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Assessing the Socio-Economic Impacts of Gully Erosion on Farming Activities in Northern Adamawa State, Nigeria

Ezekiel Alhassaan[1], Ibrahim Saidu[2] , Alfred D. Mshelia[2] and Yohanna Peter[2]

[1]Mubi North Local Government Secretariat, Adamawa State
[2]Department of Geography Adamawa State University, Mubi

ABSTRACT

Gully erosion is a significant environmental challenge in Northern Adamawa State, Nigeria, with profound socio-economic impacts on farming activities. This study assesses the extent and effects of gully erosion on the local farming communities. Using a combination of field observations, transect walks, and questionnaire surveys, data were collected from 400 farmers, with a 72.5% response rate. The study reveals that 94.2% of the respondents are aware of gully erosion in their areas, and 76.7% recognize its threat to their farmlands and residences. The results indicate that 33.3% of farmers have lost farmland, 20% have experienced soil quality degradation, and 12.5% have faced increased crop transportation costs due to gully erosion. The findings underscore the urgent need for intervention to mitigate the adverse effects of gully erosion on agricultural productivity and community livelihoods.

KEYWORDS

gully erosion; socio-economic impacts; farming activities; soil degradation

INTRODUCTION

Gullies represent one of the most destructive and widespread forms of soil erosion (Brooks, 2013). In Nigeria, the World Bank has identified three primary environmental issues: soil degradation and loss, water contamination, and deforestation, with gully erosion contributing to each of these problems and causing significant damage (Agagu, 2009). Additionally, the 2009 World Bank Country report highlighted gully erosion as one of the top five hazards threatening Nigeria's environment (Mbaya, 2013). Gullies can be viewed as indicators of disruptions and accelerated erosion resulting from climate change or alterations in land use. Gully erosion poses acute challenges, leading to high sediment yields, loss of fertile soil, destabilization of hillsides, and the depletion of water tables in alluvial aquifers. Besides the decline in soil fertility and the continual reduction of arable land, there are additional losses such as homes, household possessions, agricultural crops, and infrastructure (Danladi and Ray, 2014).

Gully erosion, identified as one of the most severe and impactful forms of erosion, leads to the depletion of substantial soil volumes (Burkard and Kostaschuk, 1997; Valentin et al., 2005; Rahmati et al., 2016). This phenomenon is influenced by several key factors, such as overland flow, subsurface water movement, and soil piping (Kirkby and Bracken, 2009; Valentine et al., 2005; Poesen et al., 2018). While gully erosion primarily results from natural processes, it can be significantly accelerated by human activities (Zheng, 2006; Thorburn and Wilkinson, 2013; Ionita et al., 2015; Rodrigo Comino et al., 2015). This research aims to investigate the predominant factors and impacts contributing to gully erosion in a Northern Adamawa State Nigeria, examining both natural and anthropogenic influences.

METHODOLOGY

The Mubi Region, which previously constituted the northern part of the former Sardauna province, is now recognized as the Adamawa Northern Senatorial District, encompassing Madagali, Michika, Mubi North, Mubi South, and Maiha Local Government Areas (Ikusemoran, 2009). Positioned between latitudes 9°00' and 10°11' N of the Equator and longitudes 13°00'11'' E and 13°45'11'' E of the Greenwich meridian, it shares boundaries with Borno State to the north, Hong and Song Local Government Areas to the west, and the Republic of Cameroon to the south and east (Ikusemoran, 2009). The region spans an area of 4,728.77 km^2 and had a population of 681,353 according to the 2006 National Population Census (Ikusemoran, 2009). Terrain-wise, it is characterized by highlands/mountains along the Cameroon border in the east, uplands with elevations between 400 and 800 meters covering approximately 40% of the region, and lowlands along the River Yedzeram in western Michika and Madagali Local Government Areas (Adebayo, 2004). The wet season, occurring from May to September, witnesses annual rainfall ranging from 900 mm to 1050 mm (Adebayo, 2004). Predominant soil types include lithosols, luvisols, and gleyic cambisols (Adebayo, 2004). Vegetation within the Sudan savanna belt consists of grasses, aquatic weeds along river valleys, dry land weeds, shrubs, and woody plants, supporting agriculture as the primary occupation with subsistence farming being the norm (Adebayo & Dayya, 2004). Rainfall erosivity varies between 481 m to 192 m, with daily rainfall ranging approximately from 15.5 mm to 15.8 mm and a potential evapotranspiration rate of 4.5 m to 4.6 m (Adebayo, 2004).

The climate is classified as tropical wet (April-October) and dry (November-March), with annual rainfall between 700 mm and 1,050 mm (Adebayo, 2004). The Sudan savanna vegetation includes short grasses, shrubs, and some trees (Adebayo, 2004). Lithosols, predominantly found, are characterized by shallow depths and stoniness due to rock basements near the surface (Adebayo, 2004). They typically support orchard-type vegetation due to limited fertility (Nwaka et al., 1999). Additionally, arenosols and regosols, relatively young soils with minimal profile development or homogenous sands, are also found in mountainous areas (Aduayi et al., 2002).

Data Source and Analysis

The primary sources of data were the farmers and farmers. Tools used for the primary data collection included; personal field observation. Fields transect walks (preliminary/reconnaissance survey) of the study area at different times and villages were undertaken. Questionnaire surveys were administered to farmers during the field trips.

In this research, connivance and simple random sampling techniques were adopted for selecting the famers affected by the threat of the gully erosion for questionnaire administration. Purposive sampling was used to administer questionnaire to farmers in the immediate neighbourhoods that were living within the 0.2km^2 radius of the gully site. This was done in order to have the participation of all the farmers selected as respondents that were living within the 0.2m^2 radius of the gully site within the study area. Convenience sampling was used because the questionnaire schedules were administered only to the respondents that were close to the gully site and whose farm are already affected by gully erosion. This was done by distributing the copy of the questionnaire to each respondent chosen in the area who could answer the question correctly. About 400 questionnaires as suggested by Yamane method of determining sample population was distributed in the five (5) local Government base on the percentage of the population as out of which 290, (72.5%) were retrieved successfully. About 27.5% copies of the questionnaire were not returned while some were not filled correctly, hence, the data analysis was based on the 72.5 % (240) copies of the questionnaire that were filled correctly. Selection of the farmers was based on convenience. On each farmland, the head of the household was chosen and a copy of the questionnaire was administered to him. These farmers were selected on the basis of their knowledge and experience on the threat of gully erosion on the farming activities in the study area, those that have relevant work experience in the field of gully erosion.

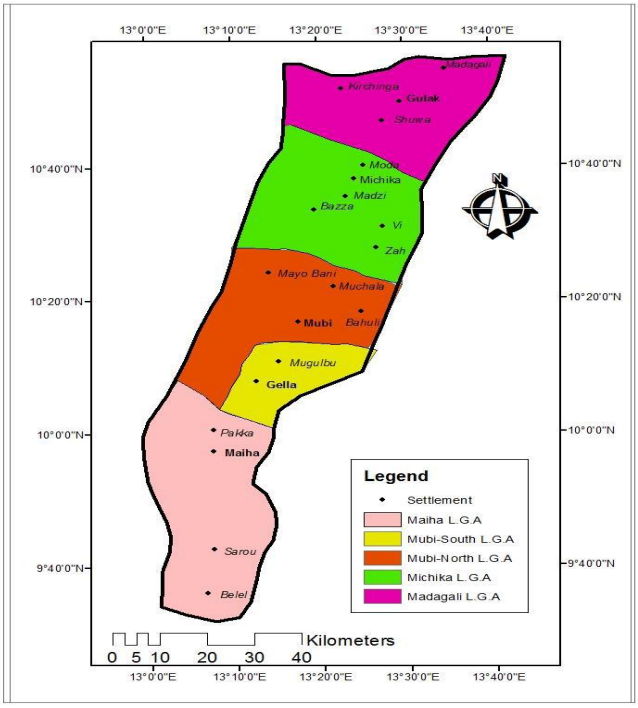

FIGURE 1: The Study Area.

RESULTS AND DISCUSSION

TABLE 1: Demographic Characteristics of the Respondents.

Gender	Frequency	Percent
Male	145	60.4%
Female	95	39.6%
Total	**240**	**100.0%**
Marital Status		
Single	62	25.8%
Married	150	62.5%
Divorced	28	11.7%
Total	**240**	**100.0%**
Age(years)		
Below 30 Years	64	26.7%
30 - 39 Years	83	34.6%
40 - 49 Years	70	29.2%
50 - 59 Years	18	7.5%
60 Years and Above	5	2.1%
Total	**240**	**100.0%**
Educational Qualification		
Vocational	18	7.5%
Primary	25	10.4%
Secondary	57	23.8%
Tertiary	79	32.9%
Informal Training	31	12.9%
Adult Education	30	12.5%
Total	**240**	**100.0%**

Table 1 reveals that 60.4% of the respondents in the study area were males, while39.6% of them were females. The larger percentage of the male respondents sampled was reflective of the fact that men in the study area are bread winners spending most of their time on farm work, fending for their family members. Therefore, men have taking up farming activities more seriously so as to provide enough food for the family.

The Table 1 still reveals that 62.5% of the respondents were married, 25.8% were unmarried, while the remaining 11.7% were divorced and 25.8% were single, therefore the farming status of the respondents made him to look for a better farmland to produce food for the wife and children.

Furthermore, the data in Table 1showthat the majority (34.6%) of the respondents were in the age range of 30 and39 years, 29.2% fall within the age range of 40 and49 years. Data also shows that 26.7% falls within the age range of less than 30 years, while 2.1% are in the age bracket of over 60 years. This however, means that majority of the respondents aged between 30 to 39 years were still in their economically active age characterised by more enthusiastic and physical vigour. Hence, there is high likelihood for increased demand for more hectares of farmland to be cultivated by those in this age group.

The result on the farmer's level of education shows that 32.9% of the respondents had tertiary education, while 23.8% had secondary education. The results also show that 12.9% had informal training, 12.5% having adult education, the remaining 10.4%, and 7.5%, had primary and vocational level of education, respectively. This implies that the farmers are fairly knowledgeable, hence, have the ability to provide information as well as demonstrate their level of knowledge regarding their ancestral occupation and knowledge about the threat of gully erosion on their farmlands. However, the high percentage of the respondents being educated coupled with educational status as literate farmers have better chances of understanding of the risks associated to the gully erosion on farming and most likely knowledge on better methods of mitigating the menace.

Threat of Gully Erosion on Farming Activities

The perception of the respondents in respect of the threat of the gully erosion on the farming activities of rural dwellers in their communities was investigated and the data are presented in the following sub- section:

Awareness of Gully Sites in the Locality

The perception of the respondents on their awareness of the existence of the gully erosion sites in the study area was sought and majority (94.2%), of the respondents, were aware of the presence of the gully erosion site(s) in their respective areas, while 5.8% of the respondents were not aware of such sites in the study areas. This shows that the greater proportions of the respondents are familiar with the areas devastated by the incident of the gully erosion at different sites.

TABLE 2: Residents Level of Awareness of Gully Sites Situations.

Response	Frequency	Percent
Yes	226	94.2%
No	14	5.8%
Total	**240**	**100%**

Assessment of Threats of Gully Erosion in Northern Adamawa State

Data were sought on the potential threats of gully erosion to farmlands and residences in the study area. Table 2 reveals the percentage computed based on the frequency and percentage of each response. The result shows that, most of the respondents (76.7%) agreed with the potential threats of the gully erosion to their place of residence and farmlands. About 11.7% of them did not agree with the potential threats of the gully erosion to their place of residence and farmland, while 11.7% of the respondents were undecided, this could be attributed to the fact that in the African context, many feel shy to disclose such instances associated with the natural phenomenon.

The result of the finding clearly depicts that the greater proportion of the respondents (76.7%) strongly agree with their stand regarding the threats of the gully erosion to their places of residence and farmlands which makes them loss their farmlands and houses see plate i and ii.

PLATE I: A Secondary School Degraded by Gully Erosion in Pakka, Maiha Local Government Area.

PLATE II: Scene of Farmland Threatened by Gully Erosion in Kuda, Michika Local Government Area.

TABLE 2: Perception of Respondents on the Threats of Gully Erosion.

Response	Frequency	Percent
Undecided	28	11.7%
Disagree	28	11.7%
Agree	184	76.6%
Total	**240**	**100%**

Assessment of Gully Erosion Incidence in the Study Area

The incidence of gully erosion in the study area was assessed. The results in the Table 3 reveals that majority (36.7%) of the respondents, being, acknowledged that they noticed the incident of the gully erosion in the last 5 and10 years. About 27.9% alluded to the occurrence of the gully erosion between the last15 and 20 years. This is followed by15.8% of the respondents who noticed gully erosion occurrence over the period of 25-30 years, 9.6% of the respondents noticed it taking place over the period of 45 and50 years.

The remaining 8.3% of the respondents as well as 1.7% of them noticed the incidence between 35 and40. The implication is that the greater percentage (36.7%) of the respondents had experienced of the erosion incident not quite longer than the period between 5 and10 years. The above revelation gave the farmers experience to look for a proper ways of mitigating the threat of gully erosion to farming activities in the area.

TABLE 3: Perception of Respondents on the Occurrence of Gully Erosion.

Response	Frequency	Percent
5 - 10 Years	88	36.7%
15 - 20 Years	67	27.9%
25 - 30 Years	38	15.8%
35 - 40 Years	20	8.3%
45 - 50 Years	23	9.6%
Since childhood	4	1.7%
Total	**240**	**100%**

Rating the Development of Gully Erosion in Northern Adamawa State

The Table 4 reveals that most (46.3%,) of the respondents, opined that the rate of development of the gully erosion in the study area is high as shown on Plate 4 bellow. About 33.8% of them revealed that the rate is medium and 20% pointed out that the rate is low. The rate of development of gullies is, however, a source of concern. The alarming increase in the trend of the gully erosion demands an urgent intervention and support before it escalates into unimaginable scenario that would further exacerbate the threat to the social and economic development of the citizenry in the area. The rating is based on (Frevert, et. al, 1955) findings who asserted in his research entitled, "Development and classification of Gullies", that gully development is based on size, depth and the area covered/ha. He rated gullies into the following categories. Small gully as less than 1m, less than 2 /ha, Medium gully as 1 to 5m and 2 to 20/ha, Large gully as above 5m and more than 20/ha.

TABLE 4: Rating of the Development of Gully Erosion.

Response	Frequency	Percentage
High (large)	111	46.3%
Medium	81	33.8%
Low (small)	48	20.0%
Total	**240**	**100%**

Causes and Consequences of Gully Erosion in the Area

The data were sought on the causes, and the consequences of the gully erosion in the study area. The result in Table 5 shows that majority (46.39%) of the respondents reported that expansion of the farmland rarely causes gully erosion. About 34.2% of them opposed that it does not cause gully erosion. The remaining 17.9% affirmed that farmland expansion could result to gullies in addition to other factors such as rainfall intensity, nature of soil and runoff. Indiscriminate construction was also considered as a rare cause of the gully erosion in the study area as indicated by 37.9%, of the respondents. However, 34, 2% of the respondents argued that it was always the source of stimulating the gully erosion. About 27.1% held to the fact that it was never a source of gully erosion. The remaining 8% of the respondents attributed it to other factors such as the nature of the soil, topography of the area and rainfall intensity.

Fuel wood exploitation was considered by most (39.6%) of the respondents as a factor though not being popular, but a rare cause of gully erosion. About 35%, of the respondent's noted that fuel wood exploration as never a cause of the gully erosion. Almost 23.3% of the respondents were of the opinion that gully erosion could be caused by fuel wood exploitation contrary to the opinion of the remaining 2.1% respondents who attributed it to other factors such as the nature of the soil, topography of terrain, land cover, sand excavation, and overgrazing.

Mining activities is rarely considered as the major cause of the gully erosion as pointed out by a significant proportion of (49.6%) of the respondents. Almost 23.8% of them disputed mining activities as the cause of the erosion. About 22.5% of them agreed that mining activities such as monazite mining in Bagira and Bahuli villages of Mubi North Local Government, and quarry work along Muda road, Mubi South Local Government cause erosion, while the remaining 4.2% of the respondents attributed it to other causes of erosion like water runoff and soil precipitation.

Table 5 shows that 37.9% of the respondents agreed that bush burning and wild fires are the major sources of gully erosion in the study area. This is by removing the natural land cover that exposes farmland to gully threat. About 32.5% of them noted that it rarely causes gully erosion. About 25% revealed that it never caused any erosion in the area. Other factors were considered by 4.6% of the respondents. From the Table 5, it can also be seen that most (43.8%), of the respondents, reported that settlement expansion rarely causes gully erosion; about 31.7% reveals that it has never been the cause of the erosion. However, 21.7% of the respondents acknowledged that it has always been the cause of the erosion. Sometimes new settlements are built on water ways and cause gully erosion that threaten farmland. It also brings the shortage of land leading to the population migration from the village to the urban areas. The remaining 2.7% revealed that it is caused by other factors such as nature of soil, improper land use intensive and short period rainfall.

Extraction of forest resources for commercial purposes, such as, leaves, herbs for medicinal purposes; gums for consumption, was considered by majority51.7% of the respondents as a rare cause of the gully erosion in the study area. About 30% of the respondents asserted that it has never caused any gully erosion. However, 34, 2% of the respondents reported other causes of gully erosion such as over flooding and human factors such as blockage of drainages. Fifteen percent (15%) of them argued that it is a cause of the gully erosion. About 3.3% revealed that it is caused by other geomorphologic factors such as wind, waves and ocean current. Overgrazing of animals was perceived by most (53.8%) of the respondents, being as a rare cause of gully erosion, 22.5 % of them noted that it is always the cause of the gully erosion. A cursory examination also showed that 20% of the respondents were of the opinion that gully erosion is never caused by overgrazing.

Population Upsurge was not regarded as a cause of the gully erosion and this was rightly revealed by a significant proportion (43.8%) of the respondents. About 33.3% said population upsurge does not lead to any visible instance of gully erosion. The remaining 3.3% revealed that, it is caused by other factors such as deforestation and nature of the soil. Most of the respondents (44.5%) agreed that all the items mentioned above rarely cause gully erosion, while 28.9% of them clearly spelt out that these items do not cause gully erosion in the study area. However, only 23.8% subscribed to the fact that the items are solely responsible for triggering gully erosion in the area. Only 3% of the respondents attributed the cause to other factors such as the agents of denudation (wind, water and man). In the end, it is logical to state that the significant proportion (97%) of the respondents subscribed to the fact that the instance of gully erosion is caused by other geomorphologic factors such as water runoff, high precipitation more than the identified causes in this study.

TABLE 5: Causes and Consequences of Gully Erosion.

No.	Factors	Never		Rarely		Always		Others	
		F	%	F	%	F	%	F	%
1.	Farmland Expansion	82	34.2	111	46.3	43	17.9	4	1.7
2.	Indiscriminate Construction	65	27.1	91	37.9	82	34.2	2	0.8
3.	Fuel wood Exploration	84	35.0	95	39.6	56	23.3	5	2.1
3.	Mining Activities	57	23.8	119	49.6	54	22.5	10	4.2
4.	Bush Burning and Wild Fire	60	25.0	78	32.5	91	37.9	11	4.6
5.	Settlement Expansion	76	31.7	105	43.8	52	21.7	7	2.9
6.	Extraction of Forest resources for commercial purposes e.g. leaves herbs for medicine purposes, Gums for consumptions.	72	30.0	124	51.7	36	15.0	8	3.3
7.	Overgrazing of animals	48	20.0	129	53.8	54	22.5	9	3.8
8.	Population Upsurge	80	33.3	105	43.8	47	19.6	8	3.3
	Total	624	**28.9**	957	**44.3**	515	**23.8**	64	**3.0**

Problems Associated with Gully Erosion

This aspect sought to find out the perception of the respondents on the problems associated with gully erosion in the study area. The result in the Table 6 reveals that most (37.9%) of the respondents were of the opinion that the incident of gully erosion is traceable to the problem of water pollution that causes disease such as diarrghea and vomiting. It is also revealed in the Table 6, that 16.3% of the respondents were of the opinion that gully erosion increases loss of lives as a result of trauma caused by gully erosion in the study area. It is also revealed by 4.6%, that the problem of the gully erosion is loss of socio-economic value such as income, amount and kind of education ethnic origin and religious background. The remaining 3.3% of the respondents pointed out that the greatest problem was the high cost of controlling the erosion. This analysis shows that erosion was identified alongside other problems such as the land slide which leads to loss of access road as in plate5, which threaten the people with relative degree of risks.

TABLE 6: ***Problems of Gully Erosion.***

Response	Frequency	Percentage
Water Pollution/Siltation	91	37.9%
Health Hazard	52	21.7%
Loss of Lives	39	16.3%
High Control Cost	8	3.3%
Loss of Socio-economic Value	11	4.6%
All of the Above	39	16.3%
Total	**240**	**100%**

The perception of the respondents on the threats of gully erosion on the farming activities in the Northern Adamawa state was assessed. The data in the Table 7 shows that 33.3% of the respondents seriously loss their farmlands to gully erosion. 20% of the respondents indicated that they Loss their soil quality. However, 12.5%of the respondents also said that they experience serious increase in crop transportation cost. While, 9.2% of the respondent were of the opinion that they loss their income as a result of gully erosion. It is also revealed in Table 7 that 8.3%of the respondents experience huge increase in labour cost as an effect of gully erosion. Also, 7.5%, 5.4% and 3.8% said that they experience loss of crop productivity, loss of cultural heritage and loss of social value respectively due to gully erosion. The above finding reveals that there is a great threat experienced by the farmers in Northern part of Adamawa state as a result of gully erosion. This finding also reveals that the farmers experienced increase in the cost of transportation as a result of loss of access road due to gully erosion threats as on plate iii bellow.

PLATE III: The Nature and Intensity of Gully Erosion Development in Kirya, Mubi North Local Government.

TABLE 7: The Threat of Gully Erosion to Farming Activities in Northern Adamawa State.

Responses	Frequency	Percentage
Loss of farmland	80	33.3%
Loss of soil quality	48	20%
Loss of social value	9	3.8%
Loss of cultural heritage	13	5.4%
Loss of crop productivity	18	7.5%
Loss of income	22	9.2%
Increase in labour cost	20	8.3%
Increase in crop transportation cost	30	12.5%
Total	**240**	**100%**

CONCLUSION

Gully erosion poses significant socio-economic challenges to farming communities in Northern Adamawa State, Nigeria. The study highlights the widespread awareness of gully erosion among residents and the substantial impact it has on farming activities, including loss of farmland, soil degradation, and increased production costs. Addressing the root causes of gully erosion and implementing effective mitigation strategies are critical to safeguarding agricultural livelihoods and promoting sustainable development in the region.

RECOMMENDATION

Based on the findings, it is recommended that immediate interventions be implemented to mitigate the adverse effects of gully erosion on farming communities in Northern Adamawa State. These interventions should include measures to control soil erosion, promote sustainable land use practices, and provide support to affected farmers through awareness campaigns, technical assistance, and financial incentives. Additionally, collaborative efforts involving government agencies, local communities, and relevant stakeholders are essential to address the underlying causes of gully erosion and ensure long-term environmental sustainability and socio-economic development in the region.

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