# Site Suitability Analysis for Housing Development in Osogbo Local Government Area, Osun State Nigeria

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**Abstract: Due to the influx of people and the increase in the population in urban centers, the demand for residential houses has become a major concern for town planners today. With the high increase in urbanization as a result of the increase in the population, residential houses are becoming more difficult to find. Planners aim at developing new ideas to solve the problem of the high increase in the demand for residential buildings. In recent times, different approaches to analysis have been introduced that will help planners select the most suitable locations for building residential houses. This study aims to analyze suitable sites for future housing development in Osogbo Local Government Area of Osun State. A combination of nearest neighbour analysis, Chi-square, geographical information system, and analytical hierarchical process techniques (AHP) were used in the present study. A total of nine thematic layers, such as land use/land cover, elevation, slope, aspect, population density, proximity to road networks, proximity to tourist centres, and geology, were prepared and studied for site suitability analysis. The weights assigned to each class in all the thematic maps are based on their characteristics and significance for selection of suitable sites through the AHP method. The site suitability map thus obtained was categorized into five classes-not suitable, less suitable, slightly suitable, more suitable and most suitable. The study reveals that the southern, eastern, and a part of the western sides of the study area are suitable for building residential houses.**

***Keywords:*** *Geographic Information System; Remote Sensing; Suitability Analysis*.

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## I. INTRODUCTION

➢ *Background of the study*

Urbanization can be described as the population shift from rural to urban areas or centers. It is the response to the decrease in the proportion of people living in rural areas, and the ways in which societies adapt to this change. It can also be defined as an increase in the general population of any urban area, and it is one of the changes happening in the world today (Cheng *et al*. 2007). Urbanization plays a very vital role in any city in relation to the environment, economy, and social ways of life (O ’Meara, 1999). One of the major causes of urbanization is the movement of people from rural areas to urban centers in search of white-collar jobs and a modern way of living as a result of the increase in industrialization.

Housing is one of the basic needs of man, which is usually provided by private or public enterprise. State governments have tried to provide for their citizens by building housing estates. In recent years, sustainability has increasingly become a priority for building projects. Sustainable construction begins with suitable/safe site selection. With the high increase in rural-urban migration plus immigration, pressure on residential demand has drastically increased. So, as urbanization tends to increase, more houses are being constructed, thereby increasing the quest for sites for engineering construction (Dai *et al.,* 2001).

The purpose of site selection is to determine the best possible site for a building within a specific region (Ghobarah, 1987). Site selection significantly influences the success or failure of a project. Furthermore, planners/decision makers are often faced with the challenge of dealing with decisions in planning a city and selecting the best suitable locations to build houses (Witlox. 2005). Therefore, in planning a city, a proper and comprehensive plan is the key to the development of the city.

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Geoinformatics technology is a management support tool that enhances geographical analysis and effective spatial data management. It has become open to value-added applications in many other disciplines using spatially referenced data (Konecny, 2002). Kufoniyi (1998) described geoinformatics as a body of knowledge that deals with the acquisition, processing, and management of geoinformation.

A Geographic information system (GIS) is the collection, processing, storage, management, and analysis of spatial data. It is divided into the GIS platform software, GIS and engineering applications, and GIS industry development services. GIS permits geographically referenced information to be stored, edited, manipulated, and analyzed to generate interpretative maps relevant for decision making. With this technology, a range of possible scenarios can be explored in the management of spatial data within an estate. The primary objective of the study is to demonstrate the effectiveness of GIS as a functional decision support system in the management of real estate.

Geographic Information System (GIS) and remote sensing (RS) technology have been very useful in monitoring different problems that occur in the development of a city, thereby guiding planners to make rightful and accurate decisions in the development of a city. It is a database management system which is used in calculating, monitoring, modeling, and predicting urban growth in cities around the world (Sudhira *et al*., 2004).

➢ *Study Area*

The study area is Osogbo local government area, Osun state (Figure 1). The study area is located between latitude 7º46’N and 7.767ºN and longitude 4º34’E and 4.567º E . Osogbo, which has a population of 715, 306, has become a major urban, commercial, and industrial center since the colonial period. This started in 1907 when the British Cotton Growing Association set up an industry for growing and ginning cotton. In this same year, the Nigerian Tobacco Company (NTC) built its first factory in Osogbo. The above was a major turning point for the city, which helped trigger its industrial and commercial development. Later, railway tracks were constructed linking it to other parts of Northern Nigeria. This attracted people from far and near. Osogbo shares boundaries with Ikirun, Ilesha, Ede, Egbedore and Iragbiji and is easily accessible from any part of the state because of its central location. It is about 48km from Ife, 32km from Ilesa, 46km from Iwo, 48km from Ikire and 46km from Ila-Orangun (https://www.osun.gov.ng). The arrival of the railway in 1970 transformed Osogbo into a commercial town, which brought the colonial government to the threshold of the town. Settlers and immigrants were attracted to Osogbo as a result of industrial and commercial development. Some of the commercial and industrial establishments which are widely spread across the study area include: a lead pencil manufacturing factory, sawmills, motor vehicle garages, Osogbo steel rolling company, wire and nails industry, plastic pipe factory, agro-alliedindustry, and hotels and garment industries, among others. This has now given birth to housing demand due to an influx of people to the town.

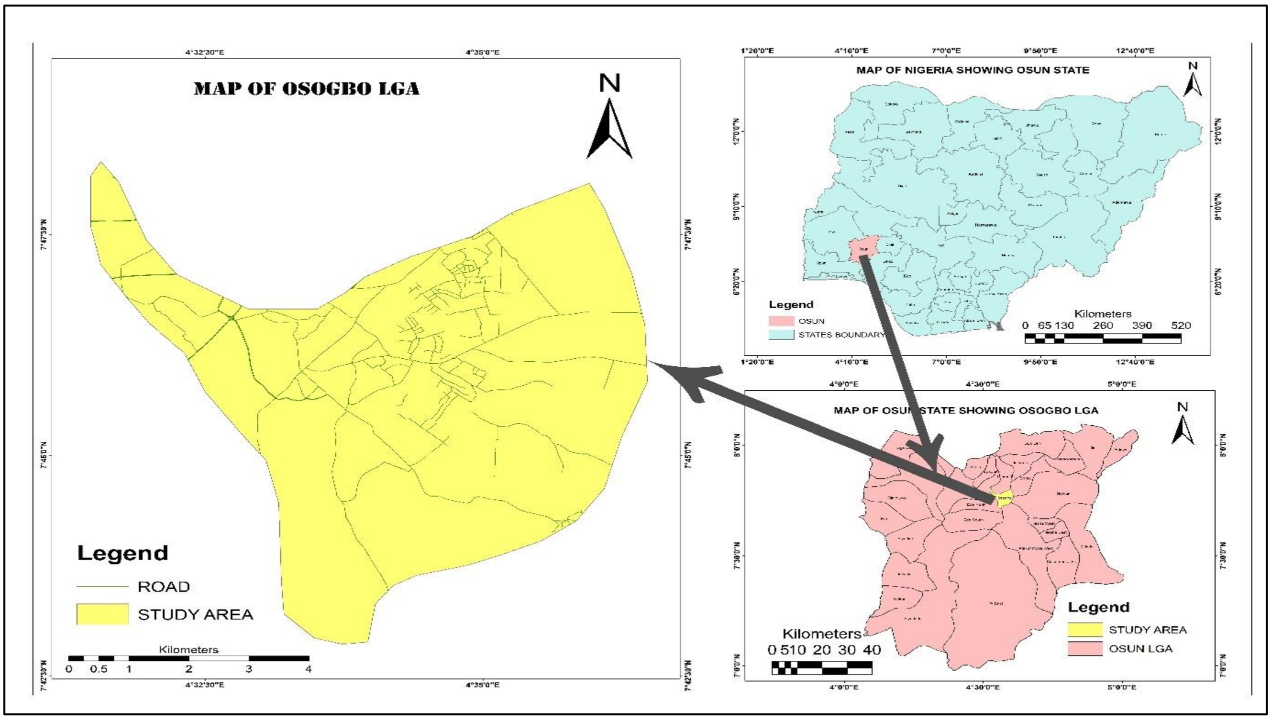


Fig 1 Map Showing the Study Area
Source: Author’s GIS Analysis

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➢ *Statement of the Problem*

Due to the population growth in urban areas, land use and management have frequently been altered along the urban borders (Sudhira *et al*., 2004). Problems such as land use management, population density, housing density, and movement patterns have been major concerns for both planners and urban developers. Therefore, planners have tried to find different ways to provide housing facilities to combat the rapid increase in urbanization, while still considering different features that affect land use and the environment in order to provide sustainable living. Hence, this research tends to look at the various factors that affect critical decision making.

➢ *Aim and Objectives*

The aim of the study is to analyze suitable sites for future housing development in Osogbo local government area.

The specific objectives are to:

- Assess the spatial distribution of the pre-existing buildings.
- Identify various factors critical for suitable site selection.
- Produce a building site suitability map.

## II. MATERIALS AND METHODS

### *A. Data and Software*

Both primary and secondary data were used in this research.

➢ *The various data used are:*

An aerial photograph of the study area which was obtained from Google Earth by using Universal Map Download (UMD). The aerial photograph has a resolution of 0.25 m and was produced in 2020.

- Shuttle Radar Topography Mission (SRTM) of the study area
- Satellite Imagery-Landsat 8 Operational Land Imager (OLI)
- Soil map of Nigeria
- Geological map of Nigeria
- Population data

➢ *The software that was used in the processing of the available data are:*

- ARCGIS 10.41
- ERDAS Imagine 2014
- Universal Map Downloader (UMD 9.977)
- Chi-Square Calculator
- Analytical Hierarchy Process (AHP)

### *B. Methods*

The available raw data was processed using different methods to generate the nine factors that were considered in the selection of a suitable building sites for the study area by the application of multi-criteria decision-making analysis. The methodology flowchart for the study is shown in Figure 2.

➢ *Georeferencing*

Georeferencing can be seen as an umbrella term for techniques which are concerned with the unique identification of geographical objects. The term ‘geographical object', in a broader view, refers to any kind of object or structure which can reasonably be related to a geographical location, such as points of interest (POIs), roads, places, bridges, buildings, or agricultural areas.

Sommer and Wade (2006) define georeferencing as' aligning geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data’. Coarser views include the domain of georeferencing multimedia (Zheng *et al*., 2011) and the exploration of means for the identification of geographical objects in general. Part of the techniques involved in the processing of the acquired aerial photograph used for this study is to georeferenced it so that it is spatially located in the ArcMap environment as it is in reality. In order to georeferenced raster images, they are connected to digital maps via so-called ground control points (GCPs) (De Leeuw *et al*., 1988). GCPs are landmarks located in well-known positions which are chosen so that they can easily be identified in satellite or aerial imagery, such as road crossings or artificial targets. Since orthorectified images are of uniform scale, it is sufficient to correlate several (at least three) GCPs to sets of pixels within an image which have been classified accordingly. Using the geo-referencing tool in ArcGIS, the aerial photograph can be geo-referenced to the right coordinate system. To yield a better result, all data used for this project must carry the same projections and coordinate system. The three ground-control points used in geo-referencing the aerial photograph were obtained from the study area, representing the same location on Google earth with the right coordinate system.

➢ *Generation of Thematic maps*

The aerial photograph of the study area was georeferenced and the locations of some buildings and facilities were digitized. The Nigeria SRTM file was downloaded from the United State Geological survey website (www.glovis.usgs.gov/). The SRTM of the study area (Osogbo LGA) was extracted from the general SRTM image

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of Nigeria with the use of an Arcmap tool called extraction by mask. The elevation map of the study area was then generated from the extracted SRTM by using Arcmap.

The SRTM data was used to generate the elevation model of the study area. The elevation model was in turn used to produce the slope and aspect map of the area. The soil map of the study area was extracted from the general soil map of Nigeria. The soil map contains the different types of soil found within Osogbo local government. In addition, the land use land cover of Osogbo local government for the year 2021 (May 2021) was generated with the use of ERDAS IMAGINE 2014.

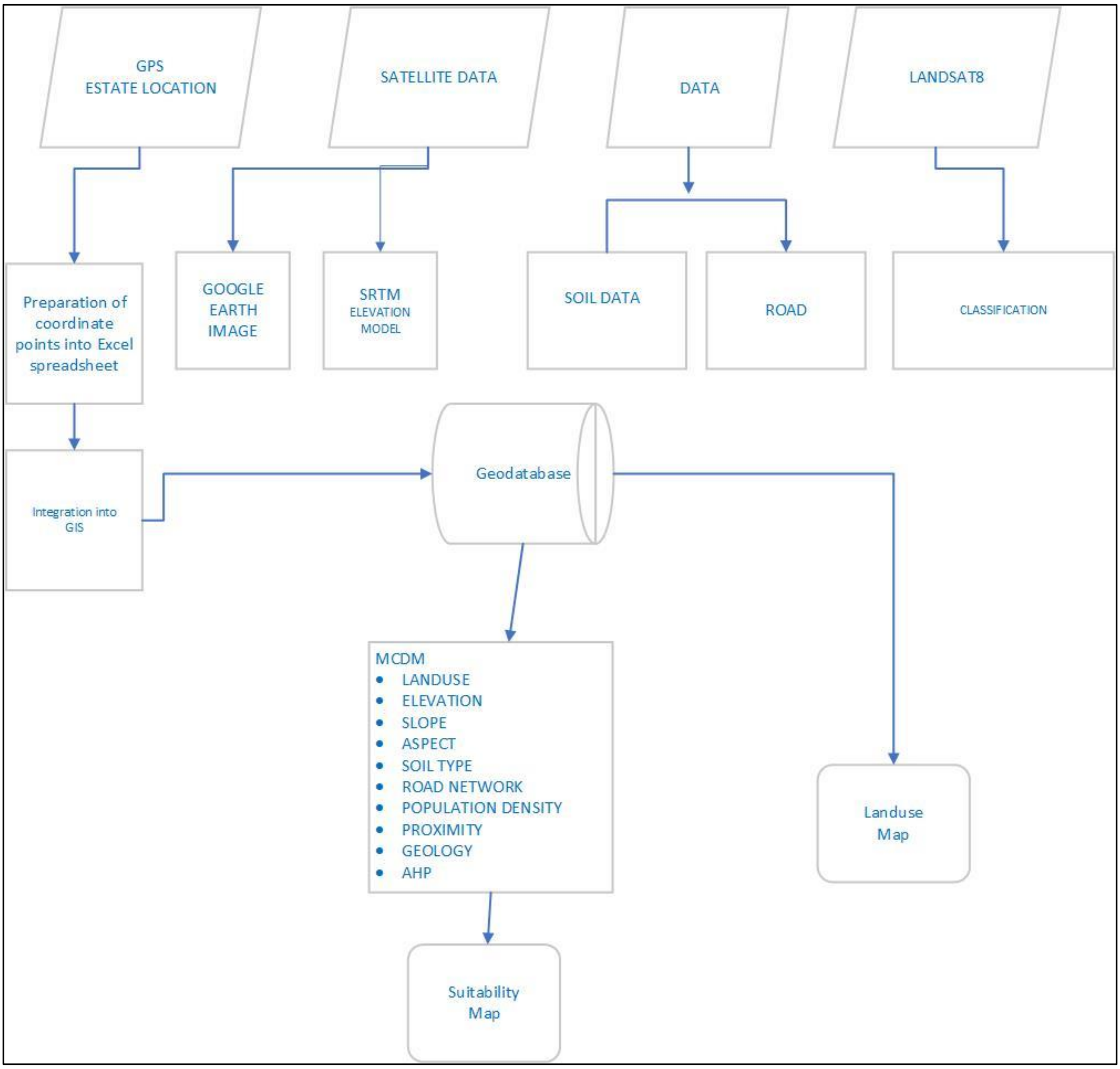


Fig 2 The Methodology Flow Chat Adopted for This Research

- *Land Use/Land Cover*

Land use and land cover change have become a central component in current strategies for managing natural resources and monitoring environmental changes. Land cover refers to the physical characteristics of the Earth's surface, captured in the distribution of vegetation, water, soil, and other physical features. Land use refers to the way in which land has been used by humans and their habitats (Chaudhary *et al.*, 2008). Land use/land cover is arrived at through a process called image classification.

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The data (Landsat) needed for the image classification of this study was downloaded from the United State Geological survey website (www.glovis.usgs.gov/). The Landsat imagery was downloaded using the Path (190) and Row (055) of the study area. The data was first subjected to a series of image pre-processing to remove the cloud and to make it more visible by enhancing it. The imagery was later classified by using software called ERDAS IMAGINE (2014), by passing through a series of processes which involved:

- *Layer Stacking*

This is a process for combining multiple images/bands into a single image. The Landsat imagery used for this study is Landsat 8, with a band combination of 5,4 and 3. The band combination was done in order to produce a single with a much-improved quality.

- *Subset/Clip*

This is the process of extracting the area of interest (AOI). This was done by using the boundary of the study as the AOI for the extraction process.

- *Supervised Classification*

After the combination of bands and extraction of the area of interest, the signature editor was picked for the classification of the imagery into different land uses. Representative samples for each land use/land cover classes were selected; the software then uses these "training sites" and applies them to the entire image. The image is classified using spectral signatures (reflectance values) obtained from training samples (polygons that represent distinct sample areas of the different land cover types to be classified).

The different land use classes identified for the purpose of this study are:

- ✓ Settlement
- ✓ Cultivation
- ✓ Vegetation
- ✓ Water body
- ✓ Bare surface

Each class was represented by different colours; settlement with red, cultivation with yellow, vegetation with green, water body with blue and bare surface with gray. In supervised classification, you select.

### *C. Analytical Hierarchical Process (AHP)*

The multi-criterial decision making (MCDM) analysis that was employed in this study is called the Analytical Hierarchical Process **(**AHP). The hierarchical decision model is the design phase of AHP in which the top level exhibits the overall goal of the decision. Indicators can be criteria at the upper level of the model and each of them is further broken down into sub-criteria. Each pair of criteria or sub-criteria element is compared in terms of its relative importance using a 9-points system from 1 (if two indicators equally contribute to the objective) to 9 (when one indicator is strongly favoured over another to meet the objective) (Table 3.1). A score of 1 denotes equal importance, a score of 3 refers to weak preference, while scores of 5 and 7 represent obvious and strong preference. The even numbers (2, 4, 6, and 8) are used when a compromise is needed between the odd numbers.

The local priority (weight) for a criterion is computed from a pairwise comparison matrix by normalizing the points in the columns (dividing a cell value by the sum of a column) and averaging the normalized points in the row of the criterion. The consistency of the comparisons is evaluated by calculating a Consistency Ratio (CR). If the CR is equal to or less than 0.1, the comparisons are considered consistent, otherwise they would be revised. The CR is defined by the following equation: CR = Consistency Index/Random Index.

Table 1 Saaty's Scale

| Comparative Importance | Definition | Description |
|---|---|---|
| 1 | Equal importance | Two indicators equally influence the parent decision |
| 3 | Weak importance | One factor is moderately influential over the other |
| 5 | Essential or strong importance | One factor is strongly favoured over the other |
| 7 | Demonstrated importance | One decision factor has significant influence over another |
| 9 | Absolute importance | Evidence favouring one decision factor over the other is the highest order of affirmation |
| 2,4,6,8 | Intermediate | When compromise is needed, values between two adjacent judgments are used |
| Reciprocals | If Ai is the judgmental value when it is compared with j, then AJ has the reciprocal value when compared to AI | A reasonable assumption |

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## III. RESULTS AND DISCUSSION

### *A. Spatial distribution of Pre-existing Estates*

Figure 3 below shows the spatial distribution of the pre-existing estates in the study area. In the course of this study, the following estates were identified:

- Atiba Community
- Griffing House Osogbo
- Ibikunle Estate
- Ile Egunaje
- Lanre Estate
- Olorunsogo Community
- Oran Ayegbaju

Furthermore, figure 4 shows the spatial distribution pattern of the pre-existing buildings in the study area. The distribution pattern was determined using Average Nearest Neighbor Distance Analysis (NNA) in ArcGIS. This analysis revealed the distribution pattern in terms of clusters, random, and dispersed. If the nearest neighbor ratio (NNA) falls between 0.0 – 0.5, the distribution pattern is said to be clustered, hence, the distribution lark's wider coverage. If the ratio is between 0.6 – 1.0, the pattern is said to be randomly distributed without any significant pattern in terms of planning. If the ratio is greater than one, the distribution pattern is said to be scattered or dispersed spatially, hence, leading to wider coverage distribution.

From the NNA, it was observed that the location of preexisting buildings in the Oshogbo Local Government Area reflects a dispersed distribution pattern. The NNA value is 1.5895, which is in the range of a dispersed pattern, and the P-value is 0.0028, which clearly shows the significant level of dispersed distribution pattern.

Given the z-score of 2.9838, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance.

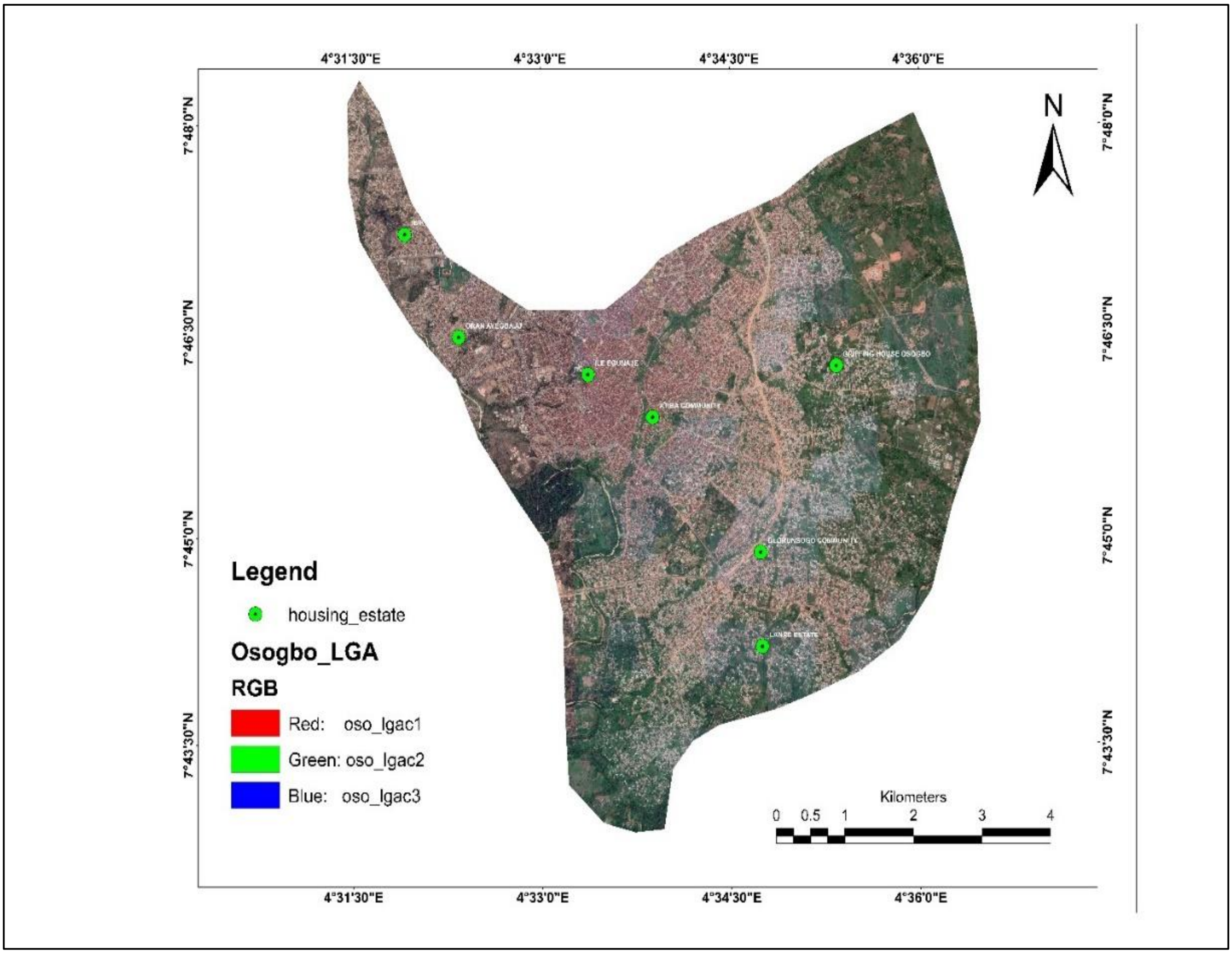


Fig 3 Map showing GPS Coordinate of Pre-Existing Estates in the Study Area

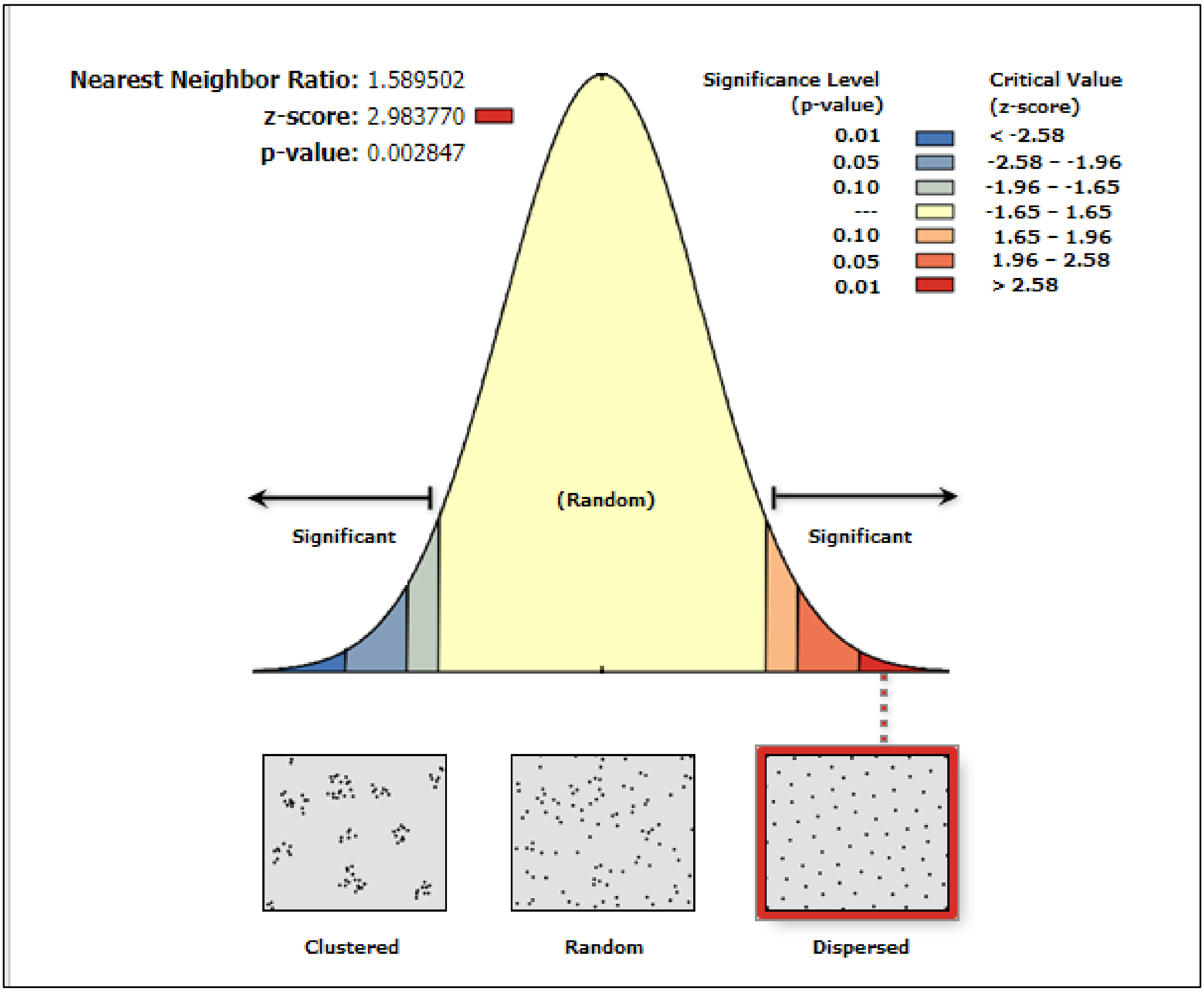


Fig 4 Nearest Neighbor Analysis of Pre-Existing Estates Considered in the Study Area.

### *B. Statistical Analysis*

The statistical analysis adopted in this study is the Chi-square. Twenty (20) questionnaires were administered majorly to professionals in the built environment, which includes city planners, estate surveyors and valuers, architects, builders, and land surveyors, in order to identify the factors influencing the selection of a suitable site for building construction. The factors were assessed on a scale of 1-9 by the respondents. Out of twenty questionnaires administered, nineteen were retrieved. The feedback from the experts' opinion is shown in Appendix 2, and were analyzed, and interpreted with the use of Chi-square (Table 2).

Table 2 Significance Level of Factors Considered

| S/N | Factors | Value | Significance Level |
|---|---|---|---|
| 1 | Land Use | 20.056[a] | 0.03 |
| 2 | Elevation | 14.037[a] | 0.033 |
| 3 | Slope | 34.978[a] | 0.045 |
| 4 | Aspect | 28.833[a] | 0.029 |
| 5 | Soil Type | 24.383[a] | 0.05 |
| 6 | Road Network | 12.825[a] | 0.01 |
| 7 | Population Density | 26.089[a] | 0.037 |
| 8 | Proximity To Tourist Centre | 17.873[a] | 0.12 |
| 9 | Geology | 19.589[a] | 0.041 |

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In general, we can deduce from the table that the professionals ranked the factors influencing site suitability in the study area in order of importance as land use and land cover, elevation, slope, aspect, soil type, proximity to road network, population density, proximity to tourists' area, and geology, with land use/land cover as the most important factor and geology as the least important factor.

This was supported by the result of the chi square test ($x^2$) where the p-value was less than 0.05 for land use/land cover, elevation, slope, aspect, population density, proximity to road network, proximity to tourist areas, geology while the p-value for soil type was equal to 0.05 respectively.

*C. Factors Influencing Site Suitability in the Study Area*

➢ *Land Use/Land Cover*

This is the most significant factor considered for the selection of a suitable site for the construction of an estate. The land use/land cover of the study area is ranked first with a calculated weight of 32.2%. The land use/land cover map, as shown in figure 4.3, represents the various land uses/land cover that occur in the study area. It shows the distribution of the five (5) different classes of land use/land cover, which include water bodies, cultivation, settlement, vegetation, and bare surface. The water body is denoted by blue colour, cultivation with yellow, settlement with red, vegetation with green and bare surface with bare surface. Table 3 shows the area occupied by the different land use/land cover classes. The land use/land cover were reclassified based on the weights assigned (Figure 6).

Table 3 Land Use Distribution

| **Land use** | **Area (HEC)** | **Area (%)** |
|---|---|---|
| Vegetation | 2777.49 | 59.30 |
| Settlement | 1672.11 | 35.70 |
| Bare surface | 116.37 | 2.48 |
| Water body | 80.55 | 1.72 |
| Cultivation | 37.8 | 0.80 |
| Total | 4684.32 | 100.00 |

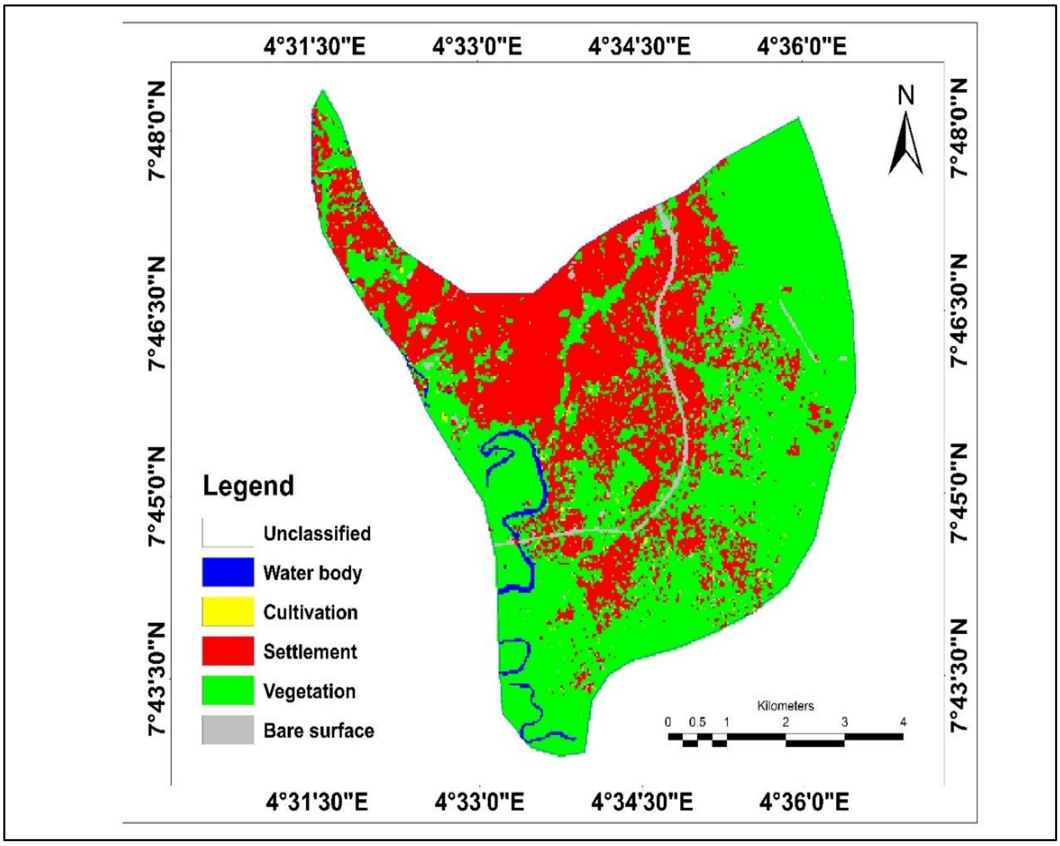

Fig 5 Land Use/Land Cover Map

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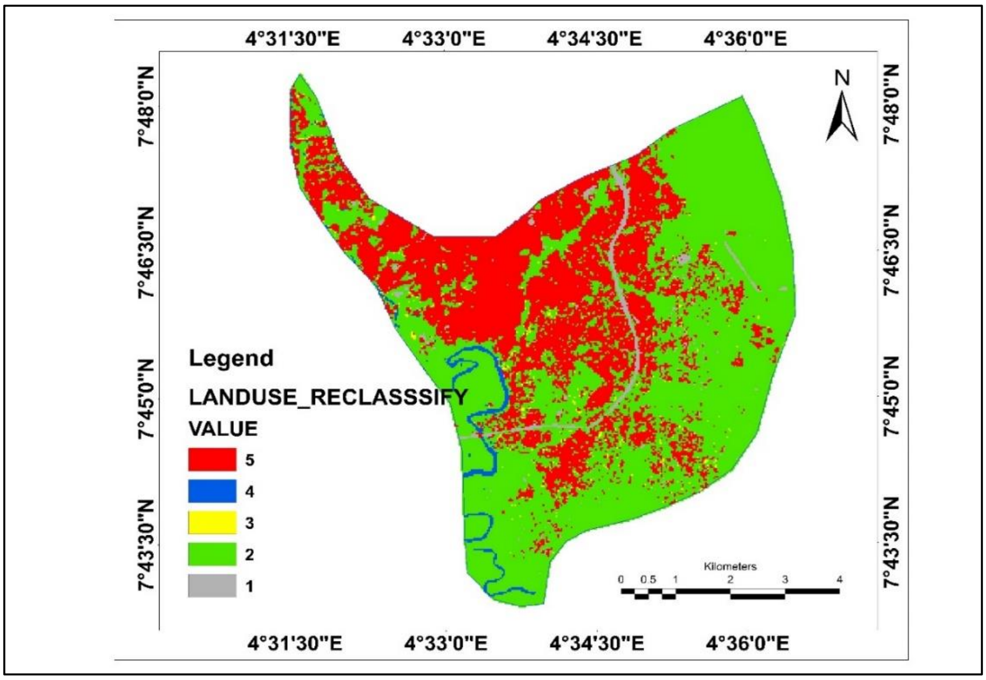


Fig 6 Reclassified Land Use/Land Cover Map

➢ *Elevation*

This is the second significant factor considered for the selection of a suitable site for the construction of an estate. The elevation of the study area is ranked 2nd with a calculated weight of 21.7%. Figure 6 below shows the elevation profile of Osogbo local government. The map shows the variation in height of the study area. The map is divided into five (5) different portions. The green portion of the map represents the flat area (not elevated) which ranges from 130m-167m. The light green portion of the map represents the areas that are less elevated, with heights ranging from 167m to 175m. The areas that are slightly elevated are represented by the yellow portion of the map with a height ranging from 175m-182m, while the more elevated area is represented by the light red portion of the map with a proportionate height of between 182m – 189m. The most elevated area, with heights ranging from 189m to 220m, is represented by the deep red portion of the map. The reclassified elevation map is shown in Figure 8.

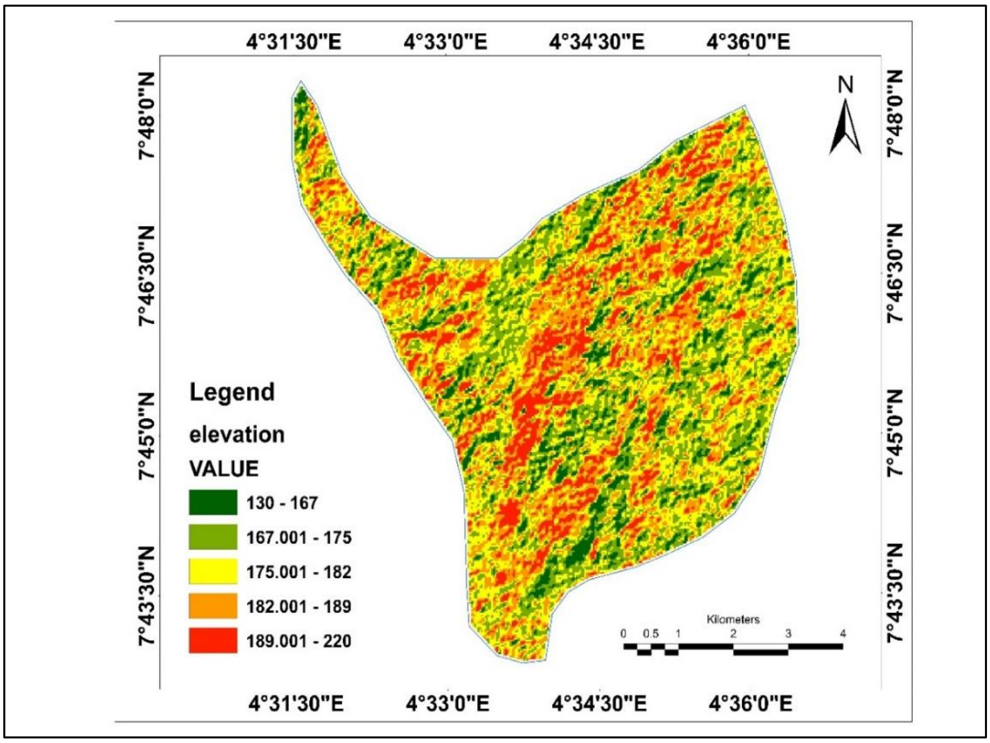


Fig 7 Elevation Map

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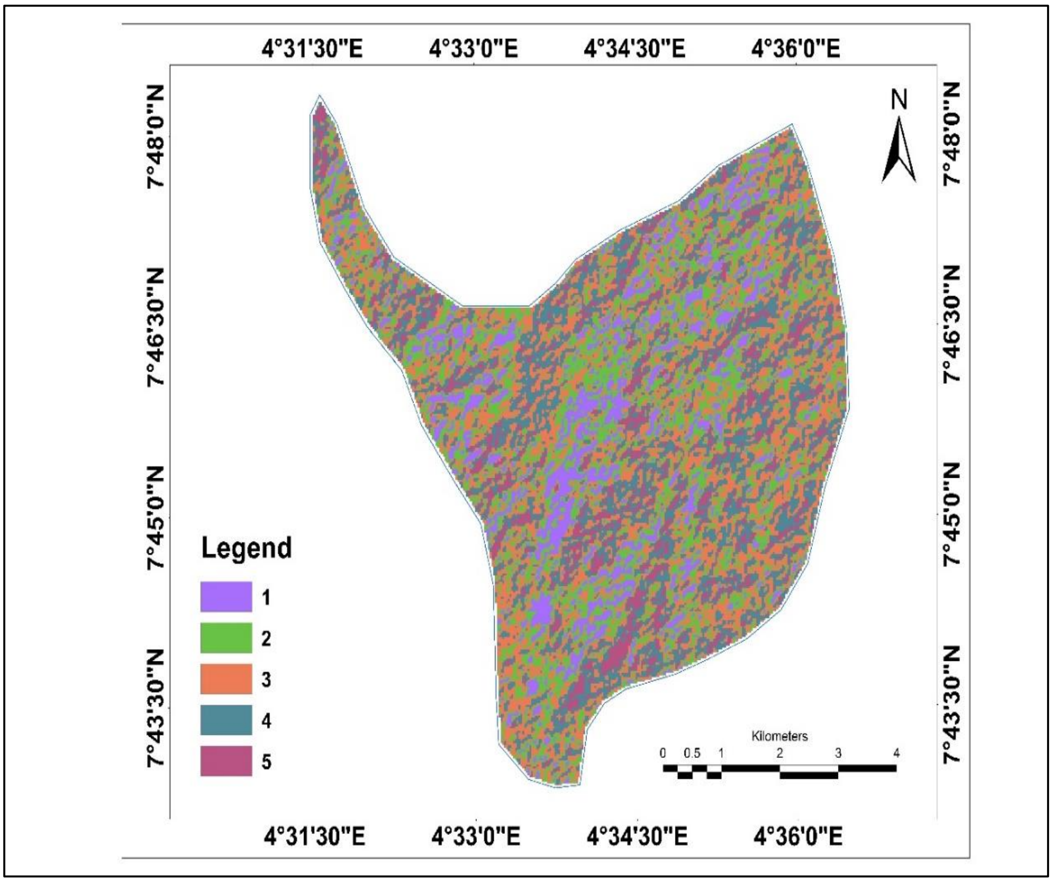


Fig 8 Reclassified Elevation Map

- *Slope Factor*

This is the third significant factor considered for the selection of a suitable site for the construction of an estate. The slope of the study area is ranked third with a calculated weight of 15.1%. The steepest downhill slope for a location on a surface. The slope is calculated for each triangle in TINs and for each cell in the raster. For a triangulated irregular network (TIN), this is the maximum rate of change in elevation across each triangle. For raster, it is the maximum rate of change in elevation over each cell and its eight neighbors.

The Slope command takes an input surface raster and calculates an output raster containing the slope at each cell. The lower the slope value, the flatter the terrain; the higher the slope value, the steeper the terrain. The output slope raster can be calculated as percent slope or degree of slope. For the purpose of this, the slope is calculated in percentage, with five different classes ranging from 0%-2.03%, 2.04%-3.44%, 3.45%-4.96%, 4.97%-7.33% and 7.34%-14.38% (Figure 9). The classes are further grouped into five suitability classes: most suitable, very suitable, highly suitable, slightly suitable and not suitable respectively. The slope was reclassified based on the contribution of each class to site suitability (Figure 10).

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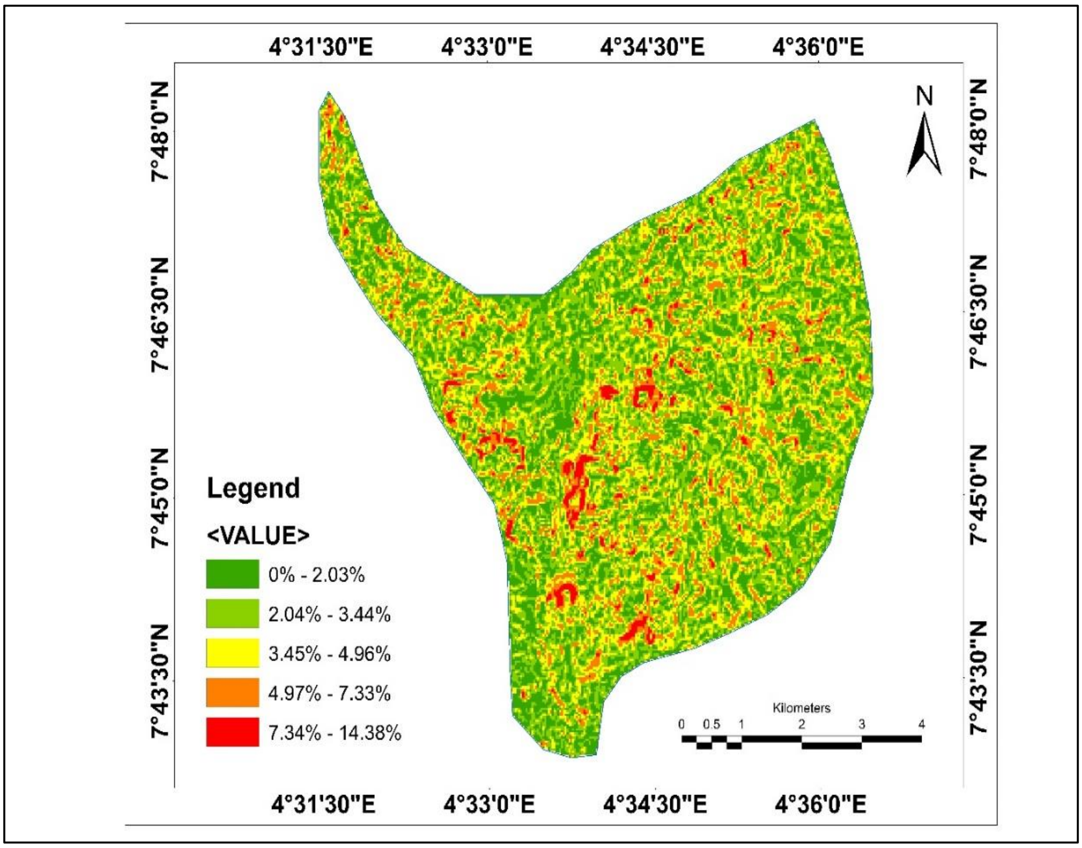


Fig 9 Slope Map

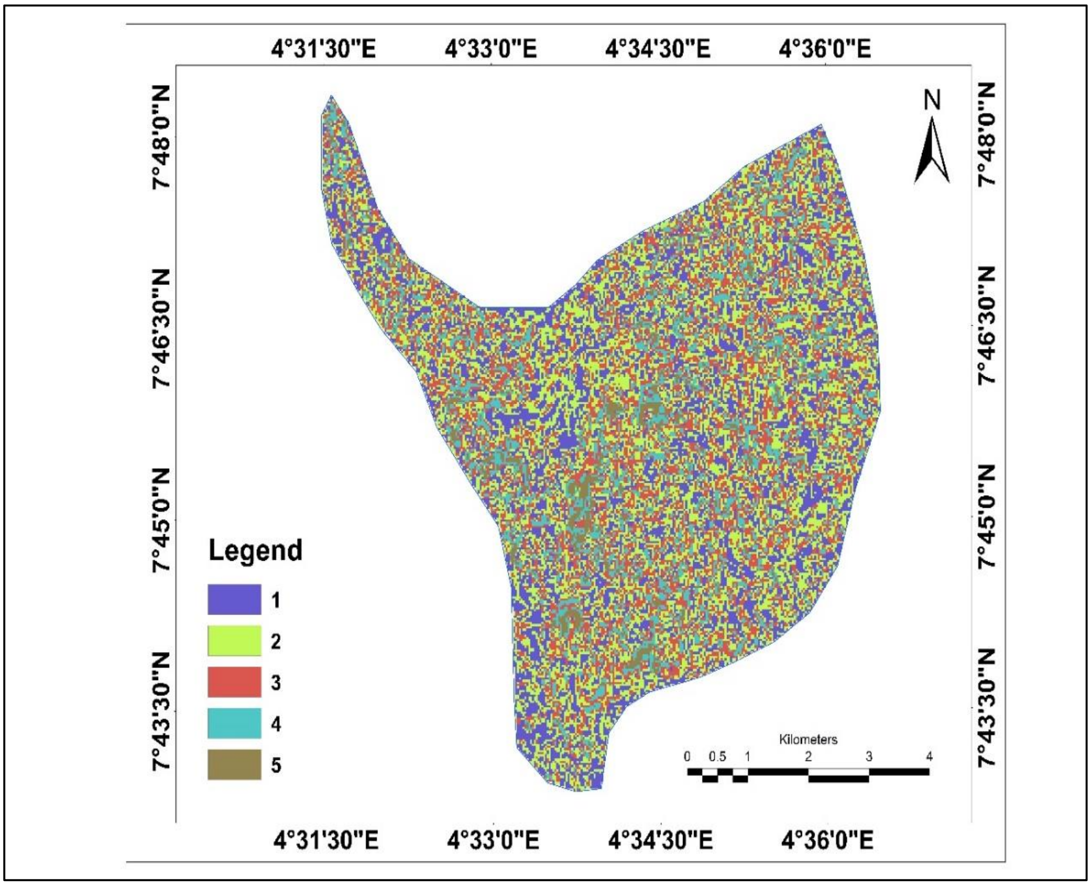


Fig 10 Reclassified Slope Map

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➢ *Aspect*

This is the fourth significant factor considered for the selection of a suitable site for the construction of an estate. The aspect of the study area is ranked fourth with a calculated weight of 11.6%. This is the compass direction that a topographic slope faces, usually measured in degrees from north. Aspects can be generated from continuous elevation surfaces. For example, the aspect recorded for a TIN face is the steepest downslope direction of the face, and the aspect of a cell in a raster is the steepest downslope direction of a plane defined by the cell and its eight surrounding neighbors (Esri Support GIS dictionary, 2017). Aspect is the slope direction on a terrain surface. The aspect is measured clockwise starting North as 0–360North again with flat areas given a value of-1 (or 0) (The Ultimate GIS Dictionary, 2017). Figure 11 shows the direction of the slope (aspect) in Osogbo local government. The grey portion of the map represents an area that is flat with an angle of-1 degree. The northern area of the map has an angle ranging from 0 – 22.5 degrees, the northeast 22.5-67.5 degrees, the east 67.5-112.5 degrees, the southeast 112.5 – 157.5 degrees, the south 157.5-202.5 degrees, the southwest 202.5-247.5 degrees, the west 247.5-292.5 degrees, the northwest 292.5 – 337.5 degrees, and the north 337.5 – 360 degrees. Figure 12 shows the reclassified aspect map.

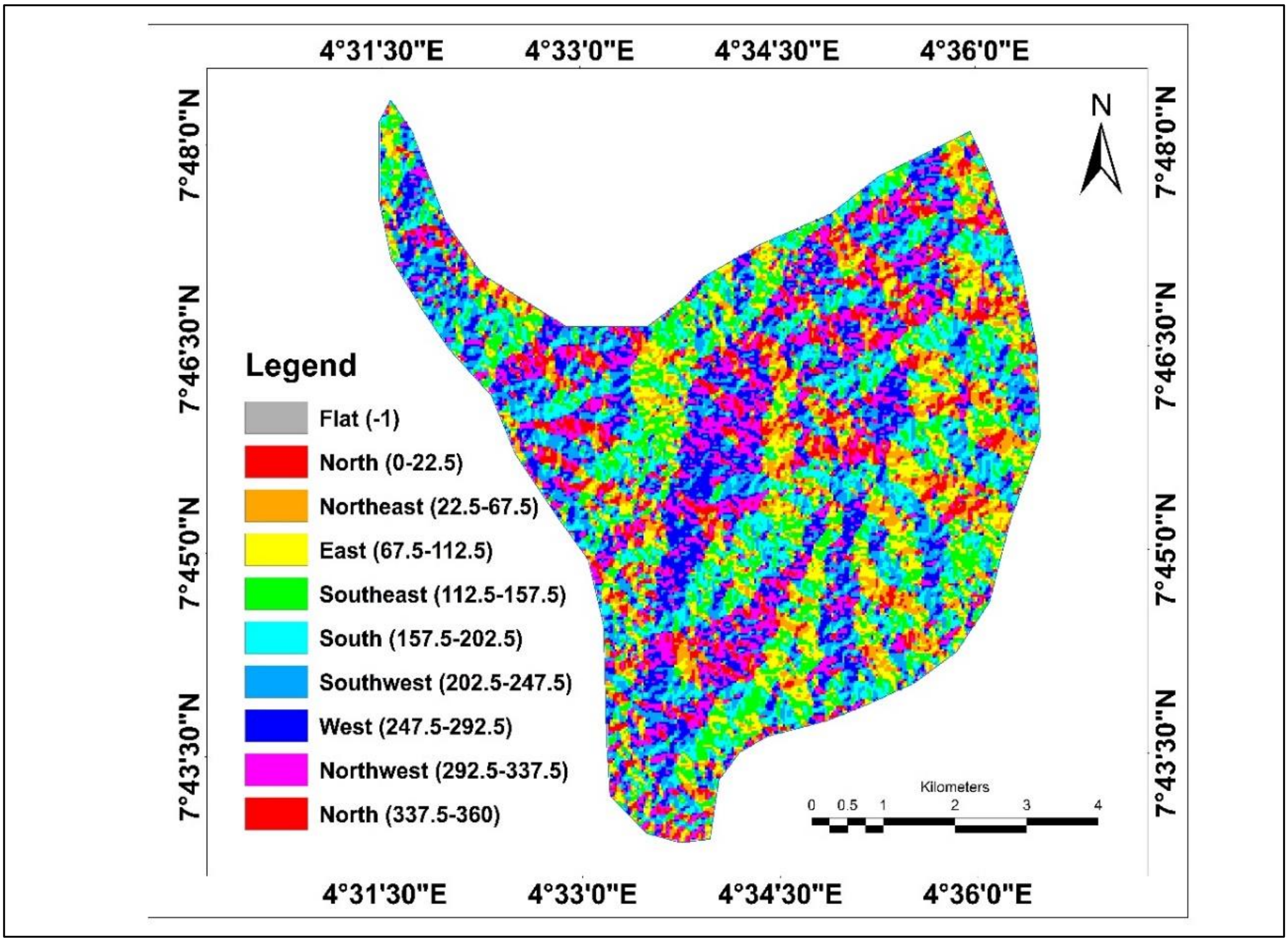


Fig 11 Aspect Map

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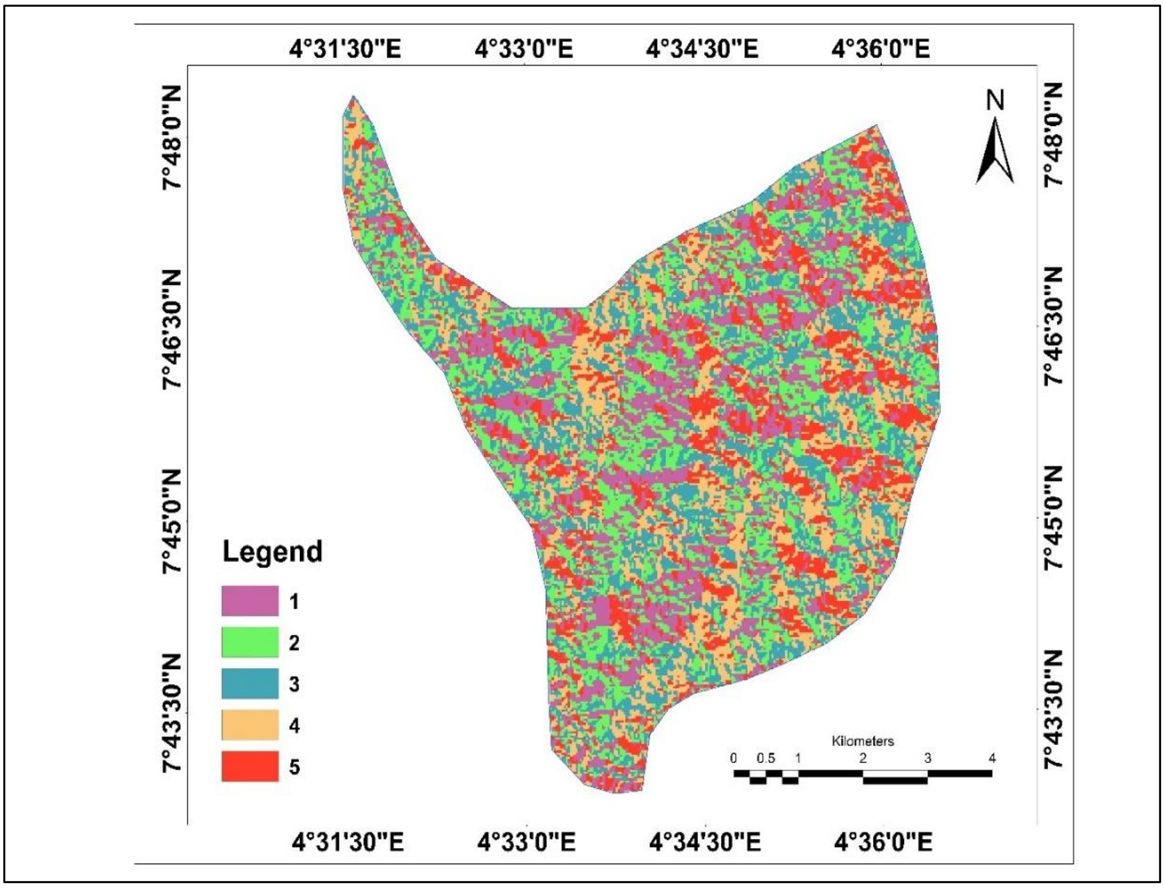


Fig 12 Reclassified Aspect Map

➢ *Soil Type*

This is the fifth significant factor considered for the selection of a suitable site for the construction of an estate. The soil type of the study area (Figure 13) is ranked fifth with a calculated weight of 7.2%. The dominant soil type in Osogbo local government is clay soil. Clay is a type of fine-grained natural soil material containing clay minerals. (Olive *et al* 1989). Clays develop plasticity when wet, due to a molecular film of water surrounding the clay particles, but become hard, brittle and non–plastic upon drying or firing (Guggenheim and Stephen, 1995).

Also, found in the study area is a soil type known as humus soil. The thick brown or black substance that remains after most of the organic litter has decomposed is called humus. Earthworms often help mix humus with minerals in the soil. Humus contains many useful nutrients for healthy soil. One of the most important is nitrogen. Nitrogen is a key nutrient for most plants. Agriculture depends on nitrogen and other nutrients found in humus.

Building foundations need to be on stable and strong soil. Soils range in strength. Some soils are able to support a skyscraper, while other soils are not able to support the weight of a human. If the soil under a building is not stable, the foundation of the building could crack, sink, or worse–the building could fall. The strength and stability of the soil depend on its physical properties. Soil with a good structure is more stable. Clay textures are often more stable than humus textures, which are mostly used for agricultural purposes, because they have better structure. The soil type was then reclassified based on their suitability for building construction (Figure 14).

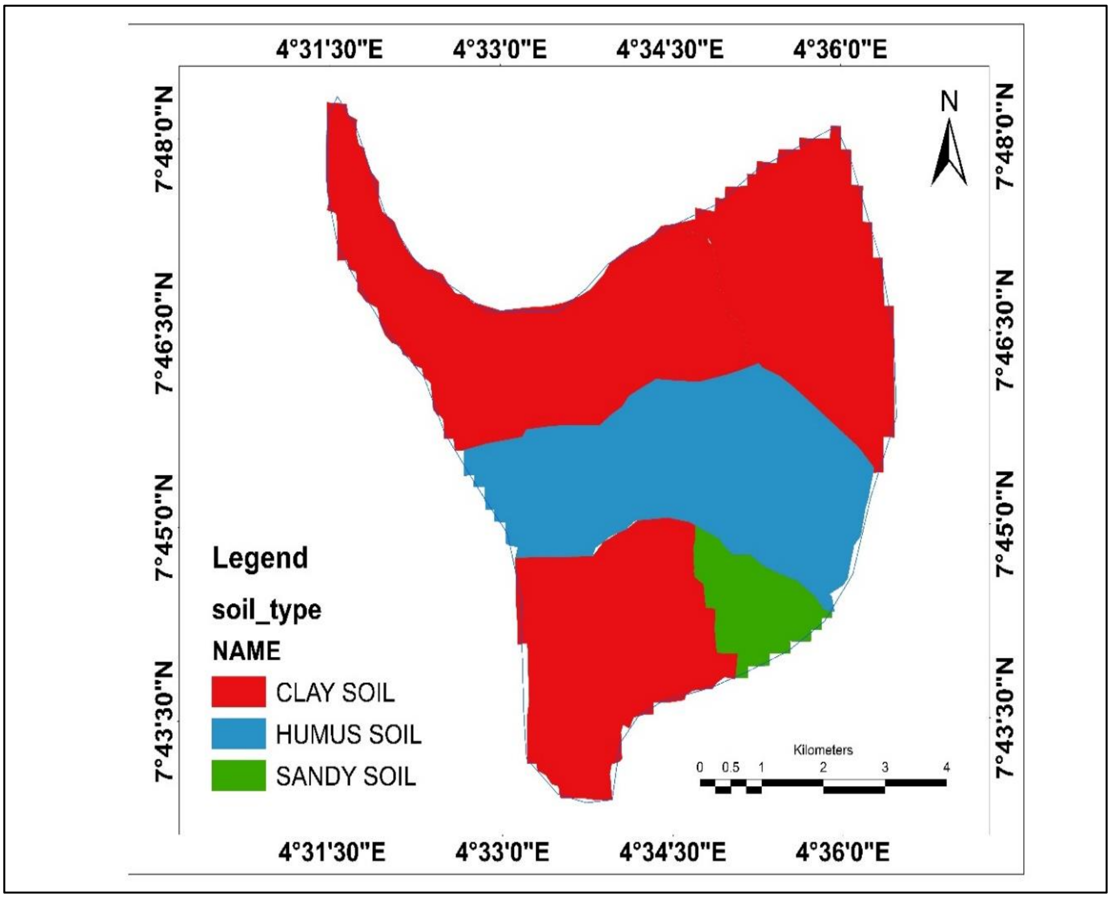


Fig 13 Soil Map

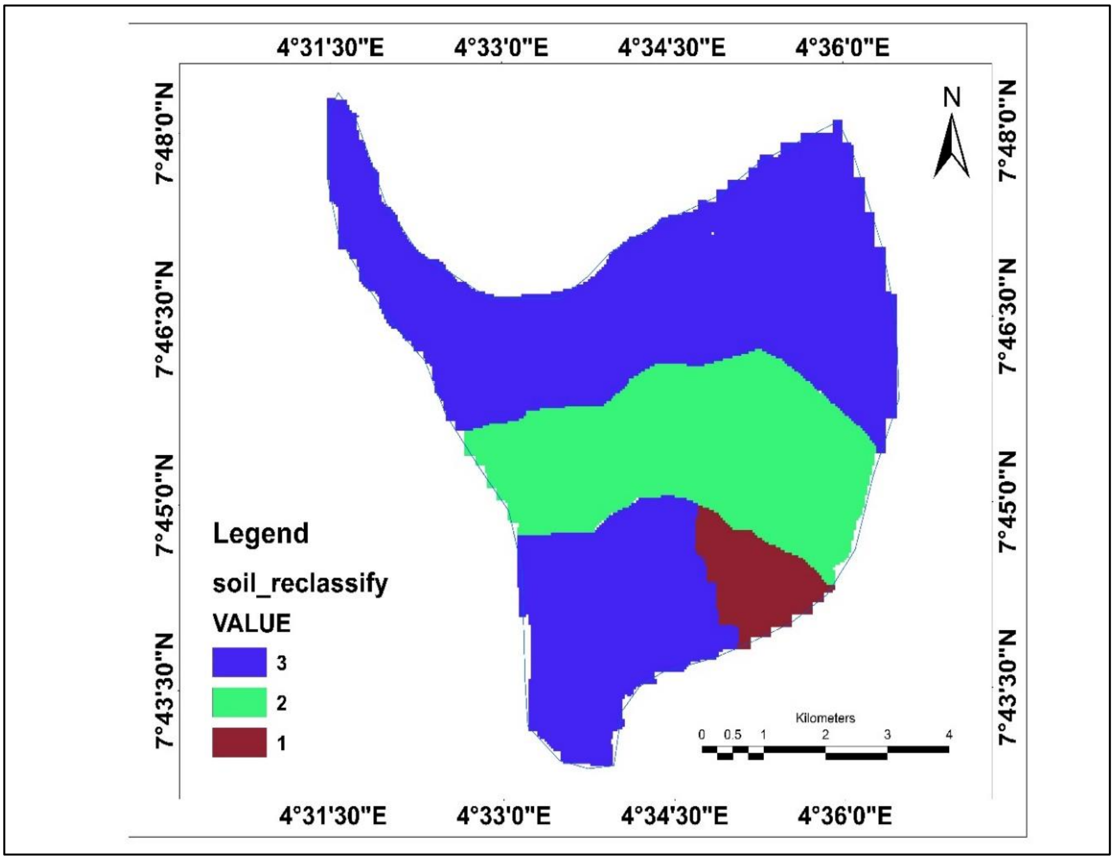


Fig 14 Reclassified Soil Map

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➢ *Proximity to the Road Network*

This is the sixth significant factor considered for the selection of a suitable site for the construction of an estate. The proximity to the road network is shown in Figure 15 and with a calculated weight of 5.6%. Proximity to roads refers to the closeness of a site to the available major roads. It is an important factor in determining how suitable a site will be for construction purposes. For the purpose of this study, the proximity analysis was done by computing multiple buffering analysis of selected major roads in Osogbo local government. The multiple buffering analysis was divided into five different zones of suitability, which included most suitable (200m), highly suitable (400m), slightly suitable (600m), less suitable (800m) and not suitable (1000m). Figure 16 shows the reclassified proximity to road network map.

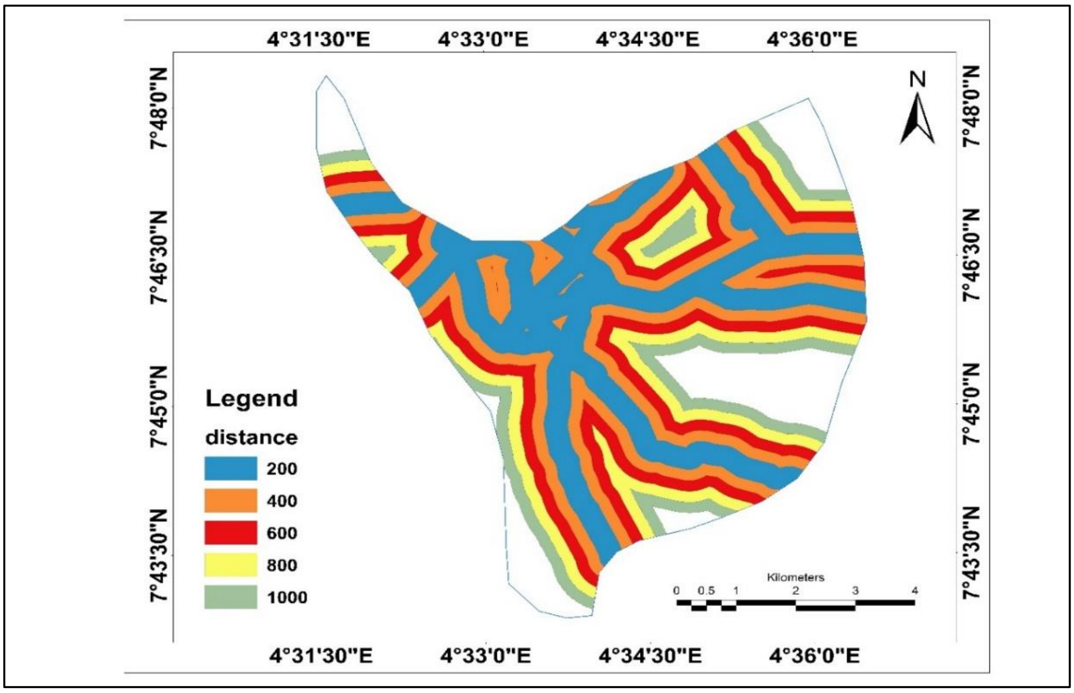


Fig 15 Proximity to Road Network Map

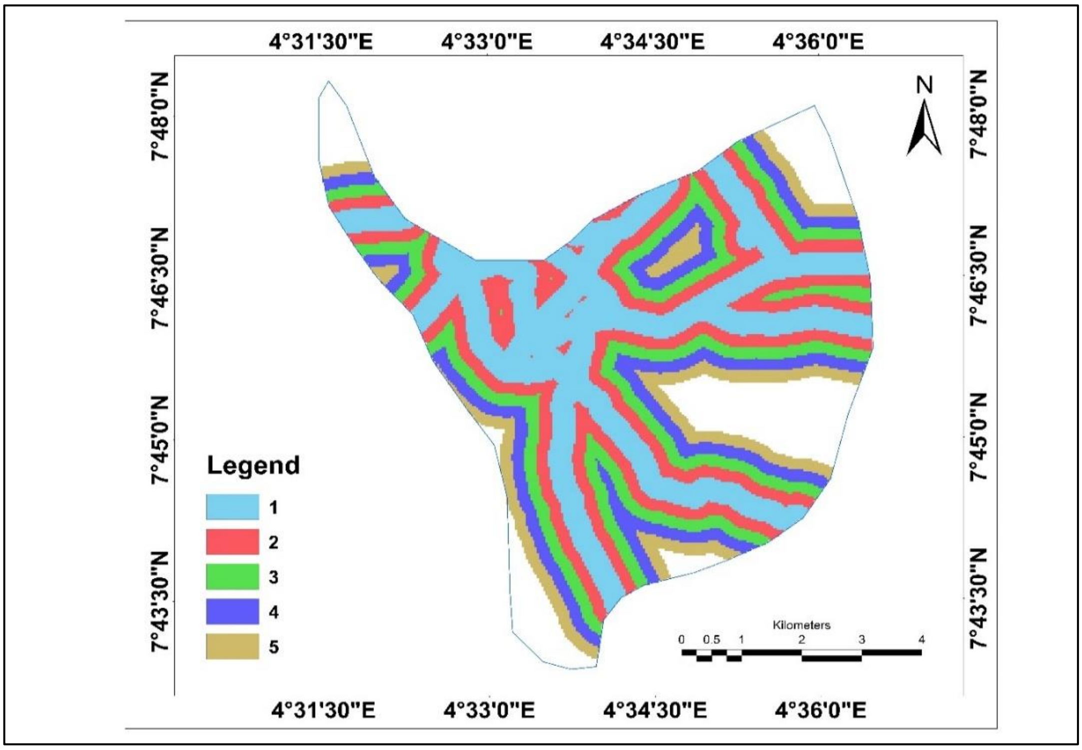


Fig 16 Reclassified Proximity to Road Network Map

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➢ *Population Density*

This is the seventh significant factor considered for the selection of a suitable site for the construction of an estate, with a calculated weight of 3.2%. Population density is a measurement of the number of people in an area. It is calculated by dividing the number of people by the land area. Population density is directly associated with the comfortability of living. Figure 17 shows the population distribution of the study area. It is divided into five different classes of the human population in Osogbo local government. The classes are; 305 – 616, 617 – 926, 927 – 1236, 1237 – 1547, 1548 – 1857. The classes can be further classified into not densely populated areas, slightly densely populated areas, high densely populated areas, very densely populated areas and the most densely populated areas. The reclassified population density is shown as Figure 18.

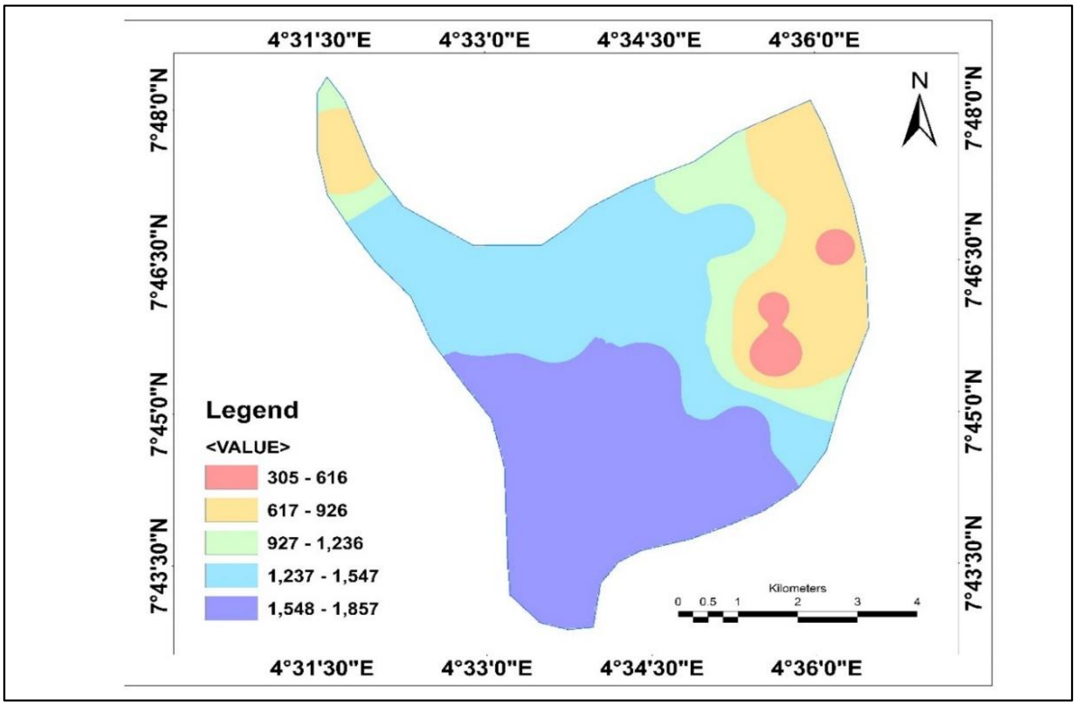


Fig 17 Population Density Map

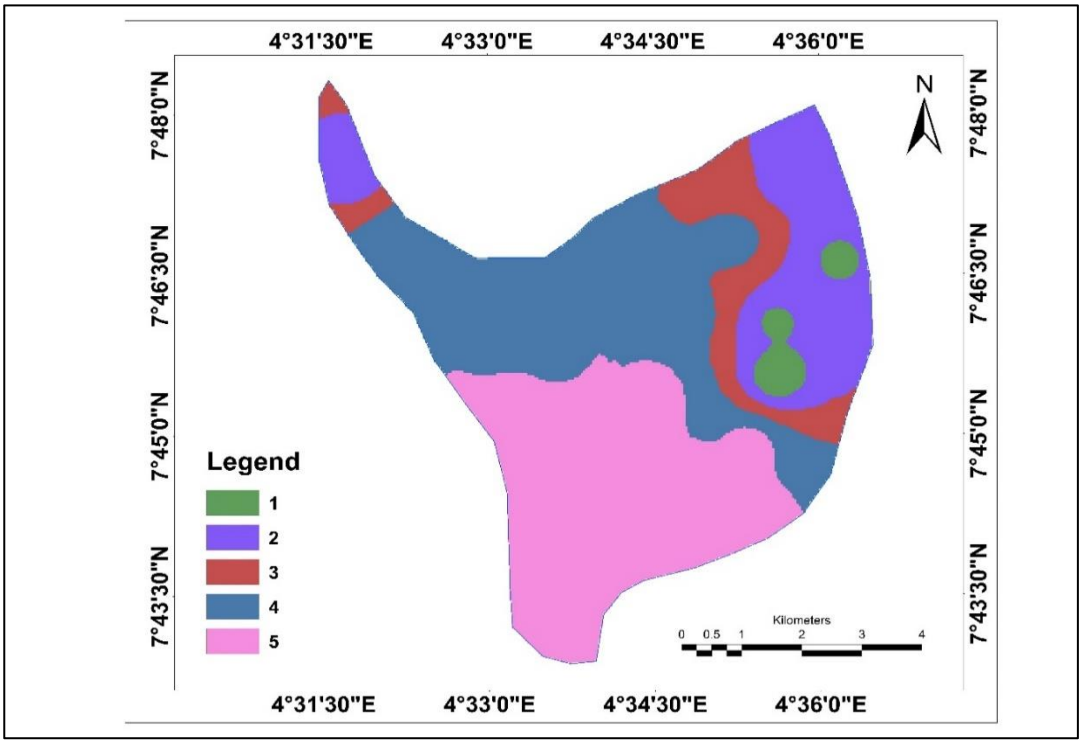


Fig 18 Reclassified Population Density Map

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➢ *Proximity to the Tourist Centre*

This is the eighth significant factor considered for the selection of a suitable site for the construction of an estate and has a calculated weight of 2%. Proximity to the tourist center refers to the closeness of a site to an area or building that serves as a source of attraction in Osogbo local government. It is an important factor in determining how suitable a site will be for construction purposes. For the purpose of this study, the proximity analysis was done by computing multiple buffering analysis of the identified tourist center in Osogbo local government. During the course of this study, four tourist centers were identified and they are as followed:

- Nelson Mandela Park
- Freedom Park
- African Heritage
- Osun Sacred groove

The multiple buffering analysis was divided into five different zones of suitability (Figure 19), which included most suitable (200m), highly suitable (400m), slightly suitable (600m), less suitable (800m) and not suitable (1000m). Figure 20 showed the reclassified proximity to tourist centre map.

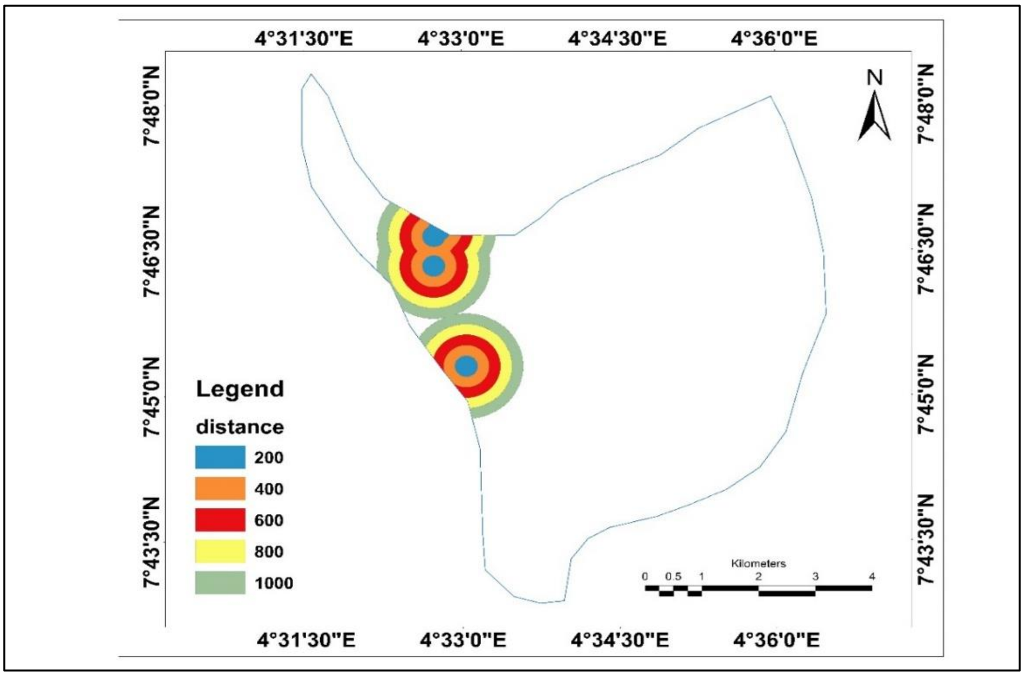


Fig 19 Proximity to Tourist Centre Map

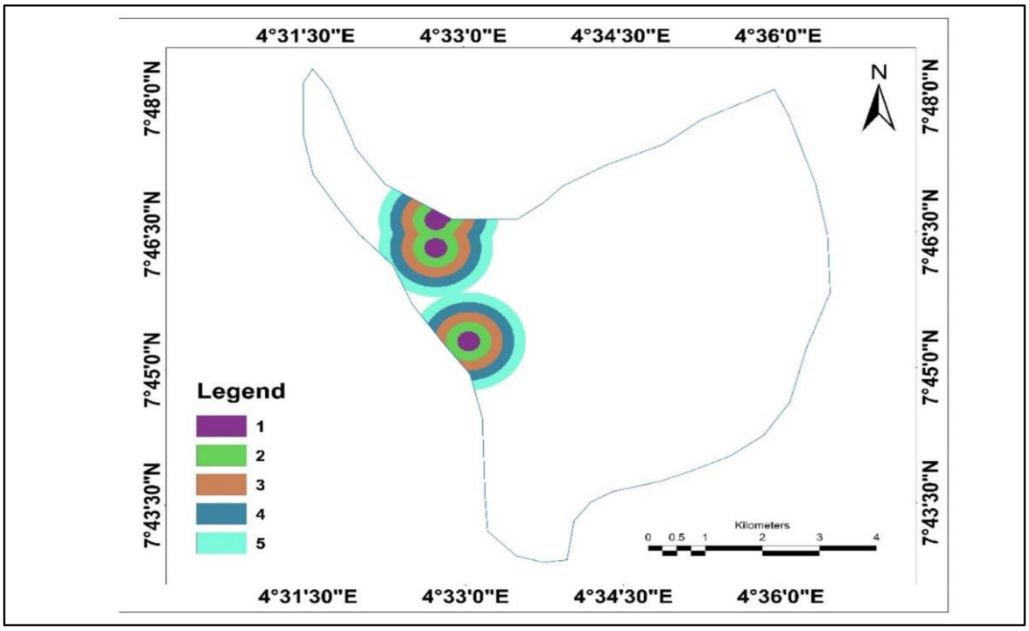


Fig 20 Reclassified Proximity to Tourist Map

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➢ *Geology*

This is the ninth significant factor considered for the selection of a suitable site for the construction of an estate, with the least calculated weight of 1.6%. The geology of an area is the structure of its land, together with the types of rocks and minerals that exist within it. The basement complex is one of the three major litho-petrological components that make up the geology of Nigeria. It was formed as a result of three major organic cycles of deformation, metamorphism, and remobilization. They comprise quartzites and quartz-schists of the Effon Psammite Formation, quartz-mica schists, biotite schists, migmatite gneisses, granitic gneisses, and late and post-tectonic granitic rocks, including pegmatites. The information above shows that the basement complex is good geology for the construction of buildings. Figure 21 shows the geology of the study area.

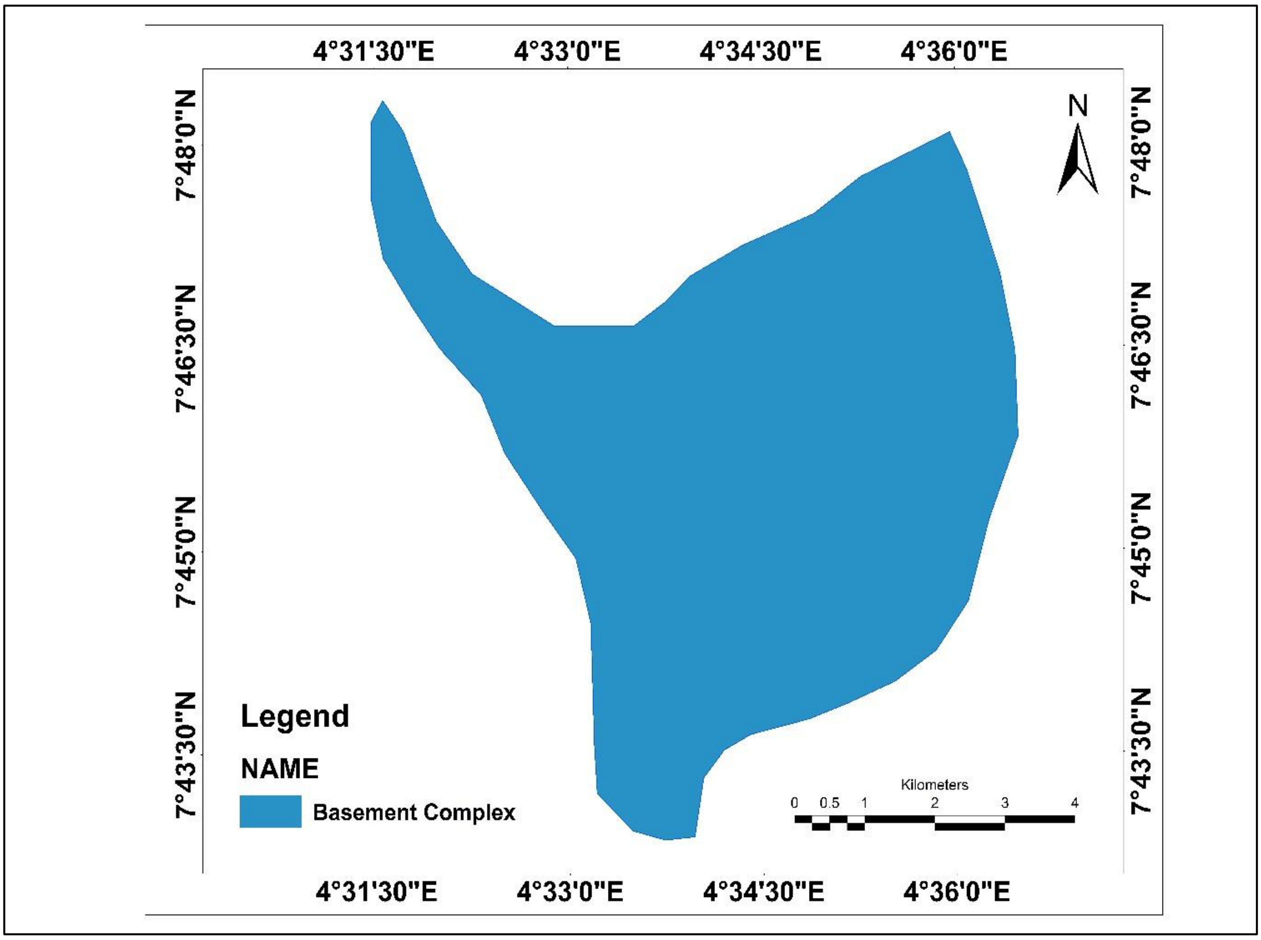


Fig 21 Geology Map

*D. Suitability Map*

The suitability map (Figure 22) was produced by the combination of the reclassified factor maps necessary for selecting suitable sites based on the weight generated using the Saaty's scale (1980). The weight generated by the AHP calculator (Table 4.3) was used to multiply each factor.

The result was then computed by using the equation below by a raster calculator in the ArcGIS tool box.

Site suitability = Reclassified geology * 32.1 + Reclassified land use * 21.2 + Reclassified soil type *17.8 + Reclassified slope *10.6 + Reclassified proximity to road *6.5 + Reclassified elevation* 5.1 + Reclassified population density *3 + Reclassified aspect *2.3 + Reclassified proximity to tourist area * 1.6.

The site suitability was classified into five (5) zones. The red portion represents the area that is not suitable for building construction, the light-yellow portion represents areas that are less suitable, the light-green portion represents slightly suitable, the light-blue portion represents areas that are more suitable, and the most suitable area for building construction is represented by the blue portion respectively.

Table 4 AHP Priority Assigned Weights

| S/n | Parameter | Priority (%) | Rank |
|---|---|---|---|
| 1 | Land use | 32.2 | 1 |
| 2 | Elevation | 21.7 | 2 |
| 3 | Slope | 15.1 | 3 |
| 4 | Aspect | 11.6 | 4 |
| 5 | Soil type | 7.2 | 5 |
| 6 | Proximity to road | 5.6 | 6 |
| 7 | Population density | 3.2 | 7 |
| 8 | Proximity to tourist area | 2.0 | 8 |
| 9 | Geology | 1.6 | 9 |

CONSISTENCY RATIO (CR) = 6.3% (Source: AHP-OS Priority Calculator (BPMSG.COM)

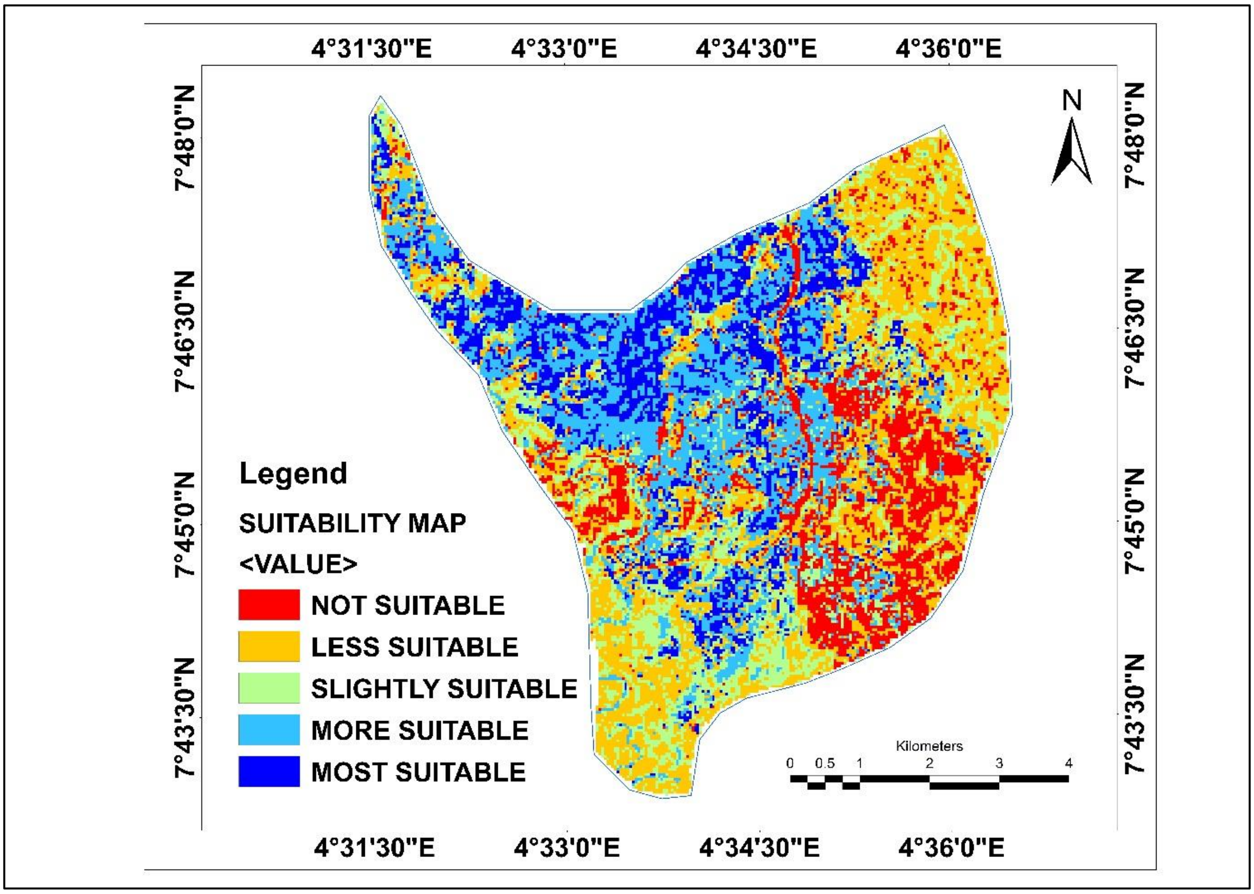


Fig 22 Site Suitability Map of the Study Area.

## IV. CONCLUSIONS AND RECOMMENDATIIONS

### A. Conclusions

The selection of suitable locations to build residential houses can be best achieved by the combination of GIS and MCDA. The municipality hardly uses MCDA in selecting locations suitable for building residential houses. The method of using certain criteria, such as land owner, environmental factors, valuable green areas, cultural heritage, and physical boundaries (roads and utilities) surrounding the landed property as factors in selecting a suitable area is not only a technical method of selecting a suitable area to build residential houses. Certain locations may have positive aspects in terms of the land owner, environmental, cultural heritage and physical boundaries, but in terms of the soil type, the direction of slope and the land use type, it may become a problem selecting such areas as suitable areas. One of the major aims of this research is to analyze factors critical for housing development and show possible locations where residential houses can be built, which is of great importance to the municipality. Different factors and constraints were combined to produce an MCDA result. Weights were selected and multiplied with these factors. As two out of the three

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different soil types found within the study area were considered good for building residential houses, residential houses can be built in the northern part of the study area, the southern part and the western part of the study area. The combination of the MCDA map with proximity analysis provided an extra flittering to select locations where residential houses can also be built. These locations are close to existing infrastructure such as roads and tourist centres. GIS technology combined with MCDA has proved to be a useful tool in determining the best locations to build residential houses. The combination of these two technologies has been of tremendous help in the selection of suitable locations to build residential houses. The combination of different factors and constraints has produced better ways of selecting suitable areas. This study has helped understand that MCDA is a useful tool in selecting suitable locations in any area within the municipality. Planners can make effective use of this technology to reduce the problems they face in selecting possible locations for building residential houses. The use of GIS and MCDA will be helpful to the municipality in the future in making informed decisions. Selection of a suitable area can be done in different ways.

### B. *Recommendations*

The suitable area of any location is the first step in determining the housing density of any site location. The types of buildings to be built on the said property depend on setbacks and the property laws guiding the municipality. A better understanding of the property being built, the property divisions, community facilities, or rights of way must also be well understood when determining the housing density.

Further, I recommend that the municipality pay attention to the following:

- Different weights in determining the MCDA should be tested.

Considerations of other factors and constraints that can help determine the possible location for building residential houses, such as social, economic, and environmental factors, must be considered.

Social facilities and amenities such as schools, parks, hospitals, fire stations, should be considered.

Other infrastructures, such as power, security, water network, can be added as factors in deciding the best locations to build residential houses.

Other methods of selecting suitability can be tested.

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