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Research Paper

Exploring the geomorphological nature and its consequences in Agaie & Lapai LGAs of Niger State and environment using GIS & Landsat-8 imagery

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ABSTRACT

The activities of geomorphology has persisted over many years in the study area un-noticed, un-checked or controlled and un-abaited. That is why, this article is poised to evaluate the morphological consequences on the study area topography, particularly settlements and farm-land areas along the fringes of the river (coast) and suggest way-out. In order to assess the magnitude of morphological changes over-time, the of Geographic Information System (GIS), Remote Sensing (RS) techniques (that is, using LandSat Imagery-8) and Shuttle Radar Thematic Mapper (SRTM) were deployed and survey method (via a structured questionnaire) to extrapolate the socio-economic consequences on the inhabitants of the study area. The GIS, RS and SRTM revealed the morphological changes and its evolution such as the drainage pattern, topography (that is, relief), flooding and flood plains. It is expected that, policy makers, water resources engineers and environmental managers would find the out-come of this investigation use for planning and making informed decision to avert future environmental hazards of different types.

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1. INTRODUCTION

Nigeria coastal areas have been experiencing frequent flooding, resulting in significant socio-economic and environmental impacts. [1], [2] Geomorphology according to Oxford English Dictionary; can be sub-divided into two parts, 'geo' and 'morphology'. The 'geo' refers to the geographic space, which include Land, Water bodies, the Atmosphere and all that exists within it. While 'morphology' is the form and structure of plants, places and animals scientifically. Therefore, geomorphology could be described as, the scientific study of land-forms, its causes and associated consequences. But, the world seem to be more interested in the global environment and how it operates and changes. It is the science that investigate the origin and development of landforms (such as hills, valleys, sand dunes, caves) and how those landforms combine to form landscapes. Consequently, it provides critical contribution in answering questions pertaining different evolution in land-forms.

Geomorphological studies include both qualitative and quantitative analysis of land-form shapes, the monitoring of surface and near-surface processes (e.g. running water, ice, wind) that shape landforms and the characterisation of land-form changes [3], [4] that occur in response to factors such as tectonic and volcanic activity, The threats of climate change and species extinctions as a result of general global warning and polar ice melting are common and recent phenomena, but what about the potential changes to physical landscapes? Understanding how landscapes operate and change is a crucial part of gaining a fullunderstanding of the obvious physical changes in Agaie LGA and environs which allows for better environmental management with timely intervention. Landforms and evolution, and the consequences of not having empirical evidence to validate the imminent adverse effet has been an issue of concern to the researcher and the general public. But, in order to have an accurate assessment of the landform situation of Agaie LGA and environs being the most affected, both the qualitative and quantitative approach was adopted, which describes the landforms and its process-base with the description of forces acting on Earth's surface to produce landforms and landscapes evolutions. There were no evidence or proof of any geomorphological research in the recent past years about the study area for the purpose of reference, therefore, this article relied on supervised classification of data on the satellite imagery of the year 2018 in order to reflect the evolution of landforms using Landsat 8 of 30meter resolution and SRTM-GDEM data for relief and drainage pattern. But, in some few decades ago, the local government area had experienced dévastating flood that resulted into some cracks along the lines of weakness from within the land leading to land protuding outside thereby making many farmers and land owners suffered loss of farmland and other valuables.

It was argued that, flowing water has produced the greatest amount of geomorphic work through geologic time and is the primary agent for surface erosion and landform evolution [5]. That portion of the surface of Earth that has been elevated by tectonic forces, over geological time, is continually and gradually weathered and eroded. The time component is an issue in extrapolating landform and landscape from the satellite imagery; because gestation time is quite long since erosion on land surface may be slow but consistent. It is against this backdeop that, an assessment of the flooding that took place some years ago and its consequences on topography and the environment including socio-economic activities of the people in the study area was examined using Geographic Information System (GIS) and Remote Sensing (RS)to determine the land-form pattern in order to engender effective planning, harnessing the hidden mineral resources and avert future flooding by enforcing the required meter (s) of set-backs for any building or settlement from water body .

2. RELATED WORK

Gilbert (1843-1918) was the first American in the world to pronounce 'Geomorphology' and the C.E.Dutton (1841-1912). The concept of 'Powell' which was known for base level; meaning a level below which the dry lands cannot be eroded was their own understanding of Geomorphology [5]. But the present law of landscapes development are built around Gilbert's equation mechanism. According to W.D. Thom bury, Geomorphology is the science of landforms including the submarine and topography; while A.L. Bloom (1979) says, it is the systematic description and analysis of landscapes and the processes that change them. These two authors had virtually the same assertion, except W.D. Thom bury that included submarine as part of landscape science (i.e., Study).

In the nutshell, investigating geomorphological consequences using either qualitative or quantitative method, reveals changes over-time on topography, water bodies, plants and animals, then the environment. The recent climate change all over the world changed the usual narratives or patterns which challenge popular solution.

The Nigeria Meteorological (NIMET) agency in early 2024 gave early warnings [6] to localities and those building along water ways, flood plains including those whose socio-economic activities are along the coast or trough of a big river; the likelihood of flooding in twenty-three (23) states during the raining season. It went further to say that, the usual 'August Break' in 2024 shall start from mid-July to Mis-August; then rain shall resumme and extend to mid-November, 2024. All these are outcome from weather alteration as a result of change in climate. However, the direction of this review was both quantitative (that is by observation) measurement and qualitative analysis using landSat 8 imagery in order to make am empirical inferences for decision and policy makers.

3. THE STUDY AREA, MATERIAL AND METHOD

3.1 The Study Area

Agaie and Lapai LGAs, are the two contiguous LGAs of study, but Agaie LGA is mostly affected because of its topography [7] and proximity to the River Niger trough therefore, the investigation is concentrated on AgaiAgaie had 132,098 human population while Lapai had 117,021, according to National Population Commission's Census figure of 2006. But using the Population Reference Bureau (PRB, 2012 formula, the projected population as at Dec, 2018 for Agaie LGA is 183,999 while Lapai LGA is 162,998 respectively. Agaie local government area has a total land area of 1,948.984kmsq and It is located at latitude 90 01' 00''N and longitude 60 19' 00''E. While Lapai LGA has a land area of 3,121.596kmsq and located along latitude 9 03' 00''N and longitude 60 34' 00''E and it is roughly conterminous with Lapai emirate. Below Figure *1* is the map of the study area.

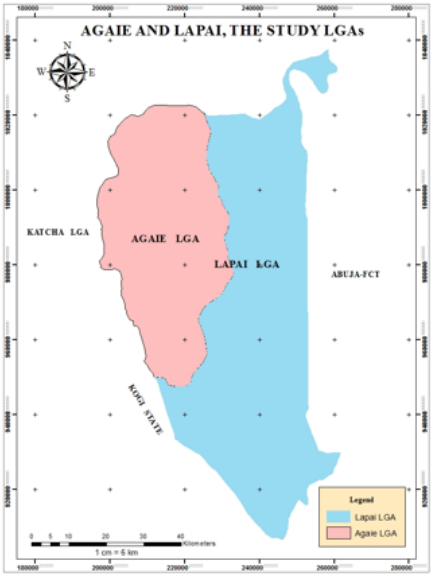


Figure 1. The Study Area Map

3.2 Material

Materials used for this article involved both primary and secondary data collection for physical investigation and remote sensing primary data needed was from Landsat-8 downloaded from the Global Land Cover Facility (GLCF) [8], [9], [10] through the earth explorer platform with a 30meter resolution acquired on the 23rd September 2018, NASA Shuttle reader topographic missionSRTM and GDEM for relief/topography or terrain modeling. A closed ended and well structured questionnaire to filter the opinions of flood victims on the socio-economic consequences of flooding in tge study area.

3.3 Method

The LandSat scenes covering the study area was Path 189 of Row 054 and the NASA Shuttle reader topographic mission SRTM GDEM provided digital elevation data for modeling (DEMs) in over 80% of the globe. These data were downloaded from the United State Geological Survey (USGS) web site. The elevation details was obtained from the SRTM using the ArcMa.p l0.1 of ArcGIS software. The LandSat Scene used covered a region of approxilnately 182kmx185km and had a spatial resolution of 30metres. It was then ortho-rectified; the systematic radiometric atmospheric and geometrical distortions of the imagery were also corrected to a quality level delivered by USGS (2015). But, there were no serious proof or evidence of any geomorphological available data of the study area, therefore this article relied on supervised classification of data on the satellite imagery of the year 2018 in order to reflect the evolution of landforms using LandSat 8 of 30meter resolution and SRTM-GDEM data for relief and drainage pattern modeling. The supervised classification of features on the 30meter resolution was made possible because the researcher is familiar with the study area, coupled with ground-truth exercise during reconnaissance survey.

The SRTM data shows the relief in the form ocontour lines, then set parameters at prompt of file geo-geodatabase for contour interval and the index. The drainage pattern is vivid enough on the imagery and based on the residual knowledge of the area by the researcher, description or image interpretation was not too difficult.

4. RESULTS AND DISCUSSIONS

4.1 Land use and Land cover (LULC) of Agaie and Lapai LGAs

The result generated from the LandSat-8 image after indepth processing revealed the under listed six different classes of land use and their attribute table generated at prompt of the file geo-database; it unveilrd the extent of land cover and use per LGA in percentages as shown in Figure *1* & Figure *2* below. Then Table *1* respectively: The six classes of laad use is as revealed below with different colour accordingly;

the red colour is for built up areas, the green is light forest, deep green is thick forest, ordinary green is for farm land, while deep blue is for water bodies and bare land is ordinary brown.

Table 1. Land Use and Land Cover of Agaie LGA

Agaie	Count	Class Name	Area Msq	Pct
1	98322	Built up Area	88489800	4.75
2	867689	Farm Land	780920100	41.91
3	992595	Light Forest	893335500	47.94
4	75768	Thick Forest	68191200	3.66
5	18046	Bare Land	16241400	0.87
6	18089	Water Body	16280100	0.87
Total			1863458100	100.00

The above table as represented in Figure *2* below showed that, built-up areas occupied about 47.5 percent of the total land area which is equivalent to 88.4kmsq; followed by 41.91% of the overall land are being used for agricultural farming which represents 78.0kmsq, while 47.94 percent are light forest, thick forest occupies 36.5% representing 62.8kmsq land area, 16.2 kmsq is the bare land which is about 0.87% and only 0.87% of the land occupied the water bodies, representing 16,2kmsq land area.This means, there are abundance of land area for infrastructural development. See Figure *2* below.

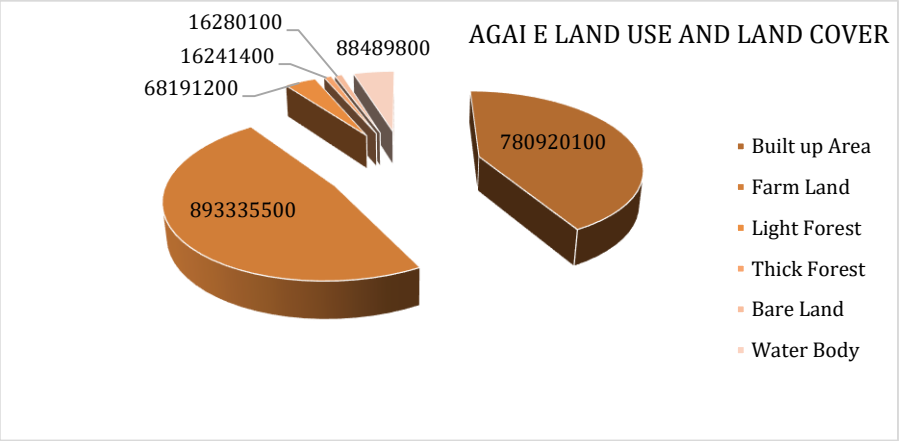


Figure 2. Agaie LULC Pie-Chart

The percentage of light forest (47.94%) implies that, it has unlimited economic potentials which include farming, recreation, even power project is feasible and other irrigation and allied projects that could stimulate socio-economic well-being of the Agaie people.The proportion of farm land (41.91%) revealed the main pre-occupation of Agaie inhabitants which is agricultural farming because of the available fertile land.The volume of water in the entire study area and its coverage due to climate change in the recent time and the relatively flat terrain suggested why the people are pre-dominantly farmers.The high farming activityimplies that, there is the likelihood of economic diversification compelled by the poor socio-economic status of the residents in the study area as seen in Figure *3* below.

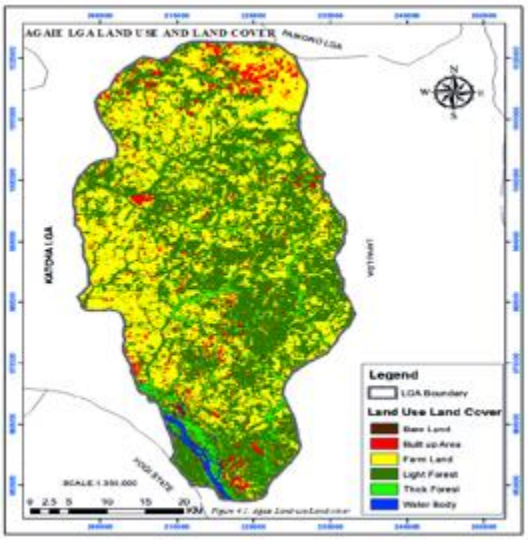


Figure 3. Light Forest Area of Agaie LGA

Figure 4: belowis the graphical representation of Land use & Land cover of Agaie LGA. The horizal axis of the graph is the LULC, while the vertical axis is the corresponding land area occupied per land-use and land-cover in cm2. The peak of the land-use and land-cover is light forest with a corresponding land-cover of about 5.00km2 and the lowest land-use is water body occupying 2.00km2.

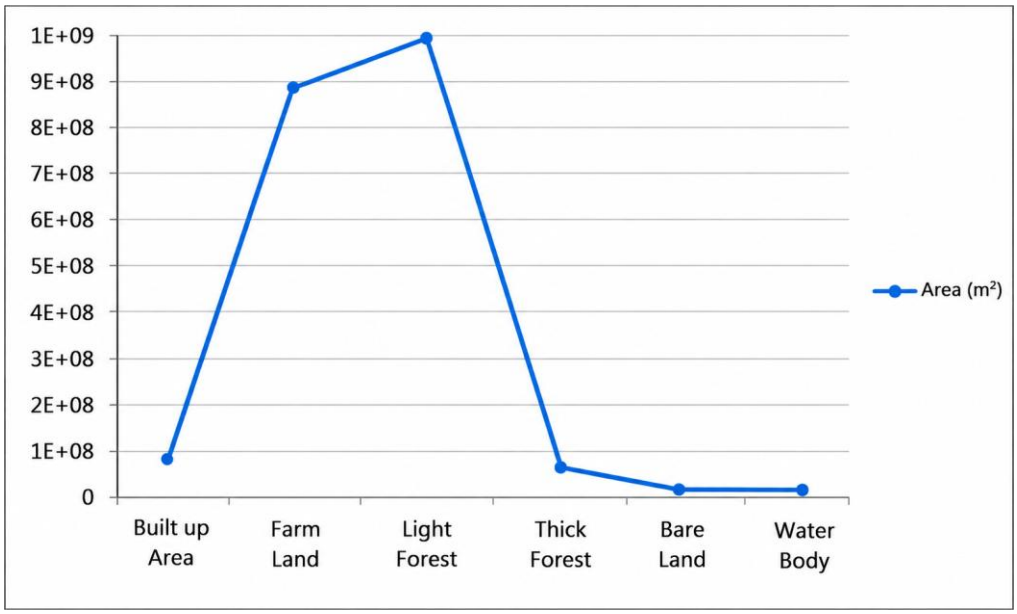


Figure 4. Land Use & Land Cover Graph of Agaie LGA

4.2 Relief of the Study Area

The topographic nature of the study area ishow steep or flat and a Shuttle Radar Topographic Mapper (SRTM) data of GDEM was downloaded, processed, then contour lines and hill shading were generated at prompt of the file geo-database to determine the actual configuration of the study area as shown in Figure *5* and Figure *6* respectively The relief s generally a low-land with a lowest height of 50meters above the sea level; which means, there are lots of siltation taken place particularly at the Baro area and other localities along the River Niger and the major tributaries. The thick contour lines usually is the fifth contour referred to as INDEX contour which are evenly distributed at a regular interval; meaning the study area is fairly undulated. These implies that, the soils are very rich in mineral deposits in

commercial quantity, the rich soil can be used for cash crops such as rice and sorghum farming in commercial quantity.

While those contour lines that are not thick are referred to as normal or regular contour which depicts the smoothness and roughness.However, the topographic nature of the study area made it susceptible to flooding, land slide, siltation of water channels by virtue of its proximity to the trough. Although,, constructions of hydro and solar power stations may be easier and cheaper to make than resources expended on 'cut and fill', of road constructions, but efforts be made to dreg the river in order to reduce flood disaster.

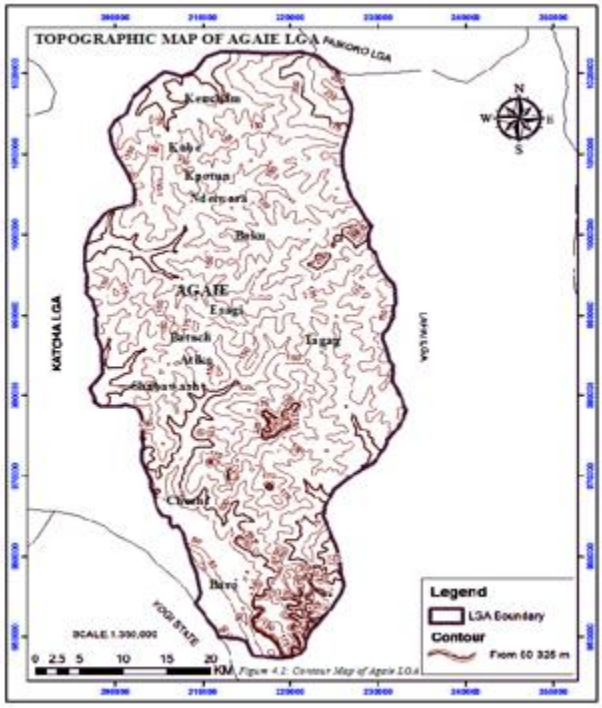


Figure 5. Relief of Agaie LGA

Figure 6 below shows that, the southern part of the study area, that is, the Baro area is on a flat plain which made dredging not too difficult in order to harness the available natural resources in the area. The drainage pattern formation began in earnest as a result of the relief and continuous flooding and siltation.

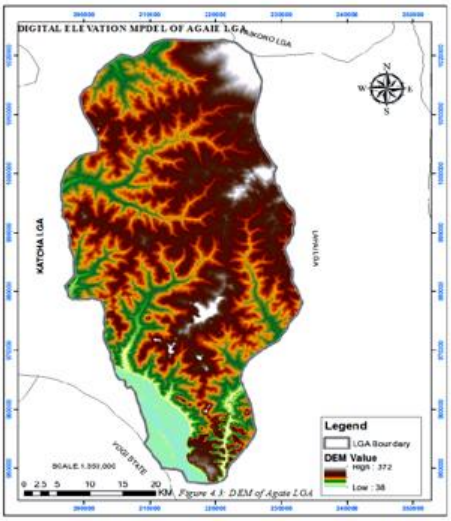


Figure 6. Digital Elevation Model of Agaie LGA

In order to ascertain the amount of precipitation (rainfall) in the study area, the roughness and smoothness of the terrain, then soil texture and or color to a great extent determines the drainage pattern; while temperature (including surface temperature) ; that is, results from NDVI over a period of time determines the amount of precipitation. According to these authors, R. L. Njinga, M. N. Moyo, and S. Y. Abdulmaliq; (2011), observed in their analysis of soils in Agaie LGA that, the pH (i.e. alka linity or acidity) value in the soil is about 7.3%. This implies that, the soil is slightly acidic in nature and it is therefore, beneficial for hing plant growth. Figure 7 below revealed the pattern in which water flows in the study area. The almost flat nature of the topography and soil type made fluvial flow continuouslythereby causingtrellisedrainage pattern which is suitable for growing of rice in commercial quantity and sorghum and other variaty. It also explant why the main pre-occupation of most in- habitant is farming, coupled with the soil texture and moisture content. Baro, Kacha and other localities around river Niger main tributaries are in the southern part of the study area lend itself for rapid industrial growth when harnessed.



Figure 7. Drainage Pattern of the Study Area

Figure 8 below shows the relationship between relief or topography and the consequences of continuous fluvial flow that shaped the drainage pattern of the study area. It also explains why most of the land areas are suitable for farming, except for the north and north east portion of the study areas that are

close to the southern Paikoro LGA The flat topography and constantly wet soils hindered clustered built-up areas, instead they are scattered all over the study area, looking dor a fairly solid soil for building.

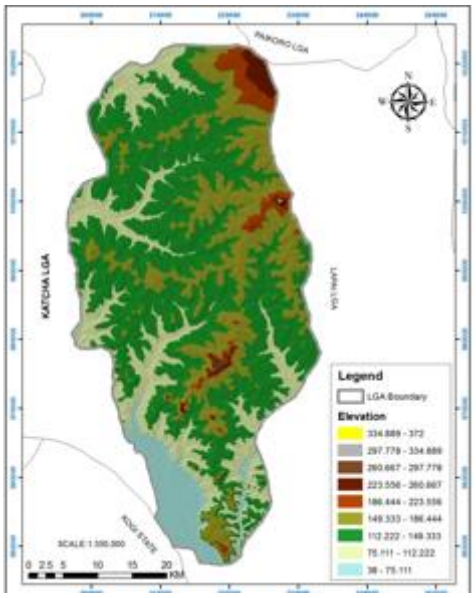


Figure 8. Relief Water Flow Pattern of Agaie LGA

5. CONCLUSIONS

The study has provided an input in the management and control of the landscape conservation, river basin, ecosystem conservation and restoration of, héritage. It jz possible to conserve the original landscape conservation with the timely use of LandSat-8 of at least 30meter resolution and SRTM data to monitor the slopes. The geomorphological processes and landforms can provide the needed template for ecological projects and patterns can be developed.For example, , rivers and floodplains typically exhibit a zonation of plants and animals that reflect differences in the frequency, depth and duration of flooding (See Figure *8* above).Therefore, an understanding of the nature of a river and floodplain geomorphology, including the driverse and rates of development, can help with the design of conservation strategies for near-pristine systems, and with restoration planning for degraded systems.

Furthermore, an understanding of weathering rates processes [11], [12] could help with the design of conservation strategies for protecting buildings, especially those ones along the flood plains and at close proximity to the main river... The geomorphological nature of Agaie LGA is an advantage for socio-economic activities if the policy makers can properly harness the untapped numerous natural resources.TheEnvironmental and Engineering consultants could plan effectively by leveraging on the geomorphological reports on land resources and turn Agaie LGA to an industrial hub, thereby launchingit to the outside worldfor industrial based technology.

5.1 Acknowledgement

I cannot forget the constructive critism from Dr. R.N. Ndukwu, which provided great impetus for the completion of this article.

My professional friend and colleague; Soule man Lamidiwhose contribution cannot be forgotten, particularly during filtering and image classification for the phenology of potato fields for this article. The contributions of Chukwunonyelum Ike can never be over-emphasized, especially when analyzing the environmental consequences of continuous fluvial flow in the study area.

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Author Contribution Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Isa Agaie Dawodu	✓	✓		✓	✓				✓					
Raphael Ndukwu			✓			✓	✓			✓				
Souleman Lamidi				✓				✓			✓	✓		
Chukwunonyelum Ike		✓			✓								✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

No conflict of interest.

Informed Consent

Not Applicable.

Ethical Approval

Not Applicable.

Data Availability

The data that support the findings of this study are available from the corresponding author on reasonable request.

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