ground station operators, additional steps were necessary to guarantee data accuracy. These included:

a) **Radiometric Correction:** Adjusts for differences in sensor response across the image.
b) **Geometric Correction:** Removes distortions caused by Earth's rotation or other imaging conditions.
c) **Geo-referencing:** The image was transformed to the UTM Zone 32 North map projection system using ground control points (GCPs) to precisely align the image with a specific map.

Additionally, band combination and image subsetting were performed during the initial processing of the raw data. Band combination merges different spectral bands of a remote sensing image to create a composite image highlighting specific features. Image subsetting involves extracting a smaller, relevant portion of the image to reduce the amount of data processed and analyzed. These steps are crucial for ensuring the highest quality and accuracy of the data used in subsequent analysis.

2.2.3 ALOS palsar processing

The ALOS PALSAR provides a topographical model containing elevation records for specific cell sizes. However, sunken areas not captured due to data errors or karst topography might exist. These errors arise from limitations in DEM resolution or errors in its generation. To address these issues, sinks were filled using ArcGIS Pro software. Subsequently, the elevation and slope of the area were calculated based on the corrected DEM data. These layers were then utilized as key components in the suitability analysis, serving as constraints and factors for further analysis.

2.2.4 Image classification

Supervised classification techniques were applied using ArcGIS software. The Image Classification toolbar facilitated the creation of training samples and signature files. The primary classification method was the Maximum Likelihood Classification tool. This method required a signature file outlining the characteristics and statistics of the different classes being analyzed, generated by collecting training samples through the Image Classification toolbar.

2.2.5 Urban development potential

Saaty [7] introduced the Analytical Hierarchy Process (AHP) for modelling urban development potential. By breaking down difficult decisions into a series of pairwise comparisons and synthesising the findings, AHP is a useful tool for complex decision-making. It assists decision-makers in setting priorities and arriving at the best choice. AHP measures the benefits and risks of a choice by giving each criterion a numerical value, thereby capturing both the subjective and objective aspects of the decision-making process.

2.2.6 The AHP process involved several steps:

Comparing Factors: Judgment values for each factor relative to other factors were obtained from expert judgments sourced from the literature, based on Saaty's [7] scale (Table 1).

Table 1. Relative importance

Value	Meaning
1	Equal importance
3	Moderately important
5	Strongly important
7	Very strongly important
9	Extremely important

The Judgment value of each factor in relation to other factors was obtained to a higher degree of consistency from the judgment of experts in various field of concern. These judgments of experts were obtained through literatures where the experts provided the relative importance of the factors under consideration based on Saaty [7] judgment value in Table 1. Table 2 shows the coding of factors that were considered where F1 to F6 represent the factors.

Table 2. Coding of factors

Factor	Code
Land Cover/Land Use	F1
Proximity to Developed Areas	F2
Proximity to Road Network	F3
Elevation	F4
Slope	F5
Population Density	F6

Forming Pairwise Comparison Matrix: Using judgment values, a pairwise comparison matrix was created. Matrix elements reflect the relative importance of factors. The normalized pairwise comparison matrix was then formed by dividing each element by the sum of its column. The average of each row in this normalized matrix provided an estimate of the relative weights of the criteria.

Computing Criteria Weights: The normalized sum of each row was divided by the number of criteria to obtain the criteria weights. These weights were converted to percentages for prioritization.

Consistency Ratio (CR): The CR was used to check the reliability of the judgment values relative to large samples of purely random judgments. If CR < 0.1, the weights are considered consistent. If CR > 0.1, the weights need revision.

The consistency ratio is calculated as follows:

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI}$$

Where RI is the random index based on the size of the matrix (Table 3).

3. RESULTS AND DISCUSSION

3.1 Establishment of Evaluation Criteria

Based on their theoretical applicability, the criteria and factors for the AHP-based evaluation of urban development were chosen [26-30]. This study employed the criteria listed in Table 4.

The data used to accomplish the research's goal were gathered in accordance with the criteria chosen (Table 4). Slope and elevation were extracted from the SRTM that was downloaded from www.earthexplorer.usgs.gov, and land cover/landuse was extracted from the image classification that was done on the Sentinel-2 image. Using the Euclidean distance algorithm, the FCT road network and FCT urban areas were used to determine the road proximity and urban proximity areas. The NASA Earth database was then used to obtain the population density. The Figs. 3–8 display these data.

3.2 Reclassification and Standardization of Criteria

Reclassification and standardisation of criteria is the first step in implementing AHP. Each cell contains a value for each input criterion. At this point, it will be practically impossible to combine the criteria, necessitating the reclassification of each individual dataset. Different number systems cannot be combined effectively. For example, combining a cell value with a slope of 2˚ and a distance of 50m is nearly impossible due to unit differences. However, standardising them to a common measurement system that represents a relative weighting scale allows for free analysis across datasets and displays the suitability level for each of the standardised criteria.

Table 3. Random Index [7]

Size of Matrix (n)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49

If CR < 0.1, the pairwise comparisons are considered consistent.

Table 4. Criteria (Factors/Constraints)

S/N	Criteria	Factor	Requirement	Reason for Selection	Original Data Structure	Resolution
1	Land Cover/ Land Use	Factor	Barren/Open spaces	Barren/open spaces are prime areas for development	Raster	30m
2	Proximity to developed Areas	Factor	< 500m from developing areas	< 500m from developing areas are adjudged to attract faster developments due to edge expansion development pattern in FCT	Euclidean Raster	30m
3	Proximity to Road Network	Factor	< 500m road networks	< 500m from road networks are considered high development potential	Euclidean Raster	30m
4	Elevation	Factor	Between 140m – 378m (Flat, Undulating and Rolling terrains)	Flat, Undulating and Rolling terrain are considered typical terrain for development	Raster	30m
5	Slope	Factor	Between 3 – 13 degrees	Steady slopes are considered typical terrain for development	Raster	30m
6	Population Density	Factor	Areas with highest population density	Areas with high population density are considered to attract development	Raster	30m

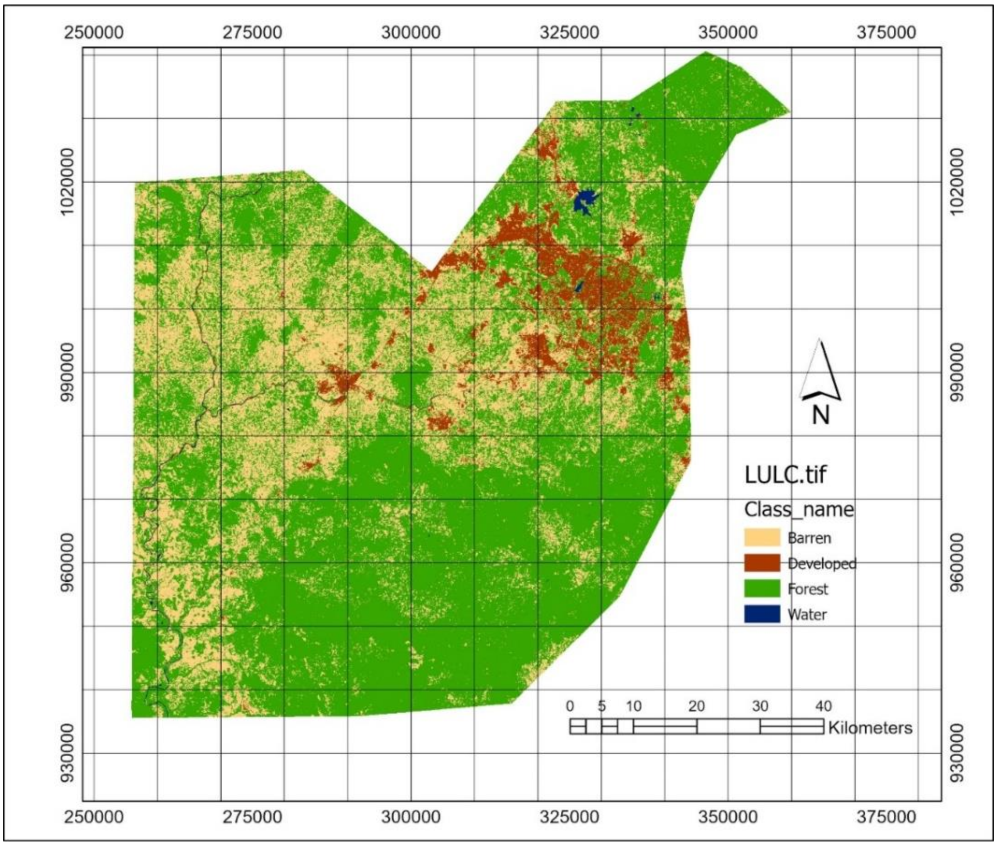

Fig. 3. Landcover/landuse data

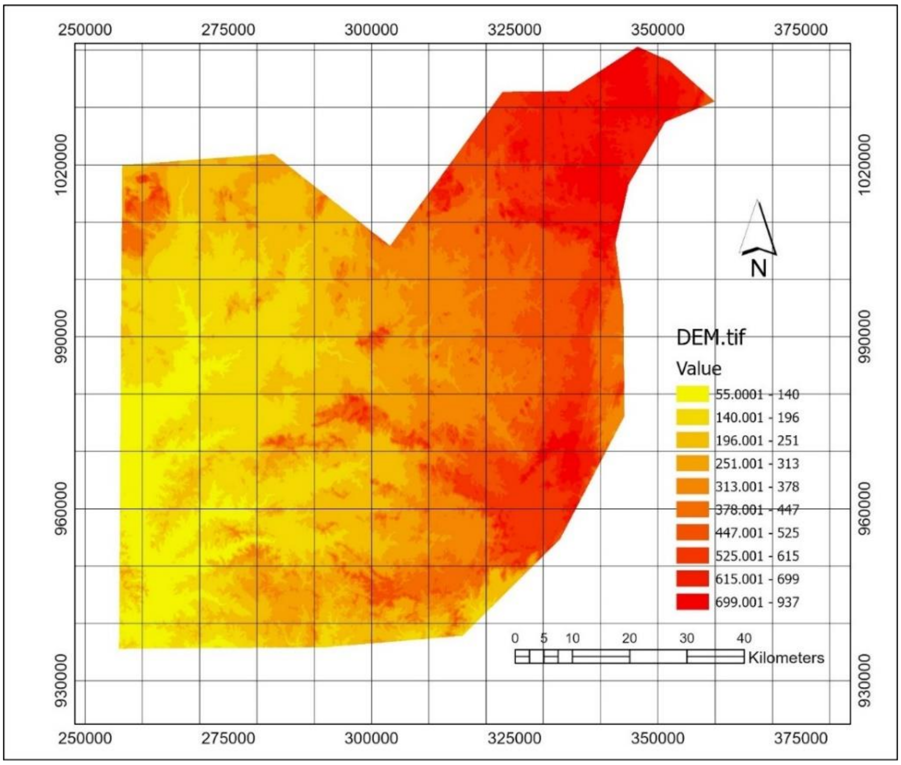

Fig. 4. Elevation data

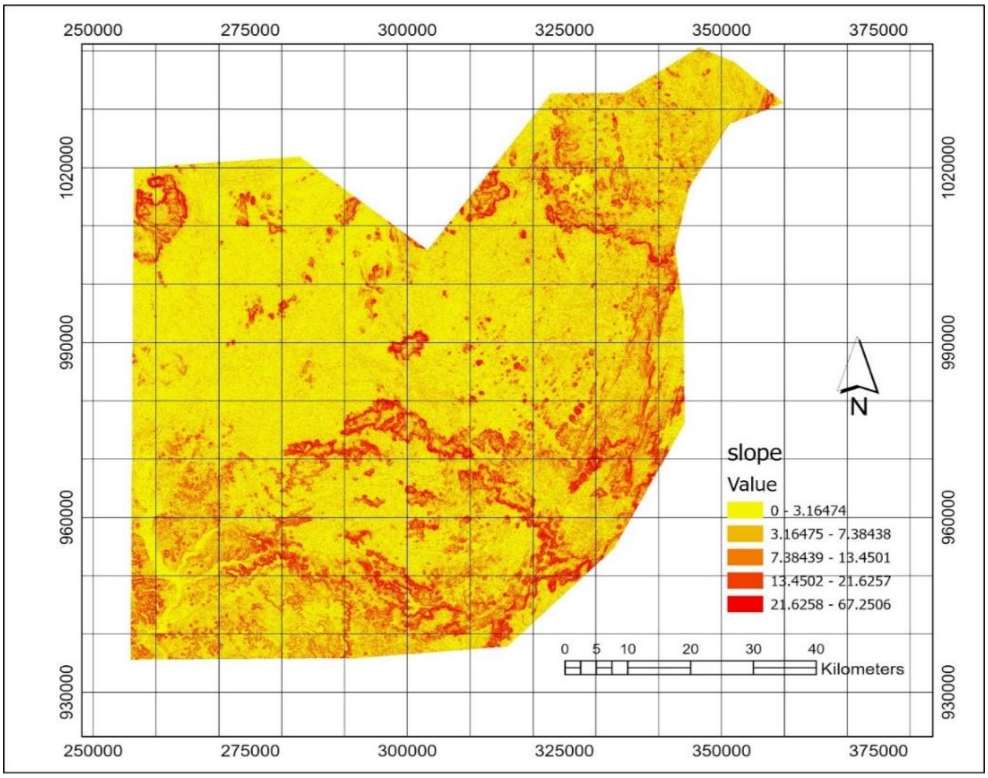

Fig. 5. Slope data

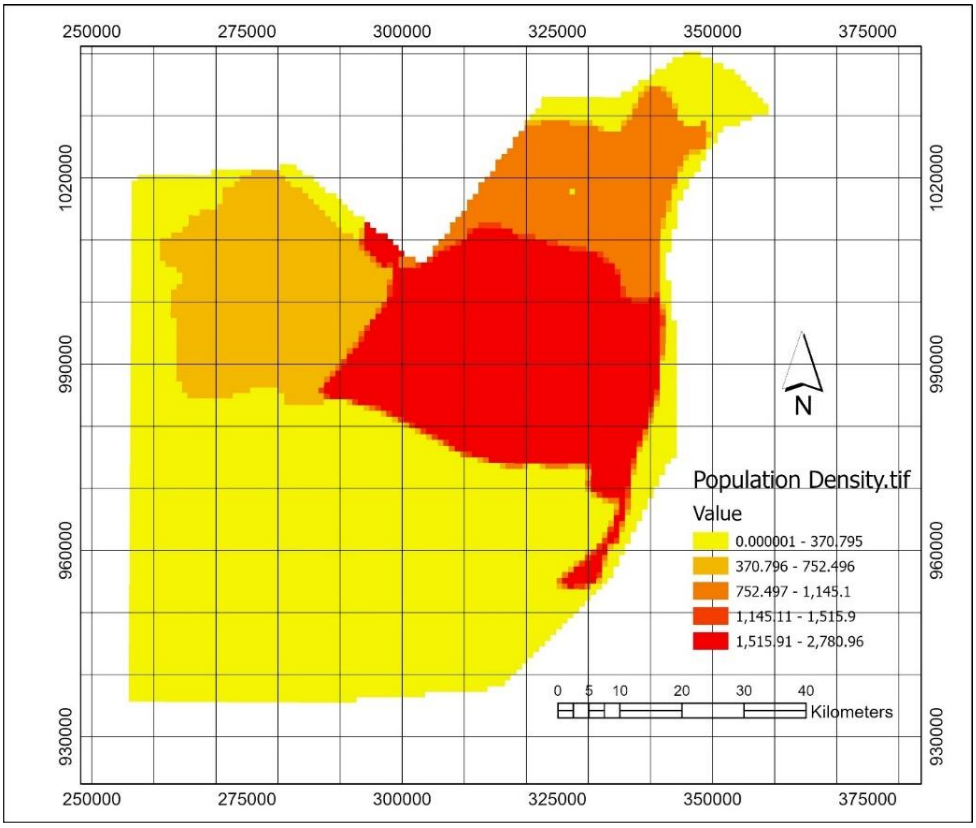

Fig. 6. Population density data

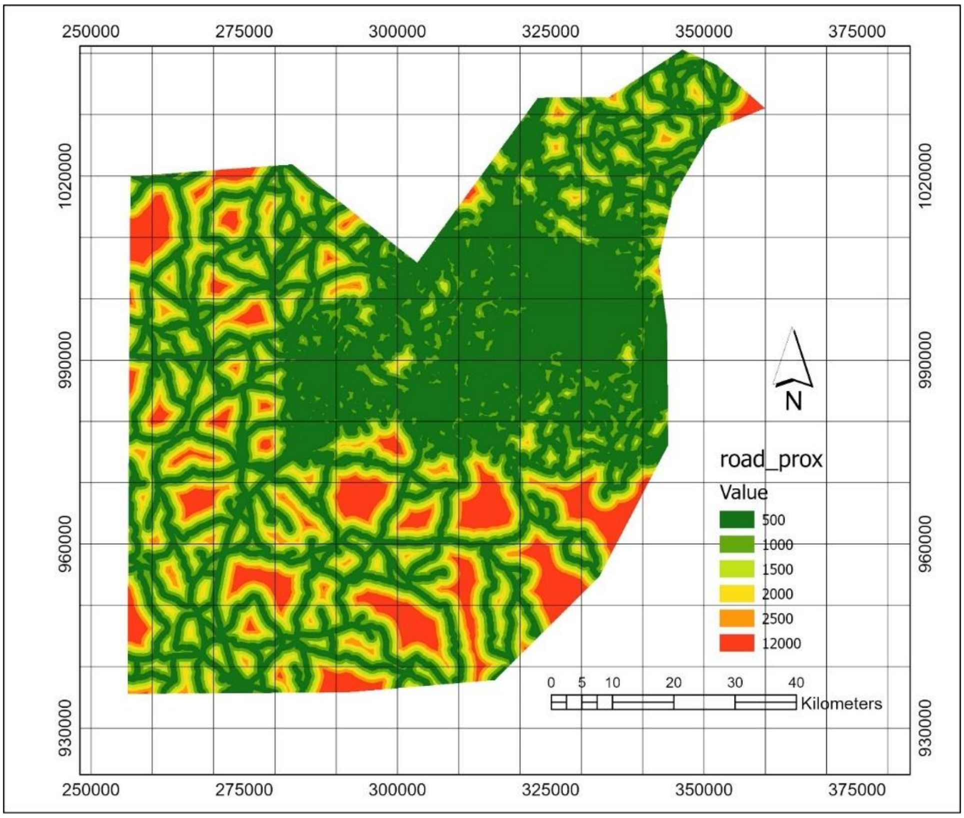

Fig. 7. Road proximity data

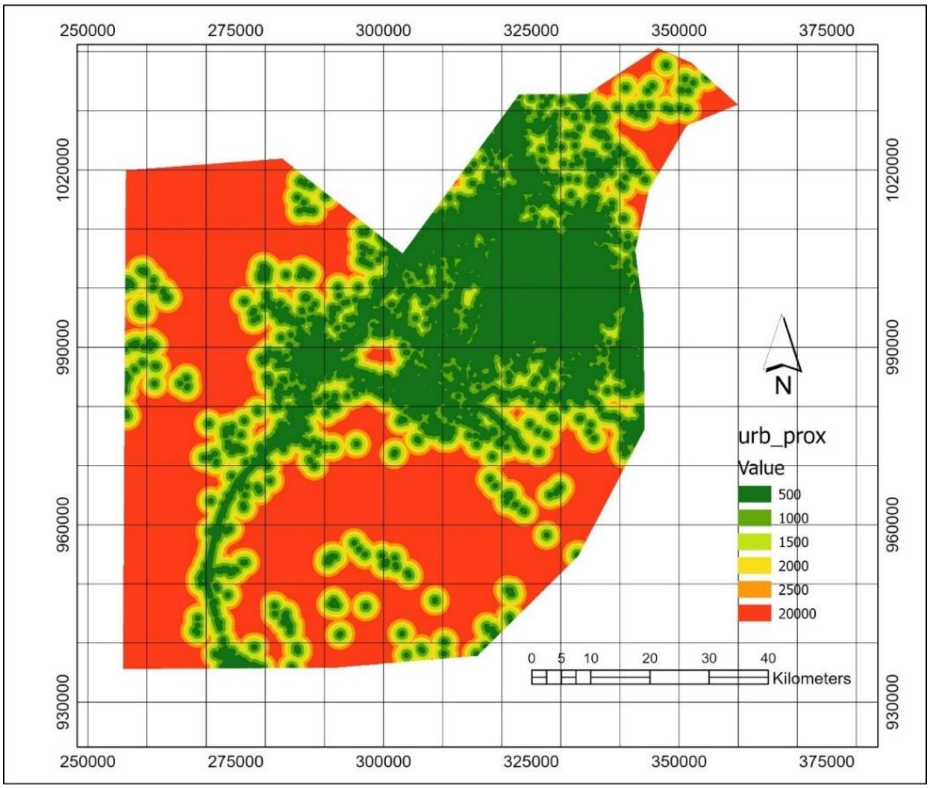

Fig. 8. Urban area proximity

Every dataset used in this study was reclassified into one of three categories: high potential areas, moderate potential areas, or low potential areas. It was necessary to reclassify the originally derived datasets because the values that were categorised into ranges were continuous and floating. This allowed each range of values to be assigned a single discrete integer value, such as 1, 2, 3, in accordance with the measurement scale. This is due to the requirement that discrete integer values be present in the weighted overlay's inputs. Fig.s 9–14 display the reclassified and standardised criteria.

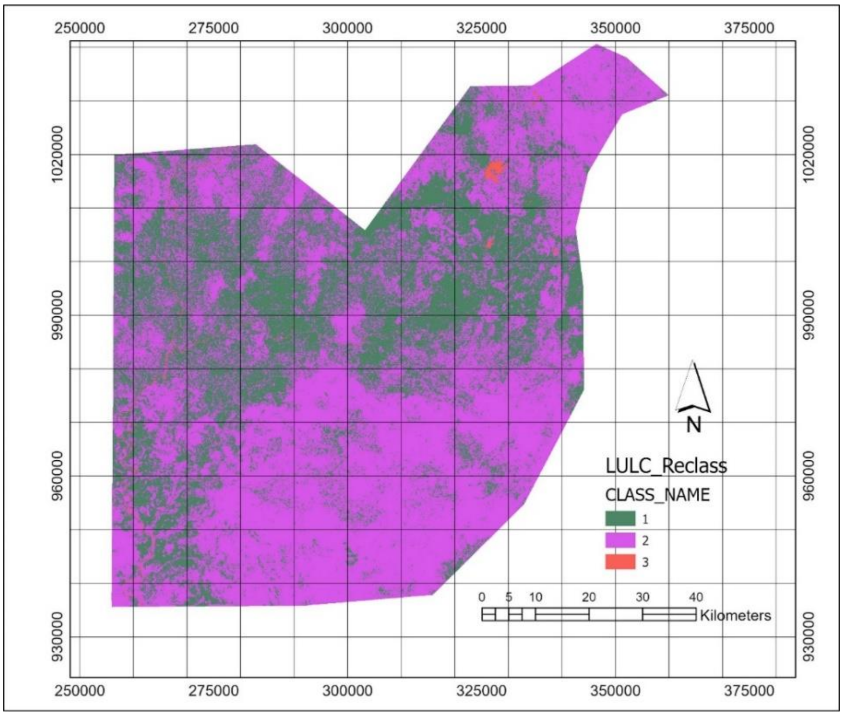

Fig. 9. Landcover/Landuse reclassification and standardization

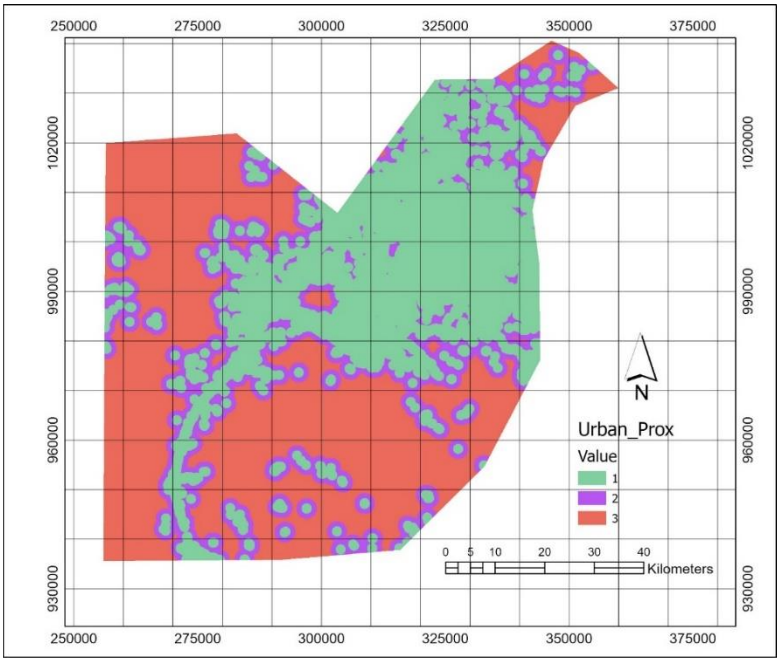

Fig. 10. Urban area proximity reclassification and standardization

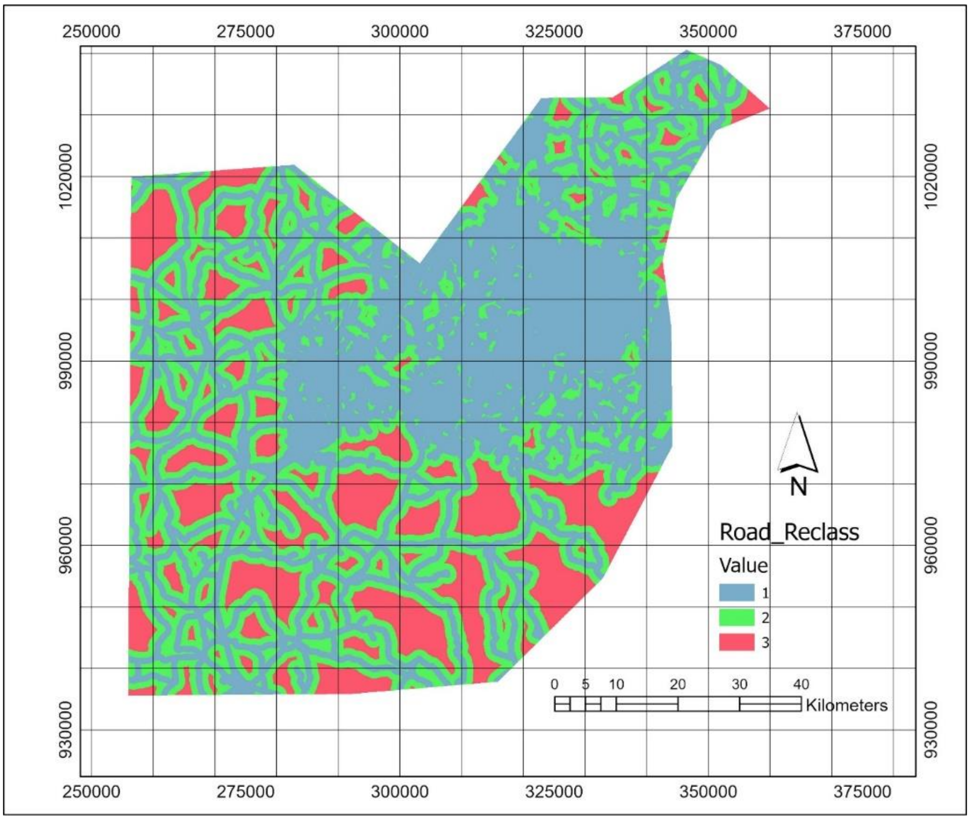

Fig. 11. Road proximity reclassification and standardization

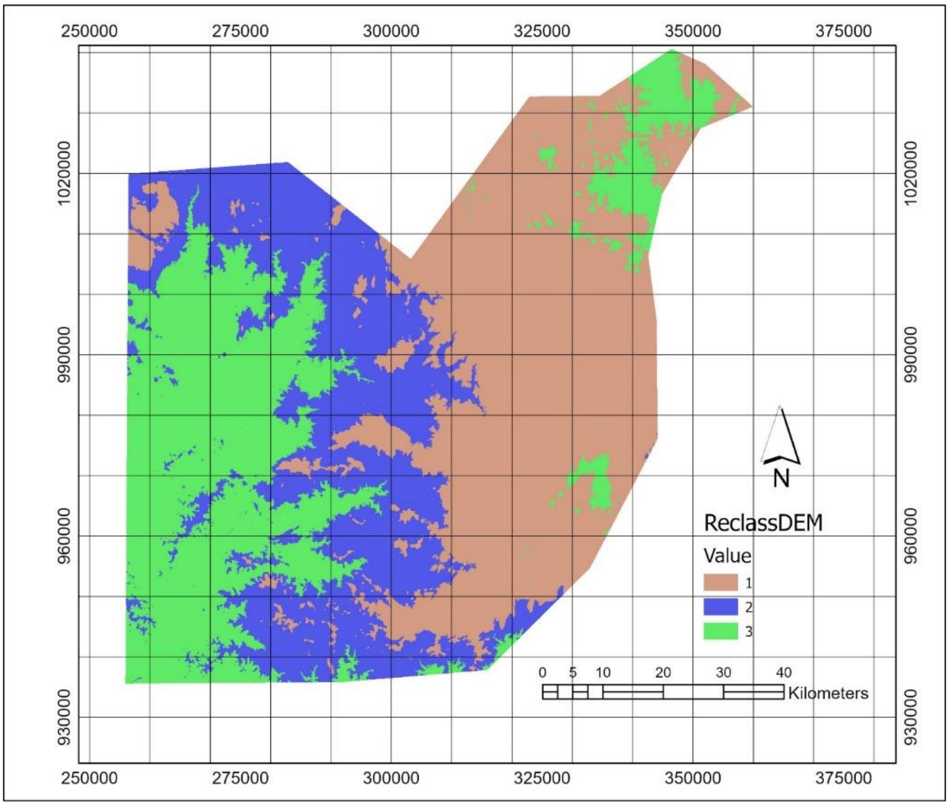

Fig. 12. Elevation reclassification and standardization

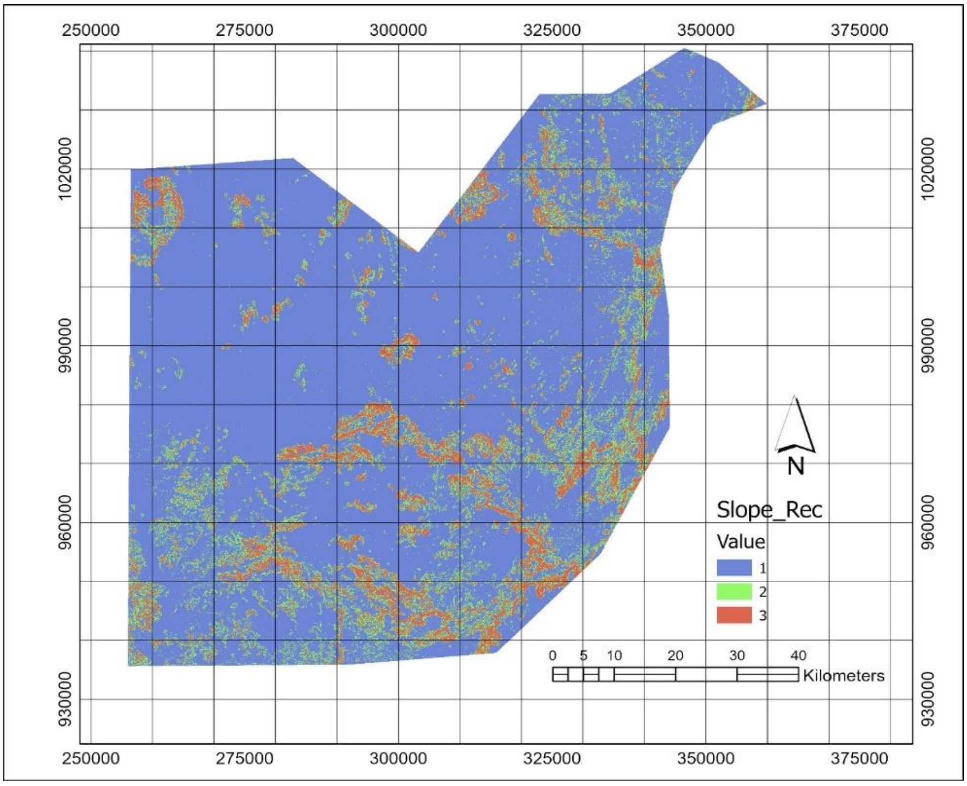

Fig. 13. Slope reclassification and standardization

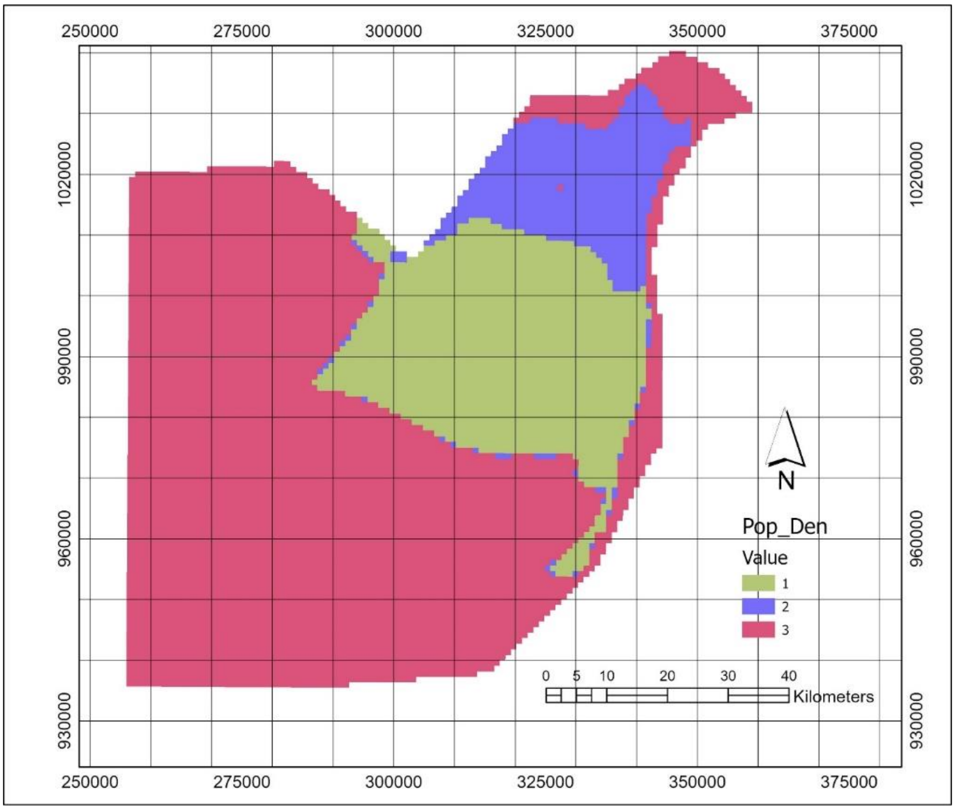

Fig. 14. Population density reclassification and standardization

3.3 Determination of Criteria Weight

By breaking down difficult decisions into a series of pairwise comparisons and then synthesising the findings, the analytical hierarchy process is a useful tool for handling complex decision-making. It can help the decision maker set priorities and make the best choices [7]. The Eigenvector method, a ratio matrix, is used by the AHP approach to compare one criterion with another. It also employs a numerical scale, as indicated in Table 5, with values ranging from 1 to 9. 1 denotes that the two factors are equally important, and 9 denotes that one factor is clearly more important than the other. Reciprocals of the 1 to 9 values (1/1 to 1/9) indicate whether a factor is more or less important [7].

Table 5. Pairwise comparison relative importance source: [7]

Judgment value	Description
1	Equal importance
3	Moderate importance
5	Strong Importance
7	Very strong importance
9	Absolute importance
2,4,6,8	Intermediatory Values

3.4 Pairwise Comparism Matrix

Using the judgement value between factors as the matrix elements and adhering to Saaty's [7] fundamental guidelines, a pairwise comparison matrix was created. Table 6 was created using a pairwise comparism matrix in Table 5.

3.5 Calculation of Criterion Weights

The criteria weights were computed following the creation of the pair-wise comparison matrix. The process involved calculating the average of elements in each row of the normalised matrix, which is the result of dividing the sum of the normalised scores of each row by the number of criteria, and finding the sum of the values in each column of the pair-wise comparison matrix. The resulting matrix is called the normalised pair-wise comparison matrix.

3.6 Normalized Pairwise Comparison Matrix

The resulting normalised pairwise comparison matrix is displayed in Table 7. The normalised F1, F1 = (1/2.92) = 0.34 is displayed in Table 7 as a result of, for instance, obtaining the element of the normalised matrix of Landcover/Landuse (row) against Landcover/Landuse column, or the matrix element in 1, 1, where 2.92 and 1 from the pairwise comparison matrix is the sum of the element of the first column and the judgement value of Landcover/Landuse (row) against Landcover/Landuse (column).

3.7 Prioritization Weight Matrix

The weight matrix prioritised is displayed in Table 8. The normalised sum of each row is divided by the total number of criteria in order to calculate the element of this matrix. An estimate of the relative weights of the criteria under comparison is given by the obtained averages. For more information, see Table 8.

Table 6. Pair-wise comparison matrix

	Land Cover/ Land Use	Proximity to developed Areas	Proximity to Road Network	Elevatio n	Slop e	Populatio n Density
Land Cover/ Land Use	1	2	2	3	3	4
Proximity to developed Areas	0.5	1	2	3	3	4
Proximity to Road Network	0.5	0.5	1	2	3	3
Elevation	0.33	0.33	0.5	1	2	3
Slope	0.33	0.33	0.33	0.5	1	2
Population Density	0.25	0.25	0.33	0.33	0.5	1
Total	2.92	4.42	6.17	9.83	12.5	17

Table 7. Normalized pairwise comparison matrix

	Land Cover/ Land Use	Proximity to developed Areas	Proximity to Road Network	Elevation	Slope	Population Density	Mean
Land Cover/ Land Use	0.34	0.45	0.32	0.31	0.24	0.24	0.32
Proximity to developed Areas	0.17	0.23	0.32	0.31	0.24	0.24	0.25
Proximity to Road Network	0.17	0.11	0.16	0.20	0.24	0.18	0.18
Elevation	0.11	0.08	0.08	0.10	0.16	0.18	0.12
Slope	0.11	0.08	0.05	0.05	0.08	0.12	0.08
Population Density	0.09	0.06	0.05	0.03	0.04	0.06	0.05

Table 8. Prioritization weight matrix

	Land Cover/ Land Use	Proximity to developed Areas	Proximity to Road Network	Elevation	Slope	Population Density	Mean	W%	row total of normalized matrix
Land Cover/ Land Use	0.34	0.45	0.32	0.31	0.24	0.24	0.32	31.66	1.90
Proximity to developed Areas	0.17	0.23	0.32	0.31	0.24	0.24	0.25	25.04	1.50
Proximity to Road Network	0.17	0.11	0.16	0.20	0.24	0.18	0.18	17.77	1.07
Elevation	0.11	0.08	0.08	0.10	0.16	0.18	0.12	11.81	0.71
Slope	0.11	0.08	0.05	0.05	0.08	0.12	0.08	8.20	0.49
Population Density	0.09	0.06	0.05	0.03	0.04	0.06	0.05	5.48	0.33
Total	1	1	1	1	1	1	1	100	6

3.8 Calculation of the Consistency Ratio

In order to assess the reliability of the judgement values, which are related to sizable samples of completely random judgements, this step involved computing a consistency ratio (CR) [7]. The analytical hierarchy process compares it using the random index (R.I.) to determine the consistency ratio [7]. The following is a mathematical definition of consistency ratio (C.R.):

$$CR = \frac{CI}{RI} \quad (1)$$

Where CI = Consistency Index

RI = Random index (RI) (Table 9).

In order to evaluate the consistency of judgement in AHP and ascertain whether pairwise comparisons are consistent enough to be dependable, the Random Index (RI), a constant that represents the average consistency index of a randomly generated matrix of a given size, is employed.

The Consistency Index (CI) was computed using the following formula:

$$CI = \frac{(\lambda\max - n)}{(n-1)} \quad (2)$$

Where λmax represents the Principal Eigen Value n represents the number of factors

The principal eigenvalue λmax was determined by summing the product of each of the values in the pairwise matrix and its corresponding relative weight.

$$\lambda max = (2.92\,x\,0.32) + (4.42\,x\,0.25) + (6.17\,x\,0.18) + (9.83\,x\,0.12) + (12.5\,x\,0.08) + (17\,x\,0.05)$$

$$= 0.93 + 1.10 + 1.11 + 1.17 + 1 + 0.85$$
$$\lambda max = 6.16$$

Using the calculated λmax:

$$CI = \frac{(6.16 - 6)}{(6 - 1)} = 0.032$$

The Consistency Ratio (CR) was then calculated as:

$$CR = \frac{0.032}{1.24} = 0.002$$

$$CR = 0.002 < 0.10\ (Acceptable)$$

Since CR = 0.002, which is less than 0.10, the consistency is considered acceptable.

3.9 Development Potential

To evaluate the development potential, the weighted sum of each criterion's weight and its corresponding standardized suitability score was calculated using the following equation3:

$$DP = \Sigma\ w_i x_i \quad (3)$$

Where;

DP represents Development Potential,

W*i* denotes the relative weight of each criterion

x*i* denotes the standardized score of each criterion

The development potential, considering the imposed constraints, was determined using the equation 4:

$$F = \left(\sum_{i=1}^{n} wi \times xi\right) \times \prod cj \quad (4)$$

Where F represents the development potential adjusted for constraints, and c_j denotes the constraints applied.

To make the result more understandable, it was reclassified into three index levels/categories: low, moderate, and high, from which high potential areas were extracted using natural breaks. To calculate the development potential, a model was created using the formula and weighted linear combination. The formula is: DP = (D1*0.32) + (D2*0.25) + (D3*0.18) + (D4*0.12) + (D5*0.08) + (D6*0.05). D1, D2, D3, D4, D5, and D6 are thematic layers that represent the factors; see Table 10. The results are shown in Figs. 16 and 17.

Table 9. Random index

Size of matrix (n)	1	2	3	4	5	6	7	8	9	10
Random index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49

Source: [7]

Table 10. Coding of factors

D1	Land Cover/ Land Use
D2	Proximity to developed Areas
D3	Proximity to Road Network
D4	Elevation
D5	Slope
D6	Population Density

Fig. 15. Urban development potential model

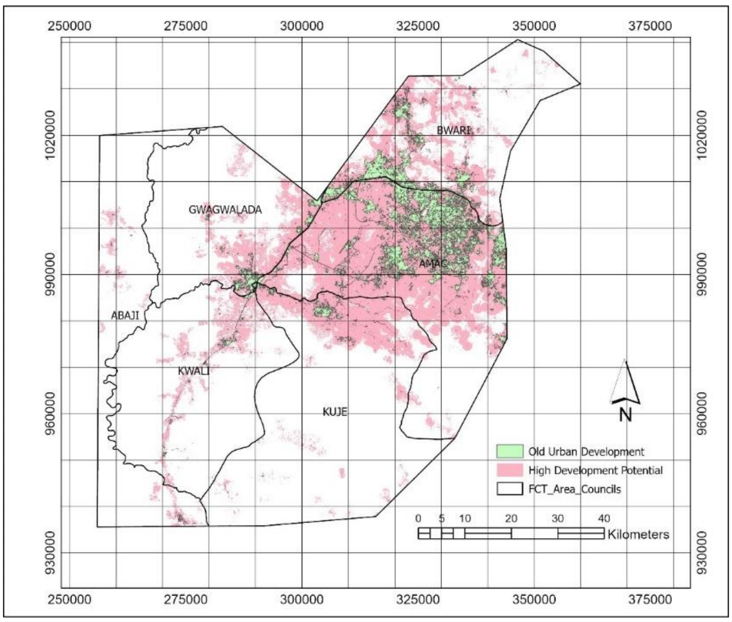

Fig. 16. High development potential map

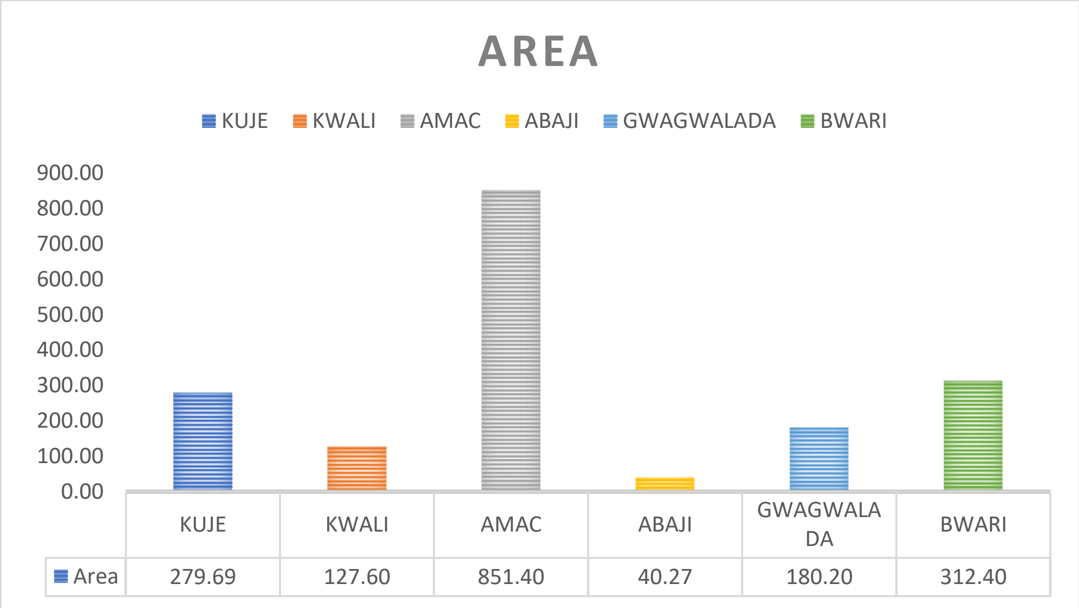

Fig. 17. High development potential map

From the results, the development potential analysis in the Federal Capital Territory (FCT), Nigeria, reveals insights into the spatial expansion capabilities of the study area. The Abuja Municipal Area, exhibiting the highest development potential with an area of 851.40 km², stands out due to its centrality as the nation's capital. This area's high development potential is driven by favorable topography, extensive public infrastructure, such as roads and urban centers, and substantial population growth over the past two decades. This indicates the necessity for focused urban planning to manage and sustain its rapid expansion.

The Bwari and Kuje Area Councils, with area coverages of 312.40 km² and 279.69 km² respectively, rank second and third in development potential. These areas benefit from their strategic proximity to Abuja and ongoing improvements in infrastructural frameworks, which make them prime targets for urban development.

Gwagwalada and Kwali Area Councils, with developable area coverages of 180.20 km² and 127.60 km² respectively, rank fourth and fifth. These emerging urban centers are characterized by growing infrastructure and enhanced accessibility, contributing to their development potential. Strategic planning in these areas should focus on bolstering infrastructure and ensuring that development is managed to prevent potential issues related to urban sprawl and congestion.

Abaji Area Council, ranked lowest with a developable area coverage of 40.27 km², presents unique challenges and opportunities. Despite its lower ranking, targeted investments in infrastructure and strategic development initiatives could spur growth in Abaji, demonstrating that even areas with initially low development potential can become significant urban centers with the right planning and investment.

The implications of these findings are profound. For urban planners and policymakers, the detailed mapping of development potential provides a data-driven foundation for strategic decision-making. Understanding which areas have the highest potential for development allows for efficient allocation of resources, ensuring that infrastructure investments and urban planning efforts are directed towards regions that will yield the greatest benefit. This approach can mitigate the risks of urban sprawl, reduce infrastructure strain, and promote sustainable urban growth.

For the scientific community, this study's methodological approach is particularly relevant. The combination of Geographic Information Systems (GIS) and the Analytical Hierarchy Process (AHP) in this research offers a robust framework for evaluating urban development potential. This integrative approach can be applied to other rapidly urbanizing regions, providing a valuable model for comparative studies and contributing to the broader body of knowledge on urban expansion and sustainable development.

Moreover, the value of this research extends to enhancing existing knowledge in several ways. First, it provides an understanding of the spatial distribution of development potential within the FCT, Nigeria, identifying key areas for targeted development. Second, it highlights the critical drivers of urban growth, such as suitable topography, infrastructure availability, and population dynamics, offering insights that can inform future urban development policies and strategies. Third, by presenting a replicable methodological framework, this study enables other researchers and urban planners to conduct similar assessments in different contexts, fostering a more comprehensive understanding of urban development dynamics globally.

4. SUMMARY AND CONCLUSIONS

This study effectively leveraged the Analytical Hierarchy Process (AHP) to evaluate urban development potential in the Federal Capital Territory (FCT), Nigeria. The comprehensive approach integrated diverse datasets, including land cover, slope, elevation, road proximity, urban proximity, and population density, into a coherent analytical framework. The reclassification and standardization processes ensured that disparate data types could be combined into a unified model, facilitating a robust evaluation of development potential across the region.

The AHP method proved instrumental in assigning weights to the various criteria, reflecting their relative importance in determining urban development suitability. The high consistency ratio (CR = 0.008), well below the acceptable threshold, attests to the reliability of the pairwise comparisons used in this study. The methodological rigor applied in this evaluation underscores the robustness of the resulting development potential map.

The spatial analysis revealed significant variations in development potential across different areas of the FCT. The Abuja Municipal Area emerged as the region with the highest development potential, suggesting a concentration of favorable conditions such as suitable topography, existing infrastructure, and dense population. Conversely, areas like Abaji were identified as having lower development potential, indicating less favorable conditions for urban expansion.

The findings of this study offer valuable insights into the spatial dynamics of urban development in the FCT. They highlight key factors driving urban growth, including the availability of infrastructure and population pressures, which are critical for effective urban planning and management. These insights can inform policymakers and urban planners in making data-driven decisions that align with the region's development goals.

Moreover, the methodological framework established here, combining AHP with geospatial data analysis, provides a replicable model for evaluating urban development potential in other regions. By integrating objective data and subjective judgments, this approach ensures a balanced and comprehensive assessment, supporting sustainable urban development strategies.

Finally, this study not only maps the current urban development potential in the FCT but also provides a strategic tool for guiding future urban planning efforts. The identified high-potential areas should be prioritized for infrastructure development and investment, while the lower-potential areas may require targeted interventions to enhance their suitability for urban expansion. This balanced and informed approach can contribute significantly to the sustainable growth and development of the FCT and similar urban environments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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