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MANAGEMENT OF GULLY EROSION IN AKKO LOCAL GOVERNMENT AREA, GOMBE STATE: A PHYSICAL PLANNING PERSPECTIVE

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Abstract: *This paper is focused on making a critical analysis of the gully erosion problem in Akko local government area. The problems of gully erosion in Akko L.G.A have led to the loss of several lives and properties over the years and will persist if nothing is done to mitigate the situation. Data was collected to show the magnitude and the extent of the gully problem in Akko L.G.A. The study showed that, apart from the natural factors such as rainfall, the nature of the soil and the topography of Akko L.G.A., human factors in the use of land, especially in prone areas, also contribute to a great extent. An analytical method was also used to show the increase in gully erosion, and arithmetic progression was used to establish a trend for forecasting future occurrences and devastation. Based on the identified problems caused by gully erosion in Akko L.G.A., recommendations are made to manage and reduce the effects of gully erosion problems in Akko L.G.A. within the framework of the present and the future.*

Keywords: Erosion, Gully, Escarpment, Torrential precipitation, Soil Nature.

Introduction

Gully erosion has caused significant suffering and hardship to individuals from the last century to the present, resulting in the loss of dwellings and disruption of land usage, which hinders proper physical planning and leads to the depletion of agricultural land. This has impeded rural development. The emergence of gullies has become one of the most significant environmental catastrophes confronting Akko L.G.A. Every year, hundreds of individuals are directly impacted and must be relocated. Extensive regions of land are becoming uninhabitable for human settlements (Mbaya, 2012). Akko L.G.A. is confronted with a significant occurrence of gully erosion. Babagana (2008), in a study on gully erosion in Akko L.G.A, Gombe State, determined that the local government is marked by intense precipitation and steep topography, resulting in 3.85% of arable land being compromised by gully erosion. The proliferation of gully sites in diverse settlements is ascribed to rainfall intensity, steep slopes, geological composition, and insufficient drainage systems to manage stormwater runoff.

It is, therefore, essential to understand that the natural causes of gully erosion cannot be prevented but can be alleviated through effective physical planning.

This paper, therefore, examines the physical nature and condition of gullies in conjunction with their impacts on Akko L.G.A. by collecting spatial data directly from the field.

Problems Statement

Akko L.G.A is situated on the Akko escarpment, which descends eastward and concludes to Kaltungo in the following local government area. This escarpment is an issue since it facilitates rapid runoff, draining the eastern section. The soil of Akko L.G.A is especially susceptible to erosion due to its sandstone geological formation, which overlays the less water-resistant Precambrian complex (Emeh & Igwe, 2017). This comprises the alluvium, the Cretaceous Sedimentary Formations of the Kerri-Kerri Formation, the siltstone, sandstone, and ironstone of the Gombe Formation, the shale and limestone of the Pindiga and Yolde Formations, the Bima Formation, and the basement rocks (Mohammed *et al.,* 2024; Finthan *et al*., 2022; Iyioriobhe & Ako, 1986). This mechanism results in the gradual creation of gullies. These gullies have endangered and obliterated towns, regional roads and culverts, agricultural and grazing areas, and vegetation cover, as well as resulting in loss of life property and the relocation of individuals. The government and community have made numerous efforts to reduce and control the problem, yet it remains persistent and is escalating in magnitude. Given that gully erosion in Akko L.G.A. poses a significant threat to the built environment, it is imperative to implement physical planning solutions to manage and mitigate its impact on lives and property effectively.

The study area

Akko L.G.A is located in central Gombe state, and it lies between latitudes 9^{o} 15'N and 10^{o} 30'N and longitude 10^{o} 00'E and 11^{o} 30'E. It has a total area coverage of 2840.51 km^2 (Lamogo et al., 2022). It shares a boundary with Dukku and Kwami local governments to the north, Billiri and Kalthungo local governments to the south, Gombe and Yamaltu-Deba local governments to the east and Bauchi state to the west. Akko L.G.A is located within the sub-Sudan climatic zone, which is characterised by high shrubs and fairly tall trees (Mohammed et al., 2024). The wet season comes with the southwesterly wind, which is moisture-laden. The relative humidity in this period is high at 86% from July to September, which also experiences more rainy days than other months of the season. This is because the rainfall in these months is torrential thunderstorms because the sandstone gets saturated by July, and the presence of heavy runoff of stormwater causes gully erosion where slope values are high. The average annual temperature for these various months is generally high, but in March/April, it is about 930F (340C). Also, wet season temperature is high with a mean value of about 800F (270C), i.e. the cooling effects of the rain are only moderation factors (Savannah Landev Consult, 2000). The Akko escarpment, which slopes eastwards to Kaltungo, where it terminates, consists of sandstone geologic formation, which is completely covered by layers of soil that belongs to the ferralitic soil group that has a high content of sand and laterite gavel. This type of soil is structurally unstable (Finthan et al., 2022). The study area has a few elevated hills between 1600m and 2100m above sea level, and its lowest part lies between 1000m to 800m

The rivers of Akko L.G.A and its tributaries produce a dendritic pattern as they drain and destroy the ground with quick runoff. Some of the rivers are seasonal. These rivers serve as a source of water supply for many needs. The study area comprises the alluvium, the Cretaceous Sedimentary Formations of Kerri Kerri Formation, the siltstone, sandstone and ironstone of the Gombe Formation, the shale and limestone of the Pindiga and Yolde Formation, Bima Formation and the basement rocks (Obaje, 1999).

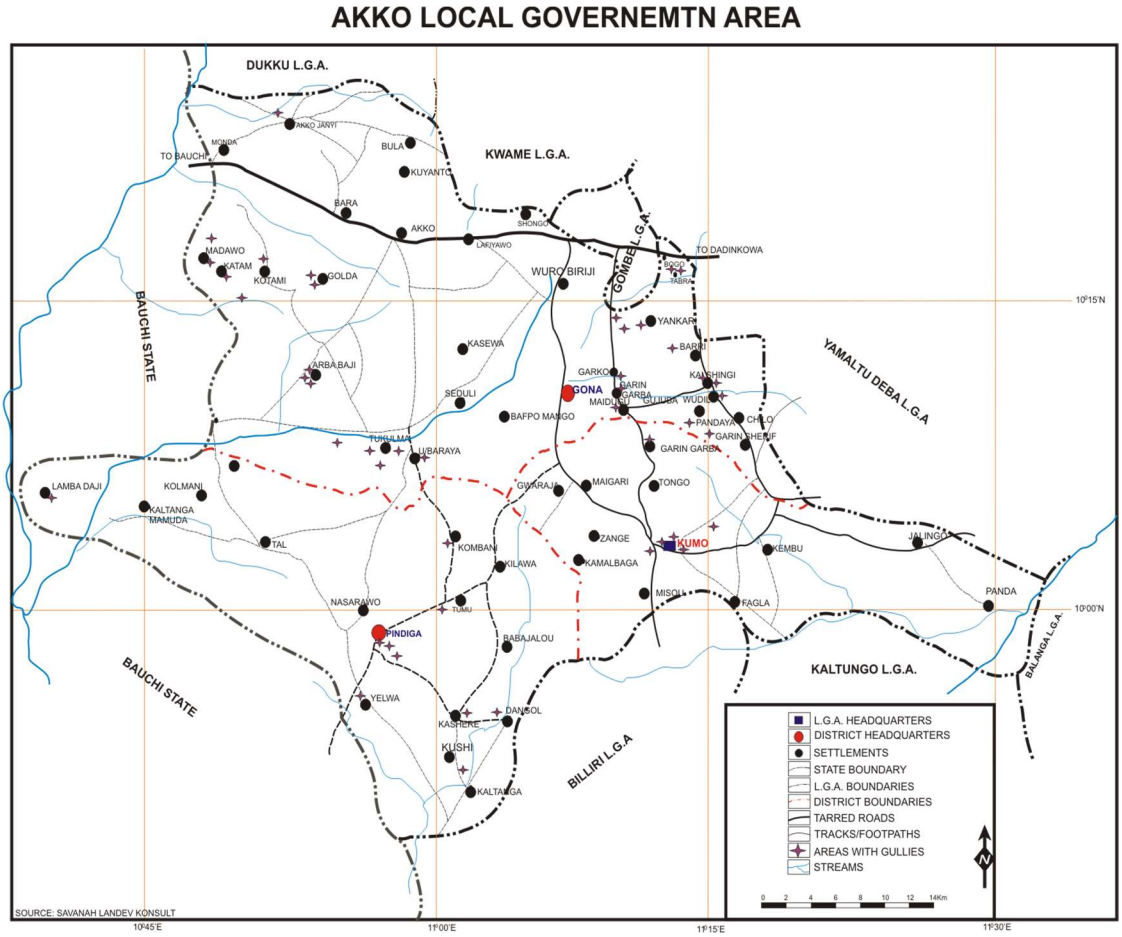


Fig 1: Map of the study area

Rainfall

The moisture-laden southwesterly breeze characterises the wet season. The relative humidity during this period is elevated at 86% from July to September, which also witnesses a more significant number of rainy days compared to other months of the season. The rainfall during this time consists of torrential thunderstorms (Twan & Oguche, 2024). As the sandstone becomes saturated by July, significant stormwater runoff is typical for this month in Akko L.G.A, resulting in gully erosion in areas with steep slopes.

The average yearly temperature during these months is typically elevated, particularly in March and April, reaching approximately 93°F (34°C). The rainy season experiences elevated temperatures, averaging approximately 80°F (27°C), indicating that the cooling benefits of rainfall serve just as moderating elements (Mohammed et al., 2024).

Fig 2 AKKO L.G.A MEAN MONTHLY RAINFALL (2015)

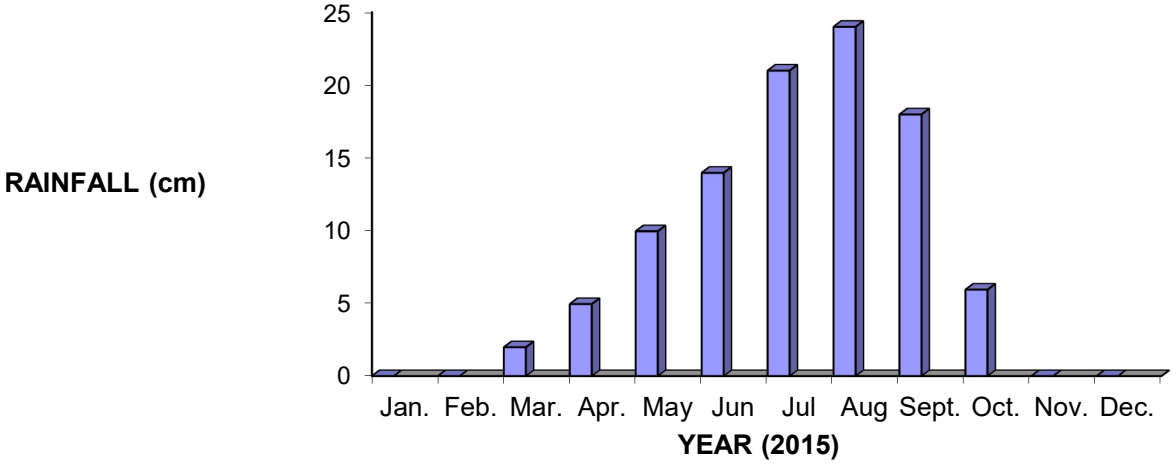
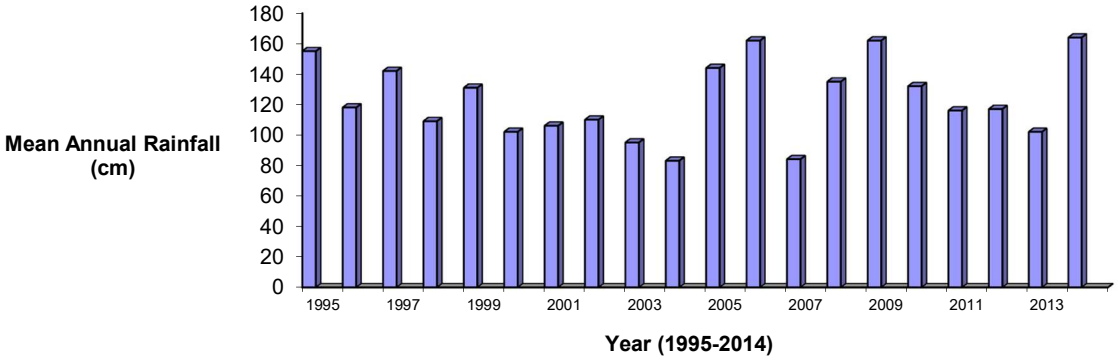


Fig 2: Akko L.G.A. Mean Annual Rainfall



Topography

The Akko Local Government Area is significantly shaped by the Akko escarpment, which descends eastward until Kaltungo, where it concludes (Giaime *et al.,* 2022). The western regions exhibit a rugged topography. The research region contains several elevated hills ranging from 1600m to 2100m above sea level. The geography facilitates stormwater drainage owing to the characteristics of the escarpment. The lowest portion of the research region ranges from 1000m down below 800m (Jibo *et al*., 2020). Figures 3, 4, 5, and 6 illustrate several slope sections within Akko L.G.A, highlighting the primary characteristics of the terrain and the escarpments. Steep regions typically feature rivers and streams, some of which possess tributaries with active gully heads.

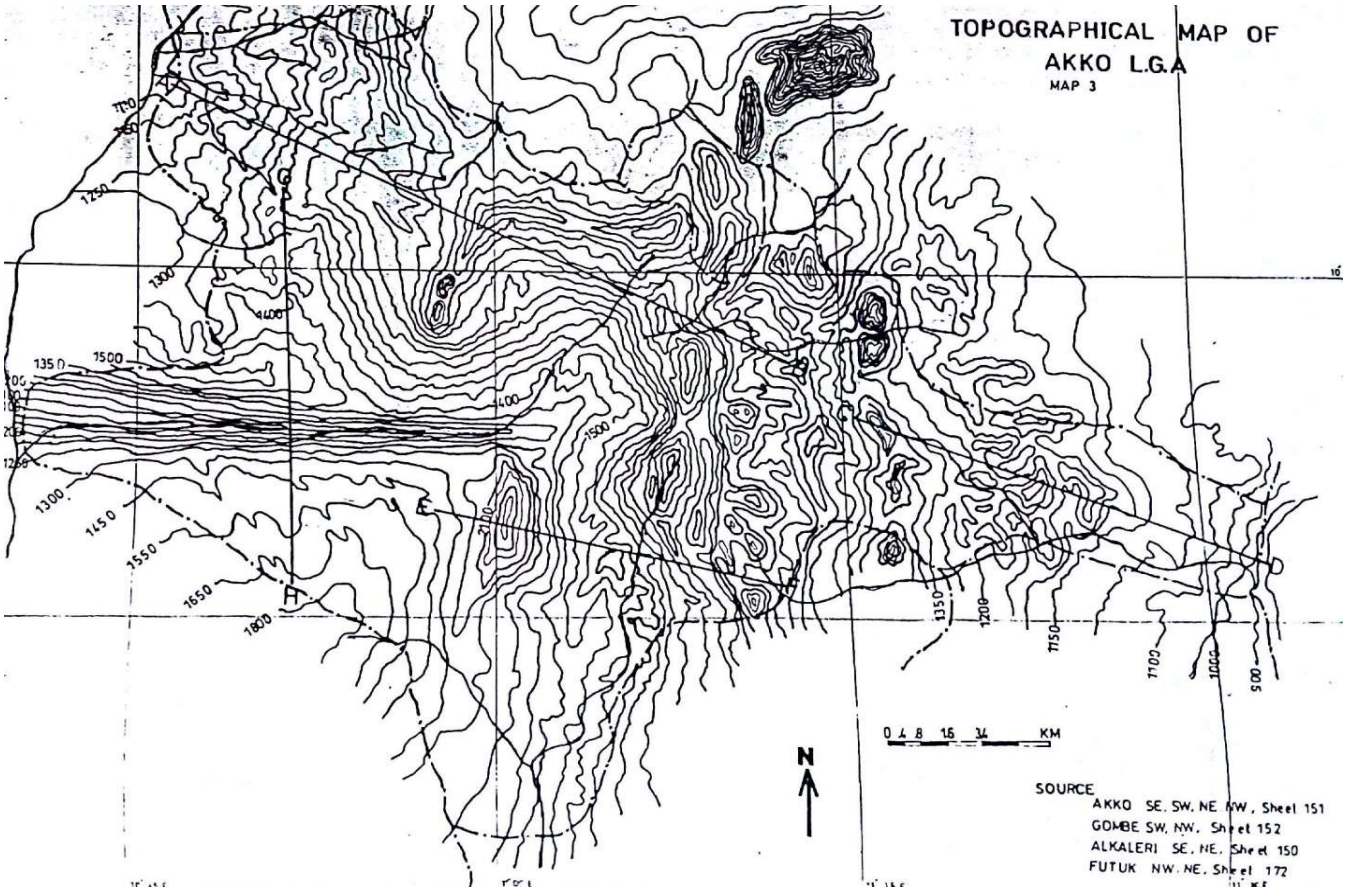


Fig 3: Topographical map of the study area

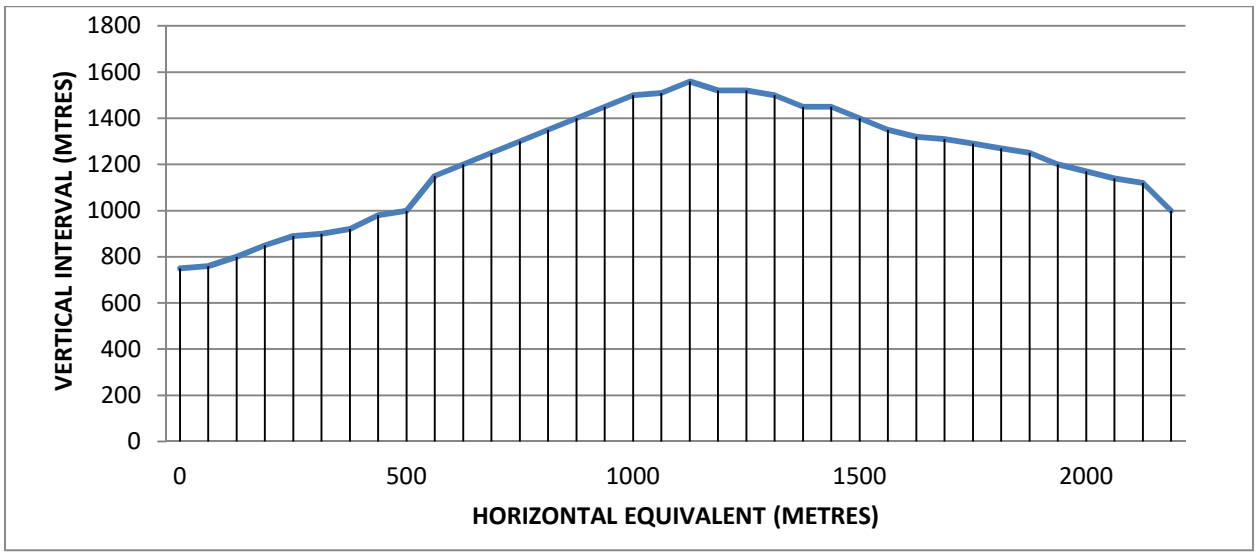


Fig 4: Contour Section A-B

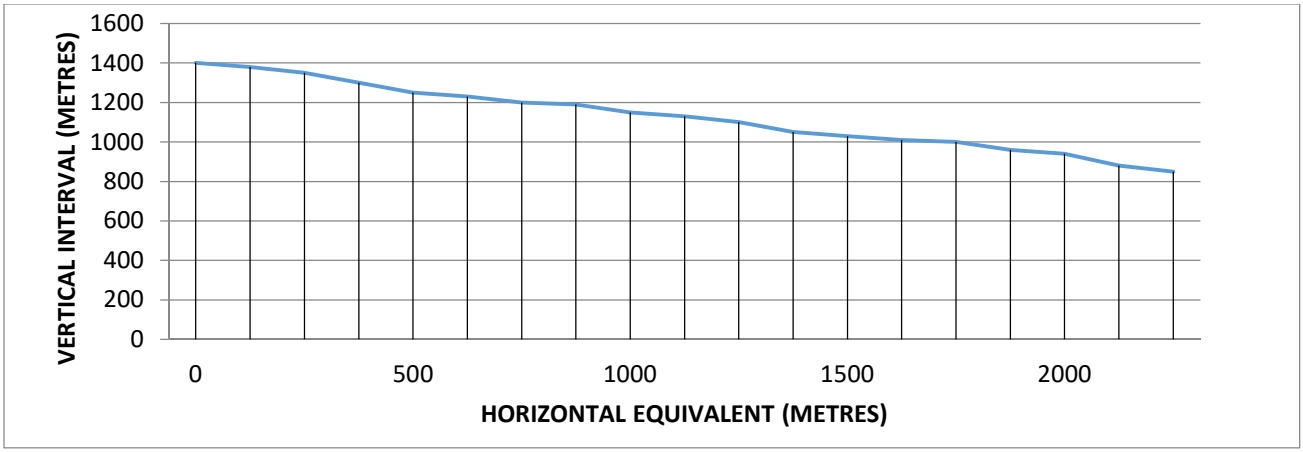


Fig 5: Contour Section C-D

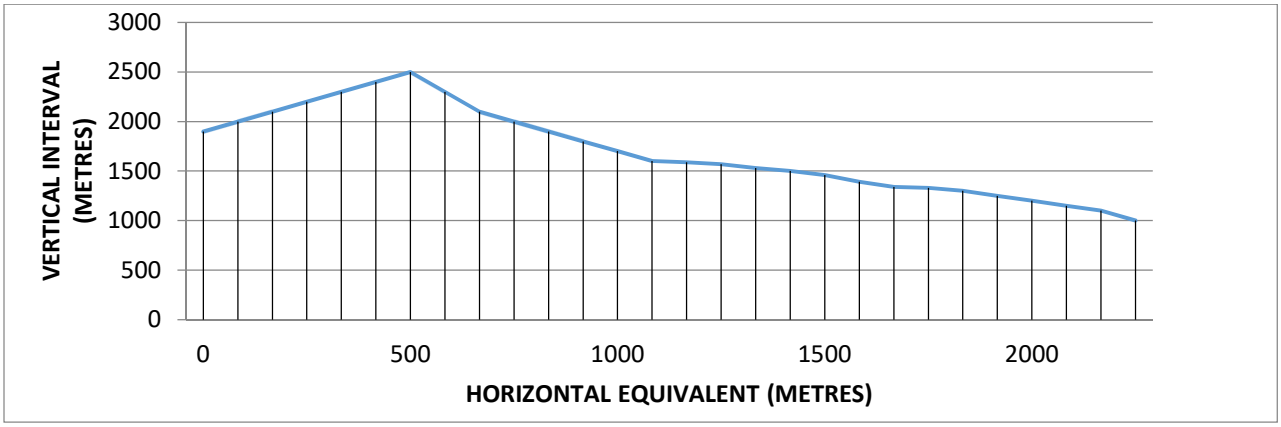


Fig 6: Contour Section E-F

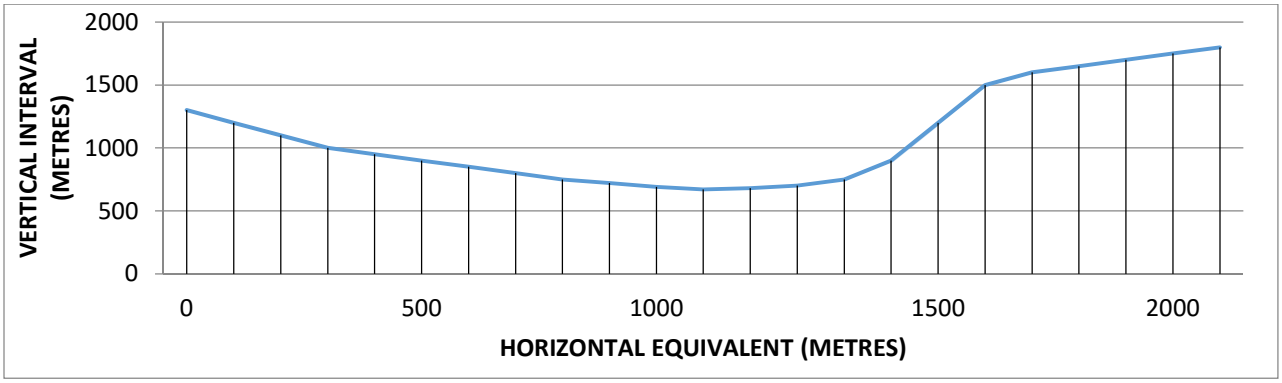


Fig 7: Contour Section G-H
Vertical scale, 1:200; horizontal scale: 1:100

Contour profiles from four selected areas (field work 2022)

Soil characteristics

The soil of Akko L.G.A is distinctly coarse-grained, loose, and well-structured. The soil exhibits high permeability and is readily eroded by rainfall due to the weak cohesive forces attaching its particles (Mohammed *et al*., 2024; Finthan *et al.,* 2022).

Materials and methods

The data for this study was obtained from relevant literature and field measurements conducted at 46 gully sites across the three wards of the local government: Gona, Pindiga, and Kumo. The gullies were classified as large, medium, and small. The gullies in Akko L.G.A. vary in depth, width, and length. The minor gullies average approximately 0.1 km in width, 3 m in depth, and 0.5 km in length. The medium gullies possess an average length of 1.5 km, width of 0.7 km, and depth of 6 m, whereas the large gullies exhibit average dimensions of 12 m in depth, 0.8 km in width, and 2.5 km in length. Currently, there are around 46 gully locations. The small, medium, and large gullies have total lengths of 8.25 km, 18.75 m, and 55 m, respectively. The obtained data was analysed using descriptive techniques to compare the extent of gully creation and damage and arithmetic progression as a mathematical method to predict future occurrences of gully formation and devastation.

Results and discussions

The data was collected and analysed. Table 1 presents the attributes of gullies and their cumulative length within the research region. There are 20 large gullies, 15 medium gullies, and 11 minor gullies, with total lengths of 55.0 km, 18.75 km, and 8.25 km, respectively.

Table 1: Characteristics of gullies in Akko L.G.A.

Classes of gullies	*District*	*No*	*Width (km)*	*Depth (m)*	*Length (km)*	**Total length (km)**
Small	Gona	8			0.5-1	
	Pindiga	3	0.1-0.2	2-3		8.25
	Kumo	-				
Medium	Gona	12			1.5-2	18.75
	Pindiga	2	0.5-0.7	4-6		
	Kumo	1				
Big	Gona	10	0.75-0.9		2.5-3	55.0
	Pindiga	5		7-12		
	Kumo	5				
Total		46				85.0

Source: Akko L.G.A. Information Unit and Savanah Landev Konsult

Table 2: Trend of Gully Erosion in Akko L.G.A.

Year	*District*	*No. of gullies*	*Area of land lost (km^2)*	*Volume of earth lost (km^3)*
2002	Gona	11		35.6
	Pindiga	5	36.01	
	Kumo	3		
2012	Gona	24		52.06
	Pindiga	9	82.02	
	Kumo	5		
2022	Gona	30		159.70
	Pindiga	10	109.36	
	Kumo	6		
	Total	46		

Source: Akko L.G.A. Information Unit and Savanah Landev Konsult

Table 2 indicates that land areas of 36.01 km², 82.02 km², and 109.36 km² were lost to gully erosion in 2002, 2012 and 2022, respectively. Additionally, 35.6 km³, 52.06 km³, and 159.70 km³ of soil were lost to gully erosion in 2002, 2012, 2022respectively.

Gully Erosion Forecast in Akko L.G.A (2008-2012)

The proliferation of gully sites escalates with each wet season in Akko L.G.A. This has resulted in significant devastation, particularly concerning the loss of land area and volume. The prediction is derived as follows by arithmetic progression:

$T_n = a + (n-1)\,d$

Where T_n = nth year of occurrence

a = 1st volume or area consumed by gully erosion

d = difference of volumes and areas consumed by gully erosion between years, which is also the annual increment.

⟶The average area of land costs annually

From 2002-2022 is 20 years

Therefore $T_{25} = a + 24d = 109.36$ …… eq1

$T_{10} = a + 9d = 36.01$ …… eq 2

By subtracting eqn. 1 from eqn. 2

$15d = 73.35$

$d = 4.89km^2$ is cost annually

⟶The average volume of earth lost annually

$T_{25} = a + 24d = 159.70$ …… eq1

T_{10} = a + 9d = 35.60…….. eq 2

By subtracting eqn. 1 from eqn. 2

15d = 107.64

d = 7.18km^3 is lost annually

From the analysis, it can be forecasted that between the year 2022 and 2026,

⟶24.45km^2 of land area should have been lost to gully erosion in Akko L.G.A.

⟶35.39 km^3 of earth should have been lost to gully erosion in Akko L.G.A

Table 3 illustrates the land use distribution of Akko L.G.A., indicating that gullies have eroded 3.85% of the total area of the local government. Nearly all elements in Akko L.G.A. have been impacted by gully erosion, including residences, agricultural grounds, and roadways. The majority of the gully sites are primarily situated within the developed areas. The destruction resulting from gully erosion escalates with each successive rainy season.

Table 3: Landuse Distribution of Akko L.G.A.

S/NO	*Landuse category*	*Area (km^2)*	*%*
1	Built area	450.22	15.85
2	Forest reserve	550.21	19.37
3	Gully area	109.35	3.85
4.	Agricultural and grazing land	1488.14	52.39
5.	River, rocks and fallow land	242.58	8.54
6.	Total	2840.51	100

Source: Akko L.G.A. Information Unit and Savanah Landev Konsult

Table 4: Impact of Gully Erosion on Housing

Nature of impact	*District*	*No. of Houses*	*%*
Total loss	Gona	23	
	Pindiga	10	7.57
	Kumo	20	
Structural damage	Gona	84	
	Pindiga	44	29.0
	Kumo	75	
Not affected	Gona	180	
	Pindiga	100	63.43
	Kumo	104	

Source: Akko L.G.A. Information Unit

Table 4 illustrates the effects of gully erosion on housing, derived from a survey executed by the Gombe State Committee on Ecological Problems in 2022 during the wet season, encompassing 640 residences situated along the principal gully locations within the local government territory. It was determined that

53 dwellings have been entirely lost to gully erosion. Approximately 203 dwellings sustained significant damage, while the others remain unscathed but are at risk due to the ongoing expansion of the gullies.

Plate 1: Gully threatening houses in Kumo

Table 5: Spatial Impact of Gully Erosion in Akko L.G.A. and the Naira Value of Damage

S/No	*Element*	*Nature of impact*	*Cost of Damage (₦ million)*	**%**
1	Buildings	Destabilisation and destruction of structural elements.	386.5	32.44
2.	Roads, culverts and drainages	Undercutting of road, culverts and drainages	680.0	57.07
3.	Farmland, grazing land	Destruction of biomass and soil	125.0	10.49
	Total		1191.5	100

Sources: Savanah Landev Konsult

Plate 2: Gully undercutting regional road in Gona

Plate 3: Gully traversing farmland in Pindiga

Table 5 illustrates the regional effects of gully erosion in Akko L.G.A. Over 36% of residences in Akko L.G.A. have suffered from various effects of gully erosion, and there is a likelihood of more harm if no measures are implemented to mitigate it. The gully locations are primarily situated within the developed region. It has also impacted roads, culverts, agricultural land, forests, and drainage systems.

Circulation is occasionally obstructed when walkways are undermined and disjoined. In some instances, the gullies form near the peripheries of villages, hindering expansion. According to the table, roads, culverts, and drainage systems incur the most financial damage impact, accounting for 57.07%. Buildings experience an impact of 32.44%, whilst farms and grazing areas endure the least at 10.49%.

Conclusion

Gully erosion, a naturally occurring process over an extended duration, cannot be entirely halted but can be controlled to a manageable extent. The residents of Akko L.G.A. in Gombe State have endured significant hardships due to the existence of gullies.

The local farmers, whose livelihoods depend on agriculture, encounter difficulties in pursuing their customary farming activities due to erosion that has compromised some fertile ground. In urban places, numerous houses have been destroyed alongside the loss of lives, resulting in suffering and adversity.

Implementing these management strategies would effectively control and minimise the issues of gully erosion in Akko L.G.A.

Recommendations

1. All existing gullies within the developed area must be restored using laterite infill and compaction to achieve the standard ground level. The compacted surface must be covered with a properly engineered drainage channel to manage future runoff effectively.
2. Structures located in gully-prone regions should be relocated to upland locations with more solid topography. Reclaimed regions beyond the gully-prone zones should undergo re-vegetation and be designated as forest reserves. Stringent procedures must be implemented to regulate developmental activities in these regions.
3. All roadways inside the settlement, particularly those most impacted, should be equipped with drainage systems. The drainage systems must be adequately reinforced and constructed with high-quality concrete that meets technical standards to endure various runoff pressures.
4. The federal and state governments should establish an erosion monitoring and control agency to oversee and manage erosion issues consistently in Akko L.G.A.
5. State and federal agricultural agencies should advocate for land conservation, management, and restoration initiatives in Akko L.G.A.
6. The government should establish and fund environmental protection clubs. They should be tasked with educating the public on appropriate and inappropriate actions for the management of gully erosion. They should also inform the public about the hazards of detrimental behaviours such as deforestation, bush burning, and sand mining in impacted regions, as well as the advantages of tree planting in the management of gully erosion. This club should comprise community members and stakeholders tasked with safeguarding government initiatives. This will also result in the provision of inexpensive labour since local males will be employed to execute the projects, thereby complementing government efforts, given that the community lacks the financial resources for these initiatives.
7. Essential administrative measures and financial resources must be allocated to implement existing environmental regulations, particularly concerning bush burning, solid minerals, mining, and significant construction projects at the local government level.
8. The federal government will allocate particular projects and execute plans via a national ecological commission following the reorganisation of the ecological fund. The planned National Ecological Commission will develop local and state ecological plans to serve as a foundation for the projects to be executed.

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