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Development of digital elevation model for Okomu National Park, Nigeria

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ABSTRACT

The type of soil, fauna and flora species that are found in an environment is affected by the elevation characteristics of the land. However, the ability to provide techniques and model that will effectively explain the elevation patterns of protected areas will aid sustainable management of the forest and its resources. This study developed Digital Elevation Model (DEM) for Okomu National Park, Nigeria. Point coordinates (2,272) with their respective elevations were randomly obtained covering the entire study area. Interpolated natural neighbour algorithm of the Quantum Geographic Information System was used to generate Digital Elevation Model for the National Park from the elevation data. Topographic map was extracted from the DEM at an interval of 10 m from one another. It was observed that the elevation in the study area ranged from 19 m to 105 m with an average of 56.32 m above sea level. Hence, the parkland is regarded as a gentle slope. This study revealed that the study area is not prone to flood or runoff due to its gentle slope nature. Therefore, this study is recommended as baseline information for ecological management as well as guide in the development of conservation strategies for flora and fauna species in the study area.

Keywords: Coordinates; Environment; Elevation; Forestry; Geographic information system; Global positioning system; Wildlife.

1. INTRODUCTION

Digital elevation models (DEMs) are computerized way of representing the Earths relief [1]. In a broader sense, DEMs can generally be described as spatially geo-referenced elevation data set that aids the encoding and representations of ground surface topography or terrain for environmental modeling purposes [2, 3]. They are also directly compatible with remotely sensed data sources; making it possible to represent intricate terrain units [2]. However, DEMs can also be used alongside other spatial data in geographic information systems (GIS) for advanced analysis [1].

In recent years, the used and application of DEM is on the increase as a tool and product. However, it provides applicable data in diverse areas such as; topographic and land cover studies, geomorphology, biology, hydrology, reservoir-management etc. [3-5]. Modeling relief has become essential in environmental research [4], especially with the increase in floods, droughts, soil erosion and other environmental effects of climate change. Digital elevation model aids better understanding and visualization of landscape and its relationships.

However, DEM provides avenue for quantification of several physical relief features such as water and erosion volumes. Thus, DEM also provides data for statistical and/or empirical modelling [1].

Furthermore, it is necessary to employ DEM as a managerial tool in the field of forestry, wildlife and ecotourism management as it will help in visualizing the fundamental relationship between altitudes and soil characteristics that enable the survival of flora and fauna on it. For instance; at higher altitude more acidic and humus soils exist in the montane or subalpine levels [6], while lower elevations exhibit fewer terrestrial species due to the thick layer of dead fallen leaves covering the forest floor in the tropical rain forest regions [7, 8]. Similarly, air temperature decreases with increase in elevation, thus influence variations in the length of a growing season at altitudes [7, 8]. Soil temperature and moisture, rate of evapotranspiration, humidity and precipitation are also related to altitude; optimum growth of a plant can be achieved by determining its suitable altitude range [6, 8, 9]. This also influences the type of fauna species that will be found in the environment. However, detail information on the relief and DEM, which helps in understanding land cover of the study area and for further spatial analysis [3] was lacking. Therefore, this study aims at developing DEM for Okomu National Park of Nigeria to providing baseline information and tool for ecological and sustainable forest management.

2. MATERIALS AND METHODS

2.1. Study area

The study was carried out in Okomu National Park formally known as Okomu Sanctuary is forest block within the 1,082 km^2 Okomu Forest Reserve located in Ovia South-west Local Government Area of Edo State, Nigeria. The park is 45 km west of Benin City with aland area of about 181 km^2 [10]. It lies between latitude 6°14'57.55" N and 6°24'55.64" N and longitudes 5°09'28.09" E and 5°20'15.51" E. The park contains the last remaining low rain forest ecosystem in southwestern Nigeria, with annual rainfall between 1524 and 2540 mm. Endowed with a complex assemblage of flora and fauna species [11]. The vegetation is semi-deciduous forest. The park has four ranges which are; Julius, Iguowan, Arakwan and Babui creeks [12].

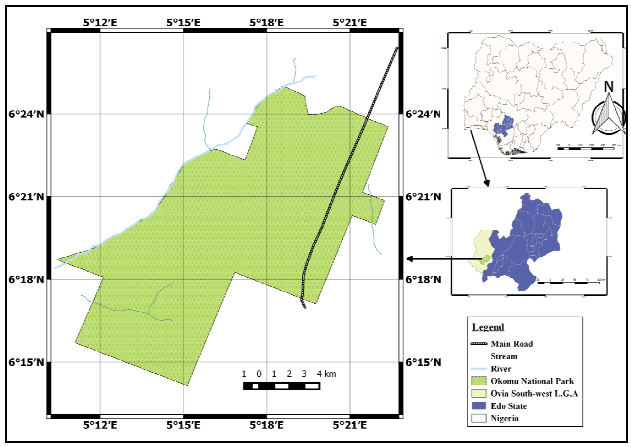

Figure 1. Map of Okomu National Park, Nigeria.

2.2. Data collection and analysis

Geographic Position System (GPS) was used to obtain point coordinates and elevations at various locations across the study area. A total of 2,272 points coordinates with respective elevation were obtained. The coordinates and elevations were saved in text (tab delimited) file format in Microsoft Excel spread sheet. Hence, was loaded into Quantum Geographic Information System (QGIS) for further analysis. The algorithm used includes interpolated natural neighbourof SAGA 2.1.2 geoalgorithm in QGIS to generate Digital Elevation Model for the National Park as was done by [3]. The Coordinate Reference System (CRS) was WGS84. The contour lines were extracted from DEM at aninterval of 10 m from one another.

3. RESULTS

The summary of statistics of the data collected in Okomu National Park was presented in Table 1. The coordinates ranged from latitude 6°14'57.55" N to 6°24'55.64" N and longitude 5°09'28.09" E to 5°20'15.51" E with elevation ranging from 19 to 105 m above sea level (asl). A total of 2,272 points coordinates with the corresponding elevation were obtained across various locations within the National Park. The GPS accuracy mean of 9 m and standard deviation of 3.961 was obtained for the data used for this

study. The graphical distribution (pie chart) of the elevation points used for development of the digital elevation model (DEM) was presented in Figure 2. The chart showed that 41% of elevation points (930) obtained from the study ranged from 30 m to 50 m asl. Elevation range of 50 to 70 m asl and 70 to 90 m asl accounted for about 24% and 23% respectively. Only about 4% (97) elevation points were less than 30 m asl. The mean elevation in is approximately 56.32 m asl.

Table 1. Summary of statistics of the spatial data for Okomu National Park.

Variables	Np	Mean (m)	SE	SD	Min	Max
Elevation (m)	2272	56.323	0.435	20.749	19	105
Accuracy (m)	2272	9	0.083	3.961	3	21
Latitude (N)	2272				6°14'57.55"	6°24'55.64"
Longitude (E)	2272				5°09'28.09"	5°20'15.51"

Where; Np = number of points, SE= Standard error, SD= Standard deviation, Root mean square, Min= minimum and Max = maximum, N= North, E = East. All coordinates are in degree minute second (DMS).

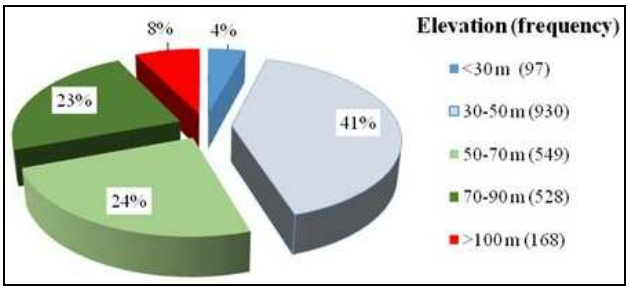

Figure 2. Distribution of elevation in Okomu National Park.

The digital elevation model and topographic map for the study area are showed in Figures 3 and 4 respectively. The colour graduated from blue (about 19 m asl) at the southern part of the national park to red (about 105 m asl) in the northern part. At the center, the colour interphase between red and blue with an elevation of about 60 m asl.

4. DISCUSSION

The descriptive statistics revealed that the average altitude of the park is about 56.32 m asl. This result is in disagreement with the work of Ejidike and Okosodo [11] that reported the average elevation of ONP was about 75 m. The elevation of Okomu National Park ranged from 19 m to 105 m (asl). This result was also incongruent with the reports of Aremu et al. [13], that the topography of ONP is gently ranging between 30 and 60 m asl and Akinsorotan et al. [14] who also reported the area to be within 300 meters asl. However, no research has been reported to obtain up to 2,272 points coordinates and elevation values in the study area. Hence, some parts of the National Park might not be effectively covered in the earlier research carried out by these researchers. Therefore, this study presents more reliable baseline information than earlier presented [11, 13, 14] because of the numbers of data used in this study.

Consequently, the effortwas directed towards obtaining Digital Elevation Model that will best describe the structure and/or nature of elevations of the sturdy area with a pattern of their distribution. Figure 2 reveals that only little portion on the park (8%) have elevation >90 m. This observation was confirmed by the DEM and topographic map (Figures 2 and 3, respectively), with only little portion around the northeastern part of the National park represented by the red colour.

The DEM revealed that greater percentage of the park land area has low altitude (between 30 to 90 m), this indicates that the forest land has gentle slope. This gentle slope helps in preventing runoff thereby retaining the soil organic matter and nutrient at the same time, prevent flooding since the land area is graduated from the south (30 m asl) to the north (100 m asl) (Figure 4). This result was in conformity with the report of Cobbina et al. [15] that assessed high conservation values in parts of Okomu's Extension I Concession and concluded that topographically, the Okomu landscape is

consistently flat and gently undulating throughout, with no steep slopes. Hence, the DEM displayed ONP land as one with less effect of soil erosion as a result of its plain landscape nature. This was also in agreement with work of Cobbina et al. [15], who affirmed that the risk of critical soil erosion in and around the Okomu National Park appears low as a result of the areas' low-lying topography.

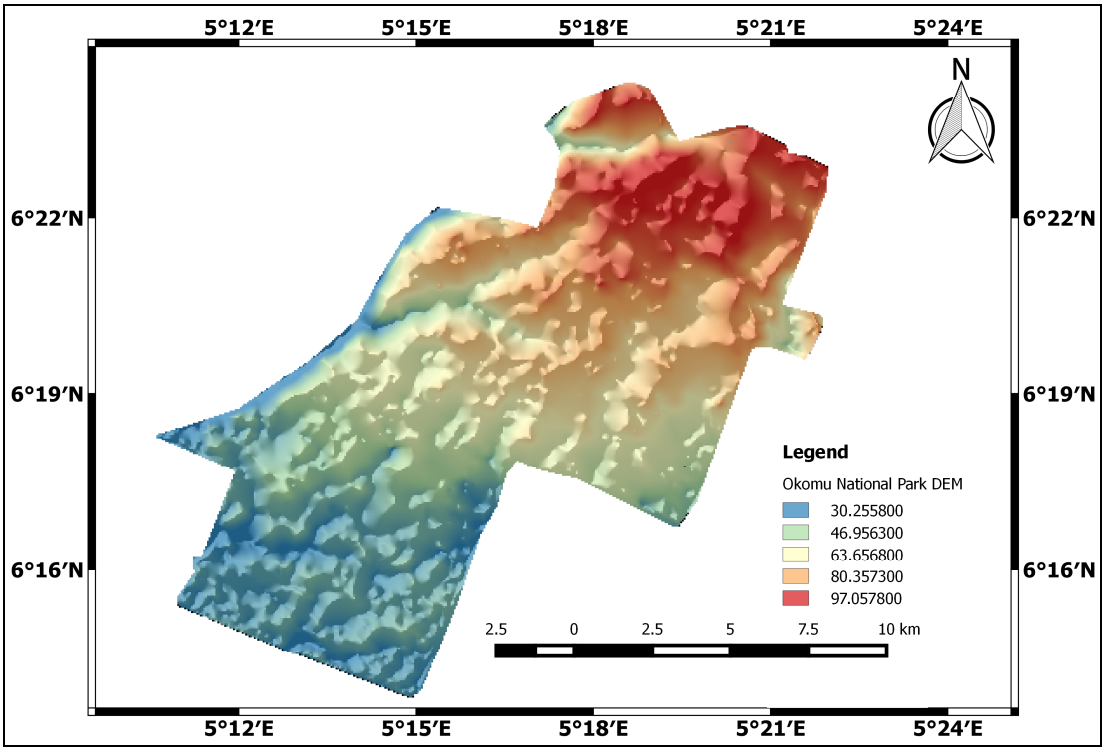

Figure 3. Digital Elevation Model of Okomu National Park.

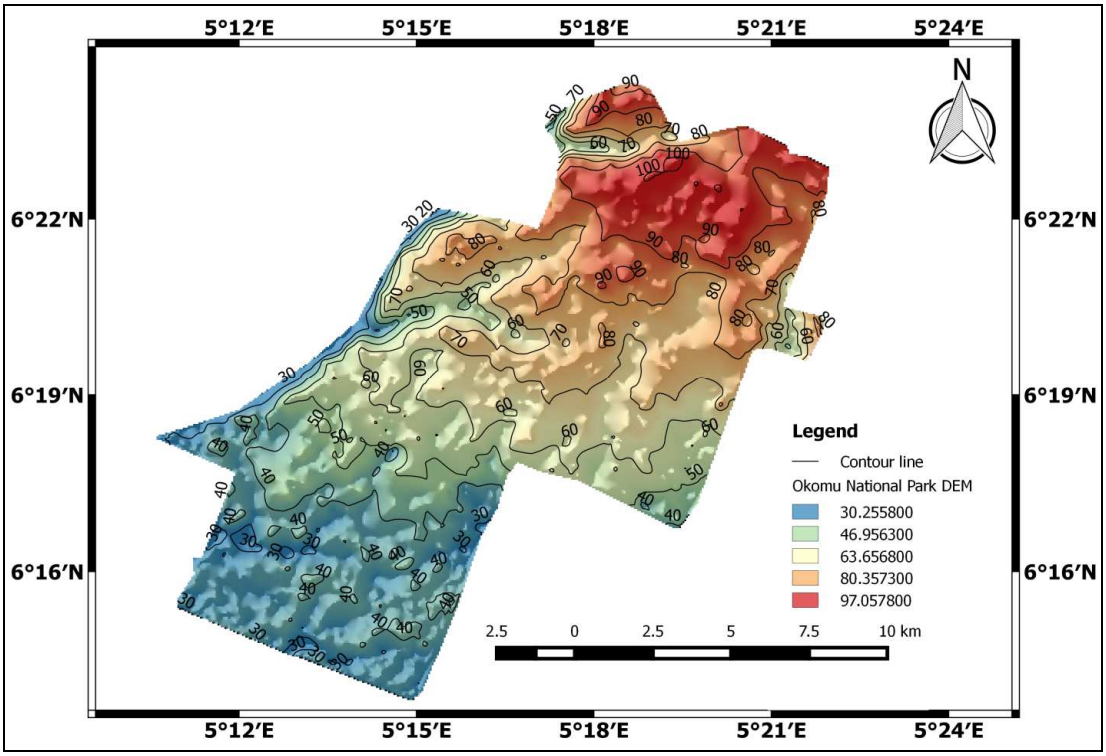

Figure 4. Contour lines of Okomu National Park on Digital Elevation Model.

Furthermore, altitudinal gradients change influences soil organic matter by controlling soil erosion, geologic deposition processes, soil water balance, species and biomass production of the native vegetation and cultivated plants [16]. However, Okomu National Park's high species richness and abundance [13], classification as an important bird area [17] and reference as habitat for numerous endangered flora and fauna species [18], might be attributed to high percentage of low altitudes in the National park. Similar result was reported by Heidari et al. [19], that evaluated herbaceous plant biodiversity in relation to physiographic factors (altitude, slope and aspect) in a protected area DalabIlam, they conclu-ded that, altitude have significant impact on the diversity and richness of herbaceous species. Karami et al. [20], Pourbabaei and Ahani [21] affirmed that diversity of plant species will decrease with increasing altitude. Additionally, the western part (border) of ONP is characterized with blue colour DEM (Figure 3) and low elevation contour (30 m asl) in Figure 4 due to the presence of Okomu river. The topographic map has towards the southwestern part of the national park has elevation ranged between 30 m asl to 40 m asl all through. This is suggesting that there is presence of river which could influence the altitude greatly. This has earlier been explained that River Okomu is responsible for this low altitude. The contour lines of the topographic map were extracted at interval of 10 m to accommodate differences in elevation of the study area unlike the topographic map of some large area of land produced by geographers which with larger interval. Extraction of ONP from such topographic map will always preclude detail of the study area. Therefore, the problem of over reliance on generalised for the development of topographic map for specific study and smaller the study area has been solved [3].

5. CONCLUSIONS

Digital Elevation Model was developed for Okomu National Park, Nigeria using geographic information system. The average elevation of the study area is 56.32 m asl. The digital elevation model could be used as a tool and/or baseline information for decision making as well as for design and implementation of habitat and ecotourism needs, conservation strategies and sustainable forest and ecological management.

This study has produced a detailed topographic map specifically for the study area, unlike generalized maps produced in most countries with no specific attention to National Parks and forest reserves.

This study therefore, provided baseline information on the relief of Okomu National Park, Nigeria. Hence, the park is not prone to flood or runoff because of the gentle nature of the slope in study area. Therefore, the DEM is recommended as tool for ecological management as well as guide in the development of conservation strategies for flora and fauna species in the study area. Similar study is recommended for other national parks.

AUTHORS' CONTRIBUTION

OC and JUE: data collection, interpretation of data, writing manuscript, material support and review of manuscript. OC and AAA: development of methodology, data analysis and development of DEM. The final manuscript has been read and approved by all authors.

TRANSPARENCY DECLARATION

The authors declare that there is no conflict of interests.

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