

Geospatial Surveillance of the Degraded River Komadugu-Gana Area, Potiskum, Yobe State, Nigeria

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ABSTRACT

Geospatial techniques is used to survey the topography and assess the degradation in terms of the presence, spatial location and the magnitudes of soil and gully erosion around River Komadugu-Gana in Potiskum town, Yobe State. The main objectives of the study are to assess the topography of the area, assess the changes in river floor, determine the spatial coverage as well as elevation and slope of the river valley between 2005 and 2014 and to analyze the land use and land cover changes along the banks of the river valley within the period of study. Coordinates and elevation data generated from GPS were used to create DEM and 3-dimensional image of the area, while Google Earth Pro image of 2005 and 2014 of the study area are also obtained to derive the land use and land cover change of the area. The elevation profile module of the Google Earth Pro is used to generate and calculate the parameters of the river profile. The results of the study show among others that the eastern side of the river bank is more inhabited because of its undulating topography, while the western side with rugged topography had scanty built-up areas. Local flood control mechanisms such as construction of embankments and planting of shrubs were also found in the area. The position of gullies were also identified and mapped, while the landcover and landuse of the area were discovered to have changed due mainly to human activities. It is suggested that geospatial techniques can be embraced for proper environmental monitoring.

Keywords: River Komadugu-Gana, Potiskum, soil erosion, gully erosion, elevation profile

INTRODUCTION

The cultural landscape reflects the socio-economic and technical capabilities of a particular area. Hence, the development of Potiskum and its environs is characterized by such activities like; deforestation, construction works, sand mining or quarrying and other intensive land uses (Oladimeji, 2008). Reports from Nyanganji (2009) and Mala (2011) reveal that the major factors influencing soil erosion were amount of rainfall, volume of run-off (taking advantage of human and animal tracks) and the soil texture. The other factors include sand mining along the river channel and diversion of run-off during construction of residential

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quarters by individuals. The river also contributed toward gullying on the slopes by incising its main channel during floods thereby initiating a new set of channel erosion along its bank. Soil erosion is an ecological problem that poses as one of the major environmental problems in many parts of the North-East Nigeria. Potiskum and Gombe environs have lost parts of its urban residential lands to this phenomenon. Gully erosion has also hampered other land uses in the area and retarded developmental projects. As erosion develops into channels and increase in size, becomes rill and develop to gullies, through other processes such as gravitational collapse of channel, walls and headward increases. Erosion leads not only to loss of organic matter and soil nutrients from the surface, causing soil and land degradation but also aids soil and land agradation the deposition of sediments and nutrients into ditches, streams and rivers via run off as alluvial load.

Gully erosion is therefore defined as erosion in channels too deep to cross with farm equipment (Ologe, 1988). Gullying is a term that refers to the wearing away of soil by the action of localized concentrated run-off in valley bottom and on valley side slopes (Olofin, 1987). Sediment eroded from catchment may either be re-deposited within the catchment system or exported from the catchment as fluvial sediment loaded with nutrient enrichment down - streams resulting in eutrophication (Ologe, 1988). The loss and wastage of land from gully erosion can ultimately halt urban expansion through the increased loss of development, and also reduces agricultural output due to nutrient loss. It affects society by restricting the freedom to build houses, schools, hospitals, roads and the development of recreational grounds (Oyegun, 1987). Therefore, the general surveillance for soil and gully erosion in an urban setting such as Potiskum, cannot be overemphasized.

The main aim of this study is to carry out surveillance on the topography along the valley of River Kamadougu-Gana in Potiskum town through the assessment of the changes in the floor and area coverage of the river valley between 2005 and 2014. The specific objectives include:

- (i) To assess the general topography of the valley of River Komadougu-Gana within Potiskum town using geospatial techniques
- (ii) To identify the positions of gullies in the study area
- (iii) To assess the changes in the river floor, spatial coverage of the river, elevation and slope of the river valley between 2005 and 2014
- (iv) To analyze the land use and land cover changes along the banks of the river valley within the period of study

The Study Area

Potiskum is located between latitudes 11°03' and 11°30' North of the Equator and between longitudes 10°50' and 11°51' East of the Meridian (Fig.1). Its distance by road from Damaturu (the State capital) is about 98 kilometers west. Potiskum is a nodal town situated along a trunk "A" Maiduguri - Kano road about 189 kilometers North-West of Gombe, the Gombe State capital, 213 kilometers North-East of Azare in Bauchi State. Potiskum lies within the wet and dry Sudano-Sahelian Savanna belt of Nigeria, West Africa, it receives an annual rainfall ranging between 600-800mm which falls within four to five months. The



mean annual rainy days are one hundred and six (106) days per annum, the onset of rain varies from May to June and terminates around September to October, virtually no rain is received during the dry season which last for at least seven (7) months, that is, from November to May (NIMET, 2014).



Fig. 1: Potiskum distance by road from Damaturu (the State capital)

Potiskum is a lowland area, which lies north west of Kerri-Kerri platform Formation of the north-eastern part of Nigeria. It comprises of brown and reddish-brown soils. These are widespread in areas with mean annual rainfall of about 600mm. Calcium carbonate concentration may be present at about a meter depth. Organic content is low but the organic matter is highly humified and well distributed in the profile. Soil physical characteristics are good but tend to deteriorate under cultivation. The main soil type around the town consist of leached ferruginous tropical soil on impoverished materials over iron pan, this is a red loam which is underlain by iron pan (Mark Lock Group, 1976). The vegetation is within the Sudan savannah vegetation zone, the region is a specific example of shrub savannah. Large areas of Sudanosahelian zone are almost continuously cultivated and little tree remains of the natural vegetation (Rountree, 2007). The Western part of Potiskum (the study area) is drained by the northward flowing Komadugu-ganna tributary, this stream has carved deep gullies in the western part of the town and has a broad pattern working more of a reversed drainage.

MATERIALS AND METHOD

The primary source of data for this study was principally on the information generated from field investigations and reconnaissance survey. In the course of the field investigation, a German 76 Geographic Positioning System (GPS) was utilized to obtain the coordinates of points of interest which was used for the establishment of the Digital Terrain Model (DTM) of the catchment area within the study area. Google Map (2005 and 2014) of the

study area was obtained, extracted and georeferenced from the entire Google image of Potiskum to determine the spatial coverage and depth changes of the River Komadugu-Gana gully valleys between 2005 and 2014. With the aid of a Geographic Positioning System (GPS), the values of the various coordinates as well as the elevation were taken in decimal degrees and metres respectively along the Komadugu-Gana River within the study area. The values obtained were used to generate the DEM and contour maps using Kringing methods.

RESULTS AND DISCUSSION

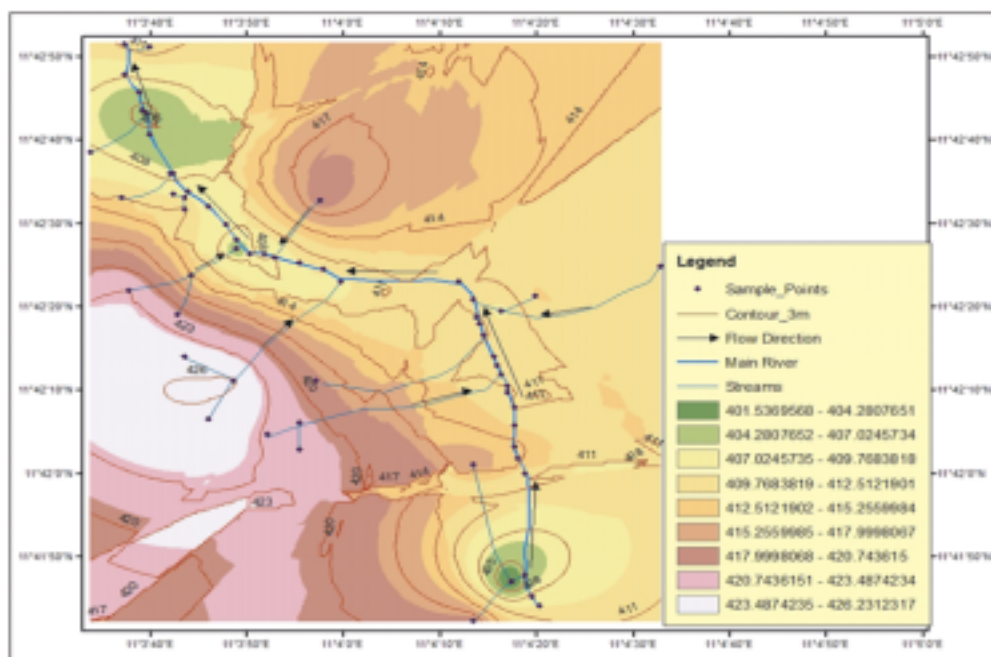


Fig. 2. DEM of the Study Area. *Source:* Generated from points obtained from GPS (2016)

The topography of the area was represented by the DEM image that shows the elevation of the area in different colours and values of each of the colours as presented in Fig. 2. Fig 2 shows that the eastern part of the area is undulating while the western part is more rugged with higher elevation. The lowest elevations were found within the river valley at the north central and at the southern part of the area. These lower elevation areas (401 - 404m) were found to be gully areas (field observation and GPS) which are depicted by green colour on the map. The eastern part with its rugged topography has elevation ranging from 412 - 426m above sea level (asl) except some narrow areas along the river valley with lower elevations. For more visual impression of the topography of the area, a 3D view of the area was generated (with suffer 10) using the same points that were used for DEM generation as shown in Fig. 3.

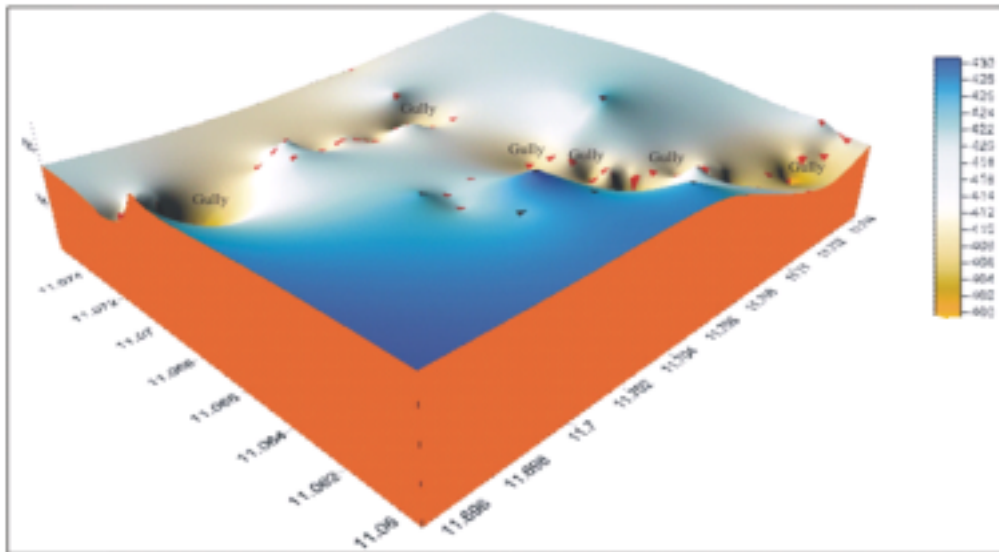


Fig. 3: 3D view of the Study Area. *Source:* Generated from points obtained from GPS (2016)

Fig. 3 shows the 3D view of the study area which conspicuously revealed the river valleys and the gullies in the valley. It also revealed the undulating nature of the eastern part of the area and the rugged western part. Gully erosion was observed to be more severe in the rugged eastern areas because topography through slope (steep or gentle) influences various types of fluvial processes. The nature of topography therefore, determines the severity of fluvial erosion in an area. In a clearer term, Oyegun, (1987) points out that the nature of topography has much impacts on soil surface flow. For instance, areas with 11 degrees of slope experience more serious soil erosion than a nearly level or plain surface, (Young, 1992; Davis, 1980).

Change Detection of the Floor of River Komadugu-Gana (2005-2014)

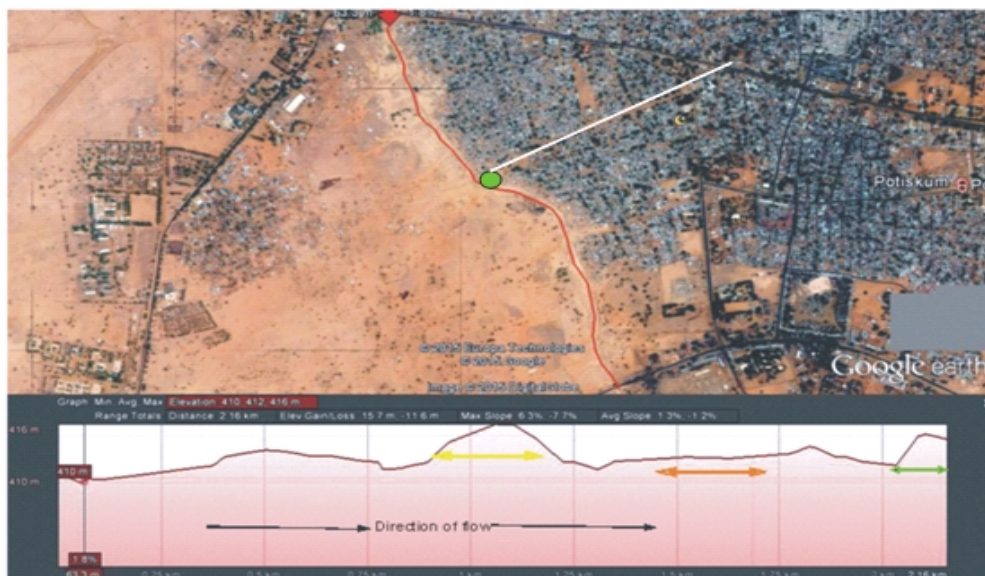


Fig. 4: Elevation Profile of River Komadugu-Gana valley in Potiskum (2005)



Fig. 5: Elevation Profile of River Komadugu-Gana valley in Potiskum (2005)

The elevation profiles in Figures 4 and 5 clearly demonstrated drastic changes in the river floor of Komadugu-Gana in Potiskum. For instance, the yellow, brown and green double edged arrow was used to analyze the changes in the area. The area around the yellow arrow in Fig. 4 was found to be of the highest elevation, about 416m in 2005. The brown arrow in Fig 4 shows a relatively undulating land area immediately after the yellow arrow area. This undulating land area was however found to have developed into an area of highest elevation of more than 419m in 2014 which might have resulted from the accumulation of the eroded materials from the river upstream. This means that at least, 3m of eroded particles have been accumulated in the area within the study period. The materials were accumulated around the brown arrow area because the river has to meander through the river bends and hence, slows the water velocity which results into accumulation of materials around the river bend (Fig.4). The elevation of the river valley around the green arrow area was found to be around 416m above sea level (asl) in 2005. The elevation of the same area in 2014 was discovered to have drastically reduced to less than 415m above sea level (asl) indicating a minimum of 1m erosion.

The green spot along the river valley signifies the point of the deepest part of the valley as derived from the GPS coordinates. This same point was discovered to be located where sand mining was mostly carried out. In fact, most of the sands that are used by the inhabitants were derived from the place. For this reason, a road was constructed (white lines in Figures 4 and 5) right into the bank of the river to ease the movements of the sand miners. Therefore the gully around this point was definitely aided by the sand mining. During the process of sand mining, according to Otu (2014), accelerated erosion and associated land degradation problems sets in. They concluded that the environmental effects of sand mining activities as are largely negative on riparian habitats; riverbed abilities to

hold water, rapid evaporation of ground water, reduction of farmlands and ground water recharge. Further analysis of the gully in the river valley between 2005 and 2014 as derived from the generated river profile from the Google earth Pro is presented in table 1.

Table 1: Calculated profile parameters of soil erosion in Komadugu-Gana River.

Parameters	2005	2014
Total Length of River Valley	2.16km	2.16km
Maximum Elevation	416m	419m
Average Elevation	412m	413m
Minimum Elevation	410m	410m
Total Elevation Gained (accumulation)	15.7m	20.2m
Total Elevation Lost (erosion)	-11.6m	-16.5m
Maximum Slope	6.3%	47.6%
Minimum Slope	-7.7%	-7.7%
Average Maximum Slope	1.3%	1.8%
Average Minimum Slope	-1.2%	-1.4%

Source: Generated from Google Image Pro of 2005 and 2014

Table 1 shows the elevation profile parameters of the study area in 2005 and 2014. The sample length of the river valley in both years was equal, that is, 2.16km. In terms of elevation, the maximum was 416m in 2005 and 419m in 2014. It was also revealed that a total of 20.2m of land was found to have been accumulated across the length of the river between 2005 and 2014, while an average of -16.5m of land area was also found to have been eroded within the same study period in the same area. This means that a lot of erosion activities were in place in the area within the years of study. Moreover, the maximum slope in 2014 was found to be 47.6% as against only 6.3% in 2005 which signifies the presence of gully erosion that is usually characterized by steep sides in the area.

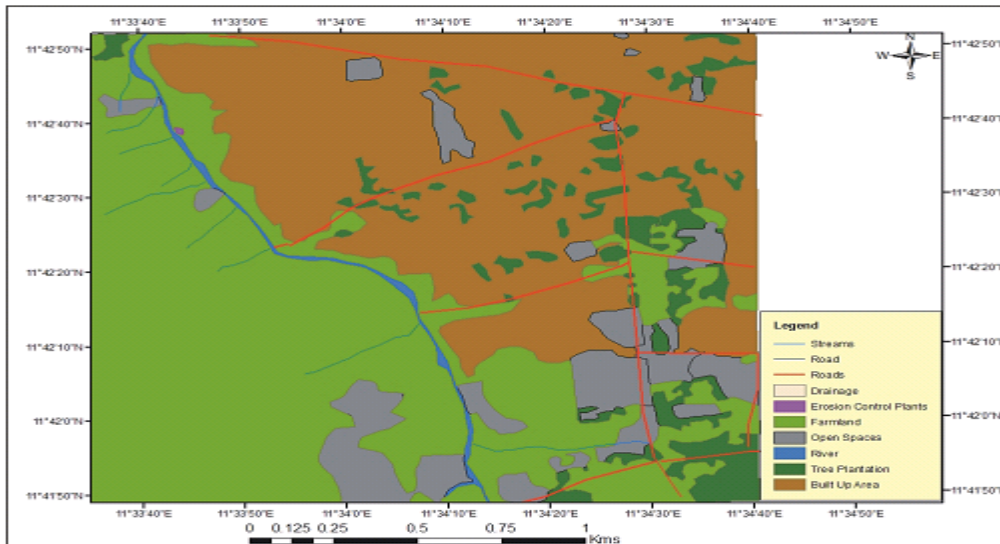


Fig. 4: Digitized Landuse and Landcover Features from 2005 Google Image

Source: GIS Work, 2014

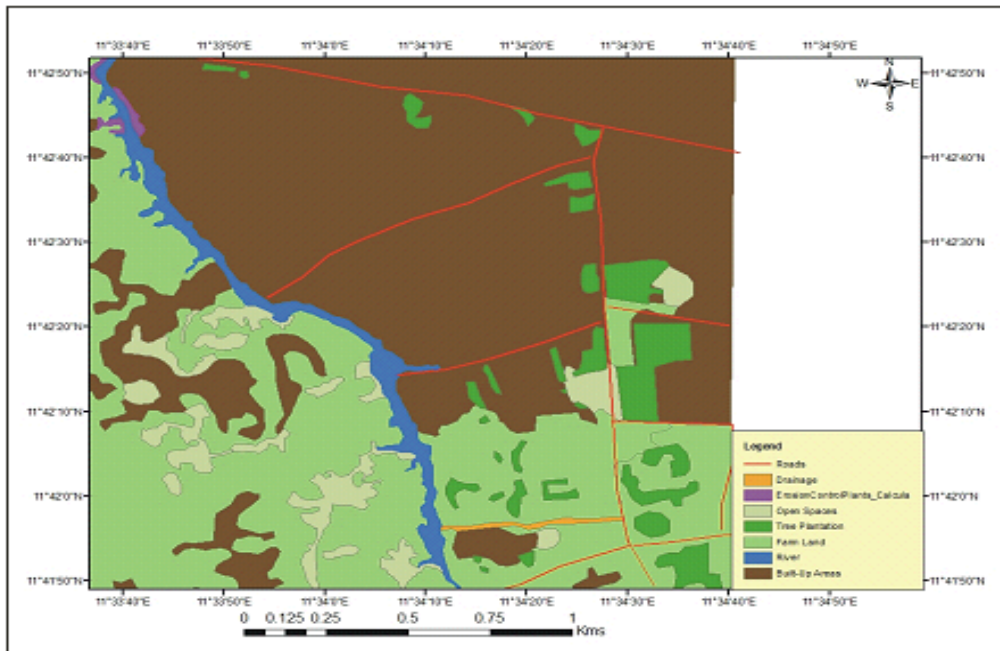


Fig. 4: Digitized Landuse and Landcover Features from 2005 Google Image
Source: GIS Work, 2014.

Landuse and Landcover Change of the Study Area

The detection of the landuse and landcover types within the study area was made possible and obtained through the acquisition of the Google Earth 2005 and 2014 images (Figs.4 and 5) respectively. Table 1 presents the information of the results of the calculated area of the landuse and landcover types in 2005 and 2014. The landuse of the area mostly comprises of built-up areas, tree plantation basically of Neem trees, orchards of fruit trees such as cashew, mangoes as well as guava plants. Soil erosion control features which include embankments and erosion control plants were mapped. Other identified features include: open spaces, farmlands and the river valley. The area coverage of each of the classes as calculated is presented in table 2

Table 2: Landuse and Landcover Change (2005 - 2014)

Landuse and landcover	2005 Area (Hectares)	%	2014 Area (Hectares)	%	Change in Percentage
Built-up areas	1.71	39.42	2.35	54.17	14.8
Open space	0.46	10.60	0.18	4.5	6.1
Farm land	1.78	41.03	1.48	34.12	7.0
Tree plantation	0.34	8.30	0.19	4.38	4.0
River	0.05	1.15	0.12	2.77	2.0
Erosion control plant	0.0007	0.02	0.009	0.21	0.2
Drainage	Nil	Nil	0.009	0.21	0.21
Total area	4.34	100			

Source: GIS Analysis, 2014

In 2005 as revealed by table 2, the entire study area was mainly comprised of built-up and farmland areas. These two landuse classes collectively accounted for about 80% of the area. There was also no embankment for drainage control in the year. However, in 2014, though the two landuse features still cover the largest part, but farmland was no longer the largest area as built-up areas became the largest landuse in the area. The built up areas have even expanded across to the western rugged areas. This increase in the land area for residential purposes resulted negatively on other landuse and landcover classes. For instance, it led to decrease in the land area of open spaces, tree plantation and farmlands. The width of the river valley in 2014 was also discovered to have increased more than double its original width in 2005 which indicates soil erosion in the river valley areas. Consequently, resulting into gully erosion as observed by Ologe (1972) that fluvial erosion create sheet, rill and gully erosions, which are already observable in the field in many parts of the savanna. Hence, gullies develop where run-off is concentrated along definite channels on the slope and grow lengthwise by headward erosion (or head scarp retreat) and sideways by basal sapping, (Coates, 1978; Igbokwe, 2008; Ologe, 1972, Nyanganji, 2009).

CONCLUSION AND RECOMMENDATIONS

The existence, spatial location and the severity of soil and gully erosion along the valley of Komadugu-Gana River in Potiskum town in Yobe State has been demonstrated in this study. The general topography of the area was found to be undulating in the eastern side but highly rugged at the west, hence, gully erosion were found in the west as well as the river valley. The longitudinal profile of the river valley also revealed that a lot of soil erosion and soil accumulation has taken place in the river valley between 2005 and 2014. The deepest part of the river valley coincides with the area where sand is mined in large quantity. Before 2005, farmland had the largest landuse closely followed by built-up areas. However, in 2014, built-up areas recorded the highest landuse area. Moreover, the rugged western part of the river was also found to be encroached by residential development. The expansion of the settlement areas was however found to have reduced the area coverage of tree plantation, farmland and open places which might not be environmentally healthy for the inhabitants especially in the future. The width of the river valley within just nine years was found to have expanded more than twice its original size despite some little control measures like construction of embankments and planting of flood control plants. Therefore, immediate environmental control measures (with the use of geospatial techniques) are needed in order to protect the town from future wrath of flood hazards, total land degradation, loss of land for residential and agricultural activities among others. Based on the foregoing, the following control measures of soil and gully erosion in the area are suggested.

- (i) There is the need for comprehensive landuse assessment so as to aid proper planning of the area for urban development and environmental sustainability.
- (ii) There has to be constant environmental monitoring of the area using remotely sensed data and GIS techniques so as to have deep knowledge about the area and therefore plan for its sustainability.



- (iii) Land reclamation of the already degraded land this can be achieved through the planting of deep-rooted perennial pastures, trees or the effective combination of both plants such as *pitadeniastrum africanum* which can boost and maintain vibrant and healthy vegetation.

REFERENCES

- Coates, D. R.** (1978). Environmental Geomorphology and Landscape Conservation. Volume III Doden Pennsylvania Pp. 286-295.
- Davis, W. M.** (1980). The Physical Geography (Geomorphology) Geography Abstracts Ltd., in their Geography Book Series Pp. 13-16.
- Igbokwe, I.** (2008). Gully Erosion Mapping/Monitoring in Part of Southeastern Nigeria. Paper Presented at Department of Surveying Geoinformatics: pdf. 3/02/2009.
- Mala, M.** (2011). An Appraisal of Gully Erosion along River Ngaddabul Flood Plain. Maiduguri, unpublished M.Sc Dissertation, Department of Geography, University of Maiduguri Borno State
- Marklock Group** (1976). Potiskum Surveys Planning Report for the North Eastern State Government in Nigeria UK Warminster Press Ltd.
- Nigeria Metrological Agency (NIMET)** (2014). NIMET Annual Report
- Nyanganji, J. K.** (2002). The morphology and Hydrograph of the Ngadda Catchment and the Bama Beach Ridge, Pp 13-31, Frankfurt am main.
- Nyanganji, J. K.** (2009). Morphology of the Ngadda River Basin in Muhammad, W. Kagu, A. and Mungono, A.K. (2009): Issues in the Geography of Borno State Vol. 1, Pp 28-39.
- Oladimeji, B.** (2008). Processes of Gully Erosion in Socol Area, Potiskum. Unpublished PGD Dissertation, Department of Geography, University of Maiduguri Borno State.
- Ologe, K.O.** (1972). Gullies in Zaria Area. A Preliminary Study of Headcarp Recessions. *Journal of the Environmental and Social Sciences*, 1 (1), 65 - 66.
- Ologe, K. O.** (1988). *Soil erosion characteristics, processes and extent in the Nigerian savanna*. In V.O. Sagua, E.E. Enabor, G.E.K. Ofomata, K.O. Ologe and L. Oyebande (eds) *Ecological Disaster in Nigeria: Soil erosion* Pp. 26 - 49.
- Olofin, E. A.** (1987). The Dynamic of Gully Head Recession in a Savanna Environment. Paper for the Developmental Seminar Series Geography Department, Bayero University, Kano.
- Otu, R. O.** (2014). Drainage Characteristics of Galtimari Gully System in Maiduguri, Borno State, North East, Nigeria. An unpublished M.Sc thesis, Department of Geography, University of Maiduguri.
- Oyegun, R. O.** (1987). Sediment Redistribution in Ilorin Nigeria. *The Environmentalist*, Vol. 7, No. 2, Pp. 123 - 129.
- Rountree, K. N.** (2007). Sediment Yields from a Laboratory Catchment and their Relationship to Rilling and Surface Armouring. *Journal of B.G.R.G.* Vol. 7, No. 2 Pp. 153.
- Young, A.** (2007). *Tropical Soils and Soils Survey*. Cambridge University Press Ltd. Pp 285-301.

