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Finding an Alternate Access Route from Ikire to Gbongan, Osun State, Nigeria using Geospatial Techniques

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Abstract
This paper describes Geospatial techniques to select suitable right of way and demonstrate the use of remotely sensed imagery for selecting the least cost and practically feasible alternative route in a way that reduce the cost of construction, time and effort in the field and Environmental hazard that may occurs as a result of the constructional activities. The analysis has taken Land Use / Land Cover and Slope as a determining factor in order to find appropriate path for road construction using the cost distance approach. The selected route pass through areas of low elevation and gentle slopes which is good for the construction of roads to minimize cost and time. The route avoids areas of high elevation and steep slopes, also comparing with the land use land cover it avoids regions of outcrops and dense vegetation.

Key Words: *Environmental, Geospatial, Imagery, Land Cover, Land Use.*

1. Introduction

Geographic Information System (GIS) lets us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends. (ESRI). Identification of the most appropriate and practical location of highway routes is a complicated procedure encompassing engineering factors, economic, socio-environmental and in some cases political factors [1]. The search for optimal locations is a classical problem in the GIS domain. GIS has played a large role in the siting of facilities for spatial decision making [2-4] and widely used by researchers for integration of thematic layers like land use, soil, geomorphology generated from satellite imagery. The integrated layer is useful for identifying suitable locations for construction of roads, railway lines, pipe lines and transmission lines which indicates the cost surface [5-6].In urban planning, Roadways network analysis plays an important role to make better decisions. A Geospatial technology can be used to monitor transport network, conditions of a network, shortest or best route to reach destination and closest services. The benefit of GIS is not only user-friendly access and display, but provides spatial analysis which can be used to identify more data and discover new relationships. Using traditional approaches, it is difficult to incorporate all constraints cumulatively [7-9]. The advent of GIS and its Geo processing capability has proved to be vital to integrate and examine all the parameters suitable for analysis at once [10-11] so as to arrive to a decision of suitable highway locations. Three factors that can influence the choice of practical highway selection considered in this paper include: Slope or gradient, Geology, Lineament and land use land cover. These factors were extracted form remotely sensed image (Advanced space born thermal emission and reflection Radiometer (ASTER), and Land sat 8) and other spatial data sources.

This paper describes Geospatial techniques to select suitable right of way and demonstrate the use of remotely sensed imagery for selecting the least cost and practically feasible alternative route in a way that reduce the cost of construction, time and effort in the field and Environmental hazard that may occurs as a result of the constructional activities by taking into cognizance Engineering and Environmental factors.

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2. Study Area

The study area is located in Osun State and covers two Local Government Areas (LGAs), namely Irewole and Ayedaade Local Government area (Figure 1). It can be closely mapped to latitude ranging from 7° 22' 00" to 7° 30' 0" and longitude 4° 11' 0'' to 4° 22' 0" with an average elevation of about 285m above mean sea level, covering an area of 533,457,249.36 hectares (271310728.643 sq.m)

3. Materials, Methods and Analysis

To achieve the objectives in this research work, Aster GDEM image, Land sat 8 image, Geological map and Google Earth image were used to perform the spatial analysis:

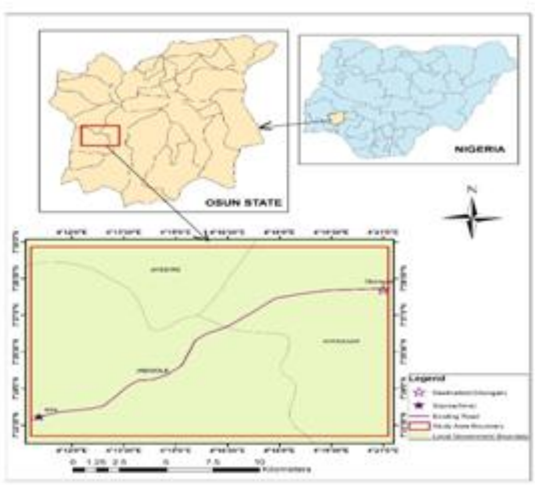

Figure 1: The study area map

Table 1: Data source

Data	Source	Year	Resolution	Relevance
ASTER GDEM	United States Geological Survey (USGS)	2018	30m	Extraction of slope and for elevation analysis.
Landsat 8 image	Global Land cover facilities (GLCF)	2018	30m	To extract land use / land cover and for Lineament analysis
Geological map	Nigeria Geological Survey	………..	1:50,000	For Lineament and analysis and interpretation
Topographic map	Nigeria Geological Survey	------------	1:10,000	To delineate Road network in the study area.
Google Earth image	Google Earth pro application	------------	----------	As a base map to interpret and validate Landsat image
GPS Coordinates	Field survey using Global positioning system	………….	………..	For source and Destination dataset

The source dataset which represent the starting point at Ikire and the destination dataset which represent the ending point at Gbongan were acquired through field survey and observation using Global Positioning System (GPS) and plotted with ArcGIS software. The Advanced Space Borne Thermal Emission and Reflection Radiometer (ASTER) GDEM was processed to extract the slope using the spatial Analysis module of ArcGIS 10.3 and Landsat 8 Imagery was used to delineate the Land use/ Land cover (LULC) types of the study area. The cost dataset which identifies the cost of traveling through each cell in the image was created using Reclassified slope and LULC in ArcGIS software with weighted overlay algorithm and weights were assigned in accordance with their expected influences (Table II).

The cost distance analysis was performed with the cost distance module of ArcGIS using the source and the cost dataset. The outputs from this tool is a distance dataset in which each cell contains a value representing the accumulated least cost of traveling from that cell to the source and a back link dataset that gives the direction of the least costly path from each cell back to the source.

The Cost Path tool in the distance toolset of the Spatial Analyst Tools toolbox in ArcGIS was used to derive the least cost path for the construction of new road. A destination layer representing Gbongan, cost distance layer and back link layer were used as input to generate a least cost path layer representing the route for construction of road at minimal cost that will link Gbongan and Ikire town. The result was initially in grid format before it was then converted to polyline using the conversion tool. The model builder tool of ArcGIS was used to model the steps in achieving the desired results; this gives a defined workflow of the project (Figure 2)

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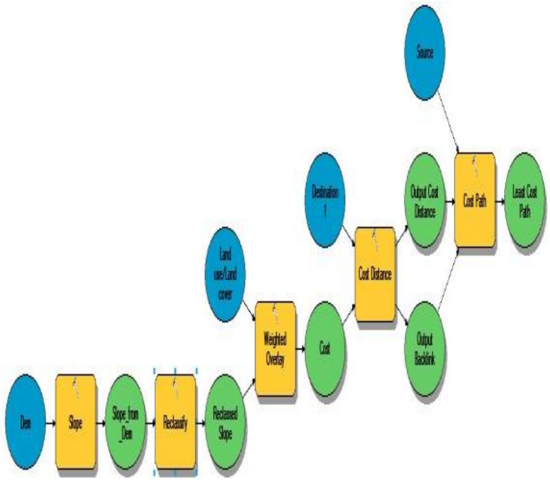

Figure 2: Model Showing the Work Flow

Slope

The slope data layer is an important criterion when analyzing the terrain especially for the selection of suitable right of way, this was used to describe the landscape and relief of land of the study area. It is the percentage change in elevation over a certain distance. Slope is measured by calculating the difference in the elevation from one point to another divided by the lateral distance between those points. Slope analysis is a very important factor to consider in road construction. This is done to reduce the construction cost, minimize risks from natural hazards such as flooding and landslides, and to minimize the impacts of proposed development on natural resources such as soils, vegetation and water systems.

Land use / Land cover

The Land sat 8 satellite image was processed to extract the land use / land cover data layer for the analysis. To derive accurate information from the imagery it was subjected to Radiometric and Geometric correction and classification was done using maximum likelihood classification Algorithm, 20 training samples were selected across the study area for each land cover type of Built up area, water body, outcrops, light vegetation and dense vegetation. Land cover classes such as rock out crops, large water bodies and dense vegetation will increase cost of construction as this might stand as obstructions that have to be removed either by blasting of the outcrops or clearing of the forests. These land cover classes that can obstruct the construction have to be avoided.

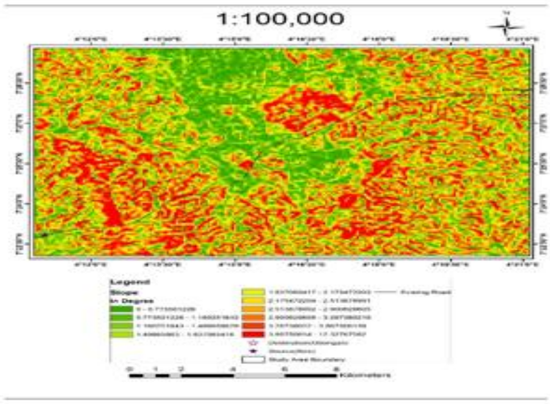

Figure 3: Slope Map of the study

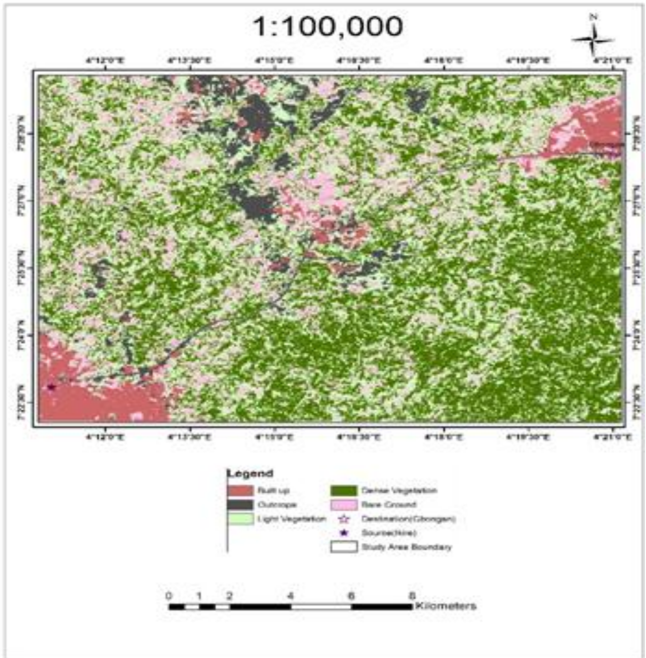

Figure 4: Land use/Land cover map

4. Results and Discussion

It is difficult to build a road on steep slopes, so, the slope of the area was calculated and analyzed so as to minimize the cost of construction and at the same time the effect of slope stress due to constructional activities that in the long run can cause increase shear stress and trigger landslide. It is preferable that the new road traverses less steep slopes. The slope was reclassified and the values were sliced into 10 using Quantile method of classification. The value of 10 was assigned the costliest slopes (those with the steepest angle of slope) and the value of 1 to the least costly slopes (those with the least angle of slope), and the values in between were ranked linearly. Figure 4 shows the reclassified slope while Table II shows the slope values and the assigned ranks.

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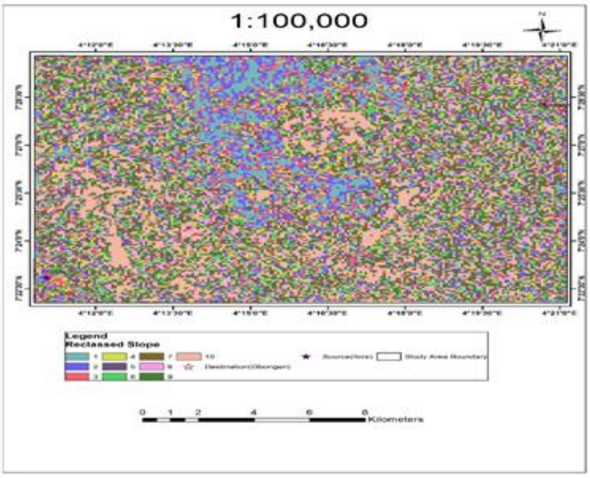


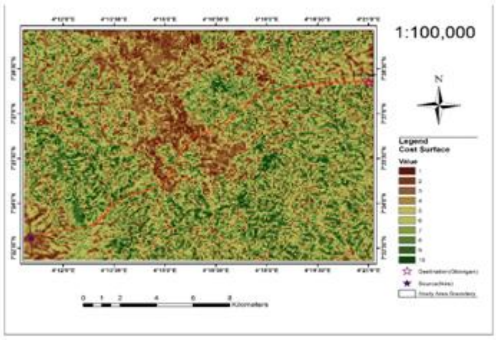
Figure 5: Reclassified slope map of the study area

Table 2: Results from Quantile classification and the assigned ranks

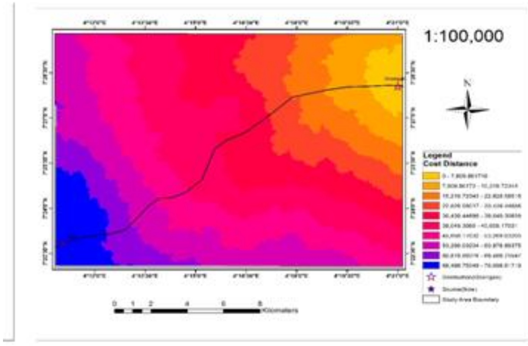
S/N	Slope Value	Rank	S/N	Slope Value	Rank
1	0 - 0.773501228	1	6	2.175472204 - 2.513878991	6
2	0.773501228 - 1.160251842	2	7	2.513878992 - 2.900629605	7
3	1.160251843 - 1.498658629	3	8	2.900629606 - 3.287380219	8
4	1.49865863 - 1.837065416	4	9	3.28738022 - 3.867506139	9
5	1.837065417 - 2.175472203	5	10	3.86750614 - 12.32767582	10

To minimize cost of construction, land cover/land use types were also considered. From the classified Land sat 8 image five land cover classes were identified: Built up, Bare Ground, Outcrops, Low vegetation and dense vegetation. Also scale values were assigned to each land cover classes based on their suitability as they affect the cost of road construction. Following are the scale values assigned to the land cover types: Built up—9, Outcrops—7, Low vegetation—2, Dense Vegetation—10, Bare Ground—1

To verify the authenticity of the result, the polyline representing the route for the road construction was overlaid on the hill shade which represent the relief of the study area. It was found that the selected route pass through areas of low elevation and gentle slopes which is good for the construction of roads to minimize cost and time. The route avoids areas of high elevation and steep slopes, also comparing with the land use land cover it avoids regions of outcrops and dense vegetation.



(a)



(b)

Figure 6.a: Cost Surface map, b: Cost Distance map

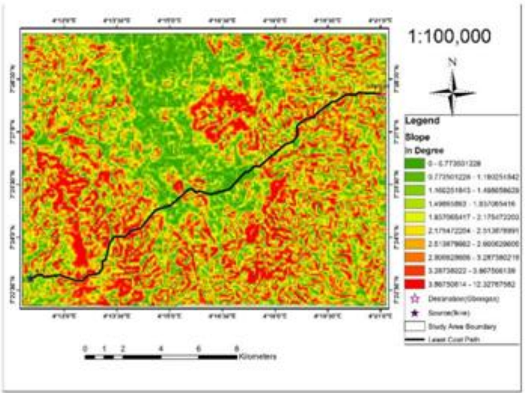
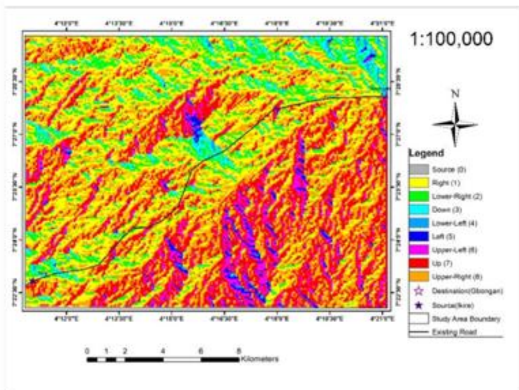


Figure 7: New Route on Slope



(a)

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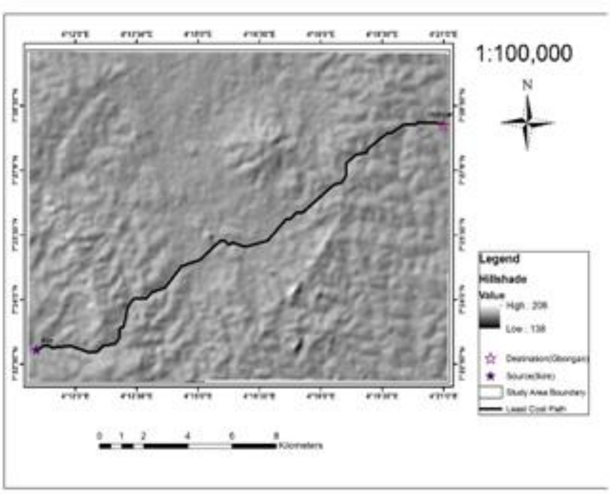
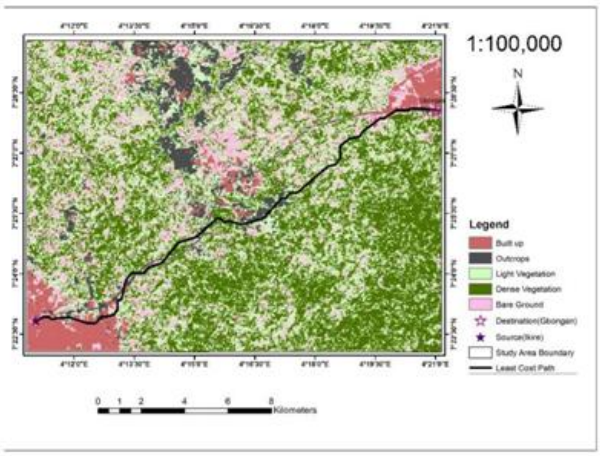


(b)



(c)
Figure 8: a) Cost Direction map b) New Route on Shaded Relief c) New Route on land use land cover

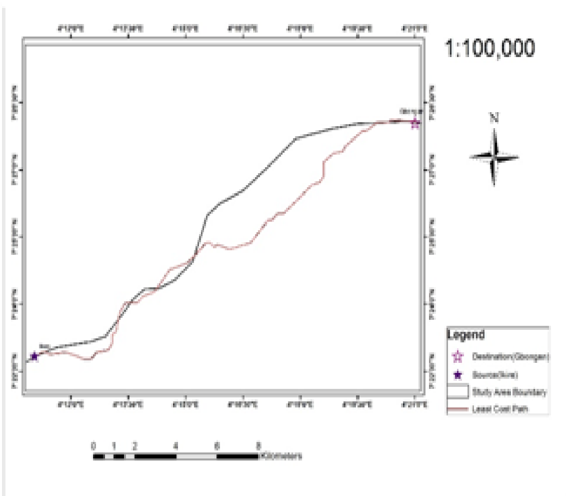


Figure 9: New Route

5. Conclusion and Recommendation

The findings have shown the ability of GIS and remote sensing as a veritable tool for analysing the criteria for decision support. The analysis has taken land use Land Cover and Slope as a determining factor in order to find appropriate path for road constructing using the cost distance approach. The selected route pass through areas of low elevation and gentle slopes which is good for the construction of roads to minimize cost and time. The route avoids areas of high elevation and steep slopes, also comparing with the land use land cover it avoids regions of outcrops and dense vegetation.

Recommendation is offered to government and other bodies in favorable position to push the idea for the actual construction of road along the selected route to link Gbongan and Ikire. The availability of this road will mean lower cost in terms of finance and time of journeying from one of the towns to the other and serve as alternative Route to Ever Busy Existing route in the study area. This will improve the relationship and communication between the two towns.

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