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Socio-economic effect of gully erosion on land use in Gombe Metropolis, Gombe State, Nigeria

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Gully erosion is one of the severe environmental problems facing Gombe metropolis. It threatens urban infrastructure, properties, lives and the physical growth of the town. This article assesses the socio-economic effect of gully erosion in Gombe metropolis. The aim of the study was to assess the socio-economic effect of gully erosion on land use in Gombe metropolis. Data used in this study were derived from field administration of questionnaire and focus group discussion. Three sampled gully profiles cutting across different land use areas were purposively selected for the study. They were referred as Gully A, transect FCE-Arawa-M/Inna-U/Uku Gully site; Gully profile B, transect Fed.lowcost-B/Yero-Idi-Herwagana-Idi-U/Uku Gully site and Gully profile C, transect Old/GRA-Gabukka-Barunde-Madaki-Bogo-Doma. From each gully profiles, 10% of the population around the gully site was used as population sample administering the total of 207 questionnaires in all the three gully sites under different landuse areas. Results obtained through questionnaires and focus group discussions was analysed, using simple percentage presented in different tables and discussed.The results indicated that several buildings, farmlands/plots and other properties worth millions of naira as well as both human and animal lives were lost due to effect of gully erosion in the study area.

Key words: Socioeconomic, gully erosion, land use, Gombe metropolis.

INTRODUCTION

Soil erosion is widely recognized as a major environmental and agricultural problem affecting many parts of the world. Estimates suggest that, each year, as much as 75 billion ton of soil are removed from the land by wind and soil erosion, with most of it coming from agricultural land (Pimentel et al., 1995). While the rates at which soil erosion occurs vary over time between different locations, it has intensified in recent years,

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causing great concern in developing countries. The "on-site" impacts of soil erosion are commonly associated with shortages of arable land that is capable of supporting agricultural production, common in Asia and Africa, but also in Europe. While 0.5/ha of arable land per capita is deemed necessary to ensure people are given a diverse diet, Pimentel et al. (1995) in (Mbaya 2013) estimates that about one-half of this is currently available. The short and medium term consequences for developing countries are evidenced by the widespread prevalence of food shortages and malnutrition. Within the next forty years, he further predicts that the effects of soil erosion and rapid population's growth could mean that a little over a quarter of the arable land per capita deemed necessary to ensure people diverse diets, will be available.

There are also downstream or "off-site" impacts of soil erosion. For instance, eroded sediments can be deposited in reservoirs, reducing hydro-electric generation and the flow of water supplies for irrigation and residential uses (Mbaya 2013). The use of large amounts of fertilizers, pesticides and irrigation to help off-set the deleterious effects of soil erosion have the potential to create pollution and health problems, as well as destroying natural habitats and this contribute to high energy consumption and unsustainable agricultural systems (Pimentel et al., 1995) in (Mbaya. 2013).

The World Bank (1990) in (Mbaya, 2013) recognized three main environmental problems facing Nigeria: soil degradationand loss, water contamination and deforestation. Gullyerosion contributes to each of the three main problems and causes damage with an annual cost to the nation, estimated at $100 million in1990.

Unfortunately, the situation has not changed significantly in 2010. As at 1997, there were 5,700 gully erosion sites nationwide (Agagu, 2009) in (Mbaya 2013). This figure has certainly increased. For example in 2009, the World Bank Country report on Nigeria still listed gully erosion as one the top five major hazards threatening the Nigerian environment. Numerous new gullies have emerged and many of old gullies have grown rapidly to disaster levels. Accelerated erosion with its effects on agriculture in Nigeria is well documented, but the fact that several Nigerian towns facing gully erosion is far less well known. Urban gully erosion affects only 18,517km2, representing only 2% of the total area of Nigeria (Titilola et al., 2008) and so tends to be ignored in the literature. However, the area of land affected by gullies is not the sole criterion for estimating the damage they inflict on the national economy. The value of the lands they destroy and the cost of protective measures should be considered.

Gully erosion in towns, destroys valuable land, communications facilities, lives and buildings. This involves expensive control measures and requires more research work. The expansion of concreted surfaces in towns, heightened volume and velocity of runoff that is generated have tended to make many Nigerian towns increasingly susceptible to gully formation. When most of the available land in an urban area is built-up, increased pressure on land might lead to extension of urban land use to the stream channels, flood plains and restriction of streams to artificial channels .This is the situation being experienced in Gombe town. Gully erosion is a major problem in Gombe town since 1980s; however, the situation is getting worse annually, since Gombe town assumed the status of state capital. The infrastructural development coupled with demographic increase, have no doubt heightened the problems of gully erosion in the state capital.

Residents of Gombe town have expressed concern over accelerated erosion rates. These concerns addresses not only the loss of personal property, but also that gully erosion is causing functional and structural damage to infrastructures such as culvert outlets and roads within the stream channels as well as other public and private structures along the channel. The Federal and State Governments have attempted to solve the problem through numerous contracts awarded for gully erosion project at some key sites in Gombe town. However, the economic practicalities and engineering control measures has not met people's expectation, owing to lack of adequate information on the gully morphological parameters. Therefore, solving the gully erosion problem in Gombe town requires concerted research efforts. The main aim of this research was to study the socio-economic effect of the gully system of study area.

Socio-economic effects of gully erosion: A global perspective

Gully erosion increases loss of available land for agricultural purposes and increases labour cost. The main on-site impact of erosion is the reduction in soil quality which results from the loss of the nutrient-rich upper layers of the soil, and the reduced water-holding capacity of many eroded soils. In affluent areas of the world, accelerated water erosion's on-site effects upon agricultural soils can be mitigated by increased use of artificial fertilizers; however, this is not an option for much of the earth's population, (Mortlock, 2005).

He further stressed that, erosion's removal of the upper horizons of the soil results in a reduction in soil quality that is, a diminution of the soil's suitability for agriculture or other vegetation. This is because the eroded upper horizons tend to be the most nutrient-rich. Also, because the finest constituents of eroded soil tend to be transported furthest, eroded soils become preferentially depleted of their finer fraction over time; this often reduces their water-holding capacity. In other words, "Erosion removes the cream of the soil". Loss of soil

quality is a long-term problem; globally, soil erosion's most serious impact may be its threat to the long-term sustainability of agricultural productivity, which results from the 'on-site' damage which it causes. Crops are particularly reliant on the upper horizons of the soil, which are the most vulnerable to erosion by water and wind. In this sense, erosion removes 'the cream of the soil'. Agricultural tillage also redistributes soil, resulting in thinner soils on topographically convex areas within a field.Jeje and Agu (1990) showed that top soils affected by severe sheet wash in Ejiba area of Kwara state have suffered serious loss of their clay aggregates, organic carbon and exchangeable cation, Ca, K, Mg and N in comparison with other local soils not so affected. In addition, they are also characterized by very low infiltration rate, and very low water holding capacity. This loss in soil fertility leads to steady decrease in crop yields and this complicates the anxiety of the local farmers over their economic wellbeing. The loss of land for cultivation is a serious social and economic consequence of soil erosion, given a situation where farming is the main occupation of majority of the people.

At the Agulu-Nanka gully complex, over 1,000 hectares of land have been lost to the gullies and the modest estimate for the expansion of the gullies is at least 1% per annum, (Ofomata, 2007). Of the World's 13,500 million ha of land not under water, 22% is suitable for cropping but only 10% is currently farmed, losses in arable land have increased over the past ten years to a current rate of 7 to 10 million ha per year as a result of erosion, FAO (2007). Apart from the loss in soil fertility and continuous diminutions of cultivable land, both of which really translate to the farmer's property, there is additional loss of property, in the common sense of usage of the word and which here includes loss of homes, household property and farm crops.

In Araromi Rubber plantation about 10% of trees have been uprooted, while gullying is handicapping toping operations and increasing production cost, as the gullies have in some cases cut across some motorable roads. This often leads to diversions that have only hastened the growth of gullies. At Uyo, gullies have rendered a sizeable proportion of the land and most of the roads useless, valuable properties have also been lost, especially to old station gully and along Eka street gully, (Ofomata, 2007). In October 1988; at Enugu-Nanka, similar landslides occurred in the same area in August 1989, causing wide spread damages to homes and farm crops. Over 0.25 hectares of farm crops was cutoff and sent down to the bottom of the gully following a serious landslide, Ofomata (2007).

Gully expansion and head ward originations have led to the disruption of many roads. The gullies succeed in cutting off some roads, which causes great inconvenience to the people, several other examples exist, but the case of NgwoAgu, at Agulu and Ogbu must be known, where the busy road that leads from Agulu to Eke Ogbu market has been cut to the middle, (Ofomata 2007). These examples can be multiplied over the country, and the social implication of such a consequence as disruption of roads is well understood. The failure of the intervention schemes also causes severe psychological stress and physical damages on individuals and communities. In south eastern Nigeria, for example, as a results of landslides that accompany the flooding, houses were washed into the gullies that develop sometimes with their inhabitants, they further stated that as intervention measures fail and gully erosion expands, communication and power lines were broken, churches and schools collapse, roads are washed off, water schemes are damaged and lines are lost. Also farmland and farm produce are washed off while families are displaced and drives away as refugees. The entire social and economic lives of communities are totally disrupted, Egboka (2007).

When these happen as they often do each rainy and dry season, the internally displaced people became desperate and demoralized. Their problems are compounded because they cannot individually or even as communities solve the severe problems created by the disruptive erosion, they become further impoverished in their attempt to survive with meager resources. Even when this is done, minimal positive results are achieved and new channel and gully sites are invariably initiated. Another important economic consequence of erosion is in the financial cost of ameliorative efforts which takes money from other vital sectors of the economy. Governments, at both the federal and state levels, have shown concern and taken a number of steps to combat the problems of soil erosion in the country. A national soil conservation committee was set up in 1978 (under the auspices of Federal Department of Agricultural Land Resources) and submitted its preliminary report in 1979. After 1980, billions of naira has been spent on control and management of gully erosion in Nigeria. Egboka (2004), said an estimate of the total initial funds that can be made available by the Federal Government to Southeastern states to combat the ecological problems to make the desired impact is conservatively put at about 628 million dollars at the first instance.

The revenue act sets aside 1% of the federal account for ameliorating ecological problems throughout the country. The government also established a National committee on Ecological problems to advise government on policies and projects for effectively combating ecological problems including erosion. Such resources would have been used for other social amenities.

Study Area

Gombe Metropolis, the capital of Gombe State (Aliyu, 2012). Figure 1 is located between latitude 10^0 0'N to 10^0

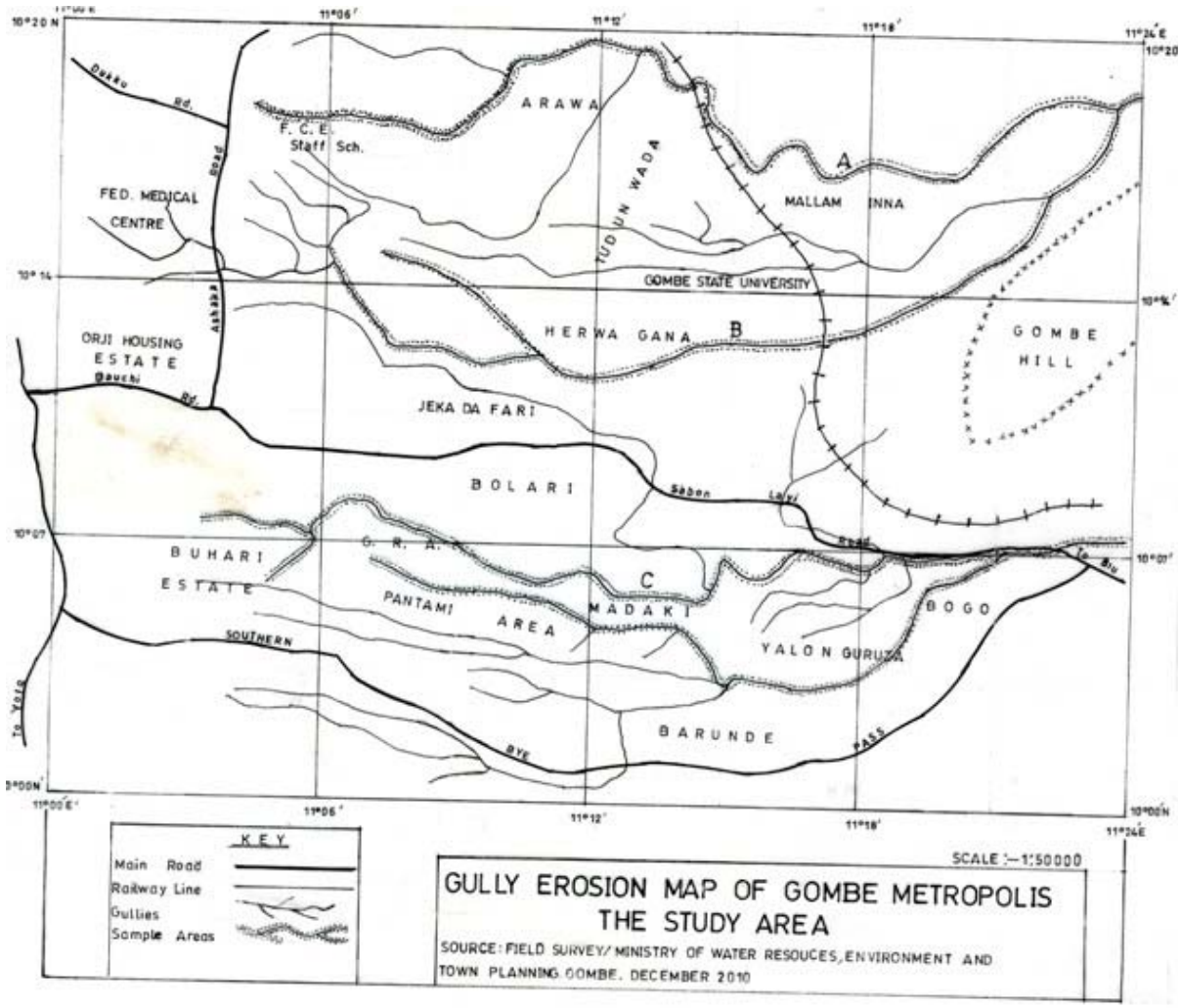

Figure 1. Gully erosion map of Gombe metropolis

20'N and longitude 11^0 01'E and 11^0 19'E. With a total area of about 40km^2, it is bordered by Akko Local Government Area in the South and West,Yamaltu-Deba to the East and Kwami to the North. Gombe lies in the stretch of the Benue trough which, the structural point of view is known as Zambuk Ridge area.

The spatial and temporal analysis of Gombe's urban layout showed centrifugal growth, building densification and urban layout modification (Balzerek et al., 2003).This development resulted in the unification of the traditional settlement and the peri- urban areas in the1990s to formed a single urban body, which reached the size of 30km2 in 2000 (Balzerek et al., 2003). This expansion, has led to an urban intrusion into the peri urban environs far beyond the original town borders and is followed by a significant change in landuse which has increased the sealed surface thereby reducing the infiltration rate of rain water (Balzerek et al., 2003). The pattern of population growth of Gombe town wasslow from 1900 to 1952 (300 to 18,500 people) while, from 1964 to 1991 the population growth has increased tremendously from 47,000 to 138,000. However, from the year 1996, when Gombe became the State capital, there was a noticeable sharp increase in population from169, 894 (1996) to 219,946 in 2000 (Tiffen, 2006) and 312,467 in the census 2006 and is projected to reachabout 400,000 in 2010 (NPC, 2007). This population explosion resulted in high demographic pressure on land and consequent developmental processes such as building of houses.

METHODOLOGY

The sources of data as it relates to this study were derived from primary and secondary sources of data. The primary data includes data obtained through questionnaire and focus group discussion with the people living around the gully sites. Secondary data

Table 1. Houses and persons affected by gullies

Landuse	Houses destroyed	%	Person(s) affected	Buildings/shops at risk
Residential	239	100	20121	1249
Commercial/industrial	Nil	0	0	452
Educational	Nil	0	0	15
Agricultural	Nil	0	4	0
Total	239	100	20125	1701

includes relevant literature on the subject matter, which was extracted from published and unpublished sources, textbooks, maps, photographic and satellite imagery of the study area. Several gully erosion sites exist within the different land use in the study area. But the major ones which cut across different land use areas within the metropolis are three. These include:

1. FCE-Arawa-M/Inna-U/Uku Gully site (labeled gully A)
2. Fed.lowcost-B/Yero-Idi-Herwagana-Idi-U/Uku Gully site (labeled gully B)
3. Old/GRA-Gabukka-Barunde-Madaki-Bogo-Doma Gully site (labeled gully C)

For the number of questionnaires administered to the people residing around each gully erosion area, 10% of the population is considered as the sampling size for the different landuse areas within the metropolis, random sampling techniques were used to determine the individual respondent.

RESULT AND DISCUSSION

Table 1 present the results of the questionnaires administered to household heads within the vicinity of the sampled gully sites as well as direct observation within the landuse areas on socio -economic effects of gully erosion. The findings showed that gully erosion has over the years destroyed houses, roads and bridges/ culverts, loss of lives and depreciation of land values. For most families in Gombe metropolis, land has remained a traditionally inheritable commodity, and is passed on from one generation to another. The problem with gully erosion is it's difficult to fully reclaim if lost. Once it takes hold, it becomes almost a lost battle to reverse the degradation. Thus, when it occurs to any land, that precious piece of land is permanently lost to the owner(s) or depreciates in its value when selling or when rent out.

Table 1, showed a total of 239 houses were destroyed within the land use areas with a total of 20125 people displaced within the period of fifteen years from 1996 to 2011. This implied average loss of 16 houses or 128 persons per year within the period of fifteen years from 1996 to 2011.Table 1, also shows that 239 houses/ buildings were destroyed in the residential land use by gully erosion with no single house destroyed by gullies within the other three land use areas (that is; commercial, educational and agricultural).Table 1 also shows the total of 20121 people that lives in the houses/buildings destroyed by gullies are directly affected within the residential land use, but a total of four persons were affected by gullies in the agricultural land use and none identified to be directly affected in the other two land use areas (commercial and educational). Cracking and falling of buildings and other physical structures into gully sites are common features in the erosion prone areas within the study area. Shown in Plate 1.

Table 1 further revealed that about a total of 1701 houses located at the distance of 100m from the sampled gullies within the different land use areas are at risk of losing their houses or lives to gully erosion in the near future if no control measures are taken, with the total of 1249 houses at risk in the residential land use, 452 and 15 houses are at risk in the commercial and educational land use respectively. The gully erosion has also destroyed many roads, culverts and bridges in the different land use areas investigated. Table 2 showed that a total of 19 roads both tarred and untarred and 22 culverts and bridges that provide easy transportation of people and goods were destroyed.

Table 2, also shows that 11 out of 22 culverts destroyed are within residential land use representing 50% of the total culverts/bridges destroyed by gullies, 7 out of 22 culverts destroyed are in the commercial land use while 4 out of 22 culverts are in the educational landuse representing 31.8 and 18.2% respectively. Table 2, also shows numbers of plots/farms destroyed, it shows that 103 plots/farms were destroyed by gully erosion within the different land use area with residential land use having 64 plots destroyed, commercial land use 31 plots and educational having 4,b representing 30.1% for residential, 62.1% for commercial and 3.9%, as well as3.9% for educational and agricultural land use respectively.

Table 3, revealed that the total of about 15 persons died within all the land use areas studied as a result of gully erosion within a period of 15 years from 1996 to 2011 with 8, 5, 2 people in the residential, commercial and educational land use respectively, representing 53.3, 33.3 and 13.3% for residential, commercial and educational land use respectively. A total of about 40 animals are also said to be lost as a result of collapsed buildings and gully walls from 1996 to 2011 (15 years) with residential, commercial/industrial and educational land use having 15, 15 and 10 animals respectively. The

Plate 1. View part of houses destroyed at Herwagana by gully erosion
Source. Fieldwork, 2011.

Table 2. Culverts, road and undeveloped lands affected

Landuse area	No of Culverts/bridges destroyed	%	No of plots/farms destroyed	%	No of roads destroyed	%
Residential	4	18.2	31	30.1	6	31.5
Commercial/industrial	7	31.8	64	62.1	8	42.1
Educational	11	50	4	3.9	5	26.3
Agricultural	0	0	4	3.9	0	0
Total	22	100	103	100	19	100

Table 3. Human and animal lives lost

Landuse area	No of lives lost	%	No of animal lost	%
Residential	8	53.3	15	37.5
Commercial/industrial	5	33.3	15	37.5
Educational	2	13.3	10	25
Agricultural	0	0	0	0
Total	15	99.9	40	100

above findings was also supported by Belzerek (2003), which states that floods and streams/gullies undercut buildings near the banks of gullies, they destroy roads and drown people and animals. Some of these gullies measure shoulder widths of 50 to 75m and reach depths between 3.5 and 18m.

Causes of gully erosion in the study area

The causes of gully erosion in the study area are numerous, some of which are identified both through questionnaire administration and physical observation shown in Plate 2.

Table 4, shows the causes of gully erosion in the study area as observed by the respondents. The respondents mentioned the improper erosion control, poor drainage, construction along the water ways, as well as indiscriminate clearing of vegetation. In the residential land use, 43.7% of the respondents attributed the causes of gully erosion in the study area to improper erosion control, 24.3% in the educational land use also believed on

Table 4. Causes of gully erosion in the area

Causes	Improper Erosion Control		Poor Drainage		Construction along water ways		Clearing of vegetation		Land escavation	
Variables	**Fq**	**%**	**fq**	**%**	**Fq**	**%**	**fq**	**%**	**fq**	**%**
Residential	45	43.7	30	41.7	8	20.5	28	50.8	05	62.5
Educational	25	24.3	18	25	20	51.3	14	25.5	-	00
Commercial	27	26.2	20	27.7	11	28.2	09	16.4	02	25
Agricultural	06	5.8	04	5.6	-	00	04	7.3	01	12.5
Total	103	100	72	100	39	100	55	100	08	100

Note. fq= frequency

Plate 2. Bello Sabo Kudi road/ bridge destroyed by flooding in 2004.
Source. Field work, 2011

in the control of gully erosion within the metropolis, these wrong control techniques adversely contributed to the widening of existed gullies in the study area. For example, sometimes only simple stone walls are used, this do not prevent the gully extension at all, but are undermined and subsequently flushed away during a hazardous event like the large scale flooding event of 2004 in Gombe metropolis. Interms of poor drainage, 41.7% of the respondents within the residential land use mentioned poor drainage as one of the major causes of gully erosion in the area, in the educational land use, 25% recognized poor drainage while it is 27.8 and 5.6% in the commercial and agricultural land use respectively.

The poor drainage facility as observed by the respondents within the metropolis has led to the formation of several gullies in the area, also as a result of inability of the existed drainage to contain much volume of run-off as a result of rainfall. Table 4 shows that 20.5, 51.3, and 28.2% of the respondents identified construction and dumping of refuse along water ways as one of the major causes of gully erosion in the residential, educational and commercial land use respectively, while it was 0% in the agricultural land use. The respondents observed that people construct buildings and dump refuse along water-ways. This makes the water to flow with full force thereby expanding the existing gullies.

The indiscriminate clearing of vegetation in the study area, has been identified as one of the major causes of gully erosion by the respondents, table 4 shows that 50.9% in the residential area believed that clearing of

Table 5. Measures taken by the Communities/Individuals

Variables	Fq	%	Fq	%	Fq	%	Fq	%
Landuse	**Sand Bag**	**%**	**Tree Planting**	**%**	**Stone embkmt**	**%**	**Others**	**%**
Residential	31	41.9	38	52	10	28.6	9	9.6
Educational	21	28.4	15	20.5	12	34.3	20	43.5
Comm./Ind.	18	24.3	16	21.9	13	37.1	17	36.9
Agriculture	4	5.4	4	5.5	0	0	0	0
TOTAL	74	100	69	100	35	100	46	100

Note. fq= frequency.

vegetation is one of the problems that led to gully erosion in the area, while 25.5, 16.4 and 7.3% in the educational, commercial agricultural land use areas respectively also identified clearing of vegetation as one of the causes of gully erosion. Table 4 also shows 62.5% of the respondents in the residential land use as those that identified indiscriminate sand escavation as one of the causes of gullies in the area, while it is 25% in the commercial land use and 12.5% of the respondents in the agricultural land use, none of the respondents in the educational land use identified sand escavation as one of the major causes.

The indiscriminate sand excavation at different point in the study area for construction activities provide a major source of concern, as it lead to the development of several gullies especially at the western part of the metropolis where kerri-kerri formation dominate.

Measures of preventing and/or controlling gully erosion

Table 5, present the results of the interview conducted on the effort of community on the prevention and controlling gully erosion in the study area. The respondents mentioned the use of sand bag, tree planting, stone embankments, use of other vegetation such as vetiver grass in gully erosion control. In the residential land use for instance, 41.9% of the respondents used sand bags in their control and 52% used tree planting while 10 and 9% of the respondents used stone embankment and other local methods respectively.

In the educational land use on the other hand, 28.4% used sand bag, 20.5% used tree planting, 37.1% used stone wall while 43.5% used other methods such as planting of vegetation along the gully wall layers such as vertiver grass. In the commercial/industrial landuse, the respondents interviewed had 25.7% for sand bag, 21.9% for tree planting and 37.1, 36.9% for stone wall and other method respectively. While agricultural landuse for sand bag and tree planting are 5.4 and 5.5% respectively.

Government's intervention effort

Recently, the Gombe state governments have earmarked and awarded the contract for the continuation of gully erosion control within the metropolis, for instance, the sum of 1,250,000 dollars was earmarked for the control of gully erosion from Shongo Housing Estate through Central Bank of Nigeria main office and another from Pantami Market to GGSS Doma at the cost of 987,500 dollars only. The ecological fund office also earmarked the sum of 439 million naira for the control of Bogo-BCGA gully erosion. Previous studies conducted on the Gombe township erosion control shows that, the total length of gully within the metropolis is about 121.5km, out of this only 5.6km in length have been controlled, while 7.62km have been partially controlled, leaving about 107.3km still uncontrolled, SEEDS (2006).

CONCLUSION

Gully erosion has been on increase and advancing at alarming rates over the past few decades in Gombe metropolis, causing untold hardships, misery, loss of houses, lives and other properties worth millions of naira. As human population within the study area rises, more land is cleared of its available natural vegetation and replaced with impervious surfaces leading to low infiltration-runoff ratio. The situation is further worsened by rise in value of urban land due to population increase. These force people to erect buildings on floodplains, consequently increasing the magnitude and frequency of gully erosion in response to high storm water runoff and channel concentration, this led to more destruction of lives and properties as observed in the study area. There exist no significant structures of protection instituted by government for victims of the menace. The affected population is almost left to cope with and manage the disaster on their own.

Solving the problem of gully erosion in Gombe metropolis therefore; requires adequate funding, committed political will (not lip-service) and well-articulated sustainable policies. The development of an effective gully erosion control/prevention management programme must be based on accurate scientific and engineering data on the size of the gullies, the engineering geological properties of the soils, the characteristics (volume/velocity)

of the surface run-off and the associated human activities. The implementation of the adopted remedial management programme, must be holistic in approach, (preferably on watershed basis), with well co-ordinated participation of government, private sector and the affected communities.

Conflict of Interests

The authors have not declared any conflict of interests.

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