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MULTI-CRITERIA ANALYSIS OF SUITABLE SITES FOR ESTABLISHMENT OF RESERVOIR IN NNAMDI AZIKIWE UNIVERSITY, AWKA, NIGERIA

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Abstract

Water is one of the most undervalued resources on earth. One of the ways to conserve this resource is through construction of dams/reservoirs. The scarcity of irrigation water in Nnamdi Azikiwe University especially during dry season can be resolved by the siting of a reservoir. Choosing a suitable site is a crucial phase in reservoir construction. However, due to the complexity of reservoir site selection, the multi criteria decision analysis techniques when integrated with Geographic Information System offers a possible way of making optimal decisions in selecting site for the construction of a reservoir. The aim of this study was to identify and assess suitable sites for establishment of reservoir in Nnamdi Azikiwe University, Awka using multi-criteria decision analysis. The criteria considered include slope, land use/land cover types and watersheds. These criteria were classified according to their rank of suitability. Weighted linear combination was applied to determine the suitable sites for establishing reservoir in the Institution. The suitability calculator tool available in ArcGIS software was used to determine the most suitable sites for location of reservoir in the Institution. About 71 areas were initially identified as suitable sites for locating the reservoir. The areas were further subjected to further analysis and field validation test. The result of the field validation reveals that only two sites were suitable for establishment of reservoir in the Institution. The study, therefore recommends that geotechnical and hydro-geological detailed investigations and environmental impact assessment be carried out on the proposed suitable sites before actual commencement of the project.

Keywords: Geographic Information System, site suitability, water reservoir, water resources

INTRODUCTION

Mankind cannot survive without water. According to health experts, human beings require at least three litres of water per day which may be taken into the body in the form of food or liquids (FAO, 2012; FAO, 2016; FAO and UN-Water, 2021). The world population has been on the increase without a commensurate increase in the availability of water resources (WHO, 2003; The World Bank, 2014). According to Bartleby.com (2023), water is a crystal clear, tasteless, odourless, and virtually pallid chemical substance that can be found on the Earth's streams, lakes, oceans, and which exits in three forms of solid, liquid and gaseous state (Mallamace, Corsaro, & Stanley, 2012; usgs.gov., 2019).

Water is essential for survival of mankind, animals, plants and a key element in any meaningful development and planning (USEPA, 2016; Garg et al, 2018; Nwinyi et al, 2020). It is a limited resource with fast increasing demand, usually taken for granted until it is gone or unsuitable for drinking. Sources of water include rivers, lakes, excavated dams, rock catchment areas, springs, surface water bores and wells. Water supply is an integral part of public infrastructural service expected to be provided by government. This infrastructure must include effective Water Supply Systems (WSS) for the steady water collection, transmission, treatment, storage and distribution of water for homes, commercial establishments, industries and irrigation. Groundwater is more reliable for irrigation than surface water, due to its slow reaction to climate change and contaminants (Kassie, et al, 2022). In this regard, a research was done to evaluate the potential of irrigable land and water availability, considering both surface water and groundwater sources using GIS-MCE techniques in the Abbay basin. A total of nine factors were selected to identify the suitable land for surface irrigation. Groundwater depth, availability, proximity to the river and the slope were found to be the dominant factors affecting the practice of surface irrigation, and their corresponding weights (Kassie, et al, 2022).

Site suitability mapping is the common method of understanding existing site qualities and factors that will determine the location for a particular activity, which encompasses detailed analysis of the natural resources and processes that characterize a site using mapping techniques like GIS tools that help in processing the geographical database that display the areas of the site, suitable for various planning objectives or its alternatives (Santosh & Ritesh, 2014). Literature (Adham, et al, 2016; Ammar, 2017) also noted that the site suitability analysis for construction of water conservation structures is an important step towards groundwater conservation in arid and semi-arid regions. Badhe, Medhe, and Shelar (2019) reported a study similarly focused on selecting the suitable sites for construction of water conservation structures in the Upper Sina River Catchment, Ahmednagar, India. The lack of such a reservoir had resulted in water scarcity, especially in the arid and semi-arid regions where precipitation is low. Hence, the conservation of the available water resources through provision of reservoir was imperative. Grouping of polygons of high ranks of all the thematic layers will help in delineating the sites that are excellent for construction of water harvesting structures. Thematic maps show parts of the study area that are most suitable for construction of rainwater harvesting structures, (Padmavathy, et al 1993)

Reservoirs are created for different purposes such as hydroelectricity, water supply, and flood mitigation. The construction of a reservoir in an area also poses some negative environmental effects on the communities and ecosystem where they are sited, thus several factors need to be considered before sitting a reservoir in any location. There has been an urgent need to apply the principles of sustainable production to land resources and land use and to meet the requirements of society while conserving fragile ecosystems (FAO, 1993). According to Tong, et al (2021), land suitability evaluation is considered as a vital link to sustainability of society, and the integration of multi-criteria analysis based on Analytic Hierarchy Process (AHP). Also, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) has been used as an effective tool for decision-makers planning for an environmental, economic and social sustainability. Kassie, et al (2022) observed that mapping the best location for this infrastructure using traditional methods is more tedious. Nevertheless, these activities can be optimized to work faster and effectively, using remote sensing and GIS techniques, while taking cognizance of the importance of parameters like land use, slope, soil map, drainage networks among others in site suitability analysis. This was highlighted by Kolekar, et al (2017) and Kassie, et al (2022). The final stage is to combine the various maps in order to identify the most suitable sites for overflow harvesting. Suitability maps will be generated by applying criteria. This suitability modelling approach is encouraged due to its simplicity. Numeric values, such as the suitability rankings are assigned to the classes within each map layer in order to facilitate the suitability analyses. The values from each map layer are ranked on a scale of most suitable to least suitable based on the criteria of each data set, with each layer being assigned an equal weighting (De Winnaar, Jewitt & Horan, 2007).

The integration of Geographic Information System (GIS) and Multi-criteria Decision Analysis (MCDA) techniques is a possible way of making optimal decisions in selecting a suitable site for the construction of a reservoir. Multi-criteria analysis is a methodology for ranking management alternatives based on evaluation criteria, weighted by the user. Several authors (Xinyi, 2016; Minatour, 2015; Al-Adamat, et al, 2012; Dorfeshan, et al, 2014; Kumi-Boateng, Stemn & Sibil, 2016) have integrated these techniques to determine suitable locations for sitting of dams/reservoirs. Remote sensing and GIS application have demonstrated its effectiveness through the use of remotely sensed data in providing the necessary spectral and spatial information for generating information layers for site selection criteria. Although the GIS methodology makes the decision-making process more objective, the experience of the planners is required to incorporate varying degree of importance to each criterion based on the flexibility of the technology and subjectivity associated with the allocation of map weights and scaling (Adeboboye, et al, 2021).

Water scarcity is one of the major problems affecting academic activities in Nnamdi Azikiwe University, Awka, Nigeria. The University community has been facing severe water shortages, and the construction of reservoir has been suggested as a possible solution to meet the increasing demand of water by the University community. This research therefore sought to identify the various criteria for selecting a suitable site for construction of reservoirs; to determine the degree of influence of each criterion and to determine suitable locations for construction of reservoir in the University. Ezeibenne, et al (2019) noted that the scarcity of irrigation/dam water in Anambra State, especially during dry season, can be resolved by the siting of a dam or reservoir. It reported the use of remote sensing and GIS for site suitability analysis for small dams for irrigation, and water supply within the State. The outcome of the suitability analysis satisfied all the constraints in the criteria and the results unveiled six potential locations for siting dam, within Ifite Awka in Awka-south Local Government Area (LGA).

Literature has observed that, owing to its value, it is important to conserve water through construction of dams/reservoirs for future use, especially in dry seasons (Odoh et al., 2012; Ezeibenne, et al, 2019). The scarcity of irrigation water in Nnamdi Azikiwe University especially during dry season can be resolved by the siting of a reservoir, and choosing a suitable site is a crucial phase in this process. However, due to the complexity of reservoir site selection, the Multi Criteria Decision Analysis (MCDA) techniques, when integrated with Geographic Information System (GIS), offers a possible way of making optimal decisions towards this. The aim of this study therefore was to identify and assess suitable sites for establishment of water reservoir in Nnamdi Azikiwe University, Awka using Multi-Criteria Decision Analysis Mapping and GIS.

Area of the Study

Geographic Location and history

The study area is the main campus of Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. The University was established by the 'old Anambra State' Government of Nigeria on 30th July 1980 as a multi-campus University system, and was called 'Anambra State University of Technology' (ASUTECH). It was reconstituted in 1991, after the creation of new states from the 'old Anambra State' and located within the Amansea area of Awka. It was later renamed "Nnamdi Azikiwe University" on November 26, 1991 to honour late Dr. Nnamdi Azikiwe, and subsequently taken over on July 15, 1992 by the Federal Government of Nigeria (Nnamdi Azikiwe University, 2022). It is situated along Onitsha-Enugu express road, at about 2.2km to the boundary of Enugu State (Odoh et al., 2012).

The landmass of the Institution has an approximate area of 4.34 square kilometres and spans between Awka North and Awka South LGAs; the Administrative block, the hostels and some other parts are in Awka South. It is geographically located between Latitudes 06° 14'N and 06° 16'N, and Longitudes 07° 06'E and 07° 08'E in WGS 84 ellipsoidal system (Figure 1, Figure 2, and Figure 3). It has a mild undulating terrain with gentle slope. The population of the area is primarily the students and staff of the institution with some business men and women who are engaged in small businesses, such as photocopying, restaurant, photography, internal transportation services, and selling of stationeries. The Institution has a student and staff population of over 40,000 and 4,500 respectively.

Climate of the Area

Nnamdi Azikiwe University, Awka is Located in the tropical zone of Nigeria. The area experiences two major seasons brought about by the two predominant winds in the area. These include the South Monsoon winds from the Atlantic Ocean and the North Eastern dry wind from across the Sahara Desert. The Monsoon winds from the Atlantic Ocean create seven months of heavy tropical rains which occur between April and October. This is followed by five months of dryness (November-March), with daily temperature of 20-38°C which results in high evapotranspiration, while the rainy season temperature ranges from 16 to 28°C, with lower evapotranspiration. The average monthly rainfall ranges from 31mm in January to 270mm in July, with the average annual rainfall varying from 1,500 to 1,650mm (Odoh et al., 2012).

According to Aghamelu et al. (2011), the climatic conditions prevalent in the Awka area might be responsible for the development of in situ lateritic covers in some parts of the area.

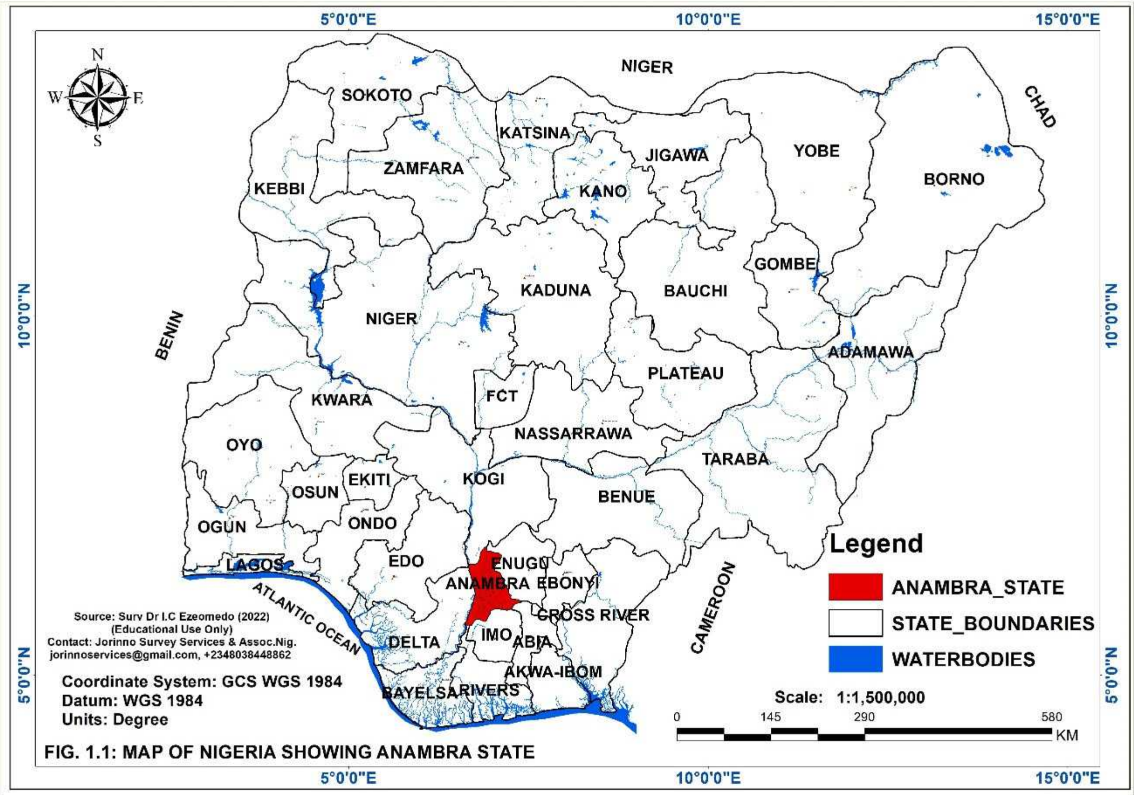

Figure 1: Map of Nigeria showing Anambra State

Source: (Ezeomedo & Igbokwe, 2019)

They noted that first order streams are found in the institution and in the rainy seasons, some locations are water logged, but will dry up in the dry seasons. Thus, the soil texture is loose and can be muddy during the rainy seasons, (See Figure 4) showing wetland areas of the study area to validate the claims.

Vegetation

The University is located in the "Ecotone" of the transition between the tropical rainforest and the wooden savannah grassland. Thus, the area is mostly dominated by grassland with some patches of gallery forest vegetation along the stream valleys, some of which may only contain water in the rainy seasons. However, this sort of grassland ecosystem might be the induced type, as a result of clearing the original vegetation for developmental purpose of the area (Figure 4).

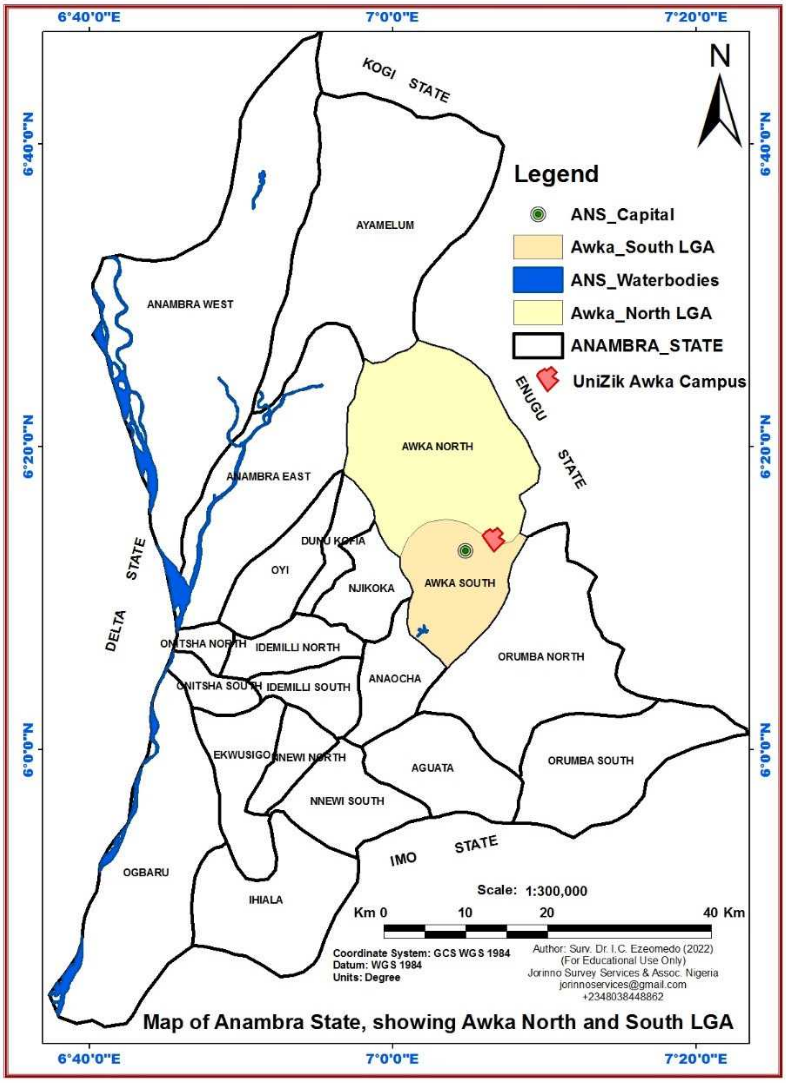

Figure 2: Map of Anambra State showing the location of the study area LGAs

Source: (Ezeomedo, 2022)

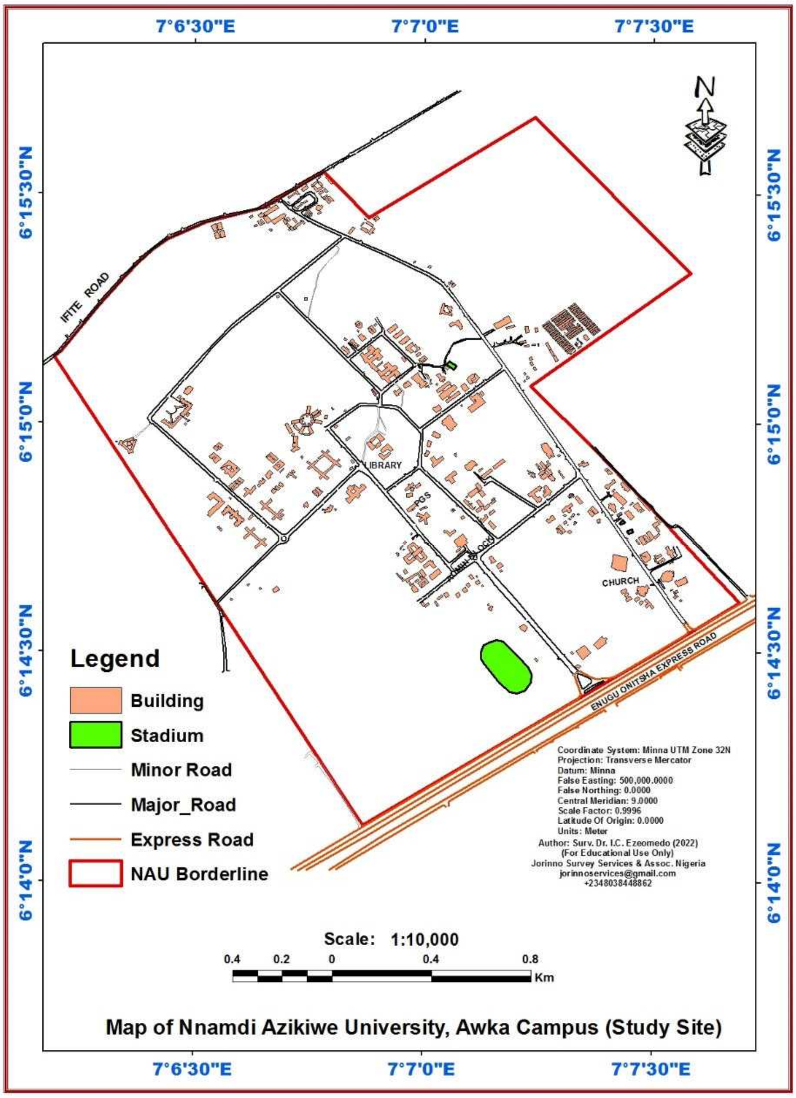

Figure 3: Map of Nnamdi Azikiwe University (NAU), Awka Campus (Study Site)

Source: (Ezeomedo, 2022)

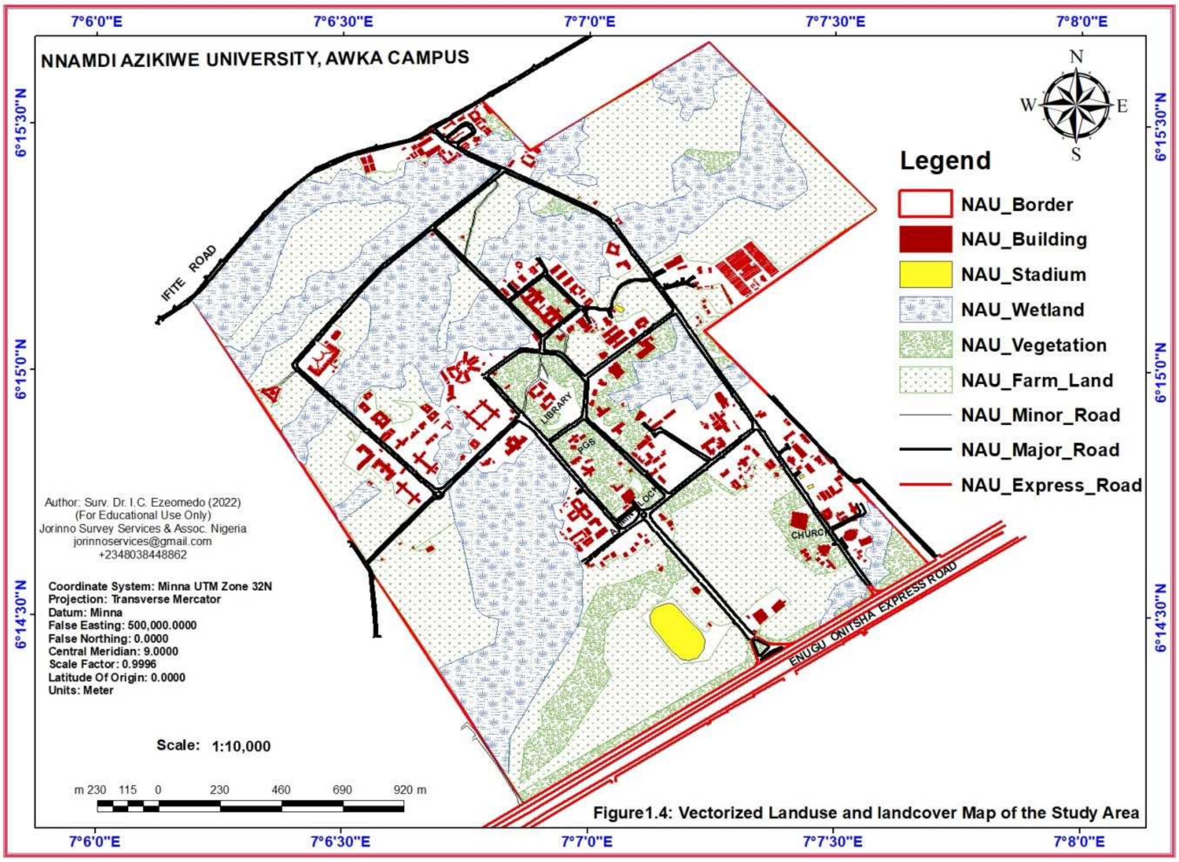

Figure 4: Vectorized Land Use and Land Cover Map of the Study Area

Source: (Ezeomedo, 2022)

Geology and Soil

According to Odoh et al., (2012), the sequence of shale and sand stones formed in the Paleocene age underlie most of the Territory. The site is underlain by the Imo Shale. The dominant lithology of this formation is shale, were siltstone, sandstone and laterite are common, and they overlie the shale, thus, the depth of overburden ranges from 0.0-3.5m in most locations within the University site. The in-situ shale is bluish to dark coloured. The siltstone and sandstone are milky to brownish, while the laterite is generally dark brownish to reddish in colour. Shale is a problem soil that is notoriously unpredictable, especially the soft non-indurated type, which undergoes volumetric changes when subjected to changes in moisture content as a result of annual rainy and rainy seasons (Odoh et al., 2012).

METHODOLOGY

The methodology adopted in this study is presented in a flow chart as shown in Figure 5.

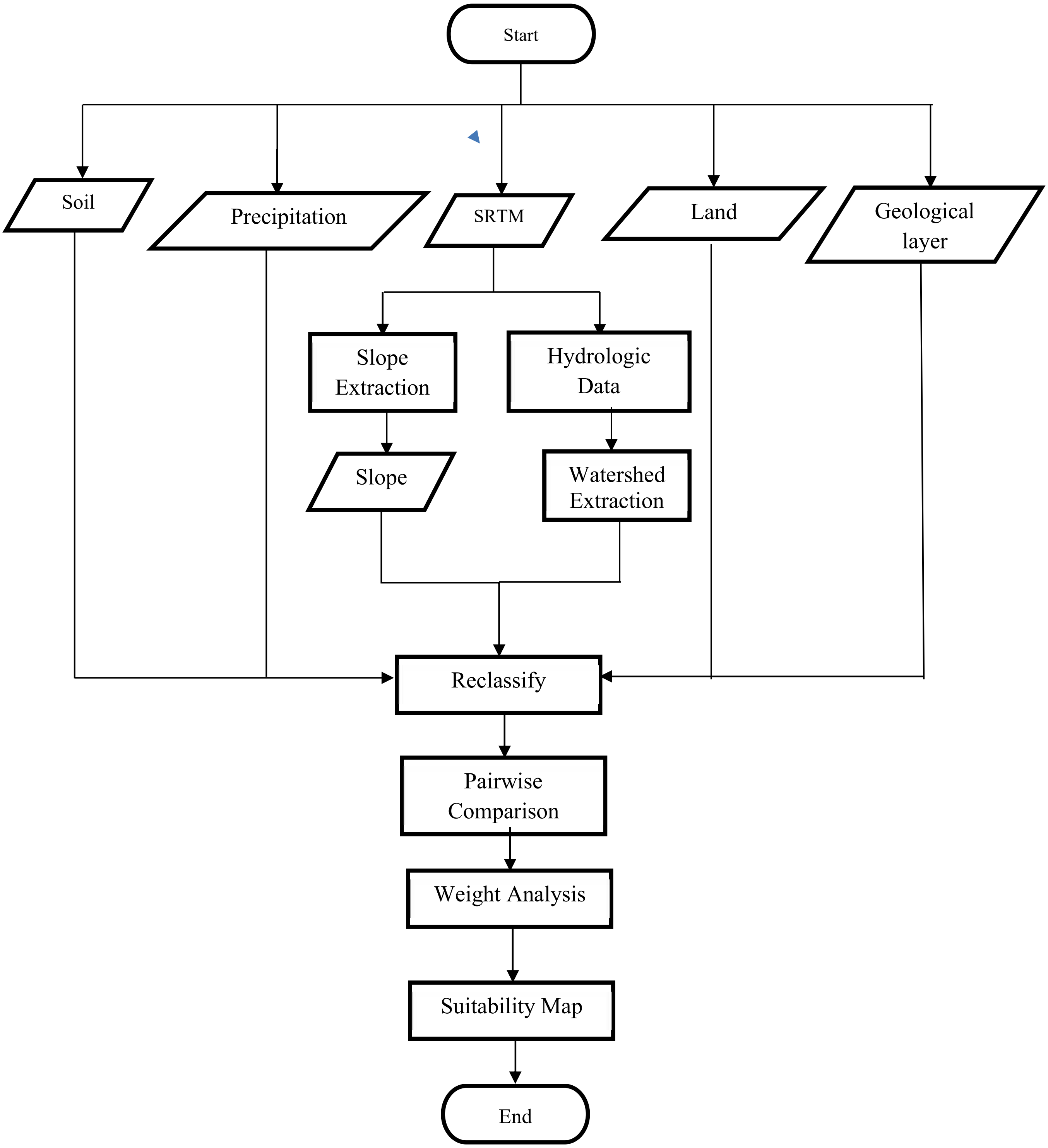

Figure 5: Flow Chart showing the stages of generating suitability map for reservoir.

For constructing reservoir, different slope thresholds have been chosen in previous studies such as less than *10* percent which equals to 5.71 degree (Singh et al, 2003), less than 3 percent which equals to 1.72 degrees (Abushandi & Alatawi, 2015; Ammar, 2017). In this study, the Shuttle Radar Topographic Mission (SRTM) image was used to generate the slope. The slope was reclassified into 5 classes as highly suitable, suitable, moderately suitable, low suitable and not suitable. In this, every 1 degree under or equal to 4 stands for a category, and slope larger than 5 degrees is defined as another category. Classes and preference table is shown in Table 1.

Table 1: Classes and Preference Value of the Slope

S/N	SLOPE (degree)	PREFERENCE VALUE	REMARK
1	0-1.02	4	Highly Suitable
2	1.02-2.16	3	Suitable
3	2.16-3.47	2	Moderately Suitable
4	3.47-5.32	1	Low Suitable
5	5.32-10.05	0	Not Suitable

Source: Fieldwork, 2022

The SRTM was further used to generate the watershed using the hydrological approach proposed by Eastman (1997). According to Malczewski (2000), the Weighted Linear Combination (WLC) technique is a decision rule for deriving composite maps using GIS. The most common errors and misconceptions associated with the use of WLC in the raster GIS environment were addressed by researchers (Malczewski, 2000; Al-Adamat, et al, 2010). WLC can be tested by means of the multi-attribute decision making (MADM) to solve any related problem(s) (Massam, 1988; Pereira & Duckstein, 1993). WLC can be analysed using any GIS software like IDRISI, amongst others, where the overlay techniques allow the attribute map layers to be aggregated in order to determine the composite map layer using the WLC modules and procedure (Eastman 1997; TYDAC Research Inc, 1997). ESRI (1995) and Chrisman (1996) stated that these methods can be implemented in both raster and vector GIS environment. Thus, the watershed was generated and reclassified, each value according to the weight of suitability (Table 2).

Table 2: Watershed Preference and Reclassification

S/N	WATERSHED	PREFERENCE VALUE	REMARK
1	200-300	1	Not Suitable
2	300-400	2	Low Suitable
3	400- 600	3	Moderately Suitable
4	600-800	3	Moderately Suitable
5	800-1000	4	Suitable
6	1000- 1200	5	Highly Suitable

Source: Fieldwork, 2022

The Landsat-7 image was classified into 5 land cover classes and each class was given a value according to the preference for establishing a reservoir. In addition, a Boolean classification was done to exclude reservoir site on settlements, roads, and water body. Table 3 shows the classes and preference value of the land use/ land cover types.

Table 3: Classes and Preference Value of the Landcover

S/N	LANDCOVER	PREFERENCE VALUE	REMARK
1	Water body	4	Highly Suitable
2	Built-up area	3	Suitable
3	Farmland	2	Moderately Suitable
4	Bushes/Forest	1	Low Suitable
5	Open space	0	Not Suitable

Source: Fieldwork, 2022

The soil properties data used was derived from an image of ISRIC-WISE global dataset showing dominant soil in Nigeria of 2013. The soil data shows that the University is composed mostly by aerosols. An aerosol is a clay-rich type of soil as classified by the Food and Agriculture Organization (FAO, 1993). It is associated with humid, tropical climates, such as those found in Brazil, and often supports forested areas. The aerosol contains low fertility and toxic amounts of aluminum that poses limitations to its agricultural use (favouring in many places). The precipitation data of Awka from 2011 to 2017 was acquired from Nigeria Meteorological Agency (NIMET, 2020). The data shows that the predicted average precipitation for the University from 2011 to 2017 ranges from 200mm to 600mm. The geological data used in this study was acquired from the National Geohazards Monitoring Agency Awka, Anambra State, Nigeria. The data shows that the University is completely covered with a particular type of layer called the Imo shale. All the data were reclassified and pairwise comparison carried out to determine the suitable sites.

RESULTS AND ANALYSIS

Development of the Pairwise Comparison Matrix

In order to ensure that each criterion was evaluated on the basis of its relative importance, variable numeric range for the various criteria was used. The pairwise comparison method proposed by Saaty (1980) was used to assign weights to each criterion based on the analytical hierarchy process (AHP). The method uses a ratio matrix to compare one criterion with another. The matrix of pairwise comparisons represents the intensities of the expert's preference between individual pairs of criteria. They are usually chosen according to a given scale ranging from 1 to 9 for a given 'n' number of criteria, where 1 represents criterion of equal importance and 9 represents a criterion with extreme importance compared to the other.

Table 4: Scale for Pairwise Comparison

INTENSITY OF IMPORTANCE	DEFINITION
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance

7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

Source: Adapted from Saaty, (1980)

Experts and decision makers were consulted to fill in the comparison matrix. Using the procedure described by Malczewski (1999), the weights for the three criteria were determined as shown in Table 4. The judgment table (comparison matrix) was represented by a 3 x 3 matrix and then multiplied by itself to obtain eigenvectors. Suppose that slope is extremely important over the landcover attribute; that is the comparison result in a value of 9. Furthermore, suppose that slope is moderately important preferred to Drainage Network, this is a numerical score of 3. Finally, consider the only other pairwise comparison, which is the land cover attribute compared to Watershed and suppose that the latter is strongly preferred to the former, a score of 5. These scores are places in the upper right corner of the pairwise comparison matrix shown in Table 5.

Table 5: Pairwise Comparison of the Evaluation Criteria

CRITERION	SLOPE	LAND COVER	WATERSHED
Slope	1	9	3
Landcover	1/9	1	1/5
Watershed	1/3	5	1
Total	1.4444	15.0000	4.2000

Source: Fieldwork, 2022

Computation of the Criterion Weights

This procedure involves the following operations:

a) Sum the values in each column of the pairwise comparison matrix
b) Divide each element in the matrix by its column total (the resulting matrix is referred to as the normalized pairwise comparison matrix), and
c) Compute the average of the elements in each row of the normalized matrix, i.e., divide the sum of normalized scores for each row by 3 (the number of criteria). These averages provide an estimate of the relative weights of the criteria being compared. Using this method, the weights are interpreted as the average of all possible ways of comparing the criteria. These criterion weights are 0.67, 0.06, and 0.27 for slope, land cover, and watershed respectively (Table 6). This means that slope is the most important criterion, followed by watershed and landcover.

Table 6: Relative Weight of Criteria

	SLOPE	LAND COVER	WATERSHED	RELATIVE WEIGHT
Slope	0.6923	0.6000	0.7143	0.6689
Landcover	0.0769	0.0667	0.0476	0.0637
Watershed	0.2308	0.3333	0.2381	0.2674

Source: Fieldwork, 2022

Estimation of the Constituency Ratio

The value of pairwise comparison relies on subjective judgment which might lead to arbitrary result, and thus could be a bias. A numerical index called consistency ratio (CR) is used for evaluating the consistency of pairwise comparison matrix following the proposal in AHP (Saaty, 1977; Saaty, 1990; Saaty, 2008). The index indicates the ratio of the consistency index (CI) to the average consistency index, which is also called Random Index (RI).

CR = Consistency index (CI)/Random Consistency Index (RI) … Equation (1)

The value of Random Consistency Index (RI) can be found in the Table 7, prepared along with the proposal of AHP, according to number of criteria involved as shown.

Table 7: Random Consistency Index

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The value of Consistency index, CI can be calculated from the preference matrix according to equation 2

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

• $\boldsymbol{\lambda max}$ is the Principal Eigen Value; ***n*** is the number of factors

• λmax = Σ of the products between each element of the priority vector or relative weights and column totals.

λmax = (1.44*0.67) + (15*0.06) + (4.20*0.27) = 3.0445

• CI = (3.0445 – 3)/3-1 CI = 0.0445/2 CI = 0.0222

• CR = 0.0222/0.58 **CR = 0.04 < 0.10 (Acceptable)**

The consistency ratio (CR) is designed in such a way that if CR<0.10, the ratio indicates a reasonable level of consistency in the pairwise comparisons; if, however, CR ≥ 0.10, the values of the ratio are indicative of inconsistent judgments. From the judgment a Consistency Ratio (CR) of 0.04 was achieved which was less than the maximum allowable ratio of 0.10.

Suitability Calculation

The weighted linear combination (*WLC*) model has become popular in recent years and for this study, WLC method was preferred over simple Boolean method. The Boolean method has limitations which include lack of flexibility in standardization process. Another limitation of the simple Boolean approach is that all factors had equal importance in the final suitability map. However, in reality, this is not likely to be the case. Some criteria may not be very important in determining the overall suitability for a given area while others may be of only marginal importance. Site suitability was calculated using raster calculator in ArcGIS 10.5. The criteria were standardized to a continuous scale of suitability from the least to the most suitable, thus giving flexibility in the site selection (Malczewski 2000; Massam, 1988; Pereira & Duckstein, 1993).

The weighted linear combination equation is given as:

$$S = \Sigma wixi \times \Pi cj \qquad \text{… Equation (3)}$$

Where: S – is the composite suitability score; *xi* – factor scores (cells); *wi* – Weights assigned to each factor; *cj* – Constraints (or Boolean factors); Σ -- Sum of weighted factors; Π -- Product of constraints (1-suitable, 0-unsuitable)

The constraint layers need to be standardized to a continuous scale of suitability from 0 (the least suitable) to 255 (the most suitable) (*Eastman, 1997*). Therefore, all the constraints in the criteria (Table 5) were standardized and re-scaled into 0 to 255 from the least suitable to the most suitable areas. The constraint was then reclassified assigning 1 to suitable areas and 0 to unsuitable areas. Example is shown in Figure 6.

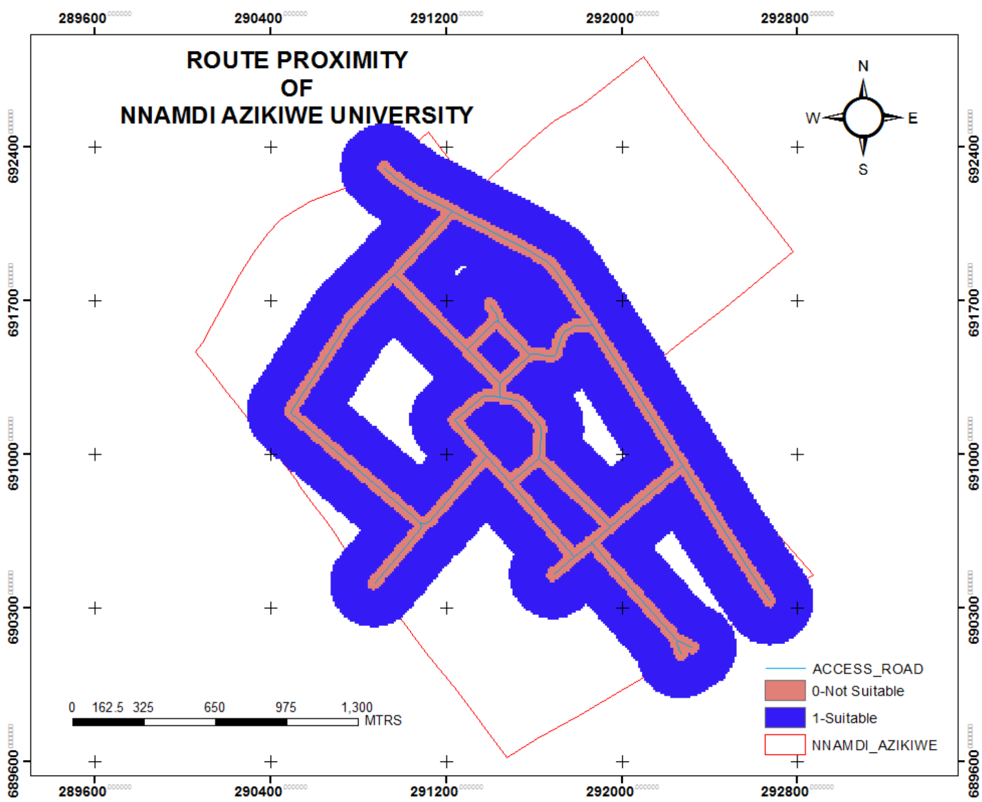

Figure 6: Constraint Map Showing Proximity to Road

Source: Fieldwork, 2022

The procedure in the WLC requires that the principal eigenvector of the pair-wise comparison matrix be computed to produce the best-fit set of weights. Subsequently, the best acceptable fit of the respective weights is used in the Multi-Criteria Evaluation function (*MCE*) to calculate the weighted linear combination (*WLC*) using the constrains in the criteria. Subsequently, the acceptable best fit of the respective weights was used in the Multi Criteria Evaluation function (*MCE*) to calculate the weighted linear combination (*WLC*) using the factors (slope, watershed, and land cover) and constraints (proximity, and open space) images. RECLASS functions of ArcGIS were used. The outputs represent potential sites with the highest suitability for reservoirs shown in Figure 7.

Applying it in GIS raster calculator S = ((F1 * 0.67) + (F2 * 0.06) + (F3 * 0.27)) * cons_boolean
Note: F1, F2, F3 & cons_boolean are thematic layers representing the factors & constraints.

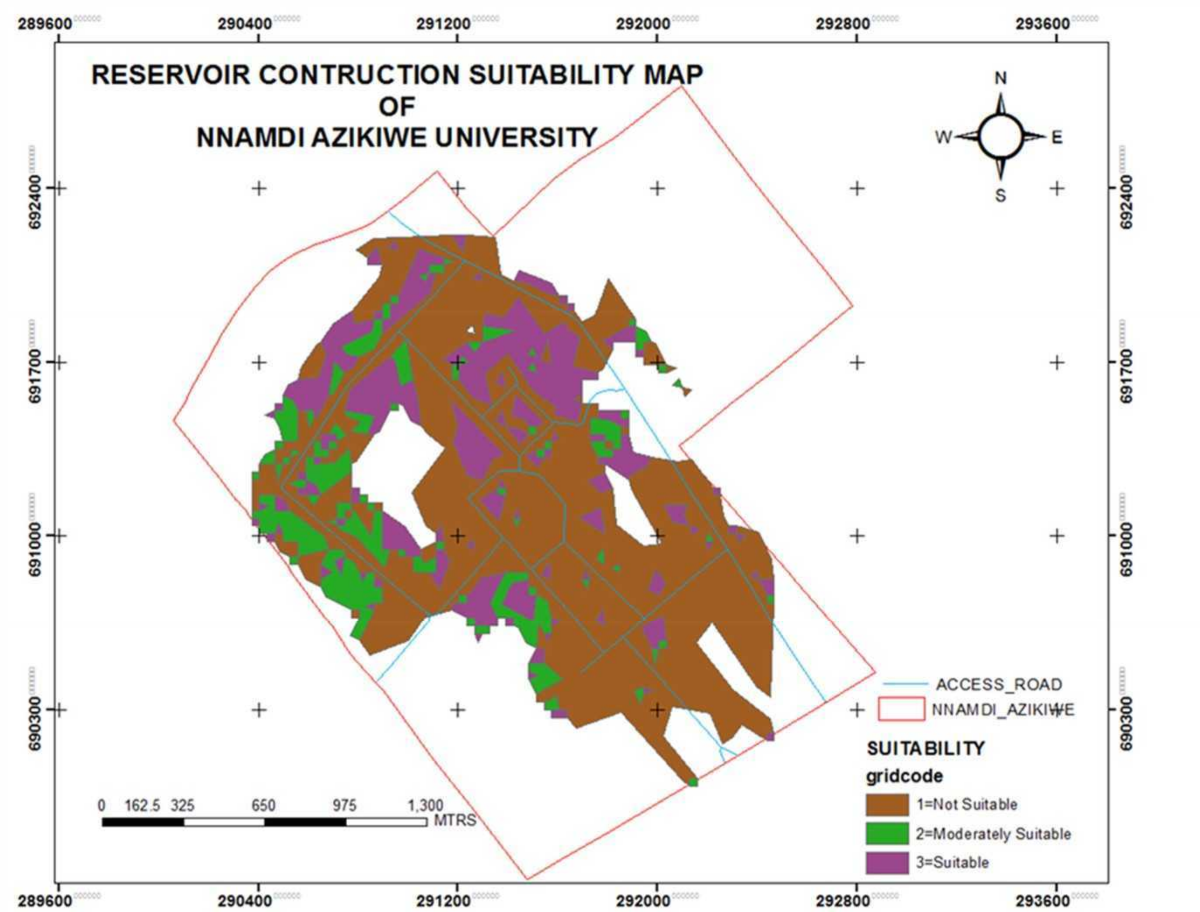

Figure 7: Reservoir suitability map

Source: Fieldwork, 2022

Selecting the Possible Optimal Reservoir Site

In order to determine the best or optimal site for the construction of the reservoir, further constraints were used. There were 71 highly suitable areas from the suitability map shown in Figure 7, but an area of about 3hectares and above is needed. Therefore, further analysis was carried out. Areas equal to or above 3 hectares were selected, with distance to farmlands not to be greater than 500m and holds water of about 500gallons (Figure 8). Field survey and verification were carried out to precisely determine the volume of water and the reality of the findings. Equipment's used for the field survey are the Level, levelling staff, tape, stop watch and cutlass. The Float Method was used to measure the Flow rate of streams which is used to determine the volume. The data collected was uploaded to the ArcGIS and used as constraints in order to determine optimal sites for reservoir establishment. Query of the site that can contain about 500 gallons and close to farmland was carried out and shown in Figure 9.

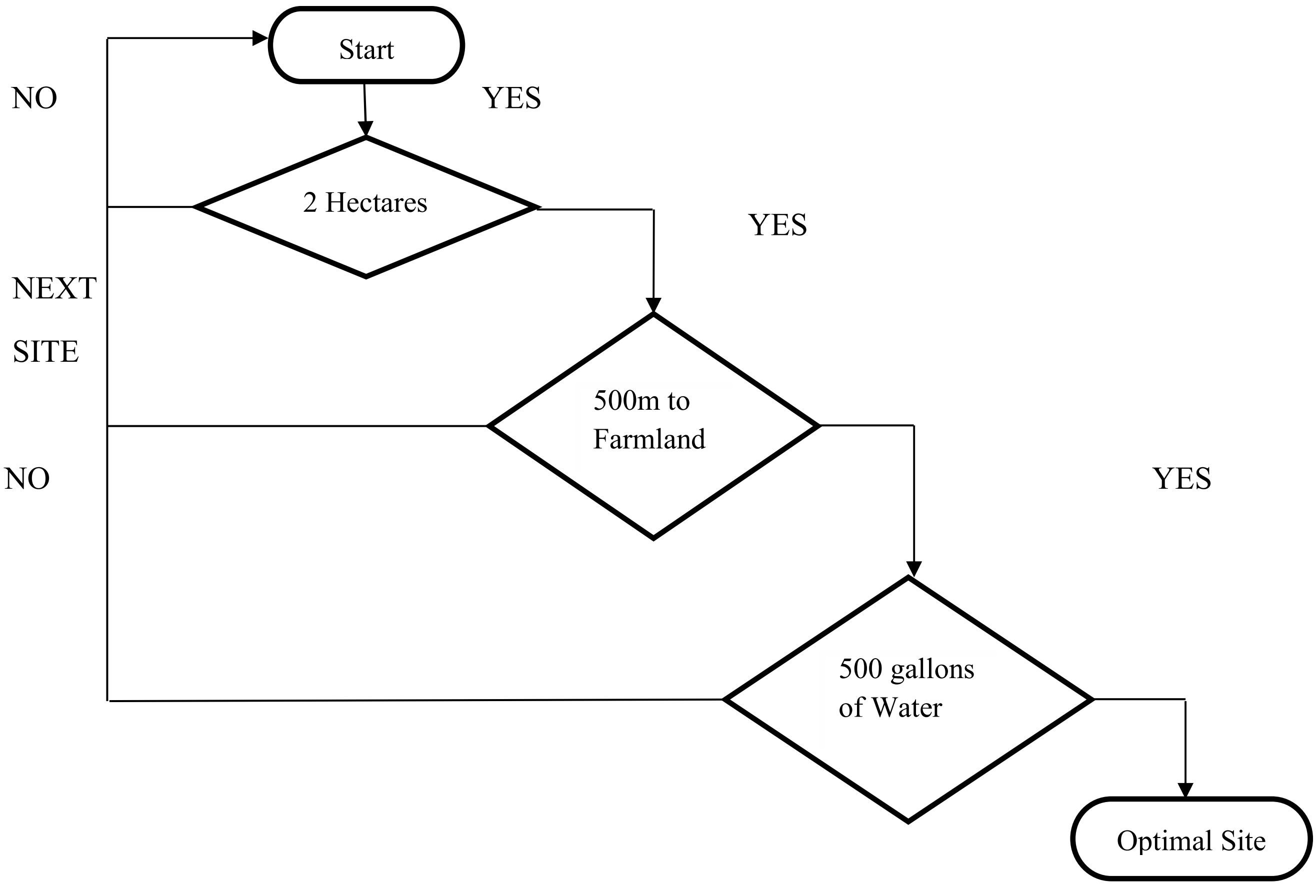

Figure 8: Flowchart for Generating Optimal Reservoir Site

Source: Fieldwork, 2022

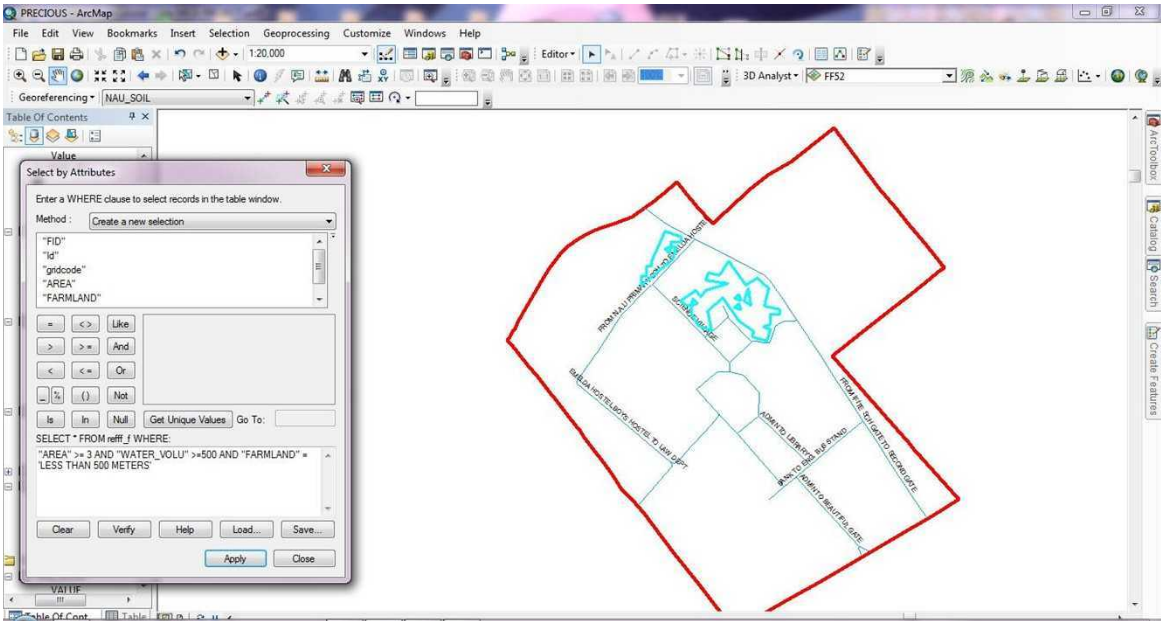

Figure 9: Showing query of suitable reservoir sites in Nnamdi Azikiwe University

Source: Fieldwork, 2022

The final suitability map is shown in Figure 10. Two areas met the criteria for establishment of the reservoir in the University.

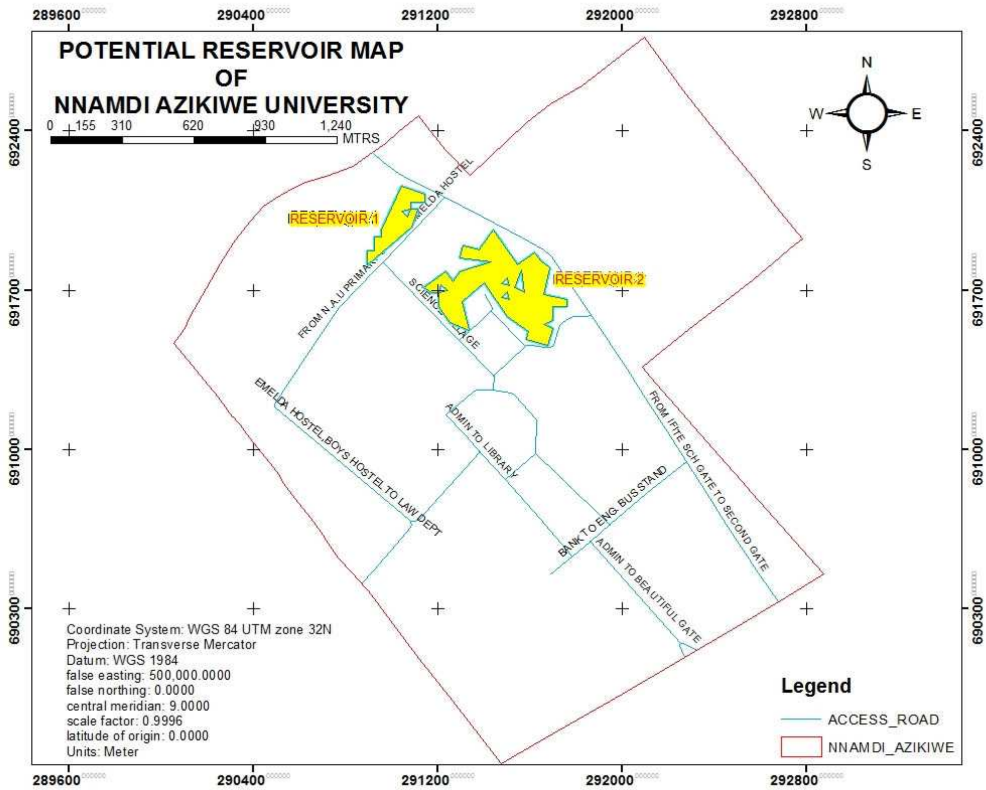

Figure 10: Potential reservoir site of Nnamdi Azikiwe University

Source: Fieldwork, 2022

CONCLUSION AND RECOMMENDATIONS

Reservoir site selection is a spatial problem. Spatial decision problems typically involve a large set of feasible alternatives. GIS and remote sensing are useful tools for generating, manipulating and handling relevant data, leading eventually to identifying a number of optimum sites for locating reservoir and ultimately providing options and, assisting with the planning process and decision making.

This study focused on the application of multi criteria evaluation in reservoir sites selection with the aim to locate potential reservoir site through the application of remote sensing, GIS techniques and expertise judgment. The outcome of the potential sites has satisfied all the constraints in the criteria. The reservoir sites selected were outside the settlement zone, on a gentle slope, have a water accumulation area and close to the road for accessibility. Optimizing the number of criteria and alternatives, standardization of criterion scores and making suitability map for each criterion allows for each criterion to be perceived separately and together through final suitability map. The large number of possible sites (71 potential sites) was resolved through evaluation and decisions made by the expert. The developed model by the expertise allows for reservoir site selection through GIS and MCEM. It is however important to realize that GIS analysis is not a substitute for field analysis. Therefore, field verification and validation of reality was done. This does identify areas that are more suitable, and directs efforts to these areas rather than areas that are unsuitable or restricted by regulations or constraints. In this way, there is increased efficiency and quality in optimally selecting the best potential reservoir sites. This work could be taken further by conducting field validation in order to compare and technically evaluate the potential sites in terms of their environmental impact assessment, from which the sites will undergo further geotechnical and hydro-geological detailed investigations.

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