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Assessment of Gully Erosion Dynamics and Environmental Impacts in the Ankpa–Ajobe Area, North-Central Nigeria.

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***Abstract*-- The incidence of gully erosion is a common phenomenon in Ankpa local government and its environs, this study assesses the dynamics and environmental impacts of gully erosion in the Ankpa–Ajobe area of North-Central Nigeria. Remote sensing data, geographic information system (GIS) techniques, and field observations were integrated to map gully distribution, evaluate gully expansion patterns, and determine the environmental consequences of erosion in the region. Satellite imagery from Landsat and Sentinel datasets was analyzed to identify erosion features and monitor their spatial growth. Digital Elevation Models (DEM) were used to analyze terrain characteristics such as slope, drainage patterns, and flow accumulation that influence gully formation .Results indicate that gully erosion in the study area is controlled by a combination of lithology, slope gradient, land-use practices, and rainfall intensity. The environmental impacts include loss of agricultural land, destruction of infrastructure, sedimentation of nearby water bodies, and displacement of local communities. The study recommends sustainable land management practices, improved drainage systems, and afforestation programs to mitigate further gully expansion.**

***Keywords*-- Gully erosion, Investigation, Impact, Topography.**

I. Introduction

Soil erosion is one of the most threatening environmental degradation problem in the world ofomata (2003). However, accelerated soil erosion mainly occur when man has tempered with the environment especially through the removal vegetation, mining activities and over-grazing Chisci, (1981) and (Ofomata2000-) and Geller P (1982) It is identified as one of the direct causes of environmental deterioration and poverty in many part of the world (Beijing Times2002). Erosion has become an endemic problem causing loss of soil resources and attendant loss of agricultural productivity as well as situation of various water bodies in Ankpa and its environs. Egboka B.C.E (2010), and Egboka (2007), in his contribution to gully erosion studies said the classical explanation of erosion is the ability of the agent of the environment (wind, water, man) to loosen, wear the soil. Deforestation, poor land management practices, and urban expansion could lead to gully expansion Jeje l.k(2019). The Ankpa–Ajobe area is particularly vulnerable because of its geological composition, topography, and seasonal rainfall patterns .Previous studies have highlighted the importance of remote sensing and GIS in mapping erosion features and monitoring their spatial evolution. However, limited research has focused specifically on the gully erosion dynamics and environmental consequences in the Ankpa–Ajobe region. North-Central Nigeria, gully erosion has become increasingly severe due to rapid population growth, In particular, the occurrence of gullies in Ankpa has created bad land topography and has destroyed properties, building schools and arable land which are eventually washed into various river channels resulting in shallowing the water bearing capacities. The development of gullies causes massive loss of soil and can be considered as one of the major attributes of degradation.

II. Study Area

Ankpa sheet 296 on scale 1:25,000 with a land area of about 30km^2 is located between latitude 7^0 15'N and longitude 7^{0}32'E and 7^{0}45'E. Ankpa comprises of cyclic sedimentary sequence that started in the early cretaceous time Murat (1972). Marine and fluvial sediments comprising, friable to poorly cemented sand, shale, clay and limestone were deposited Du Preez (1945). The study area Fig 1, falls within the humid tropical rain forest belt of Nigeria. The area experiences a tropical wet and dry climate, with annual rainfall ranging from 1200–1500 mm. Rainfall is concentrated between April and October NHSA(2023), often producing intense runoff that contributes to erosion, the average temperature of the year is 30^{0}C with the hottest period between February and April.

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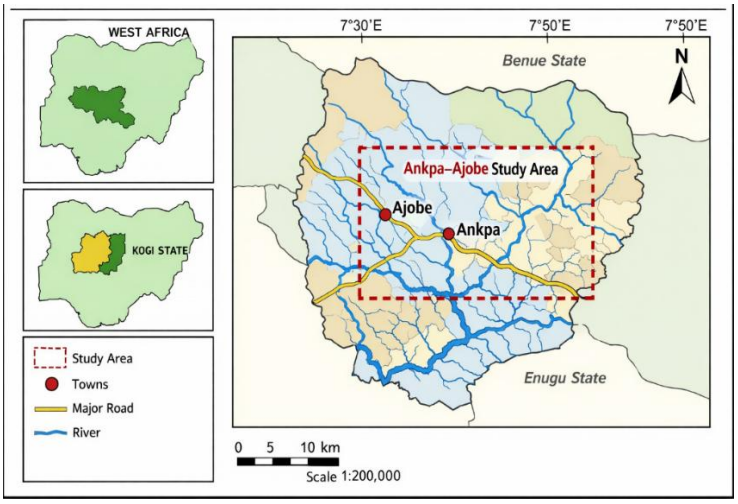

Figure:1 location map of Ankpa - Ajobe study area

III. Geology Of The Study Area

The area is underlain by sedimentary formations of the Anambra Basin, whose genesis has been linked with the development of the Niger – Delta miogeo-syncline and the opening of the Benue Trough. Murat (1972). The stratigraphy comprises of cyclic sedimentary sequence that started in the early cretaceous time. Reyment (1965). Marine and fluviatile sediments comprising friable to poorly cemented sands, shale, clay and limestone were deposited with occasional coal peat and thin discontinuous seams of lignite, Du Preez, (1945). The study area is basically the false bedded Ajali formation consisting of thick friable poorly sorted sandstone typically white in colour but sometimes iron-stained. The formation is also overlaying a considerable thickness of red earthly sand, formed by the weathering of the formation. The terrain is characterized by undulating hills and gentle slopes, which facilitate surface runoff and the development of erosion channels. Land clearing and farming practices contribute significantly to soil instability.

IV. Materials And Methods

The study adopted an integrated approach using Satellite images processed in ArcGIS and QGIS.

Image enhancement and classification techniques were applied to identify gully erosion dynamics and spatial distribution within Ankpa and Ajobe. Multi- temporal satellite imagery downloaded from United State geological Survey (USGS) was analyzed to delineate inundated area. The method also integrated Synthetic Aperture Radar (SAR), optical satellite imagery, Digital Elevation Models (DEM), Topographic and rainfall data from Nigeria institute of hydrological service agency (NIHSA) were incorporated to generate slope and drainage map of the area. These parameters were analyzed to determine their influence on gully formation and pattern. Field visit of various gullies with camera for photography was also employed. GPS coordinates recorded for all the site visited to validate satellite observation. Field visit was undertaken using traverse method to access the gully erosion sites, tape for measuring the width, length and depth of various gullies with camera for photography was also employed. GPS coordinates recorded for all the site visited to validate satellite observation was undertaken using traverse method to access the gully erosion sites, tape for measuring the width, length and depth

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Table; 1
Data Used and Their Purpose

Data	Source	Purpose
Landsat 8 imagery	USGS	Land use and erosion mapping
Sentinel-2 imagery	ESA	High-resolution erosion mapping
SRTM DEM	NASA	Slope and drainage analysis
Field GPS data	Field survey	Ground truthing

V. RESULTS

Remote sensing analysis and field observation reveal that gully erosion is widely distributed across the Ankpa- Ajobe area. The mapped gully are predominantly concentrated along drainage channel roads corridors, and agricultural lands were vegetation cover has been significantly reduced .most of the gullies occur within the central and southeastern part of the study area. Field measurement indicate that gully depths range from 2m to about 15m, while widths vary between 5m to 35m with about 50 – 500m length depending on the stage of development.

Digital Elevation Model (DEM) Analysis

Digital Elevation Model (DEM) of the Ankpa–Ajobe area reveals significant variations in elevation across the study area. Elevation ranges between approximately 120 m and 420 m above sea level, indicating a moderately undulating terrain. Higher elevations are mainly concentrated in the northeastern and central parts, while relatively lower elevations occur towards the portions southwestern. The DEM also shows that most active gully systems are located along transition zones between highlands and lowlands, where water concentrates and flows downslope Fig2, findings suggest that topography is a key factor influencing gully erosion development in the Ankpa–Ajobe area.

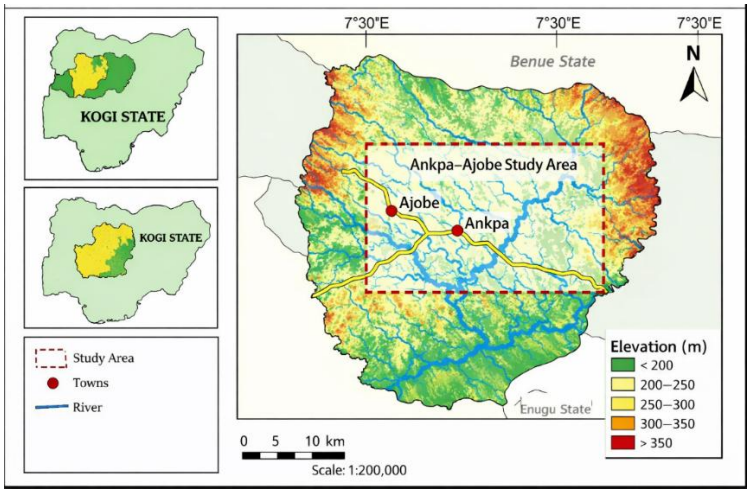

Figure:2 Digital Elevation Model map of the study area

Slope Analysis

The slope map Fig3, derived from the DEM indicates that slopes in the study area range from 0° to over 30°. The terrain can be categorized into five slope classes Table2, Gully erosion is predominantly observed in areas with moderate to steep slopes (10°–30°).

These slopes increase runoff velocity and reduce infiltration, thereby enhancing soil detachment and transportation. The results indicate that slope gradient strongly influences gully initiation and expansion, particularly where vegetation cover has been removed due to farming or urban development.

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Table: 2.
Various Classes of slope

A 0–5° (Very gentle slopes)

B 5–10° (Gentle slopes)

C 10–20° (Moderate slopes)

D 20–30° (Steep slopes)

E >30° (Very steep slopes)

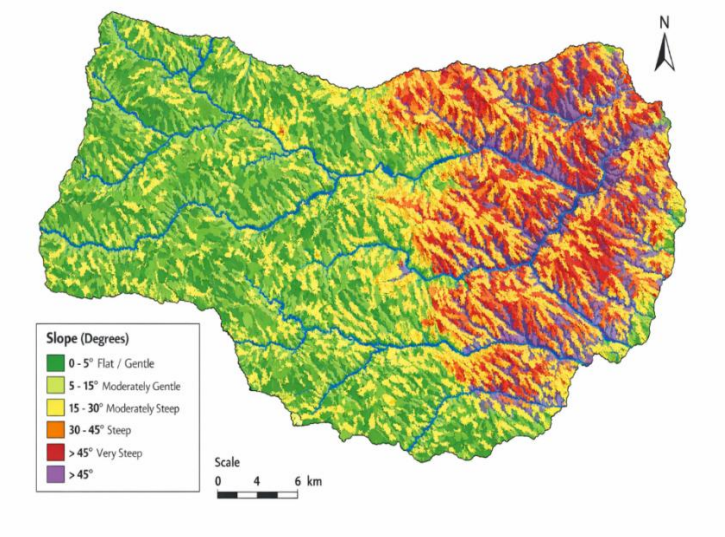

Figure:3 Slope map of Ankpa – Ajobe Area

Drainage Density

The drainage density analysis shows a moderate to high drainage network within the Ankpa–Ajobe region. The calculated drainage density ranges from approximately 1.5 km/km² to 3.8 km/km².Higher drainage density values are observed in areas with weak or erodible soil formation and sparse vegetation.

These conditions facilitate rapid concentration of surface runoff, which significantly contributes to gully channel formation and expansion. The spatial pattern of drainage density also correlates strongly with mapped gully locations, indicating that hydrological processes play a crucial role in erosion dynamics Fig4.

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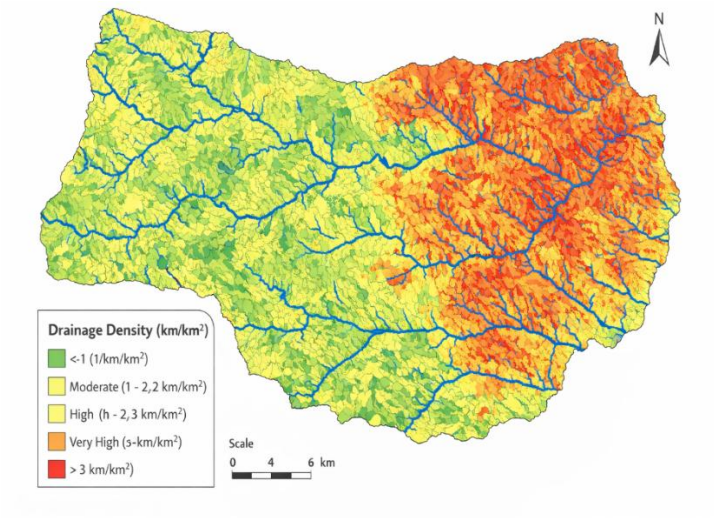

Figure:4 Drainage map of the study area

Spatial Distribution of Gullies

Gully erosion in Ankpa-Ajobe is predominantly distributed across the Ajalli sandstones, loose and poorly cohesive, making them highly susceptible to erosion. The analysis shows that gully erosion is concentrated in areas with steep slopes and high drainage density. Most gullies occur along road infrastructural networks and agricultural lands Satellite image comparison indicates progressive gully expansion over time due to population growth, excessive rain fall, poor drainage system, deforestation and unregulated land use as a result for farming wood logging

Environmental Impacts

Large portions of farmland have been destroyed, reducing crop productivity, destruction of infrastructure, and threat to residential areas. Several communities, such as Olubojo Fig 5a and b Owelle, have been severely affected for a long time. Roads, schools, hospitals and other rural infrastructure have been severely affected.

Figure:5 Field photograph of gully site in Olubojo Ankpa

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Fig 5b gully site in owelle Ankpa

Sedimentation of Rivers

Eroded sediments are transported into nearby streams, reducing water quality. The study area beset by a proliferation of gullies, especially on the most erodible Ajalli Sandstones' geological sediments Oparaku etal.. (2014) among the impacts of gully erosion in the study area is siltation leading to the shrinkage of a long reach of the Anambra River (Mabolo River) in Ankpa.

VI. Conclusion

This study reveals that gully erosion in the Ankpa–Ajobe area is a serious environmental problem driven by both natural and anthropogenic factors. Remote sensing and GIS proved effective for mapping erosion features and assessing their dynamics. Effective mitigation measures such as vegetation restoration, proper drainage systems, and sustainable land use planning are necessary to reduce further environmental degradation.

VII. Recommentation

To investigate the causes and impacts of gully erosion in Ankpa and Ajobe, it requires adequate knowledge of the environment, the consequences of soil erosion and other natural environment disasters

A. The affected study areas is encourage to improving agricultural practices, promoting agroforestry, and enhancing soil compaction to control gully expansion.
B. Laws prohibiting building of houses along waterways should be enforced by the town planning department.
C. Most of the anthropogenic causes observed during the study shows that the affected people lack awareness of the nature and action of erosion and consequences of their activities.
D. The government should stand up to its responsibility and refill areas that have been washed away and reconstruct a proper drainage system that will be channeled to a safe discharge points.

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