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Surveillance of Gully Erosion in Damagum Town and Environs, Fune Local Government Area, Yobe State of Nigeria

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Abstract
This study assessed the causes of gully erosion in Damagum town and environs, mapped out the gully affected areas, and recommended possible solutions to the menace. Data used included both primary and secondary sources. The primary data were generated through measurement, soil laboratory analyses, use of camera and taking coordinates to generate GIS maps. The secondary data, including rainfall data and other relevant journals, was used to justify findings where necessary. The causes of the gully erosion in the study area were assessed based on the physical and anthropogenic factors. However, for the mapping purpose, areas most affected by the gully erosion were purposively selected, covering about 2000m distance. In addition, the natural elements were examined by determining the slope, elevation, stream pattern, flow direction, rainfall data and land used land cover of the study area. Hence, the study concludes that the major causes of the problem of gully erosion include both natural and anthropogenic factors via sand excavation. Lastly, the following recommendations were made, the government should encourage people to engage in community development practices. Furthermore, the government needs to construct drainage systems and repair the collapsed ones in the study area. Finally, there is a need for law enforcement against those violating the environment, such as dumping waste within the drainage system and sand excavation.

Keyword: Awareness, Gully, Erosion, Environmental, and Problem.

INTRODUCTION
Gully is a relatively deep, vertical-walled channel recently formed within a valley where no well-defined channel existed. Gully erosion is an advanced stage of rill erosion where surface channels have been eroded to the point where they cannot be smoothened over by normal tillage operations (Abdelfattah *et al.*, 2014). Gullies can be active (actively eroding) or inactive (stabilized). According to Poesen *et al*. (2003), the former can occur where the erosion is actively moving up in the landscape by head-cut migration. The causes of gully erosion are poorly understood, but the processes and factors involved in its growth and degradation are well-known (Bettis III, 1985). In Nigeria, the impacts of gully erosion have been quite devastating across different parts. Consequences of the menace have led to the displacement of community's destruction of infrastructure and farmlands. Generally, aside from natural denotational forces, human activities like deforestation, overgrazing, poor drainage networks,

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blockage of waterways, sand mining and poor urban planning have been identified as either the primary causes or accelerators of gully erosion (Ologe, 1988).

The Nigerian environment is degraded through improper management and other human activities. Part of the problem is creating badlands condition in many areas of the country. People's lives were lost to erosion; equally, an average of 14, 862.8m3 volumes of soil between (1992) (and 2002) were lost to erosion (Egboka., 2004). Nigeria is among the countries that are facing the problem of gully erosion. Almost all the country regions are experiencing the effects of this menace (Ofomata, 1985). Moreover, southern Nigeria is experiencing such kind of environmental problem. Asiabaka and Boers (1988) had estimated that over 1,970 gully sites occur in Imo and Abia States. A conservative assessment shows the distribution of known gully sites in different stages of development as follows; Abia (300), Anambra (700), Ebonyi (250), Enugu (600), Imo (450), Igbokwe et al. (2003), Egboka (2004). In addition, Imo state and Enugu states also have some areas where gully has become a severe issue, and studies revealed that the significant causes of gully erosion in that rejoin include both natural and anthropogenic (Igbokwe *et al.*,2003). The type of rainfall there experience also plays a negative role in aggravating the erosion, with the highest rainfall average of 1952 mm from march to November (Egboka., 2004).

Moreover, in the Northern part of the nation, places like Gombe also experienced problems (Lazarus et al., 2012). The town is fast becoming hazardous for human habitation. Hundreds of people are directly affected every year and have to be relocated. Large areas of agricultural lands are becoming unsuitable for cultivation as erosion destroys farmlands and lowers agricultural productivity. The demographic increase and various infrastructural development meant to improve the people's standard of living has, on the other hand, devastated the environment, especially where uncoordinated development is taking place. Each yearly rainy season is accompanied by increases in gully length, depth and width. The incidents of gully have caused much concern to successive governments of Gombe state and other stakeholders where concerted efforts of control measures were taken each year. Various methods adopted by the government and residents of Gombe town in gully erosion control measures include engineering, tree planting or vegetation, stone wall sandbag and diversion of runoff. However, the control measures have not kept pace with the rate of gully expansion or growth, as some of these measures have been fully or partially successful. In contrast, others have failed due to inadequate funds to adopt the holistic control measure method that stands the test of time (Mbaya, 2017).

Similarly, in Yobe state and zone B, the study area precisely is among the areas that are seriously affected by the problem of gully erosion in the country. The area is mixed up with both undulating and rugged topography. Although various local flood control mechanisms such as the construction of embankments and planting of shrubs have been put in place, the areas' land cover and land use were discovered to have changed due mainly to human activities (Oladimeji *et al.,* 2017). Furthermore, many research studies have been conducted on gully erosion elsewhere in Nigeria. To mention but a few are a study by Okagbue and Uma (1987), which assessed the performance of gully erosion control measures in southeastern Nigeria. Nyanganji (2009) set a gully in the Ngadda basin to post mega Chad landform development through headwater erosion on the Bama Beach Ridge complex. Mala (2011) also appraised the process on the Ngaddabul plains under the influence of natural and human factors at four locations. Amangabara (2012), on the other hand, analyzed some selected failed gully erosion control works in Imo State. However, all these research works were conducted in different study areas and other locations. Hence there are differences between the rainfall, soil type, vegetation and landform of the mentioned areas and the study area of this research study. Although the work of Maina *et al.* (2020) was conducted in the same study area as this research work, they have almost the same environmental features. However, the research only looked at the control measures against gully erosion, but they did not look at the causes of gully erosion in the study. Therefore, this work bridges a gap in research by mapping out the areas affected by the menace and assessing the effects of the gully erosion in the study area

The Study Area

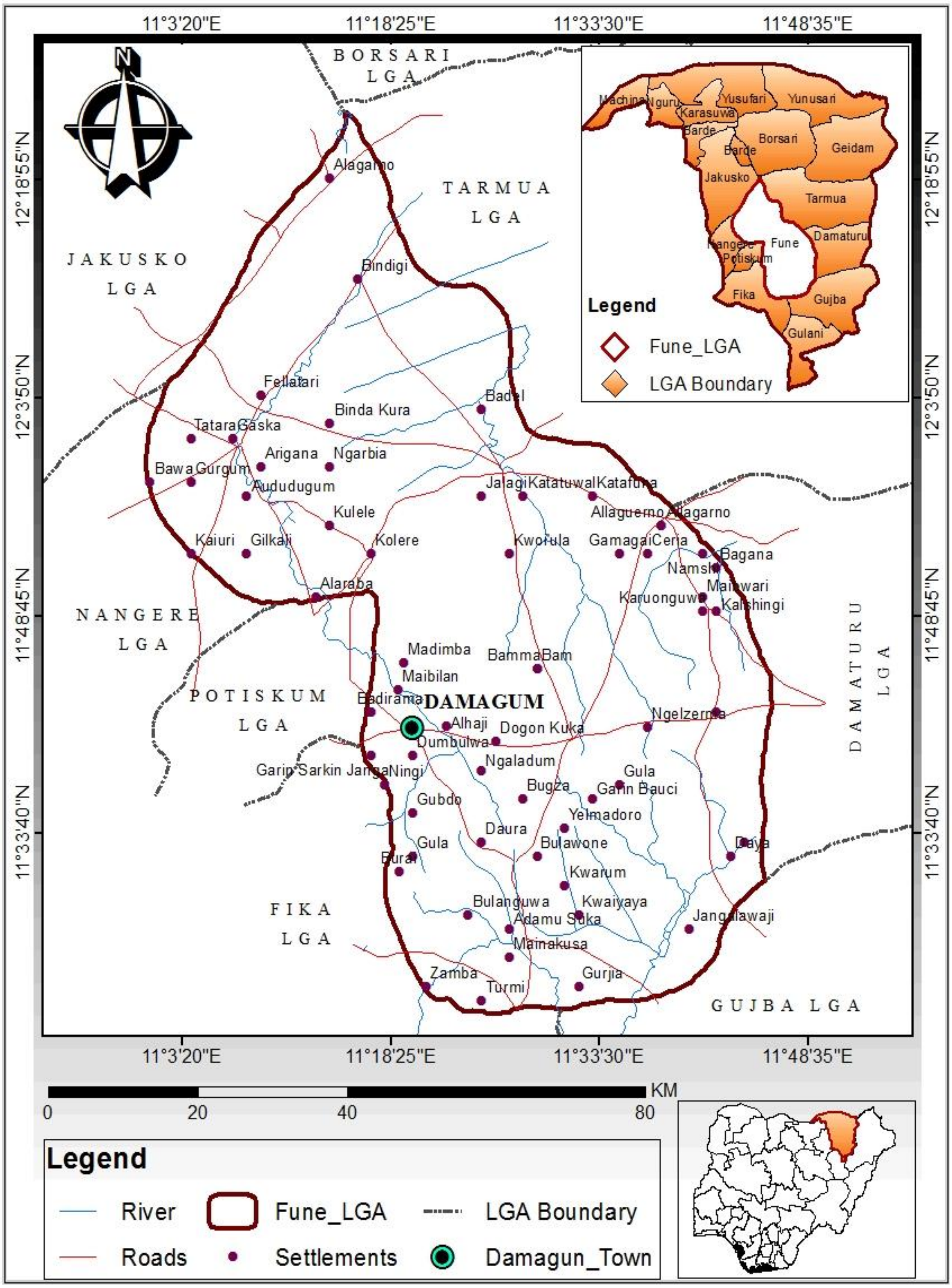


Figure .1: The study Area
Source: Quick bird imagery and Administrative Map.

Damagum town is the capital of Fune local Government which is situated on longitude 11° 40′ 39″N and on latitude11° 20′ 04″ E, with area of about 4948km² and the projected population to 2022 is 390523.Damagum town is in 'the geomorphologic unit known as the 'Potiskum plains and hills (Heinrich, 1994).Moreover the study area is located on the geomorphologic unit known as the Potiskum plains and hills. The unit consists of steep to gently undulating plains with occasional mesas (Heinrich, 1994). The parent material consists of coarse grained sandstone of the kerikeri formation with extensive iron-pan overlain by fine Aeolian sands. To the east, along Damaturu road, are isolated residual hills called mesas. The steep to undulating plain of Potiskum region is bounded on the south-east by an abrupt escarpments descending from the rolling platform to the south into the Gongola valley (Heinrich, 1994).Damagum town is on a height of 436metres above sea level, in the east is a hill referred to as Molku in the south is the valley which contains a seasonal stream that's drains into Gongola river. The northern half of the region is drained by the northerly flowing tributaries of the KomaduguGana most of which carry water following the rains but flow only persistently in the head- waters. The southern part of the district is drained by the tributaries of River Gongola, which forms the southern boundary of the district; the water table is usually 0-15 meters below the drainage line but increases rapidly in depth away from the stream lines (Mala, 2011). Over much of Potiskum, the water table is within 20-23 meters of the surface and is the source for the handling wells in the town (Mbaya, 2011).

However, two broad data sources have been used in this study, namely, primary source and secondary source. The primary source consists of collecting the coordinates of the eroded locations using a GPS receiver. It also included a Field survey, observations, measurements and interviews. Also, a soil test was carried out to know the soil type and other soil characteristics related to water erosion. While the secondary source included high-resolution satellite imagery, rainfall data was collected from the Nigerian metrological Agency (NIMET) agency in Potiskum to examine the amount and intensity of the rainfall in the area. Both primary and secondary types of data were used for this study. Data set was acquired on the regions affected by gully erosion and morphology of the sites, and data on the causes of the decline. Also, an effort was made to examine the characteristics and nature of gully erosion problems in the area. Furthermore, the particle size was determined by the modified hydrometer method adopted by Andrés *et al.* (2014), while organic carbon and organic matter were analyzed using the oxidation method adopted by Mylavarapu (2009). Lastly, the pH value was determined by the potentiometric method (Diana *et al.*, 2017).

RESULTS AND DISCUSSIONS

The natural causes of gully erosion in the study area

Natural causes of gully erosion were assessed based on the following factors, nature of the topography, the stream/river, nature of the soil and lastly the rainfall of the study area. T**opography** of an area is among the major factors that determine the occurrence of gully erosion. Hence, the factors that describe it such as profile, slope, elevation and digital elevation model (DEM) are considered and presented in figures. Figure 2 show the steepness of the topography at point B while at a distance of 700m, 1100m, 1400m and 1500m respectively the topography is undulating. Therefore the steep area aggravates run off while the undulating area is the area most affected by the gully erosion. This agrees with the findings of Ofamata (2009) which asserts that steep land are more vulnerable to water erosion than flat land. The reasons are erosive forces; splash, scour and transport all have greater effect on steep slopes. Thus, soil erosion generally is a function of slope attributes. The amount of soil erosion and the length and steepness of the slope have always been proportional.

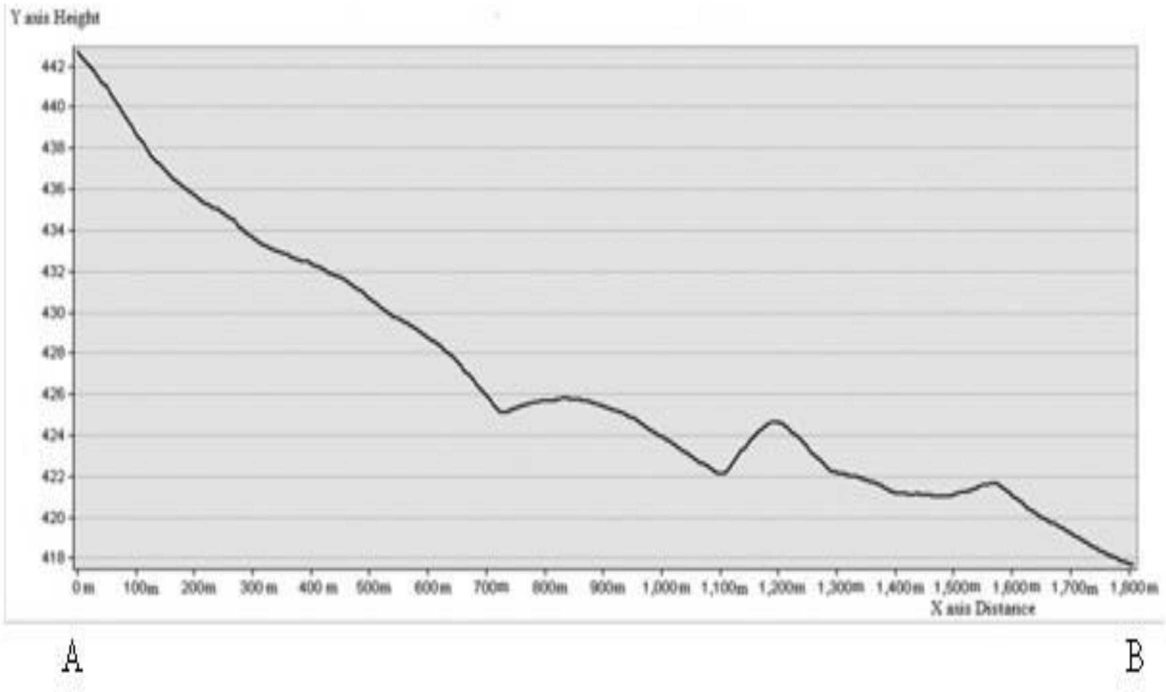
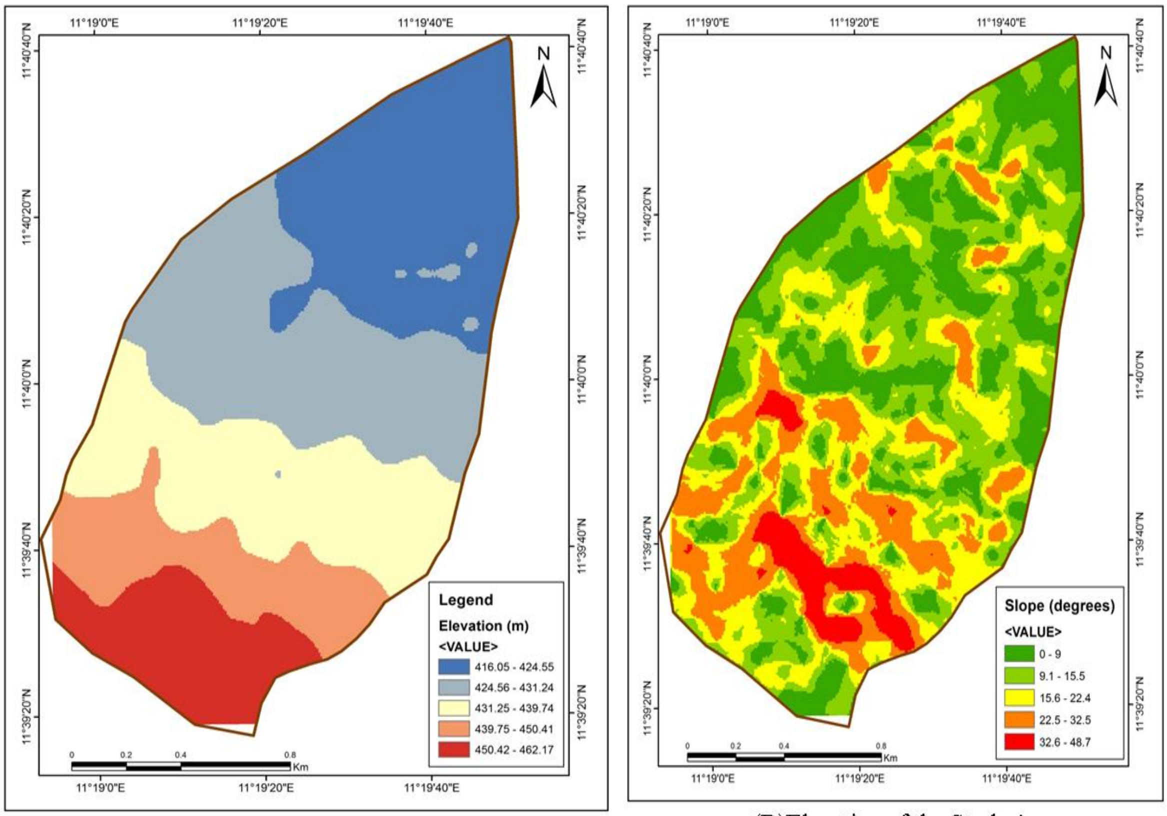


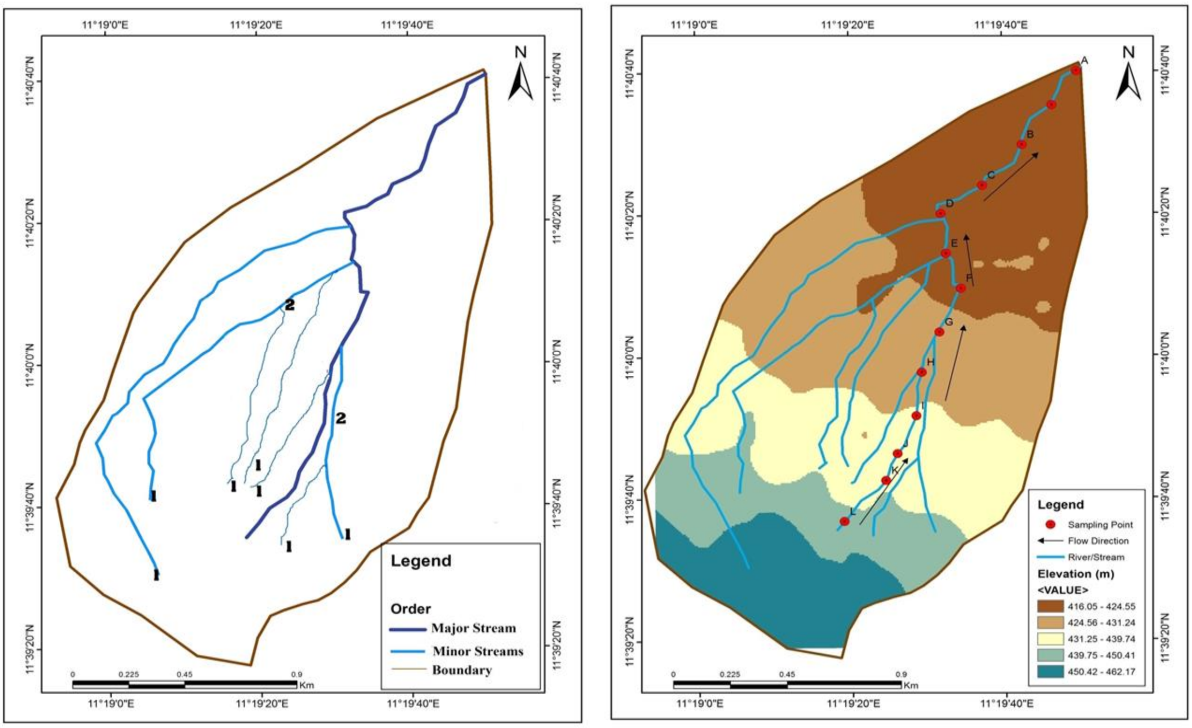
Figure 2: - Profile of the study area
Source: Fieldwork, 2022



(A) Slope of the Study Area (B)Elevation of the Study Area

Figure 3: - Slope and elevation
Source: Fieldwork, 2022

In figure three **(A)** shows the slope of the study area in 2022. The highest degree of the slope is represented by red color having 32.6 degree - 48.7 degree, followed, by pink, yellow, light green and dark green which is the lowest degree with 0 – 19 degree. The lower degree is the area where the gully erosion is observed to be occurring. Moreover, the slopes of the angle and the length have great influence on the degree of erosion in Damagum town because the slope is a little bit longer and steeper. These features influence the stability of soil due to the velocity of running water and runoff. In addition, slope constitutes one of the most important factors of soil erosion, as the steeper the slope, the faster the runoff and the more intense the detachments. The slope length indicates the gravity of low infiltration and high runoff conditions. Therefore, the implication of this finding is that Damagum town is dominated by active gully erosion and there is the need for a holistic approach to watershed management. This result is similar with the findings of Mallam *et al.,* (2016). Ordinarily under vegetation cover, the slope gradient should not have enhanced erosion processes but due to exposure to direct raindrop impact, human activities and coupled with the poor soil aggregate has accelerated gully erosion. Areas having higher slope gradients showed greater responses to decrease in gradient than those with lower slope gradients. Moreover **(B)** in figure 3 shows the elevation of the area above the sea level. The red color represents the highest elevation with 405.42m to 462.17m, followed by pink with 439.75m to 450.41, yellow with 431.25 to 439.74, then light blue with 424.56 to 431.24 and lastly the dark blue color represents the lowest elevation in the study area with 416.05 to 424.55. Elevation is also an important factor in locating the areas that are depress by the effects of gully erosion. Because it's Shows the higher relief and lower relief area. The slope of the area has also been assessed this is because it is also one of the major determining factors of gully erosion in an environment. Furthermore **(C)** shows the results showed that there are five streams order which is a bit much. This means that when there's so many stream orders the volume of the water in the river will be high and consequently increase the gullying process while (**D)** shows the river is flowing towards the northern part because the area has low elevation which is also the most affected area by the gully erosion. However **(E)** presents the three-dimensional map of Damagum area. The description of the basin observed is similar to that of Max Lock group, (1976) and (Mbaya *et al.* 2011). The area comprises of a pronounced low land which aids high water runoff and hence aggravates the gulling process. The green points in the maps indicate the most depressed places in the study area.



(C) Stream Pattern of the Study Area (D) Flow Direction of the Stream in the Study Area

Figure 4: - Stream Pattern and Flow direction
Source: Fieldwork, 2022

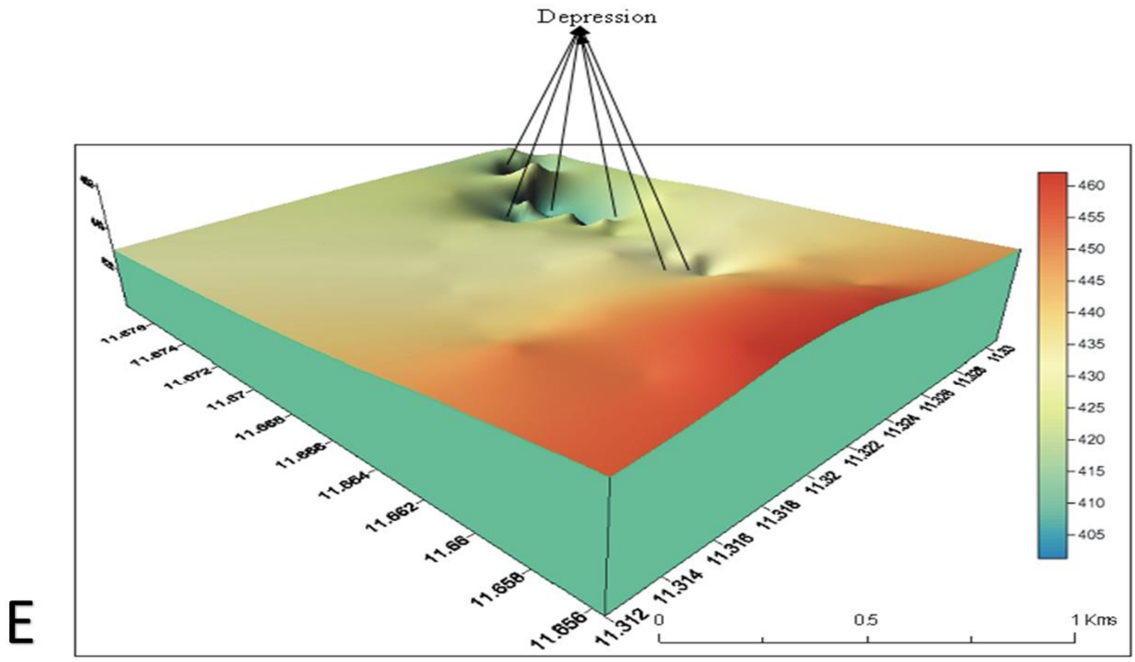


Figure 5: - (3D) Image of the Affected Area
Source: Fieldwork, 2022

While **(F)** (clearly indicate that Damagum are experiences rainfall for about six months, starting mostly from May and ends in October. The rainfall is at its peak in August and July, which indicates that most runoff and the destruction occur in these months. The concentration of the rainfall in raining season induces high runoff and effects high rate of erosion due to lack of vegetation cover as reported in the work of Nagel and Nyanganji (1991). However, from figure a 6 it can be observed that from January to April and November to January there's no rainfall. Thus, this prolonged period of dry season and other anthropogenic activities result to drying of vegetation which in turn exposes the soil to erosion as assessed by Danlai *etal*., (2014).The months of June, July and August on the other hand are characterized by heavy rainfall and since the soil is sandy in nature has low retention capacity it which enhances runoff and leads to so much destructions and increases the effect of gully erosion in the study area this is in line with the findings of (Ofomata, 2009). The work related rainfall intensity, rate of runoff, density of the vegetation cover and the size of the catchment area and conclude that if the amount of rainfall is greater than the holding capacity of the soil it will enhance runoff and accelerate the occurrence of gullies in the study area.

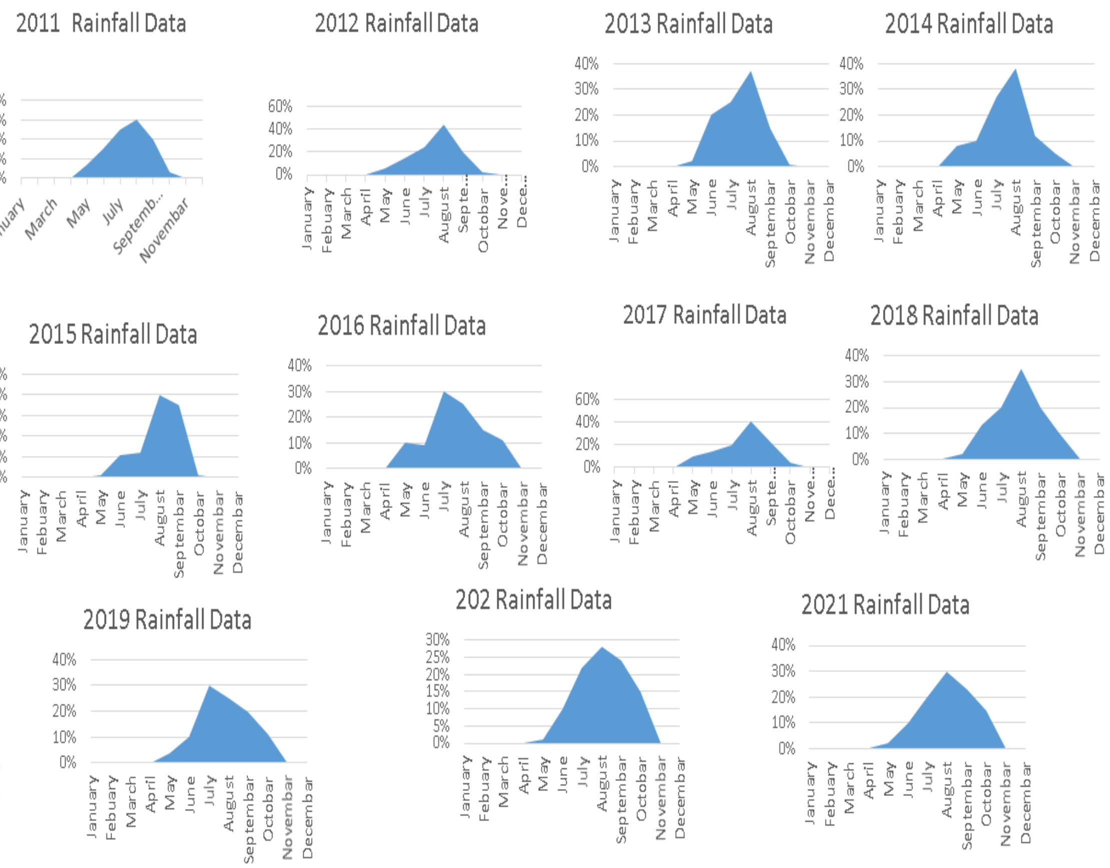


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Figure 6: - Monthly Rainfall of the Study Area for the last ten years
Source: Fieldwork, 2022

Further more figure 7 shows the land use of the area and is comprises of eroded area which is represented in white color, the buildup area in red, farm land in light green, vegetation with dark green and river/stream in blue color in both **(G)** and **(H)** respectively. The Vegetation includes guava plant; mangoes, cashew, neem tree and Datura plant which have been used for Biological control measure in the study area

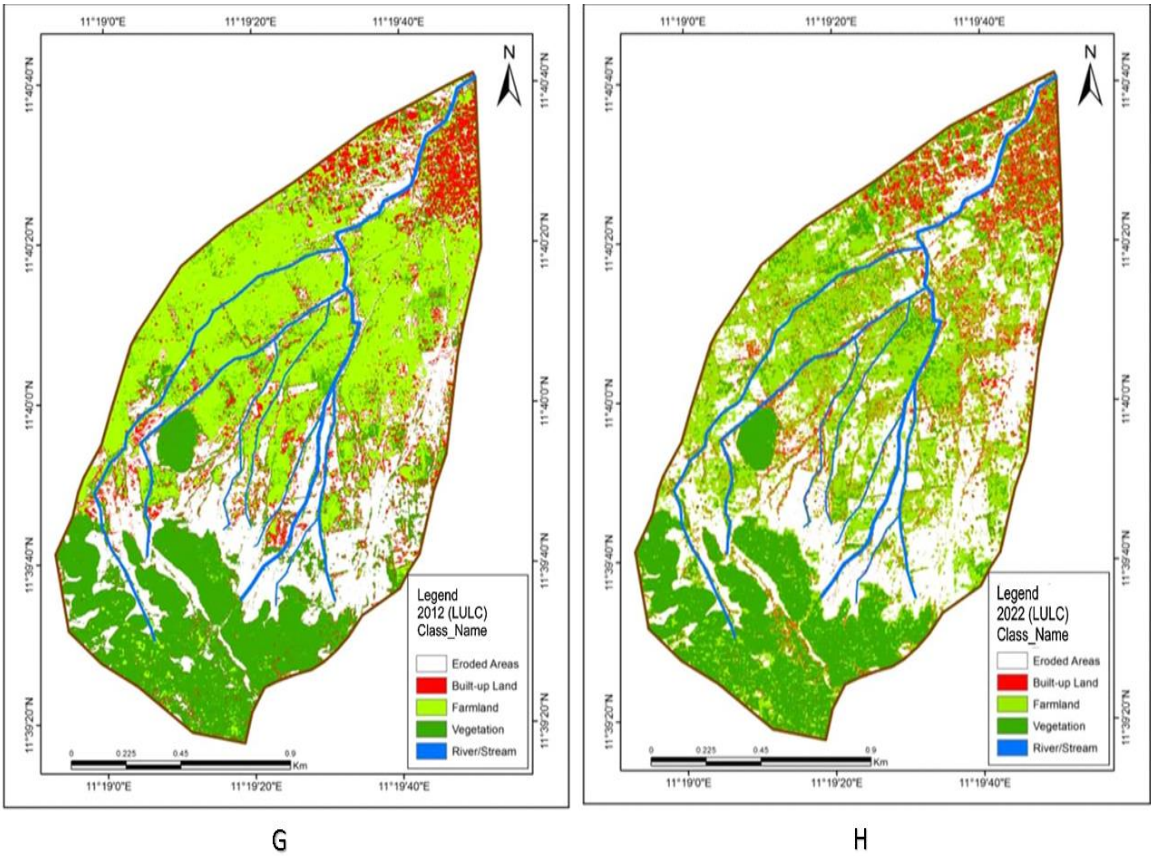

Figure 7: - Land use of the study area
Source: Fieldwork 2022

The results in table 1 show that in 2022 the build- up area has increased by 1.48% indicating that over the period of ten (10) years the population of people in the study area has increased. However, the farmland of the area has decreased by 6.32%.Similarly; the vegetation of the area has decreased by 1.49% due to building of new settlements and governmental infrastructure. While the stream/river has decreased by 0.74% although the reason for the reduced stream could be because the Google image was captured during the dry season however, the river is a seasonal stream which the volume usually increases during the rainy season. The eroded land on the other hand shows a sign of increase by 2.98% in 2022. Thus, this justifies that the effects of gully erosion have increased in the ten years 'period assessed. Furthermore, the reason why the gully erosion has not increased more than 2.98% is because some of the control measures put in place are still active. Thus, they have limited the rate of destructions of the gully erosion.

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Table 1: The Land use and Land cover change of the study area

S/N	LULC	2012 in Area km²	2012 in %	2022 in Area km²	2022 in %	Change in %
1	Built-up Land	0.26	9.67	0.30	11.15	1.48
2	Farmland	0.84	31.23	0.67	24.91	6.32
3	Vegetation	0.78	29.00	0.74	27.51	1.49
4	Rivers/Streams	0.11	4.09	0.09	3.35	0.74
5	Eroded Land	0.81	30.11	0.89	33.09	2.98
	Total	**2.69**	**100**	**2.69**	**100**	

Source: Fieldwork, 2022

Table 2 explains the chemical properties found in the various soil samples obtained from the study area. The samples include organic contain, organic matter and PH. The average percentage of organic content of the top soil in the study area is found to be 0.87% and 0.81% for the bottom layer. Thus, Mylavarapu (2009) confirms that any soil having from 0.5% to 1% organic content is regarded to be low. This means that the soil in the study area has low organic content. Similarly, the average percentage of the organic matter of the sampled soil shows that the top soil is 1.5% while the bottom soil is 1.4%, still based on the assessment by Mylavarapu (2009) shows that when the percentage of organic matter ranges from 0.7 to 2% it's regarded as low. Hence, the low organic content and matter of the soil confirm that the soil of the area is easily washed away by the impact of erosion. This is because low organic content enhances runoff and tends to lose it structure which enhances compaction and consequently results to a low infiltration rate. On the other hand the acidity of the soil, shows that the top soil in area has a pH value of 5.6 which is moderately acidic. In addition, the pH value for the subsurface soil is found to 5.5 which also indicate that is the soil of the area is acidic following (Mclean, 1982). When the soil is acidic its tends to prevent microbial activities so as result of that the nutrient of the soil will be less which can also prevent plants to grow, when there's no vegetation and plant the runoff will be high which further aggravates gully erosion. With regard to the particle size of the soil in the study area. The results further reveal that the area has more Sand soil which constitutes the highest with about 91.6%, and loamy sand 8.3% at the top layer. While the bottom layer classification is found to be a mixture of the three different soil types. Sand is found to constitute 50%, sandy clay loam 41.6% and loamy sand of 8.3%.From the results it can be explained that the high percentage of sandy is the reason for erosion in the study area. This is because sand has low resistance to the water erosion and low water retentions capability. Thus, it enhances run off and accelerates erosion. In addition, the steep topography and high amount of rainfall intensity of the area influence high rate of erodibility, this corresponds with the finding of (Olefin, 1992).

Table 2 Soil Characteristics of the Study Area

ii.

Location/Sample	PH IN H2O 1:2.5	O.C %	O.M %	Clay %	Sand %	Silt %	Class
(A1)	6.87	0.92	1.59	7.9	85.5	6.6	Loamy sand
A2	6.58	0.74	1.28	5.4	90.5	4.1	Sand
(B1)	6.71	0.59	1.02	5.4	93	1.6	Sand
B2	6.59	0.43	0.74	5.4	90.5	4.1	Sand
(C1)	6.5	0.57	0.98	7.9	90.5	1.6	Sand
C2	5.47	0.6	1.03	30.4	63	6.6	Sandy clay loam
(D1)	5.64	0.64	1.1	5.4	93	1.6	Sand
D2	5.92	0.62	1.07	20.4	60.5	19.1	Sandy clay loam
(E1)	5.63	0.59	1.02	5.4	93	1.6	Sand
E2	5.53	0.45	0.78	5.4	93	1.6	Sand
(F1)	5.51	1.17	2.02	5.4	93	1.6	Sand
F2	5.15	1.05	1.81	25.4	65.5	9.1	Sandy clay loam
(G1)	5.25	1.07	1.84	5.4	93	1.6	Sand
G2	5.05	1.01	1.74	25.4	68	6.6	Sandy clay loam
(H1)	5.14	1.05	1.81	5.4	93	1.6	Sand
H2	4.96	1.13	1.95	27.9	63	9.1	Sandy clay loam
(I1)	5.02	0.78	1.34	7.9	90.5	1.6	Sand
I2	5.11	0.92	1.59	5.4	93	1.6	Sand
(J1)	5.03	0.99	1.71	5.4	93	1.6	Sand
J2	4.97	1.01	1.74	7.9	88	4.1	Loamy sand
(K1)	5.18	0.94	1.62	5.4	93	1	Sand
K2	5.23	0.39	0.67	5.4	93	1.6	Sand
(L1)	5.25	1.15	1.98	5.4	93	1.6	Sand
L2	5.29	1.31	2.26	5.4	93	1.6	Sand

Other Anthropogenic causes of Gully Erosion

Other man-made factors that contribute to gullying process have also been identified in this study. Plate **(I)** and **(J)** present them.


I J

Plate 1:- Some Human Activities Facilitating Erosion in the Study Area
Source field survey 2022

The first man-made factor that contributes to the gullying process identified in the study area is sand excavation as shown in **(I)** The people in the study area are highly engaged in sand excavation due to the high demand for sand by individuals and construction companies. Thus, this promotes excessive mining within the stream channels, which has already formed depression in the land forms as shown in plate 1 which results to a lowest point of 406m.While **(J)** is another cause of gully erosion in the study area. The members of Damagum community mismanage the environment. They dump waste into the drainage system and which causes blockage. This aggravates the damage of gully erosion.

CONCLUSION AND RECOMMENDATION

In conclusion the study found out that the major cause of gully erosion is both natural and anthropogenic factors. The natural factors include the nature of the topography, nature of the soil and rainfall of the study area while the (human impact) include continuous mining sand in the area and dumping of waste in the drainage system. Based on the findings of the study the following recommendations are proffered: Firstly, government should encourage people to engage in community development practice, so that they will be tacking the problem by them self. In addition, Government should enlighten people in order to know the do and don'ts of the environment with that they will reduce the violation of land such as sand excavation will be stopped or will be done wisely.Finally, government should construct drainage system to enable free flow of water within the drainage system and finally to eradication poverty by creating more job opportunities to the people that would reduce their over dependence on sand excavation as a business in the area.

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