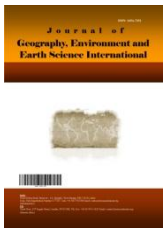

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# Index Mapping of Land Capability for Residential Land Use at Abakaliki Area, South East Nigeria

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***Authors' contributions***

*This work was carried out in collaboration between the authors. Author AAO interpreted and analyzed the data. Author UFI designed the study, wrote the protocol, set up the field work, as well as wrote the first draft of the manuscript, while author ECE did the literature searches. All the authors read and approved the final manuscript.*

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## ABSTRACT

The Search for residential land use option at Abakaliki area in Ebonyi state, Nigeria was carried out using Geographic Information System (GIS). Some laboratory experiments were incorporated to delineate some complementary information for the study. Ten determinants as capability factors were selected to develop thematic maps for over-lay analysis using software incorporated in Geographic Information System (GIS). The percentage influences of these determinants were also considered to facilitate the interpretation of the results. An Arch view model builder was employed in the over-lay analysis. The result produced the composite map where the residential land use zones were isolated, towards sustainable land use for residential purposes in the area. The residential land use option occurred at the NE-Eastern zone in the North west, South west and South east locations of the study area respectively.

*Keywords: Geographic information system; residential option; thematic map; composite map and overlay.*

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## 1. INTRODUCTION

Several environmental damages like land slide, soil creep, flooding, erosion may arise and affect residential buildings due to inappropriate land capability survey. Land use evaluation and planning is very necessary and is the basic process for right decision making in the allocation of land for various uses, especially in the practice of building development. The aim of Land capability evaluation is to assess fitness tracks to sustainable development. Land capability idea was introduced in 1971. It is the determination of the capability of various discrete geospatial heterogeneous land portions for certain use to avoid mismatch. Existing houses in various areas of the world have been abandoned due to failure and collapse of these structures to indiscriminate sitting without capability locations. It is therefore important to know the limitations of the land and the uses it is capable of supporting; how susceptible a land is to such factors as erosion and contamination influences, as well as the land use it is suitable for. Hence, the location of land is an important factor in deciding its uses.

The old Abakaliki development plan of 1970 has not been reviewed as to establish how much of the developments on ground correspond to the plan. Current overcrowding conditions of houses are severe; hence future requirements for new dwelling units would soon be a serious problem. There is therefore the need to map out areas that are geo-technically safe and economically rewarding with a view to minimizing natural hazards; as well as making life more meaningful. The work should therefore provide map to show suitable areas for residential site locations. Various theories concerning land uses have been put forward by many scholars. [1] indicated that effective land use studies should be made using a combination of maps, local knowledge and excursion. [2] concluded that no single method can be used to solve the content problem. They presented a flow chart of land use planning in Australia as problem definition and objectives, basic ground studies and land use determinant, development plan preparation and applications. In view of this, the major objective to realize the goal should be to provide data which when processed in a geographic information system (GIS) software will identify the geospatial characteristics of the area.

The application of GIS in Land use mapping especially in residential Land use as an appropriate technique is gaining more grounds [3-5]. GIS provides tools that integrate and analyze attribute of land resources as to determine its suitability for intended use [6]. Presently, residential buildings are scattered in the study area of Abakaliki without any geo-survey. The continued deterioration is due to poor Land use management practices. Based on this, it becomes necessary to use geographic information system to carve out areas most suitable for residential land use option; with site investigation, and experimental design to integrate information on geomorphology, hydrology and some basic laboratory soil tests. The study area is Located between latitude $N06^0$ 05' to $N06^0$ 30' and longitude $E08^0$ to $E8^0$ 12' covering an area of about 56.31km as shown in Fig. 1.

### 1.1 Regional Geology and Geology of the Study Area

The regional geology of the area shows that Abakaliki axis falls within the southern Benue trough [7]. The trough is composed of cretaceous marine Sediment. The major rock types are mainly shale, limestone Sand stone, pyroclasts and evaporits [8]. The major rock formations include Eze aku, Asu, mamu, Nkporo shale and Awgu Ndi Abo [7].

In more details, the development of any residential set-up needs proper geological and engineering studies as to ascertain the capability of the Land for the purpose [9]. This is accomplished by investigating to know a variety of factors such as geology, topography (slope), economic, social and political factors. The parameters to be considered include rock type, climate, flood plain, surface and ground water resources. Others are soil factors and geo-structural conditions. These are to minimize their negative impacts on the facilities, persons and the environment. Residential buildings should be sited in a near flat land or gentle slope. It is noted that slope $2^0$- $6^0$ is gentle enough and suitable for development. Slope greater than $12^0$ can cause septic problems or construction difficulty, as well as difficult to develop. [10] noted that areas with a slope of $10^0$ or less are ideal as it is good for residential development. Slope greater than $35^0$ on unconsolidated terrain is generally subject to Land slide. Development areas must be at least 1000m away from flood plant [11]. This is because ground surface and water are essential for housing and physical developments, as well as for human consumption and comfort. Residential areas should be close to water source [12].

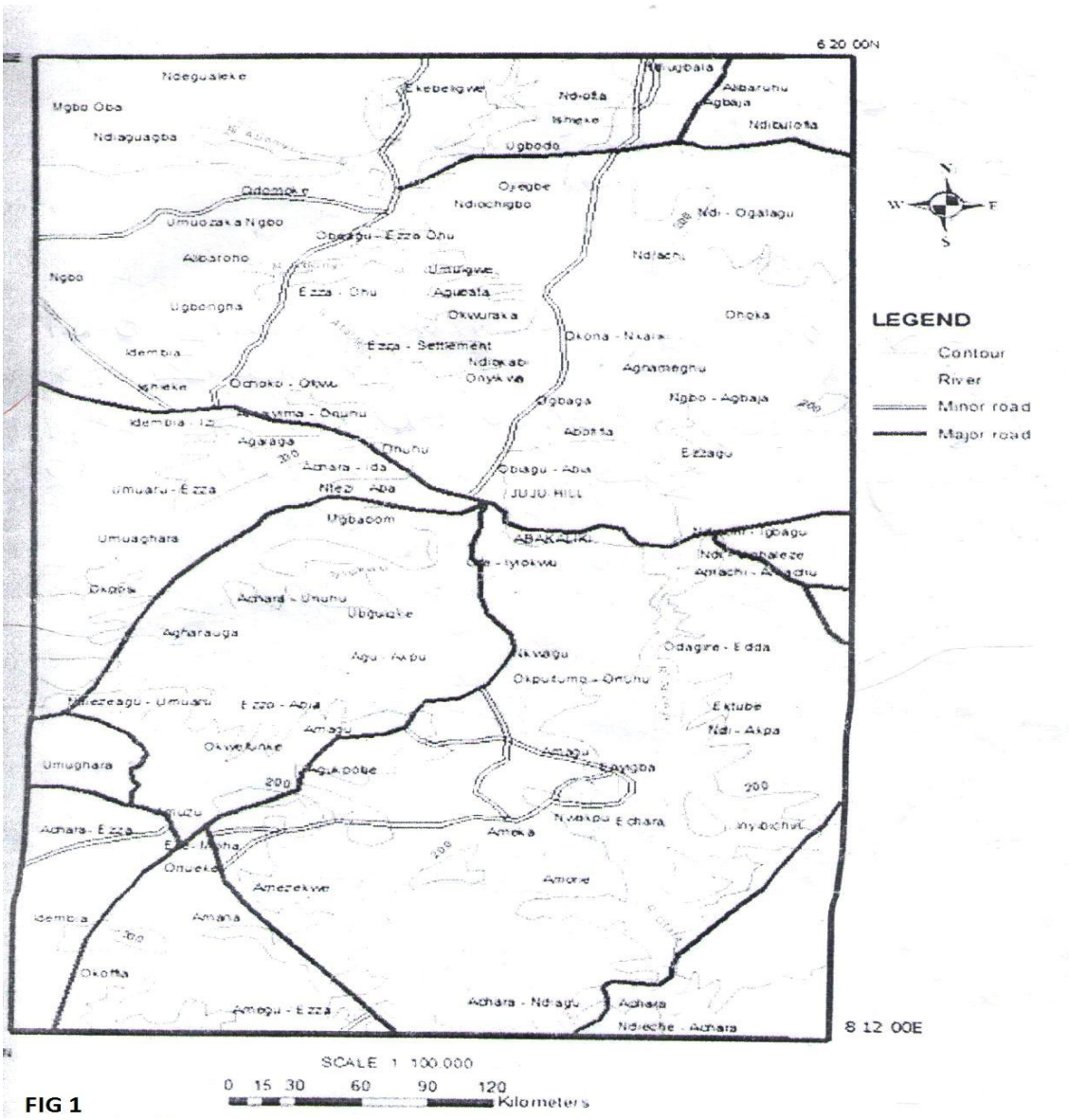


**Fig. 1. Topographic map of Abakaliki area**

*(Source: drafted from Map published by the office of the surveyor general of the federation, Abuja Nigeria 2010; part of sheets 302 and 303)*

However, care should be taken since shallow water table has severe implications to construction works; as well as underground water pollution. The position of underground water has a significant negative effect on the soil, and is bad when shallow as this causes contamination of the ground water.

Geology and soil factors are important because fractured rocks and faults adversely affect environmental stability. Soils are invaluable factor in determining choice of residential development in an area. This is because according to [13], expansive soils are problematic; and unconsolidated soil cannot offer strong engineering foundation base. Soil texture and drainage conditions also affect land use suitability. Well drained coarse soil offer lesser limitations to residential development. Geology of Abakaliki area indicates the dominant rock types exposed (Asu River group) [14]. They are mainly shale with insignificant sand stones. The formations exposed in some areas of the zone in addition to the Asu Formation are Ezeaku Formation, Awgu Ndi-Abo Formation and Nkporo Shale. About 80% of Abakaliki area is underlain by Abakaliki shale (Asu Formation) as in Fig. 3.

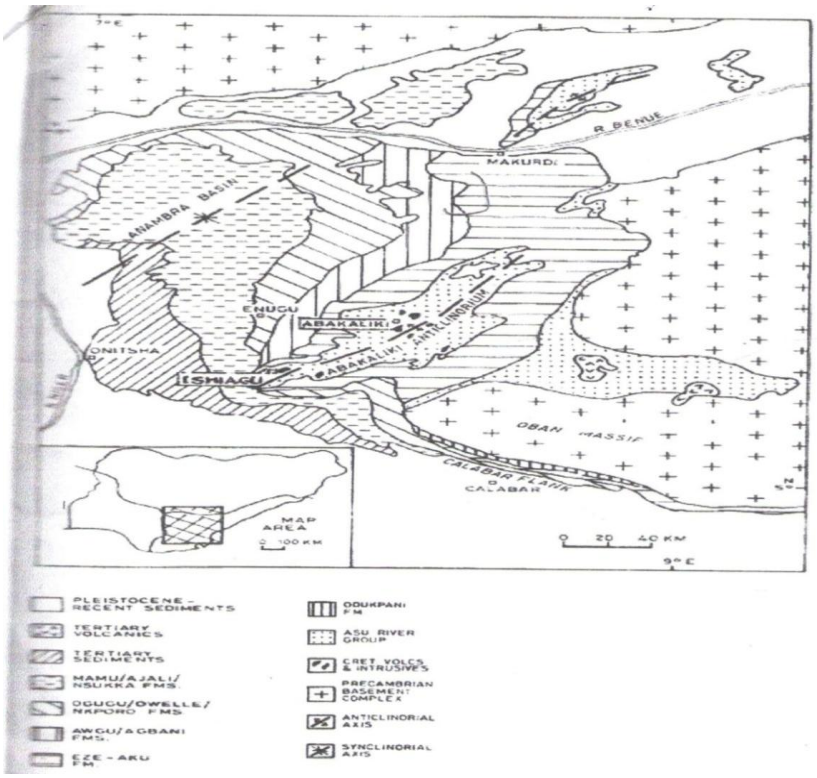


**Fig. 2. Aerial extent of rock types in Benue trough (after Hogue, 1977)**

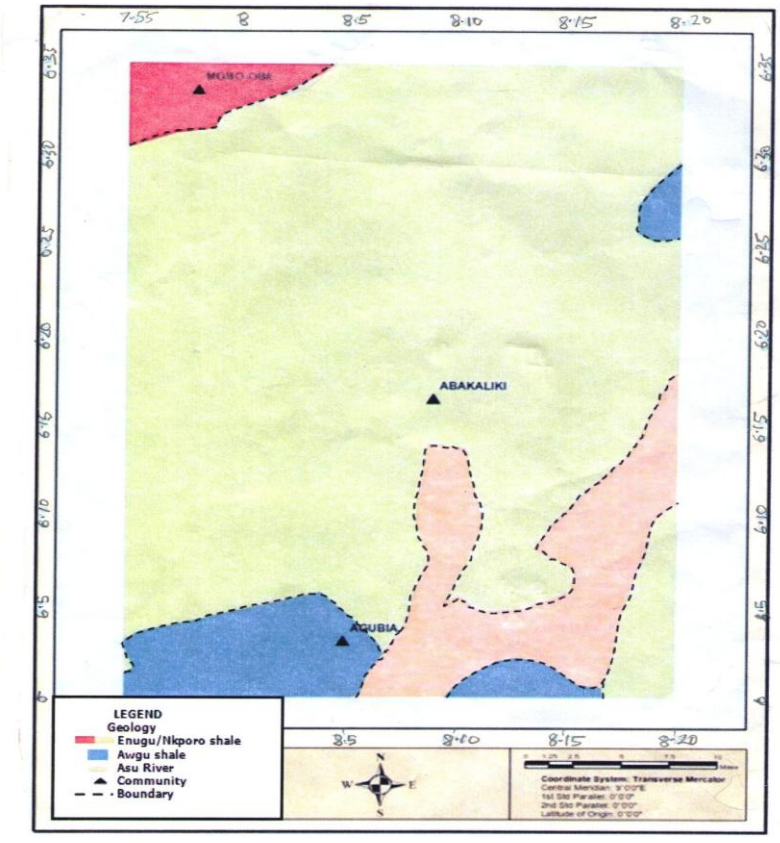


**Fig. 3. Geological map of the study area**

In collation of all the parameters identified, ten thematic maps as contained in Table 1 of the relevant element were overlaid as shown in Fig. 4.

## 2. RESEARCH METHODOLOGY

Field work incorporated with method study, physical measurements and laboratory experiments was adopted in the study. An arc view model builder's procedure incorporated in the soft ware of geographic information system was applied for analyses of data. Basic geospatial, geotechnical characteristics and climatic surveys are linked to land use planning using the Geographic Information System as a modern way of information processing. Geomorphology and the subsurface of the land were investigated to understand their influence on land use. To achieve sustainable and optimal land use indexing, the GIS framework using the heuristic procedure-based ranking of capability was employed systematically. The overall approach involved the integration of the various thematic layers (slope of the earth surface, elevation, geology, drainage, water table, flood, geo-structure, soil depths, type of soil, and hydrology maps) base on weight assignment and ranking.

Geographic Positioning System (GPS) was applied for data on slope, elevation, water table, and soil depth. Vertical Electrical Sounding (VES) was used to obtain data on geo-structure, while test on particle size distribution analysis and soil plasticity were used for basic classification of soil. Documented information on the remaining thematic layers (factors) from the appropriate authorities in the study area were adopted to complement the study.

## 3. PRESENTATION OF DATA AND DISCUSSIONS

In Table 1 are contained results on the determining factors (thematic layers) for determination of areas of land capability for residential land use in the study area.

**Table 1. Thematic layers for residential land use option**

| Input Theme | Percentage Influence | Input Field | Input Label | Scale value | Remarks |
|---|---|---|---|---|---|
| **Layer 1** | | 1 | 0-9 (G.S) | 2 | Important for the stability of |
| Slope | 10 | 2 | >9-19 (Sloppy) | 1 | buildings |
| Theme | | 3 | >19 steep | 0 | |
| **Layer 2** | | 1 | 280 – 432 | 1 | Not very important but used for |
| Elevation | 7 | 2 | 432 - 585 | 0 | slope. |
| theme | | 3 | >585 | 0 | |
| **Layer 3** | | 2 | Abakaliki shale | 1 | Shale and fracture lead to |
| Geology | 12 | 1 | Abakaliki pyro-clasts | 2 | instability |
| Theme | | | | | |
| **Layer 4** | 10 | 1 | Poor | 0 | Wet Land can lead to instability |
| Drainage theme | | 2 | Moderate | 1 | of foundations |
| | | 3 | Well drained | 2 | |
| **Layer 5** | 10 | 1 | Very Shallow | 0 | Shallow depth leads to |
| Water table theme | | 2 | Shallow | 1 | underground water pollution |
| | | 3 | Deep | 2 | |
| **Layer 6** | 12 | 1 | Buffered active | 0 | Weakens buildings |
| Flood theme | | 2 | Non active | 1 | Buffer $\geq$ I Km |
| **Layer 7** | 10 | 1 | Buffered active | 0 | Promotes |
| Geostructural | | 2 | Non active | 1 | instability and failure |
| instability | | | | | Buffer $\geq$ I Km |
| **Layer 8** | 12 | 1 | Deep | 2 | Influence |
| Soil depth | | 2 | Deep | 2 | stability of building and |
| theme | | 3 | Shallow | 1 | foundations |
| **Layer 9** | 8 | 1 | Ferrica crisols | 2 | Soil Strength depends on type |
| Type of soil theme | | 2 | Dystric | 1 | |
| | | 3 | Nitrosols Gleysols | 0 | |
| **Layer 10** | 8 | 1 | High | 2 | Important Source of water |
| Hydrology | | 2 | Low | 1 | Supply |
| Theme | | | | | Buffer $\leq$ I Km |

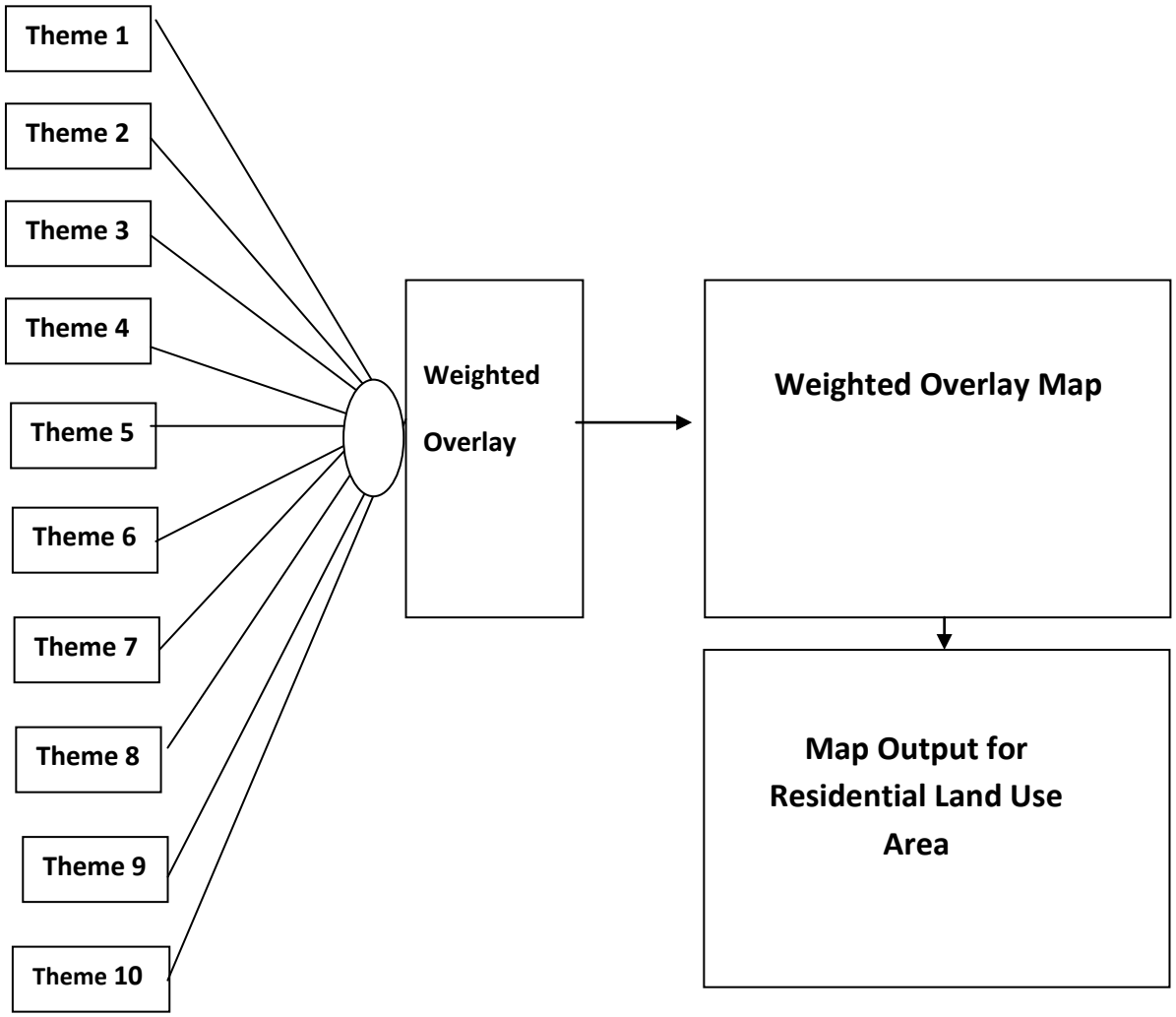


**Fig. 4. Schematic overlay model for selecting residential land use area**

The input themes in Table 1 represent the ten determining factors used in determining the capability of the land for residential purpose. Percentage influence is the degree of importance of the land use determinants in the study. The input labels are the determinants' attribute values or characteristic natures; while the weighting scale stands for capacity rating of the various thematic factors (where 0 = not capable, 1 = low capability, and 2 = capable).

The results produced the composite Map as contained in Fig. 5; where the residential land use option is isolated.

It should be observed that the suitable areas for residential land use are within the Western, North western, Northern, and North eastern to Eastern sections of the areas. Areas not suitable are within the central portions. Other areas are in pockets. The non suitable areas are most likely due to the influence of rivers around.

## 4. DISCUSSION OF FINDINGS

Hitherto, the available lands in Abakaliki zone were indiscriminately used for residential purposes without any land use plan. In view of this unfortunate practice, scientific methods of geographic information system are appropriate as adopted in this study. This is the basic platform for right decision making in various integration of several data characteristics. Various parameters for the residential land use option were prepared as thematic maps; they were overlaid after weighting and assessment of their percentage influences in order to produce the composite map for the selection of the residential land use map.

Results show that among the thematic factors (slope, geology, drainage, water table, flood, geo-structural stability, and soil depth) of high percentage influence for residential land capability, slope factor makes most of the land areas to be of low capability considering the fact that most locations in the study area are steeply in nature. This single factor therefore attributes low capability to the area as noted by [10]; that area with slope greater than $35^0$ especially on unconsolidated terrain is generally subject to Land slide. Nevertheless conditions of all the other respective factors for sustainability of residential projects in the area remain stable in most of the areas; and capable for good development.

The Geology and soil factors which are in good conditions are very sensitive and important because soil and geology of an area are invaluable factor for residential development planning. This is because according to [13], expansive soils are problematic; and unconsolidated soil cannot offer strong base for foundation works. He added that well drained coarse soil offers lesser limitations to residential development, which is the case in the study.

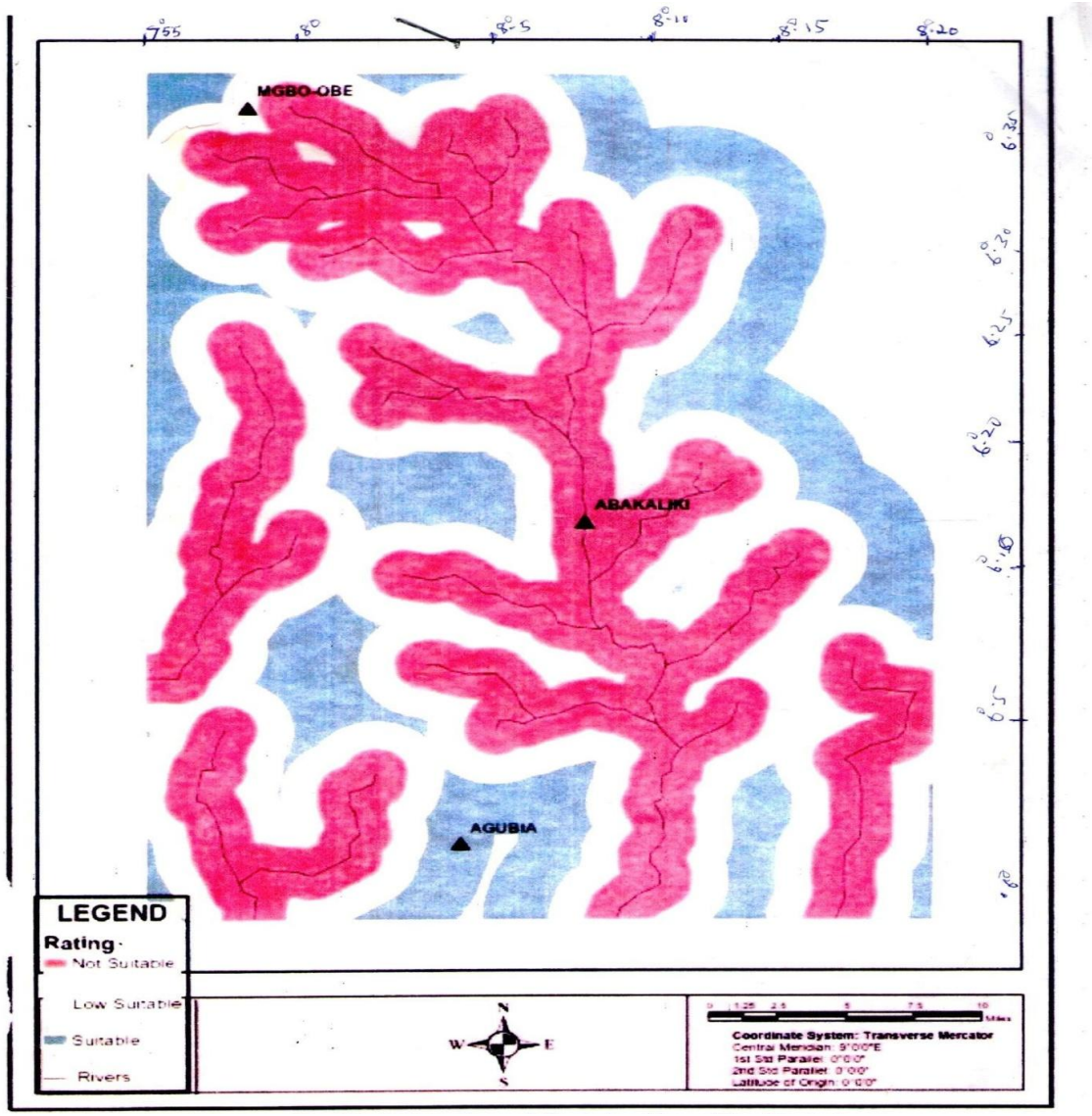


**Fig. 5. Index map for residential land capability of the study area (The Composite Map)**

## 5. CONCLUSION

Sites where residential land use should be located at Abakaliki area have been identified using the principles of Geographic Information System. Most of the areas conform to the principles of sustainable residential projects. These areas where the residential land uses are located are the North western to the Eastern axis through the Northern and North eastern are. The finding will serve as basic guide for effective residential development planning in the area. This is more appreciated in the context of affordability considering the fact that cost of procurement can never be less than cost of housing development, especially in the absence of government special intervention [15]. They noted therefore that extra financial resources are always required in the overall development and management of houses on an incapable land formation.

## 6. RECOMMENDATIONS

It is recommended that the allocation of land for residential development in Abakaliki axis should not be done randomly; politics notwithstanding. Environmental authority should also be put in place to assess the land for residential sitting, since some areas are not suitable for residential land use. Geographic Information System (GIS) and updated laboratory information of discreet locations in the study area should be integrated for evaluation of suitability of land areas for various developmental purposes to ensure sustainability of developmental projects.

## COMPETING INTERESTS

Authors have declared that no competing interest exists.

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