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ASSESSING GEOMORPHODYNAMIC IMPACTS OF GULLY EROSION IN SOUTHERN GOMBE STATE, NIGERIA

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Abstract

Gully erosion poses a significant environmental threat in Southern Gombe State, Nigeria, yet assessments and interventions have remained geographically restricted despite widespread devastation. This study assessed the geomorphodynamic impacts of gully erosion across seven local government areas, employing field surveys and morphometric measurements of 130 permanent gully sites. Results revealed three gully types: continuous (35%), discontinuous (55%), and bank (10%), affecting 34,499.2 hectares (4.3% of the study area). Continuous gullies occupied the largest area (64%) due to favorable conditions including large drainage basins and deep soils, while discontinuous gullies, though numerically superior, covered only 11% of affected land. Gully dimensions were severe, with depths reaching 20m, lengths exceeding 10km, and widths up to 68m. Distinct geomorphodynamic processes operated across LGAs: drainage capture and sediment deposition in Akko; channel widening and high sediment yield in Balanga; mass wasting in Billiri; slope undercutting in Gombe; headward retreat in Kaltungo; network expansion in Shongom; and wall slumping in Yamaltu-Deba. These processes have converted productive agricultural land into dissected terrain, threatening food security, infrastructure, and livelihoods in this agrarian region. The study concludes that current engineering-dominated interventions are inadequate, frequently failing within 2-3 years, and recommends integrated, process-based approaches that work with natural geomorphological dynamics rather than against them. LGA-specific strategies including sediment trapping, vegetative stabilization, and improved drainage management are proposed to address the varying erosion mechanisms across the region.

Keywords: Gully erosion, geomorphodynamic processes, land degradation, Southern Gombe State, Nigeria

1. INTRODUCTION

Climate change has attracted significant global attention over recent decades, with extensive research focusing on its dramatic effects on biogeographical patterns, agricultural systems, ice volumes, and sea levels (Swift et al., 2015). However, the geomorphological consequences of climate change have received comparatively little attention. This oversight stems from a common misconception that geomorphological processes occur too slowly to be relevant to contemporary environmental management (Alcantara & Goudie, 2010; DiPietro, 2013). Yet these consequences including increased soil erosion, altered runoff patterns, flood hazards, and glacier extinction have substantial resource implications. Understanding landscape dynamics through geomorphology is therefore essential for comprehending Earth's systems and enabling effective environmental management. Gully erosion represents a particularly dynamic geomorphological process that continuously reshapes landscapes. Defined as the degradation of ground surfaces (Knapp, 1979; Morgan, 1980; Blum, 1985; John & Nggada, 2019), gully erosion constitutes the final stage of a four-phase fluvial erosion sequence progressing from sheet erosion through rill erosion to gully formation (figure 1). Sheet erosion involves uniform surface soil removal, while rills are shallow parallel grooves that can be eliminated through cultivation. Both sheet and rill erosion precede gully development. Gully erosion has become a widespread environmental crisis in Gombe State, Nigeria, threatening both inhabitants and the local economy. The problem intensified following the 1996 administrative reforms that elevated Gombe Local Government Area to state status (Didams & Firuza, 2019). This triggered rapid vegetation clearance from the already fragile savannah, combined with population pressure, land-use changes, and socioeconomic dynamics (Balzerek et al., 2003; Lazarus et al., 2012). As development activities increased, gully erosion intensified, rendering many areas hazardous for human habitation.

The consequences have been severe. Field observations and organizational reports indicate that gully erosion has directly damaged settlements and agricultural lands, causing soil nutrient loss, land degradation, and secondary problems including flooding, river siltation, and water pollution. These environmental impacts compound economic hardship in a state where most people subsist on less than $1 daily (World Bank, 2016). Hundreds of people are displaced annually, large areas become abandoned, and fertile land gradually transforms into badlands (Lazarus, 2017). Despite these widespread devastations, research and intervention efforts have been remarkably limited and localized. Government intervention has focused on just five gully sites—four within Gombe town and one in Kumo—leaving the rest of the state largely unaddressed (Gombe State Ministry of Environment, 2015). Similarly, available research studies (Balzerek et al., 2003; Lazarus et al., 2012; Wanah, 2017) have concentrated exclusively on gullies within Gombe town. This neglect is particularly concerning for the southern region, which serves as the state's agricultural heartland (Patricia Taft & Nate Haken, 2015). Local communities in affected areas including Akko, Balanga, Billiri, Kaltungo, Shongom, and Yamaltu-Deba have attempted various uncoordinated interventions—converting gully sites to refuse dumps, sand-filling, sand mining, bracing channels with sandbags, and pouring gravel. Unfortunately, these efforts have often proven counterproductive, actually accelerating gully development.

Several factors explain why gully erosion assessments and interventions remain geographically restricted. First, there is insufficient knowledge of areas prone to gully erosion (Pindiga & Orisakwe, 2013; Ikusemoran et al., 2016). Existing studies have focused on quantifying soil loss rather than identifying vulnerable locations through susceptibility mapping. Second, understanding of influencing factors is inadequate. While causes include extreme weather and human activities, research has disproportionately emphasized human factors while underestimating physical variables (Didams & Firuza, 2019). Furthermore, factor contributions likely vary spatially, yet previous studies have treated them uniformly across the state. Third, assessment methods rely heavily on traditional field-based approaches using rulers, tapes, profilometers, poles, total stations, GPS, and erosion pins (Pindiga & Orisakwe, 2013). These methods are labor-intensive, susceptible to human error, and can disturb gully morphology, compromising accuracy (Zhang et al., 2015). Fourth, gully control has relied almost exclusively on engineering measures, neglecting contributions from geomorphology and related disciplines. These structures frequently fail within 2-3 years (Lazarus, 2012) due to insufficient information on gully networks, topography, soil, geology, rainfall, catchment areas, and land-use patterns. Engineering approaches are also costly, time-consuming, and spatially limited (Dube et al., 2017). Geomorphology offers a systemic view that can enhance understanding of environmental mechanisms and enable actions that complement rather than impair natural processes (Arabameri et al., 2020). By applying knowledge of morpho-dynamic factors and predicting environmental responses, geomorphologists can help ensure ecosystem services are preserved or restored. Effective gully erosion prevention and control therefore require thorough understanding of terrain conditions before implementing solutions. Therefore, the aim of this study is to assess geomorphodynamic impacts of gully erosion in Southern Gombe State, Nigeria

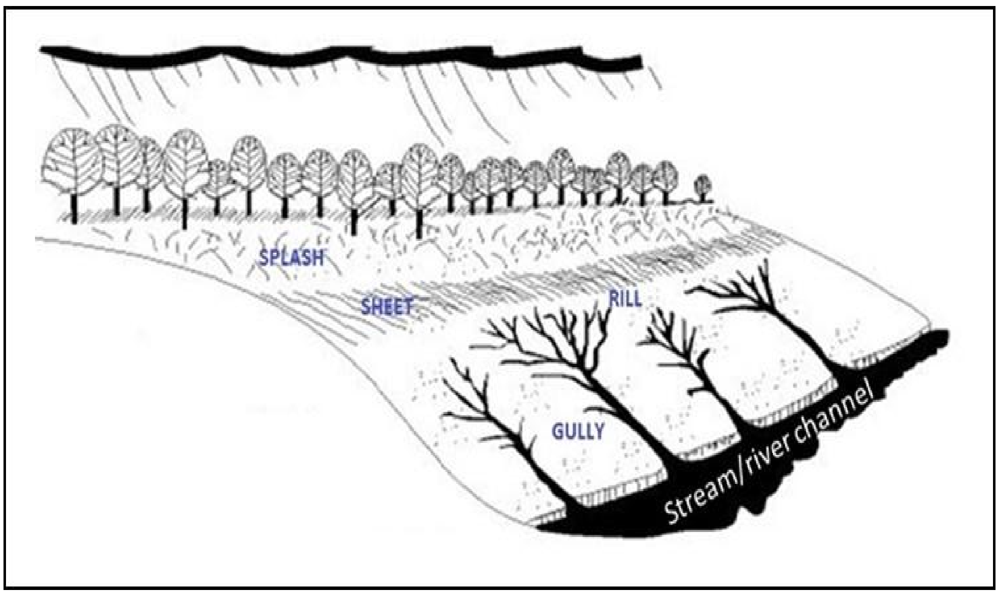

Figure 1. The four phases of soil erosion

2. MATERIALS AND METHODS

Study Area

Southern Gombe State is located approximately between latitude 9° 33’ 42. 19” and 10° 20′ 16.38” North of the equator and between longitude 10° 41′52.61” and 11° 57′52.75” East of the Prime (Greenwich) meridian and in the center of the North East region of Nigeria (Figure 4.1). It is positioned within Gombe State, one of the thirty-six (36) States of the Federal Republic of Nigeria and occupies approximately 8,023.2 Square

Kilometers (Km^2) out of 20,265.6 Km^2 of the total landmass of the Gombe State (Google Earth, 2019). Southern Gombe State is bordered by Borno State to the East, Adamawa and Taraba States to the South, Bauchi State to the West, and parts of Akko, Kwami, and Yamaltu-Deba (Y/Deba) Local Government Areas (LGAs) of Gombe State to the North. Administratively, it is made up of Akko, Balanga, Billiri, Gombe, Kaltungo, Kwami, Shongom, and Y/Deba local government areas.

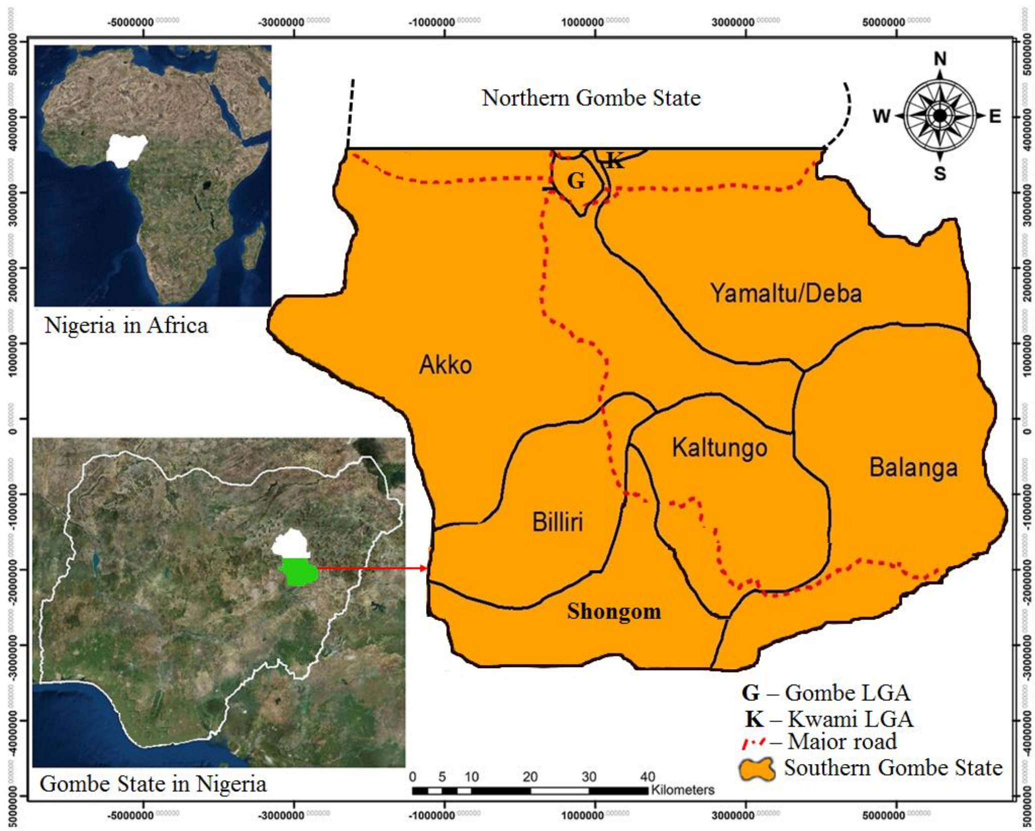

Figure 2: Location of Southern Gombe State

The terrain of Southern Gombe State comprises diverse geomorphological forms such as river basin, plains, uplands, and highlands (Figure 2) that combine to form attractive scenery. The river basins consist of the Gongola and Dadiya river basins with altitudes ranging from 184 to 351 m heights above sea level. The Gongola river basin covers the entire western part of the study area occupied by major parts of Y/Deba LGA and the northern parts of Balanga LGA while the Dadiya river basin covers the entire southern part of the study area occupied by southern part of Balanga, Billiri, and Shongom LGAs. The two river basins are separated by uplands and highlands found in the southern part of the study area. The river basin occupies over half of the total land area of Southern Gombe State and is generally utilized for agricultural activities particularly rice production. The establishment of the Upper Benue River Basin Development Authority (UBRBDA) at Dadinkowa in Yamaltu-Deba LGA for irrigation (mainly rice) agriculture is clear evidence of the suitability of the terrain.

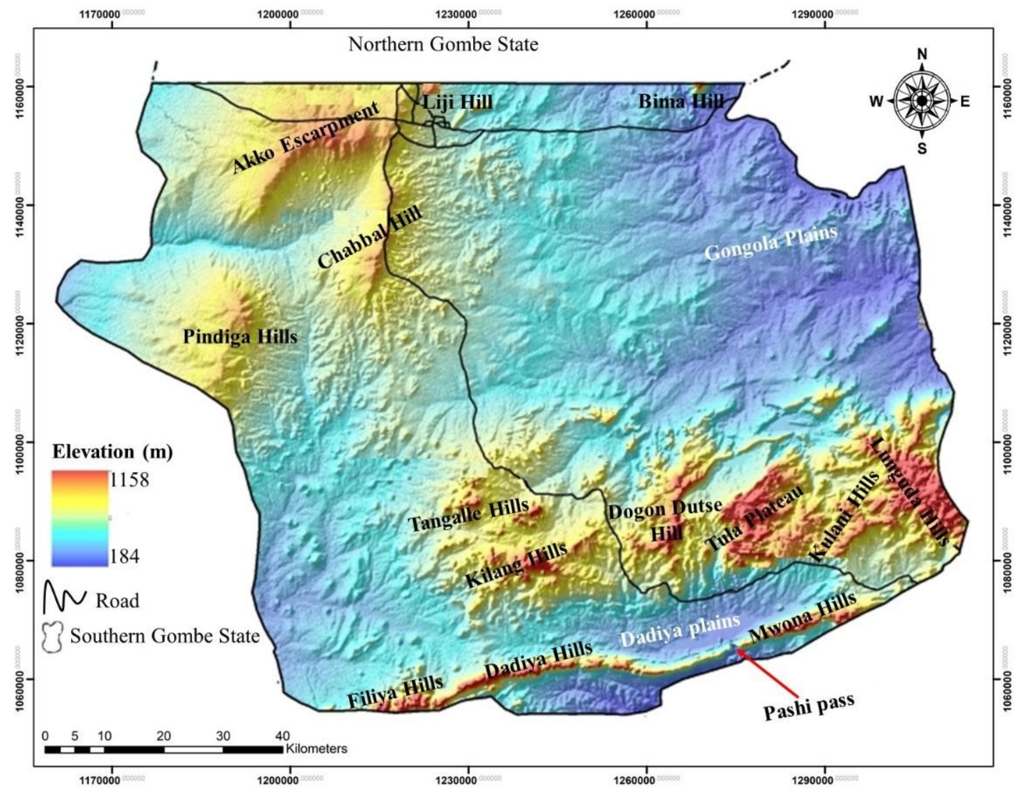

Figure 3: Landscape view of the study area

The plains consist of land areas with altitudes ranging from 351-462 m above sea level. The plains generally separate the river basins from the upland areas. This landform covers less than 40% of the total land area of Southern Gombe State. Billiri LGA has most (61.72%) of its land area in the plains, while, Akko LGA has more than 40% of its land area as plains. The plains are generally utilized for agricultural, residential, and industrial purposes. The upland areas are the land areas with a minimum of 462 m and a maximum of 590 m above sea level. These areas are generally higher in altitudes than the plains. These landforms occupy over 20% of the total land area of Southern Gombe State. Gombe and Kwami LGA in the northern parts of the study area has most of their land area as uplands, while the mountain ranges in the southern part are surrounded by upland areas.

The highlands are comprised of high mountain ranges and hills with altitudes above 590 m above sea level. The highest peak of the highlands in Southern Gombe State is the Kulani hill which is about 1158 m high. Less than 10% of the land areas of Southern Gombe State are of highlands, with Kaltungo, Balanga, and Shongom LGAs having more than 10% of their land area as highlands. The major highlands areas include the thin mountain range at the extreme southern part of the state, where they are known as Filiya and Burak hills in Shongom LGA and Dadiya and Mwona hills in Balanga LGA. Other highland areas include Kulani-Degri-Jikkar hills in Balanga LGA, Tula plateau mainly in Kaltungo LGA but extends to Balanga LGA, Dogon Dutse hills in

Kaltungo LGA, Tangale hill in Biliri LGA (which extends to Shongom LGA), Pindiga, Lamba, and Chabbal hills in Akko LGA, and Bima hills in Y/Deba LGA

The geology of the study area generally comprises ancient (Precambrian) crystalline Basement Complex rocks characterized mainly by granitic and migmatitic rocks, on which rest unconformably the sedimentary and volcanic rocks ranging in age from Cretaceous to Quaternary (Jalo, 2015; Obaje, 2009). This geological substrates, combined with a semi-arid climate and anthropogenic pressures, creates a landscape highly susceptible to erosion and mass wasting. Research indicates that approximately 19.2% of southern Gombe State falls within high-susceptibility zones for gully erosion, with 4.3% classified as extremely susceptible.Table 1 presents the lithologic characteristics and geology Formations of Southern Gombe State respectively.

Table 1. Geologic and lithologic characteristics of the study area

Geology Formation	Lithologic Units	Age
Alluvium	Alluvium	Holocene
Basalt	Basalt	Cretaceous
Kerikeri	Sandstone, Shale, and Clay	Palaeocene
Gombe	Sandstone, siltstone, shale, coal, and ironstone	Maastrichtian
Pindiga	Shale, limestone, and sandstone	Turonian
Yolde	Shale, limestone, and sandstone	Cenomanian
Bima	Sandstone, siltstone, and shale	Albian
Basement Complex	Porphyritic granite/coarse porphyritic biotite and biotite homblende granite Coarse, porphyritic homblende granite Undifferentiated granite, migmatite and granite gneiss	Pre Cambrian

Source: Didams & Firuza (2019)

Methods

Data used in this study were collected through field observation and measurement, using ranging poles, measurering tape and handheld GPS. The targeted gully types for this study wee permanent gully channels large in scale and deep enough to constitute a hindrance to land development and have potentially harmful consequences for the environment and people. The square foot, position on the landscape, and morphological criteria were used to identify and distinguish permanent gullies from other linear erosional channels in the landscape. In addition, to simplify the wide variety of terms used in the classification of the permanent gully, this study adopted the generic scheme of nominal classification where permanent gully erosion features are primarily regarded as continuous, discontinuous, or bank gullies. Field surveys allowed the identification of 130 permanent gullies. Once the targeted gullies were identified, detailed measurement of gully morphometric parameters such as length, width, and depth was carried out, geomorphodynamic processes operating in the study and their impacts were observed and analyzed.

Gully length is the longitudinal distance of the gully from the headcut to mouth along the gully channel. Lengths were measured by splitting the gully channel into segments of 20 m apart and also at abrupt changes in the profile from headcut to outlet using 100 m surveyor's tape. Hence, the average of the lengths recorded in all measured segments represents the gully length. This is computed through equation:

$$\text{Gully length (m)} = \frac{\text{Sum of segments readings}}{\text{Number of segment}} \quad (1)$$

The horizontal boundary between the left and right banks of a gully channel is called the gully width. Gully width consists of the top and bed widths. To measure the top and bed widths, the measuring tape was stretched vertically across the gully bed and top from one bank to the other every 20 m and at each interval point. This measurement procedure was repeated for all the selected intervals along the gully channel. The average value obtained from the top width and bed width represents the gully width of the channel. The gully width was computed using equations:

$$\text{Gully bed width (m)} = \frac{\text{Sum of bed width readings}}{\text{Number of interval points}} \quad 2)$$

$$\text{Gully top width (m)} = \frac{\text{Sum of top width readings}}{\text{Number of interval points}} \quad (3)$$

$$\text{Gully width (m)} = \frac{\text{Average bed width} + \text{Average top}}{2} \quad (4)$$

Gully depth is the vertical cross-section of the gullies. To measure this parameter the surveyor's tape was placed at ground level and stretched across the gully channel. A third person held a ranging pole at the deepest part on the gully floor and measured the reading of the ranging pole as it touched the stretched measuring tape. Lastly, the gully depth was calculated through equation:

$$\text{Gully depth (m)} = \frac{\text{Sum of interval depths}}{\text{Number of intervals}} \quad (5)$$

Figure 4 summarizes the procedures for measuring gully morphologies.

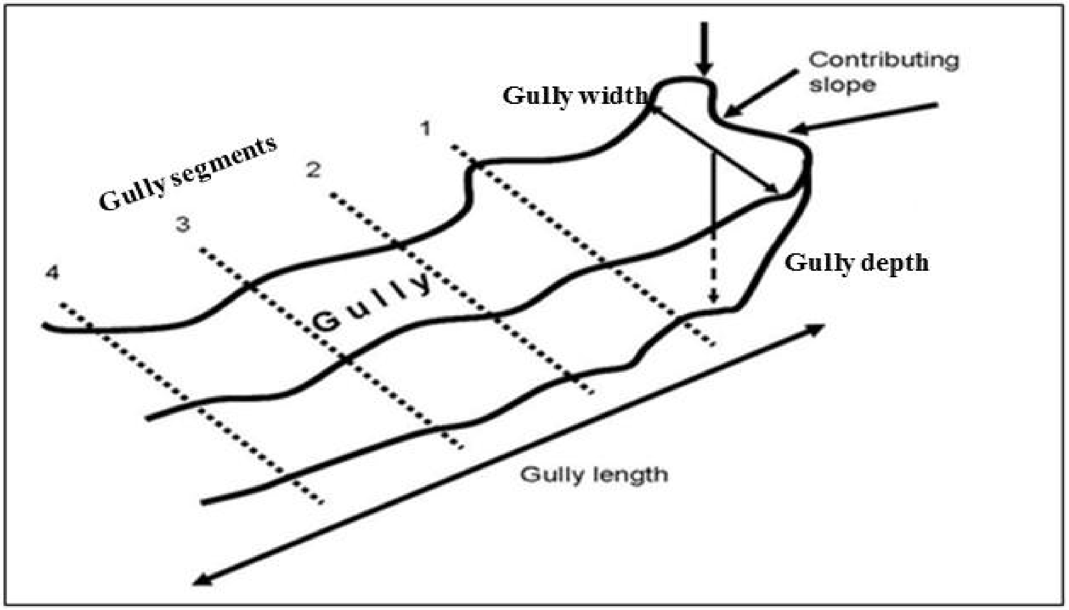

Figure 4: Schematic illustration of gully parameter measurement in the field

4. RESULTS AND DISCUSSIONS

Types and morphological characteristics of the studied permanent gullies

After an extensive field survey, the study revealed that the study area is indeed affected by gully erosion. A total of 130 critical gully eroding sites were identified in different parts of the study as illustrated in figure 5

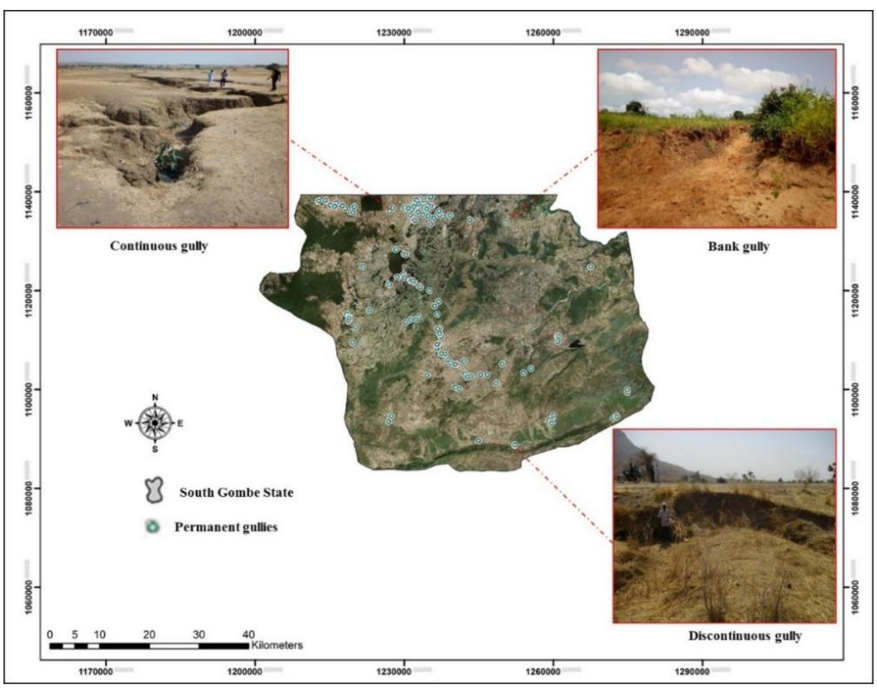

Figure 5: Example of gullies affecting the study area

Based on their position on the landscape and morphological hydraulic and geometry characteristics, the identified gullies were classified into three (3) main types of permanent gullies including continuous, discontinuous, and bank gullies. Table 2 specifies that forty-six (46) of the gullies were classified as continuous, seventy-one (71) discontinuous, and thirteen (13) bank gullies. Considering the percentage proportion of the permanent gullies in the study area, Figure 6 illustrates that the continuous, discontinuous, and bank gullies occupy 35%, 55%, and 10% respectively.

Table 2: Types of permanent gullies in Southern Gombe State

Gully type	No. gullies	Gully (%)
Continuous	46	35
Discontinuous	71	55
Bank	13	10
Total	**130**	**100**

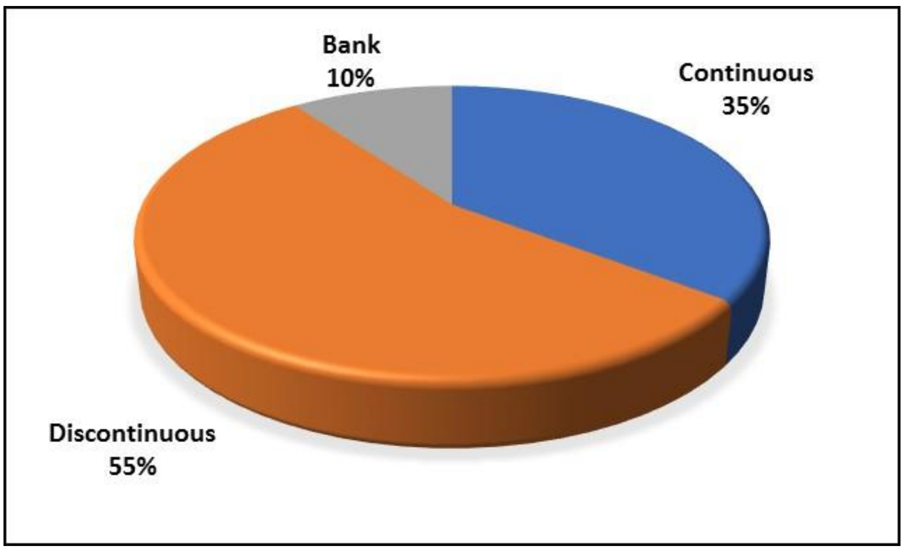

Figure 6: Percent proportion of the studied permanent gullies

Understanding the morphology of gullies is the first step in evaluating gully processes. Such an evaluation, in turn, makes projections of future gully behavior possible because gully morphology can be interpreted as the product of gully processes. Thus, gully morphology can aid in evaluating past, present, and possible future gully developments. Generally, the permanent gully features identified in the area are characterized by incisions having near-vertical banks and are mostly large. Gully depth ranges from 0.9–12.2 m, less frequently up to 20 m, and exceptionally even greater. The length reaches a maximum of 10857 m on continuous, 497.2 m on discontinuous, and 1092.3 m on the bank gullies. Cross-sections of the gullies are mostly U-shaped even though V-shaped gullies are also found. Spatially, it was observed in the northern parts of the study area, where Gombe and Kerikeri geologic formations are massively exposed that gully channels are mostly wide, U-shaped, and lack vegetation cover on the side slopes signifying active gullying stage. While in the mountainous southern part, narrow and V-shaped gullies are common with some vegetation growing on slopes indicating stabilization. However, the presence of falls on some of the channels indicated gully rejuvenation. Table 3 presents the morphometric characteristics of permanent gullies in the study area.

Table 3: Morphometric features of the studied permanent gullies

Gully type	Length (m)			Width (m)			Depth (m)			Gullied area	Gully area
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	(ha)	(%)
Cont.	2097	10857	5550.7	6.4	68	31.4	1.4	20	12.2	21950.1	64
Bank	777	1370	1092.3	4	43.1	6	0.9	13.4	1.8	8624.8	25
Discount.	99.2	915	494.2	3.1	10.1	15.4	0.9	3.2	4.9	3924.3	11
Total										**34499.2**	**100**

From table 3 it cand be deduced that the combined 130 permanent gullies identified in the study area directly affect an area of approximately 34499.2 ha translating to 4.3% of the study area. A close look reveals that the continuous gullies (46) occupy 21950.1 or 64%, while bank gullies occupy 8624.5 ha or 25% of the study area. Contrarily, the discontinuous gullies which are numerically superior (71) occupy only 3924.3 ha or 11% of the study area. This could relate to the fact that continuous and bank gullies occur and expand in locations with large drainage contributing area, gentle to mid slopes where the soils are deep, compared to discontinues which occur in locations with small drainage contributing area and steep slopes and where soils are relatively stable and shallower. These conditions can prevent discontinuous gullies from expanding extensively or from becoming continuous. Figure depicts the area in hectares affected by permanent gullies in the study area.

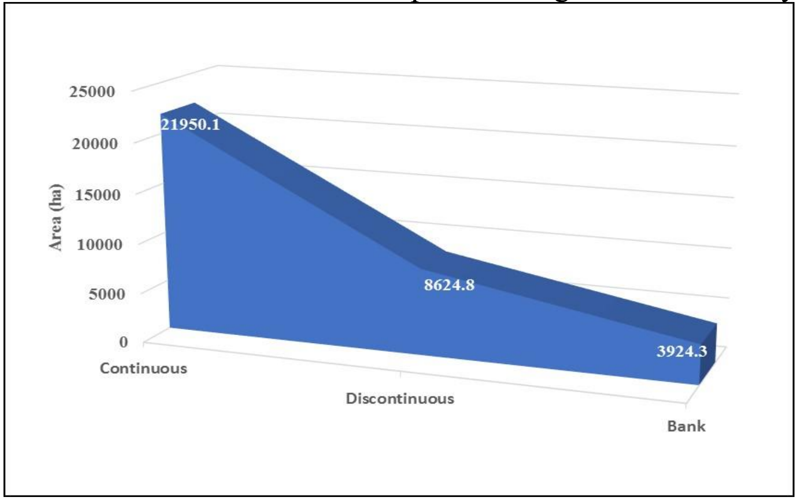

Figure 5: Area (ha) affected by permanent gullies in the study area

Geomorphodynamic processes and their Impacts in Southern Gombe State

During the survey, it was observed tha the seven Local Government Areas (LGAs) of southern Gombe State (Akko, Balanga, Billiri, Gombe, Kaltungo, Shongom, and Yamaltu/Deba) exhibit distinct geomorphodynamic processes driven by the region's underlying geology, topography, and land use pressures. The processes include drainage capture, sediment deposition, high sediment yield, channenel widening, mass wasting, network branching, slope undercutting, urban sediment load, rapid headward retreat, land dissection, gully network expansion, and substrate exposure. These process have been found to convert continuous farm/land into disected terrain in all local government areas in the study area, but the pattern and speed vried. Table 4 summarizes the dominant geomorphodynamic processes and Impacts by LGA.

Table 4. Dominant Geomorphodynamic Processes and Impacts by LGA

S/No.	LGA	Dominant Geomorphodynamic Process	Geomorphodynamic Impacts
1.	Akko	Drainage capture, sediment deposition	Altered overland flow paths, Burial of fadama farmland around Kumo and Pindiga areas
2	Balanga	High sediment yield, channel widening	Aggredation in valley bottoms, drainage shift, sand deposition on rice farms
3	Billiri	Mass wasting, network branching	Block collaps of gully walls, terrain fracgmentation, scarp/terrace formation
4	Gombe	Slope undercutting, urban sediment load	Wall collapse damaging buildings, roads, blocked urban drainage, flood risk
5	Kaltungo	Rapid headward retreat, land dissection	Fast upslope extention, isolated land islands, roads and culvert undercuting
6	Shongom	Gully network expansion, substrate exposure	Dendritic gully network, laterite and gravel exposure, permanent loss of arable land
7	Y/Deba	Wall slumping, topographic lowering	Frequent gully wall collapse, steep scarps cutting access

In Akko LGA, drainage capture occurs when headward erosion causes a stream to intersect and divert flow from another drainage system, fundamentally altering overland flow paths. In Akko LGA, this process redistributes runoff across the landscape, reducing infiltration capacity and accelerating erosion on steep slopes, a mechanism widely documented across semi-arid Nigeria. Sediment deposition follows as transported material accumulates in lower-energy environments. The primary impact is the alteration of overland flow paths, which redirects surface water away from established drainage networks and concentrates runoff on vulnerable slopes. This directly threatens fadama (lowland) farmlands around Kumo and Pindiga areas through burial by sediment. Active gully erosion sites at Jauro Tukur, Jauro Musa, and Unguwa Zana in Kumo were visited where observations confirmed ongoing degradation. Geologically, the area's shale/clay sequences are particularly susceptible to groundwater sapping and collapse, while the clayey soils with montmorillonite content exhibit shrink-swell properties that exacerbate cracking and erosion during seasonal transitions.

In Balanga LGA, the dominant geomorphodynamic processess observed are channel widening and high sediment Yield. Channel widening involves lateral erosion that expands stream channels through bank collapse and undercutting, a process intensified by high sediment yields from catchment denudation. The "undercut and collapse" model explains how groundwater penetrates permeable layers, dissolves cement, creates cavities, and eventually triggers roof collapse extending channels laterally. Visible impacts is aggradation, the raising of valley bottoms through sediment accumulation which reduces channel capacity and alters drainage patterns. This process directly impacts rice farms through sand deposition, reducing soil fertility and crop yields. Balanga is repeatedly listed among LGAs experiencing severe flood disasters, suggesting channel capacity reduction from sedimentation exacerbates flood risk during intense rainfall events. The widespread impacts across multiple LGAs indicate the scale of the erosion crisis, with estimated annual soil loss exceeding 25 million tons nationally.

Wasting and Network Branching were the dominant processes observed operating in Billiri LGA. Mass wasting encompasses downslope movement of soil and rock under gravity, including slumping and block collapses. Network branching refers to the development of tributary channels that extend the gully system headward. The underlying Pindiga Formation shales and clay-rich soils are highly susceptible to saturation-induced failure. Block collapse of gully walls creates steep, unstable slopes and fragments the terrain, isolating land parcels. Scarp and terrace formation results from differential erosion of resistant and weak strata. Assessment at the active erosion areas at COE Billiri, indicated significant degradation affecting institutional infrastructure. The rapid headward extension documented in adjacent Kaltungo LGA suggests similar processes operate in Billiri, where the fine-grained, reactive rocks facilitate efficient chemical weathering and mechanical removal of material.

Observations from Gombe LGA shows that slope undercutting and urban sediment load are active. Slope undercutting involves the removal of material at the base of slopes or channel banks, causing overlying material to collapse (a process particularly severe in urban areas where construction alters natural drainage). Lazarus, (2012) reported gullies in Gombe Town reaching shoulder widths of 50–75 meters and depths of 3.5 to 18 meters. The process is driven by the undercut and collapse mechanism: groundwater penetrates rock through cracks in expansive clayey soils, dissolves cement, creates caves, and triggers roof collapse. Impacts observed showed that wall collapse damages buildings and roads, while blocked urban drainage systems increase flood risk, a recognized hazard in Gombe where the built-up area has become compressed by informal construction. The combination of vegetation removal, urbanization, and the region's reactive shale/clay bedrock creates a vicious circle of poverty, where poor populations are forced to build near dangerous gullies due to land scarcity, exacerbating their vulnerability.

Kaltungo LGA landscape is sculpt by rapid headward retreat and Land dissection.

Headward retreat describes the upslope extension of gully channels through waterfall erosion and sapping at the channel terminus, rapidly dissecting the landscape into isolated fragments. The process is accelerated in areas underlain by reactive rocks with high secondary permeability. Predisposing factors include the region's semi-arid climate, steep topography, soil erodibility, and land use/land cover changes that reduce infiltration capacity. Fast upslope extension creates isolated land islands, fragmenting agricultural holdings and disrupting farming operations. Road and culvert undercutting compromises transportation networks and increases maintenance costs.

In Shongom LGA, gully network expansion and substrate exposure were observed. Network expansion refers to the development of dendritic (branching) gully systems that increase drainage density and expose subsurface materials. This process is particularly severe where clayey soils with shrink-swell properties develop deep cracks during dry seasons, allowing rapid water penetration during rainfall. The ironstone cappings that cap the Gombe Sandstone and Pindiga Formation are eventually breached, exposing underlying materials. Dendritic gully network development creates an extensively dissected terrain where laterite and gravel horizons are exposed on the surface. This results in the permanent loss of arable land, as exposed laterite is unsuitable for cultivation. Shongom has experienced severe flood disasters, and the European Investment Bank has assessed active erosion in the LGA, confirming ongoing degradation. The exposure of ironstone and gravel layers represents an irreversible loss of topsoil that forms the foundation of local agricultural livelihoods.

The footprints of wall slumping and topographic lowering Yamaltu/Deba LGA. Wall slumping involves the downward rotational movement of gully bank material, a common failure mechanism in clay-rich soils where basal undercutting removes support. Topographic lowering results from the progressive reduction in land surface elevation through erosion. The shrink-swell behavior of montmorillonite-rich soils creates cracks that facilitate water penetration, accelerating the "undercut and collapse" cycle. Frequent gully wall collapse creates unstable slopes that threaten infrastructure and human safety. Steep scarps cutting access routes isolate communities and disrupt transportation. Yamaltu/Deba has been identified as one of the LGAs most affected by flood disasters. The severity of erosion in this LGA is consistent with the wider regional pattern where gullies sculptured in the shale/clay member of the Gombe Sandstone and Pindiga Formation pose the "greatest danger".

4. CONCLUSION AND RECOMMENDATIONS

This study assessed geomorphodynamic impacts of gully erosion in Southern Gombe State, Nigeria, identifying 130 permanent gully sites affecting 34,499.2 hectares (4.3%) of the area. Gullies were classified as continuous (35%), discontinuous (55%), and bank (10%) types, with continuous gullies occupying the largest area (64%) due to favorable conditions like large drainage basins and deep soils, while discontinuous gullies, though more numerous, cover only 11% of affected land. The dominant geomorphodynamic processes observed include drainage capture, sediment deposition, channel widening, mass wasting, and headward retreat which vary across the seven Local Government Areas, each facing distinct challenges such as threats to fadama farmlands, rice production, infrastructure, and arable land. Gully dimensions (depths up to 20m, lengths over 10km, widths up to 68m) underscore the severity of erosion, with U-shaped cross-sections indicating active gullying in the north and V-shaped forms suggesting partial stabilization in the south, though rejuvenation risks remain.

The study highlights that current interventions are inadequate, with government efforts covering only five sites and community actions often failing due to lack of technical guidance, while engineering-only solutions frequently collapse within 2–3 years. To address this, LGA-specific recommendations are proposed: sediment trapping and drainage management in Akko; sediment control and conservation agriculture in Balanga; vegetative wall stabilization in Billiri; urban drainage and infrastructure protection in Gombe; check dams and road drainage in Kaltungo; network expansion control in Shongom; and wall stabilization with groundwater management in Yamaltu/Deba. Overall, the research emphasizes the need for integrated, process-based approaches that work with natural geomorphological dynamics, rather than relying solely on short-term engineering fixes, to break the cycle of environmental degradation and poverty in this predominantly agrarian region.

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