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ORIGINAL RESEARCH ARTICLE

Spatial Distribution, Morphological Characteristics, and Socioeconomic Impacts of Gullies in Gombi Local Government Area, Adamawa State, Nigeria

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ABSTRACT

Gully erosion is a significant environmental and developmental challenge in Nigeria, contributing to severe land degradation, loss of agricultural land, and threats to infrastructure and rural livelihoods. This study investigates the spatial distribution, morphological characteristics, and socioeconomic impacts of gullies in Gombi Local Government Area (LGA), Adamawa State. Field survey was conducted across 27 randomly selected gully sites. GPS, leveling staff, and measuring tapes were used to obtain precise coordinates and morphological dimensions, including gully length, mean widths, and mean depths. GIS-based spatial analysis was employed to assess the correlation between gullies, slope, and drainage patterns. Results revealed gully lengths ranging from 26–250 m (mean = 88 m), widths from 2–12.2 m (mean = 4 m), and depths from 0.7–5.1 m (mean = 1.5 m), classifying most gullies as medium in size. Gullies were unevenly distributed, with hotspots in the eastern, north-central, and western parts of the LGA, highlighting areas highly susceptible to erosion. Communities reported increasing gully expansion and recognized the destruction of farmlands, roads, bridges, and river channels. These findings indicate that hydrological connectivity, slope, and human land-use activities are key drivers of gully formation and growth. The study provides baseline data for targeted interventions, including slope stabilization, afforestation, engineering controls, and policy implementation to mitigate erosion and safeguard socioeconomic development.

Introduction

Gully erosion represents one of the most severe forms of land degradation worldwide, particularly in regions with intense rainfall, steep slopes, and unsustainable land management practices (Poesen et al., 2003; Valentin et al., 2005). It involves the removal of soil along drainage lines, creating channels that can deepen and widen over time, leading to permanent loss of arable land, destruction of infrastructure, and socio-economic challenges for affected communities (Nyssen et al., 2006). In Nigeria, gully erosion has been documented extensively in the southeastern, north-central, and parts of the northeastern states, where geomorphological processes combine with human-induced factors such as deforestation, overgrazing, and improper farming techniques (Ofomata, 1985; Igwe, 2012). Understanding the spatial distribution, morphological characteristics, and socio-economic impacts of gullies is crucial for designing effective mitigation strategies and ensuring sustainable land use. In the context of Adamawa State, gully erosion has become increasingly noticeable in local government areas like Gombi, which exhibit diverse topography, varying land-use practices, and seasonal water flow dynamics. Despite its significance, research focusing on gully dynamics in northeastern Nigeria, particularly in Adamawa State, remains limited, creating a knowledge gap that hinders the formulation of evidence-based interventions.

The spatial distribution of gullies is largely influenced by natural and anthropogenic factors that interact over time, leading to the development of erosion hotspots (Poesen et al., 2003; Valentin et al., 2005). Topography, slope gradient, drainage density, and soil characteristics are critical natural determinants of gully formation, while agricultural expansion, deforestation, urbanization, and poor road infrastructure exacerbate the process (Igbokwe et al., 2008; Okagbue & Uma, 1987). Geographic Information Systems (GIS) and remote sensing tools have increasingly been used to analyze the spatial patterns of gullies, allowing researchers to identify areas of high susceptibility and model future risks (Hassen & Bantider, 2020). In Gombi LGA, preliminary surveys indicate that gullies are unevenly distributed across the landscape, with higher concentrations along steep slopes and near stream channels, reflecting the combined influence of hydrological and anthropogenic factors. Understanding these patterns is essential for prioritizing intervention measures, designing erosion control structures, and improving land management practices.

Morphological characteristics of gullies, including length, width, depth, and volume, provide critical insight into their development stage, erosion intensity, and potential impact on surrounding communities (Morgan, 2005; Oparaku & Ogbeh, 2018). Gullies in advanced stages of development pose significant risks, as their lateral and vertical expansion can destroy farmlands, roads, bridges, and other socio-economic infrastructure (Nyssen et al., 2006; Igwe, 2012). Local communities often perceive the growth of gullies as a major threat to livelihoods, affecting agricultural productivity, household income, and accessibility to social services. Quantifying gully dimensions and integrating them with spatial analyses enables researchers to categorize erosion severity, identify vulnerable zones, and develop targeted mitigation strategies. In Gombi LGA, the observed gully lengths range from 26 m to over 250 m, widths from 2 m to 12.2 m, and depths from 0.7 m to 5.1 m, reflecting medium to large gully classes. These findings suggest that medium-sized gullies dominate the landscape, while high-intensity erosion processes are occurring in hotspots identified along stream channels and steep slopes.

The socio-economic consequences of gully erosion extend beyond environmental degradation to encompass loss of agricultural lands, destruction of housing and infrastructure, reduction in water quality, increased flooding, and heightened accident risks on rural roads (Valentin et al., 2005; Eboka & Okpoko, 1984). Communities affected by gully erosion often experience a decline in livelihoods, food insecurity, and increased poverty, as productive land is lost or rendered unusable. In Gombi LGA, preliminary surveys of local residents revealed strong awareness of the negative impacts, including destruction of roads and bridges, farmland loss, river channel disruption, and increased accident rates, highlighting the multidimensional nature of the problem. Addressing these challenges requires an integrated approach combining engineering solutions, vegetation-based measures, land-use planning, and community participation. This study therefore aims to comprehensively examine the spatial distribution, morphological characteristics, and socio-economic impacts of gullies in Gombi LGA, providing evidence-based insights for policy-makers, planners, and environmental managers to design sustainable erosion control strategies.

Materials and Methods

Study Area

The study was conducted in Gombi Local Government Area (LGA), Adamawa State, Nigeria., The LGA is located between latitudes 10°00'00"N and 10°20'00"N and between longitudes 12°00'00"E and 12°50'00"E. Gombi LGA shares borders with Borno State to the northwest, Shelleng LGA to the west, Song LGA to the south, and Hong LGA to the east. The region exhibits a mixture of undulating topography, varying drainage density, and diverse land-use patterns, including agricultural, residential, and grazing areas (Ofomata, 1985; Poesen et al., 2003). The climate is characterized by a tropical savanna pattern with distinct wet and dry seasons, making the area prone to rainfall-induced soil erosion. Soil types range from sandy loams to clayey textures, often susceptible to gullying where vegetation cover is sparse (Nyssen et al., 2006).

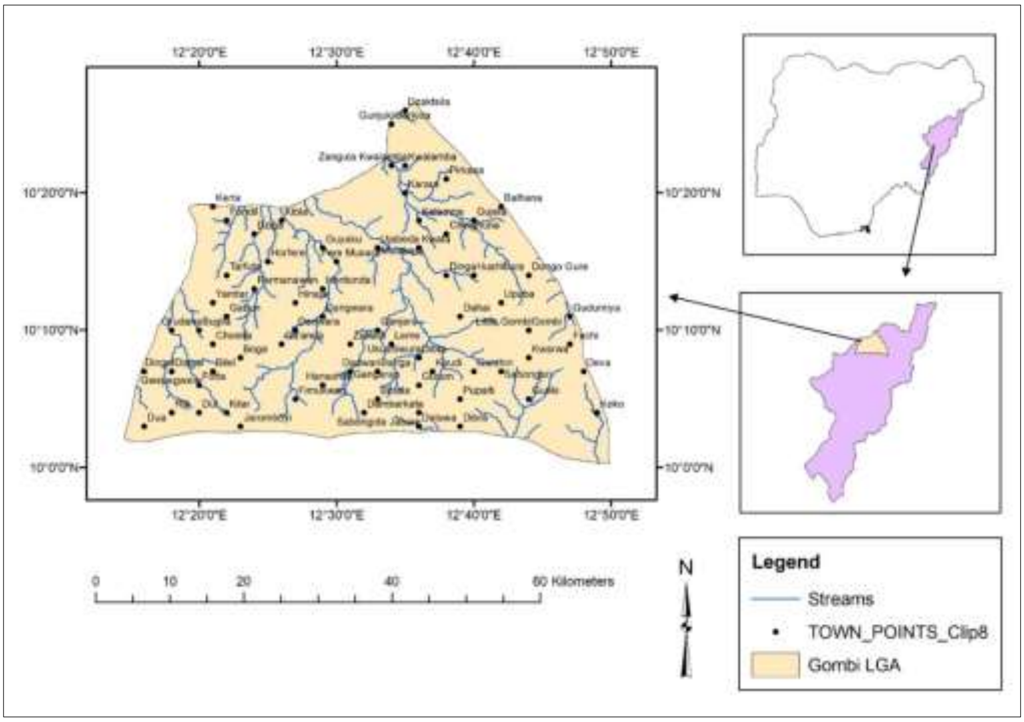

Figure 1: The Study Area

Research Design

A mixed-method research design was adopted, integrating both quantitative and qualitative data to examine the spatial distribution, morphological characteristics, and socio-economic impacts of gully erosion. Quantitative data focused on gully measurements, spatial mapping, and geomorphological attributes, while qualitative data emphasized community perceptions, livelihood impacts, and local knowledge of mitigation strategies (Hassen & Bantider, 2020; Igbokwe et al., 2008).

Data Types and Sources

Quantitative Data

Quantitative data were collected primarily from field measurements of gully sites. Parameters measured included gully length, width, and depth. Coordinates of gully heads and channels were obtained using a Global Positioning System (GPS), while levelling staffs and measuring tapes were used to determine slope, depth, and length of the gullies (Oparaku & Ogbeh, 2018). Secondary sources were used to obtain relief, slope, and hydrological characteristics, particularly using the Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) (Hassen & Bantider, 2020).

Qualitative Data

Qualitative data were obtained through structured questionnaires, interviews, and focus group discussions. The questionnaires employed a five-point Likert scale, addressing community perceptions of gully size, rate of expansion, and socioeconomic impacts. Secondary qualitative sources included previous studies on gully erosion in Nigeria and similar agro-ecological zones (Valentin et al., 2005; Igwe, 2012).

Materials and Equipment

Fieldwork employed:

- **GPS receiver**: For obtaining gully coordinates.
- **Leveling staff and measuring tape**: For depth, slope, and width measurements.
- **Ranging poles**: To demarcate measurement points.
- **Digital camera**: For photographic documentation of gullies.
- **Laptop with ArcGIS 10.3 software**: For spatial analysis, mapping, and relief/slope processing.

Sampling Design

Gully Site Sampling

An accidental sampling procedure was used due to the unknown number of gullies in the study area. Gullies encountered during field surveys were measured and recorded, resulting in 27 gully sites. Each gully was subdivided into measurement points at 20-meter intervals, and widths and depths were recorded (FOTG, 2002; Hassen & Bantider, 2020).

Respondent Sampling

Respondents were selected purposively, focusing on households located near gully-affected areas. Using Taro Yamane's (1973) formula for unknown populations, a sample size of 306 respondents was determined, with 289 questionnaires returned and deemed usable for analysis.

Methods of Data Collection

Gully Morphology Measurement

I. **Width Measurement (W):** Average of top width (Wt) and bottom width (Wb) at each measurement point:

$$W = \frac{W_1 + W_2}{2} \quad (1)$$

II. **Depth Measurement (Dm):** Average of multiple depths (d1, d2, … dn) along the gully:

$$D_m = \frac{\Sigma d_i}{n} \quad (2)$$

III. **Gully Volume (V):** Product of gully length (L), mean width (Wm), and mean depth (Dm):

$$V = L \times Wm \times Dm \quad (3)$$

Some of the field measurements procedures at the selected gully sites are presented in Plates I and II.

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Plate I: Measurement of Gully Width and depth at Boga 1

Plate II: Measurement of Gully Width and depth at Gombi 2

Questionnaire Survey

A structured **five-point Likert scale questionnaire** captured perceptions of gully size, growth trends, and impacts on socioeconomic activities. Data were coded and statistically analyzed to compute mean values, standard deviations, and grand means for perception indices.

Data Analysis

The data collected were analyzed using a combination of descriptive and spatial techniques. Descriptive statistics, including mean, standard deviation, and percentage values, were computed to summarize the morphological characteristics of the gullies and the perception indices of respondents. Spatial analysis was performed using ArcGIS 10.3 to map the locations of gullies, examine their clustering, and identify erosion hotspots within the study area. Correlation analyses were also conducted to explore the relationships between gully occurrence and key environmental factors, such as slope, drainage patterns, and land-use types.

Results and Discussion

Spatial Distribution of Gullies in the Study Area

The spatial distribution of gully points, as shown on the map, is a great way of learning the correlation between landscape processes, drainage networks, and the erosion vulnerability. The gullies are scattered in various locations in the local government area but they are clustered around certain physiographic and hydrological areas.

To begin with, the gullies are concentrated in the eastern and southeastern areas of the LGA (especially in Gombi 1-5 and Gombi 6). Such distribution indicates that the area is more susceptible to the development of gullies, which is probably because the areas are steeper, the runoff accumulation is greater, and the drainage channels meet. These places, e.g. Gombi 1 and Gombi 5 have gullies which are relatively long and deep indicating the advanced stages of gully erosion which are related to the high-intensity water flow and sparse vegetation cover.

Gullies are also evident in north-central axis (Mbewa 1, Mbewa 2, Kwalamba, and Pirkasa). These locations happen along the channels of streams, meaning that the significant stimuli are concentrated runoff and fluvial undercutting. The gully patterns in this area indicate that hydrological connectivity is an important factor in the genesis and growth of gullies (Poesen et al., 2003). The gullies in this area are fairly deep and wide indicating that there are active erosion processes that could be intensified with land-use activities like farming and grazing.

To the west, gullies are seen around Duwa 1-3, Riji 1-2, Fotta 1-2 and Boga 1-2. There are also some of the longest gullies in this zone including Duwa 1 (150 m) and Ganda 1 (250 m) which are indicative of older gully systems. Their occurrence in the western passage brings out the importance of topograph slope as well as the proximity of the streams in formation of gullies. The gullies in this region are longer indicating a long history of erosion whereby the water has been flowing in the same direction, causing the gullies to cut deep into the terrain.

Gullies such as Gabun 1-2 and Boga 1-2 are evenly spread in the southwestern sector and it indicates the high effect of streamflow concentration on gully initiation. This trend supports the conclusion that the drainage density and slope gradient are some of the important factors that regulate the spatiality of gullies (Valentin et al., 2005).

The drainage lines are significantly correlated with the distribution of gully points and therefore it can be argued that hydrological factors are the key drivers of gully formation in Gombi LGA. The concentration of the east, north-central, and western regions of the area suggests that these areas are the erosion hotspots where the activities like check dams, vegetation cover restoration and slope stabilization must be emphasized. The reduced number of gullies in the central interior has perhaps been caused by comparatively low drainage concentration and relatively low slopes.

Therefore, the spatial distribution shows that erosion of gullies in Gombi LGA is not evenly distributed but heavily relates to the slope processes, drainage systems, and land-use stresses.

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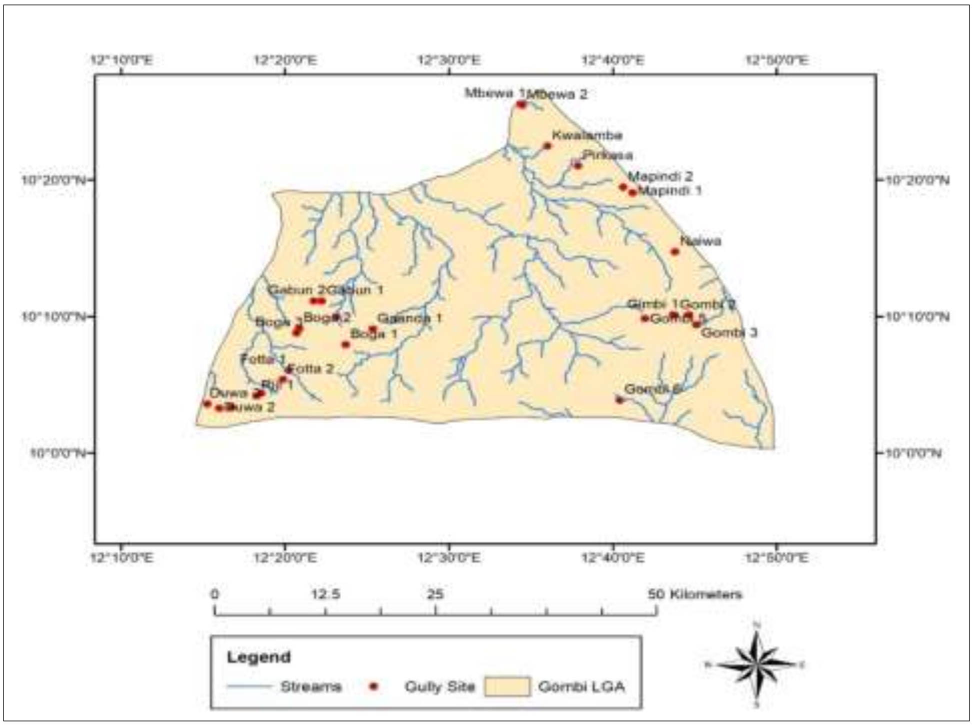

Figure 8: Spatial Distribution of Gullies in the Study Area

Gully Morphology Characteristics

The field study results of the morphological characteristics of gullies in the study area are presented on Table 1. The results revealed that the lengths of gullies in the area range from minimum values of 26.0 m or less to maximum values of 250.0 m or even more with an average length of about 88.0 m. This implies that Gombi Local Government Area is characterized by long gullies. There was also a high perception by the respondents that the gully lengths are on the increase over time (Table 1).

Table 1: Field results of the gully morphological characteristics of the study area

S/No	Name	X Coordinte	Y Coordinate	Length (m)	Mean Width (m)	Mean Depth (m)	Gully Class
1	Mbewa 1	234286	1153538	52.0	5.2	2.3	Medium
2	Mbewa 2	234478	1153379	62.0	3.0	2.2	Medium
3	Pirkasa	240490	1145182	165.0	3.7	1.1	Small
4	Kwalamba	237193	1148035	36.0	2.1	1.2	Medium
5	Mapindi 1	245552	1142421	45.0	5.2	1.7	Medium
6	Mapindi 2	246583	1141681	70.0	1.8	0.9	Small
7	Naiwa	251297	1133687	26.0	2.1	1.3	Medium
8	Gombi 3	253688	1123568	75.0	3.2	1.0	Medium
9	Gombi 4	252858	1124949	64.0	2.5	0.9	Small
10	Gombi 5	247943	1124475	92.0	4.1	1.4	Medium
11	Gombi 6	245045	1113487	100.0	3.9	1.3	Medium
12	Gaanda	217566	1123327	100.0	2.6	1.1	Medium

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13	Boga 1	214560	1121220	170.0	2.0	0.9	Small
14	Gaanda 2	213507	1125018	95.0	2.0	1.1	Medium
15	Gabun 2	211021	1127150	65.0	3.3	0.7	Small
16	Boga 3	209025	1122811	70.0	4.9	1.8	Medium
17	Fotta 1	208143	1117803	70.0	4.9	1.8	Medium
18	Fotta 2	207479	1116526	70.0	4.9	1.8	Medium
19	Riji 2	205035	1114718	140.0	6.2	1.6	Medium
20	Duwa 1	201711	1112803	110.0	4.3	1.5	Medium
21	Duwa 2	200365	1112701	100.0	3.1	1.3	Medium
22	Duwa 3	199026	1113334	95.0	2.3	1.2	Medium
23	Gabun 1	211918	1127143	65.0	3.3	0.9	Small
24	Boga 2	209348	1123468	250m	6.0	1.5	Medium
25	Riji 1	204509	1114401	150m	6.5	1.7	Medium
26	Gimbi 1	251046	1124943	157.3	12.2	5.1	Large
27	Gombi 2	251289	1124885	105.0	3.0	1.4	Medium
	Mean			**88.0**	**4.0**	**1.5**	**Medium**

Table 2: Peoples' perception of the gully morphological characteristics of the study area

Gully Morphology Characteristics	**SD (%)**	**D (%)**	**U (%)**	**A (%)**	**SA (%)**	**N**	**Mean**	**S.Dev.**	**Decision**
There are large gullies in my area	11 (3.8)	32 (11)	66 (28.8)	158 (54.7)	22 (7.6)	289	3.51	0.92	Low Perception
There are small gullies in my area	0	32 (11.1)	70 (24.2)	120 (41.5)	67 (23.2)	289	3.77	0.93	Low Perception
The lengths of gullies in my area are increasing	16 (5.5)	9 (3.1)	43 (14.9)	139 (48.1)	82 (28.4)	289	3.91	1.02	High Perception
The lengths of gullies in my area are increasing	3 (1.0)	12 (4.2)	30 (10.4)	87 (30.1)	157 (54.3)	289	4.33	0.90	High Perception
The widths of gullies in my area are increasing	0	15 (5.2)	45 (15.6)	83 (28.7)	146 (50.5)	289	4.25	0.90	High Perception
The depths of gullies in my area are increasing	0	3 (1.0)	47 (16.3)	137 (47.4)	102 (35.3)	289	4.17	0.73	High Perception
The sizes of gullies in my area cannot be controlled	71 (24.6)	47 (16.3)	33 (11.4)	48 (16.6)	90 (31.1)	289	3.13	1.60	Low Perception

Grand Mean	**3.87**

SD=Strongly Disagree; D=Disagree; U=Undecided; A=Agree; and SA=Strongly Agree

Decision Rule: *if the parameter mean is less than the Grand mean, the respondents' perception is low, else the perception is high.*

Results also show that the widths of gully in the area range from minimum values of 2.0 m or less to maximum values of 12.2 m or even more with an average width of about 4.0 m. This implies that Gombi Local Government Area is characterized by wide gullies. The perception that the width of gullies is increasing was also very high (Mean = 4.25), with more than 79% of respondents in agreement. This reflects the community's recognition of the lateral expansion of gullies, which progressively reduces available agricultural land and threatens nearby structures and settlements. Gullies also are the most destructive type of erosion since they lead to land loss as well as erosion of infrastructural stability, and thus, gullies are highly visible and alarming to the residents. Other countries with reported similar widening patterns include Ethiopia and Nigeria where lateral gully erosion was reported to be a major cause of farmland abandonment (Nyssen et al., 2006; Okagbue & Uma, 1987), (Table 2).

It is also revealed that the depth of gully of the area is also in the range of minimum depth of 0.7 m or less to maximum depth of 5.1 m or even higher with a mean depth of approximately 1.5 m. This means that Gombi Local Government Area is featured with deep gullies. There was also a high perception of the growing depth of gullies (Mean = 4.17) which was supported by more than 82% of the respondents. Deepening gullies are very dangerous as they make accessibility across landscape to be hard and lead to permanent erosion of arable land. The level of awareness of this trend among the respondents implies that the respondents pay high attention to the vertical development of gullies that frequently transform them into impassable obstacles and hazardous objects in their surroundings. This is in line with other researchers like Igwe (2012) who stressed that the depth development of gullies has a dire effect on the productivity and accessibility of land in southeast Nigeria.

The impression of the existence of large gullies (Mean = 3.51) was not much high though more than 60 percent of the respondents agreed or strongly agreed to the statement. This implies that although there are large gullies, they do not become a prevailing and pervasive aspect to the groups.
The same was witnessed in the case of small gullies (Mean = 3.77) where almost two-thirds of the respondents admitted to the presence of the same, yet the perception was low. This means that communities do not perceive the size of gullies as an issue by itself and more so, they appear to be more concerned with how the gullies were growing and evolving. The same was observed in the South-eastern Nigeria where the respondents noted that the gully development was more rapid than the initial size (Egboka and Okpoko, 1984; Igwe, 2012).

The declaration on the impossibility of controlling gully sizes brought about mixed perceptions as means of 3.13 and the largest variability (S.D. = 1.60). Although it was seen that 41 percent concurred or strongly concurred with the fact that the sizes of gullies cannot be controlled, almost 40 percent disagreed or strongly disagreed, which was a divided opinion. This finding indicates that there are communities who are not optimistic about managing the gully erosion, which may be because they have tried and failed before, and others are optimistic, maybe because they have seen such proven measures of control as check dams, afforestation, or engineering works. Similar mixed perceptions were noted by Igbokwe *et al.* (2008), who observed that some communities in Nigeria regarded gully erosion as "beyond human control," while others believed in engineering and vegetation-based solutions.

Classification of gullies based on depth, According to Morgan (2005), gullies can be grouped into three main categories: shallow, medium, and deep gullies. Based on this classification Table 7, reveals that average mean depth is 1.5m which fall under medium class of gully. This shows that field work is in line with people's perception about the morphological characteristics of gullies in the study area.

Impacts of Gullies on Socioeconomic Activities

The perception of respondents on the impacts of gully erosion on socioeconomic activities in the study area (Table 3) revealed a grand mean of 4.08, indicating a generally high awareness of the multiple developmental challenges posed by gullies. This grand mean serves as a decision rule where values above 4.08 indicate high perception and those below reflect lower perception. The results suggest that gully erosion is recognized not only as an environmental hazard but also as a significant developmental constraint affecting transport, housing, agriculture, and livelihoods (Poesen et al., 2003; Valentin et al., 2005). Specifically, respondents indicated that gullies severely damage road infrastructure, with a mean of 3.98 and almost 79% agreeing or strongly agreeing. Roads are often the first assets destroyed by advancing gullies, isolating villages from markets, schools, and healthcare facilities. This aligns with studies from southeastern Nigeria, where road collapses caused by erosion increased transportation costs and travel time (Igbokwe et al., 2008; Okagbue & Uma, 1987). Additionally, 75% of respondents recognized that gullies destroy communication networks, including telephone poles, power lines, and rural lanes, with a mean perception of 3.99, demonstrating the profound effect on information flow, electricity supply, and trade.

The effect of gully erosion on housing and agriculture was also pronounced. The perception that gullies destroy houses had a mean of 3.87, with 73% of respondents agreeing. Although not all households are directly affected, gully expansion near settlements leads to property damage, structural collapse, and displacement, consistent with findings in southeastern Nigeria (Eboka & Okpoko, 1984). Farmlands were perceived as the most severely impacted, with a mean of 4.25 and 89% of respondents supporting this observation. Erosion of agricultural lands reduces food production, weakens household income, and exacerbates rural poverty, forcing farmers to utilize marginal or less productive lands (Ofomata, 1985; Nyssen et al., 2006). Furthermore, 75% of respondents noted that gully erosion affects river channels (Mean = 3.96), highlighting awareness of hydrological alterations such as sedimentation, lowered water quality, and increased stream bank erosion.

Respondents also recognized the safety hazards and broader environmental consequences of gully erosion. Road accidents caused by gullies had a mean of 4.13, with 75% acknowledging the risk to vehicles and human lives. Gullies compromise driving conditions, particularly for motorcycles and bicycles, posing a daily threat to rural communities (Okagbue & Uma, 1987). Flooding was also identified as a significant effect, with a mean of 4.19 and over 80% agreement, demonstrating understanding of gullies as channels that concentrate runoff and increase downstream flood risk (Poesen et al., 2003; Igbokwe et al., 2008). The most widely recognized impact was the destruction of bridges, with a mean of 4.27 and over 87% of respondents concurring. Bridge destruction disrupts rural-urban connectivity, limits trade, and heightens community vulnerability in emergencies. These high consensus results reflect a comprehensive awareness among residents regarding the socioeconomic and infrastructural consequences of gully erosion.

Table 3: Impacts of Gullies on Socioeconomic Activities

Impacts of gullies on socioeconomic activities	SD (%)	D (%)	U (%)	A (%)	SA (%)	N	Mean	S.Dev.	Decision
Gully erosion destroys roads in my area	3 (1.0)	13 (4.5)	45 (15.6)	152 (52.9)	75 (26.0)	289	3.98	0.83	Low Perception
Gully erosion destroys other communication networks in my area	0	16 (5.5)	46 (15.9)	153 (52.9)	74 (25.6)	289	3.99	0.80	Low Perception
Gully erosion destroys houses in my area	0	39 (13.5)	39 (13.5)	133 (46)	78 (27.0)	289	3.87	0.96	Low Perception
Gully erosion destroys farmlands in my area	04 (1.4)	0	29 (10)	142 (49.1)	114 (39.4)	289	4.25	0.75	High Perception
Gully erosion affects river channels in my area	6 (2.1)	29 (10)	38 (13.1)	114 (39.4)	102 (35.3)	289	3.96	1.04	Low Perception
Gully erosion causes accidents on roads in my area	0	13 (4.5)	58 (20.1)	97 (33.6)	121 (41.9)	289	4.13	0.89	High Perception
Gully erosion causes floods in my area	6 (2.1)	11 (3.8)	38 (13.1)	100 (34.6)	134 (46.4)	289	4.19	0.95	High Perception
Gully erosion destroys bridges in my area	3 (1.0)	0	34 (11.8)	131 (45.3)	121 (41.9)	289	4.27	0.75	High Perception
Grand Mean							4.08		

SD=Strongly Disagree; D=Disagree; U=Undecided; A=Agree; and SA=Strongly Agree

Decision Rule: when the parameter mean is lower as compared to the Grand mean then the perception of the respondents is low and vice versa.

Some of the impacts of gully erosion on socioeconomic activities and infrastructure as observed on the field are presented in Plates III to VI.

Plate III: Impact of gully erosion on school environment at Gombi 2

Plate IV: Impact of gully erosion on rural road along Fota

Plate V: Impact of gully erosion on residential areas at Gombi 3

Plate VI: Impact of gully erosion on Farmland at Mbewa

Gully erosion mitigation in the area.

The perception of respondents regarding mitigation measures for gully erosion in the study area (Table 4) was generally high, with a weighted (grand) mean of 4.16, indicating strong community awareness and support for erosion control strategies. Riparian vegetation was identified as a key natural stabilizer, with 74.8% of respondents agreeing or strongly agreeing to its effectiveness (Mean = 3.87, SD = 1.11). Riparian buffers reduce surface runoff, filter sediments, and protect drainage channels, thereby limiting soil erosion (Adeyemi et al., 2019; Lal, 2020). However, the relatively high standard deviation suggests mixed perceptions, possibly due to low enforcement or inadequate awareness of riparian conservation benefits. Similarly, 67.1% of respondents agreed that banning grazing along drainage lines helps reduce erosion (Mean = 4.02, SD = 0.96). Overgrazing destabilizes soil, destroys vegetation cover, and compacts soil, making it vulnerable to erosion.

Planting deep-rooted trees emerged as another strongly supported intervention, endorsed by 84.4% of respondents (Mean = 4.23, SD = 0.70). The root systems reinforce soil structure, increase infiltration, and reduce runoff velocity, thus stabilizing slopes and controlling gully expansion (Bayala et al., 2019; Morgan, 2009). Cover crops were identified as the most widely endorsed measure, with 93.4% support (Mean = 4.37, SD = 0.69). These crops protect soil from raindrop impact, reduce surface runoff, and increase organic matter, significantly curbing erosion (Pimentel & Burgess, 2013). Retention of organic matter was supported by 78.5% of respondents (Mean = 4.08, SD = 0.98), reflecting awareness of its role in improving soil structure, enhancing permeability, and promoting microbial activity to reduce erosion susceptibility (Lal, 2015). Early interventions to prevent sheet or rill erosion from developing into gullies had 75.8% support (Mean = 3.93, SD = 0.96), highlighting community recognition of prompt remedial measures like mulching, contour bundling, and grass planting as essential (Okoro et al., 2016).

Other mitigation strategies were also highly supported. Discouraging bush burning received 84.8% agreement (Mean = 4.26, SD = 0.94), as uncontrolled fires destroy vegetation, expose soils, and accelerate erosion (Ojo & Akinlabi, 2019). Afforestation, endorsed by 93.8% of respondents (Mean = 4.35, SD = 0.66), replenishes vegetation cover, restores degraded lands, and stabilizes slopes, consistent with findings by Awotoye and Dada (2017). Policy-based interventions, including zoning drainage areas as protected lands, were supported by 82.3% of respondents (Mean = 4.22, SD = 0.80), reflecting recognition of sustainable land-use practices (FAO, 2019). Minimizing agrochemical usage received 85.5% support (Mean = 4.27, SD = 0.76), as excessive chemicals degrade soil structure, reduce organic content, and diminish vegetation cover, thereby exacerbating erosion (Adimassu et al., 2017). Overall, the high grand mean of 4.16 demonstrates strong community endorsement of ecological, land management, and policy-based measures to mitigate gully erosion. The most recommended interventions—planting cover crops, afforestation, and deep-rooted trees—align with international best practices emphasizing vegetation management, sustainable agriculture, and early intervention strategies (Lal, 2020)

Table 4: Mitigation Measures for Gully Erosion in the Area

Mitigation measures for gully erosion in the area	SD (%)	D (%)	U (%)	A (%)	SA (%)	N	Mean	S.Dev.	Decision
Maintaining riparian vegetation along drainages	166 (5.5)	23 (8.0)	34 (11.8)	125 (43.3)	91 (31.5)	289	3.87	1.11	Low Perception

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Stopage of grazing in drainages	0	32 (11.1)	34 (11.8)	120 (41.5)	103 (35.6)	289	4.02	0.96	Low Perception
Planting of deep root trees	0	0	45 (15.6)	133 (46.0)	111 (38.4)	289	4.23	0.70	High Perception
Planting of cover crops	3 (1.0)	0	16 (5.5)	137 (47.4)	133 (46)	289	4.37	0.69	High Perception
Maintaining high level of organic matter in the soils	6 (2.1)	18 (6.2)	38 (13.1)	113 (39.1)	114 (39.4)	289	4.08	0.98	Low Perception
immediate stablization of sheet or rill erosion	9 (3.1)	14 (4.8)	47 (16.3)	137 (47.4)	82 (28.4)	289	3.93	0.96	Low Perception
Discouyragement of bush burning	11 (3.8)	0	33 (11.4)	104 (36.0)	141 (48.8)	289	4.26	0.94	High Perception
Encouragement of afforestation	0	6 (2.1)	12 (4.2)	146 (50.5)	125 (43.3)	289	4.35	0.66	High Perception
Identifying drainages as important land classes for protection	3 (1)	0	48 (16.6)	116 (40.1)	122 (42.2)	289	4.22	0.80	High Perception
Avoiding the excessive application of agrochemicals on farmlands	0	6 (2.1)	36 (12.5)	122 (42.2)	125 (43.3)	289	4.27	0.76	High Perception
Grand Mean							4.16		

SD=Strongly Disagree; D=Disagree; U=Undecided; A=Agree; and SA=Strongly Agree

Decision Rule: when the parameter mean is lower than the Grand mean, then the perception of the respondents is low otherwise the perception is high.

Conclusion

The study provides an in-depth analysis of the spatial distribution, morphology, and socioeconomic impacts of gully erosion in Gombi Local Government Area, Adamawa State, Nigeria. The findings indicate that gully erosion is highly spatially clustered, with hotspots primarily in the eastern, southeastern, and western regions of the LGA. These hotspots coincide with areas of steep slopes, high drainage density, and concentrated runoff, emphasizing the influence of geomorphological and hydrological processes on gully formation and growth.

Morphological assessment of gullies revealed that lengths range from 26 m to 250 m, widths from 2.0 m to 12.2 m, and depths from 0.7 m to 5.1 m, with mean values of 88 m, 4.0 m, and 1.5 m, respectively. These findings indicate that medium gullies dominate, though some large and deeply incised gullies exist, representing areas of high erosion severity and potential for infrastructural and environmental damage. Field measurements were corroborated by community perceptions, with residents acknowledging increasing lengths, widths, and depths, reflecting heightened local awareness of erosion trends.

On the basis of the conclusion above, it is recommended that;

i. Check dams, gully plugs, and stabilization structures (gabions, stone pitching) be constructed by concerned organizations and agencies in erosion the hotspots to reduce runoff and gully expansion.
ii. Reforestation, afforestation, cover crops, agroforestry, and contour farming be encouraged in the area to enhance soil stability and reduce erosion.

iii. The local communities should be involved in monitoring, maintenance, and educational campaigns to improve awareness of gully hazards and control techniques.
iv. Enforcement of land-use regulations to restrict high-risk activities near gullies, and provision of funding and incentives for sustainable erosion control be encouraged in the area.
v. The implementation of long-term monitoring using GIS and remote sensing applications, studies of soil properties, rainfall, and land-use changes to inform adaptive gully management strategies should be enhanced.

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