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An Assessment of Gully Erosion in Selected Areas of Minna, Niger State, Nigeria

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Abstract : The issue of gully erosion is of a major concern both globally and locally. The focus of this study is to access gully erosion in some selected areas of Minna. The objectives are: to identify the distribution of gully erosion in the study area, to determine the length, width and depth of the gullies. The method of data collection employed is through field work which involves the use of GPS to capture the coordinates the gully sites and tape rule to measure the width, depth, and length of the gullies. GIS techniques were used in data analysis. A total of 19 gully sites were coordinated and mapped, the result reveals the gully erosion were dispersed with area GbeganuKpakungu having more concentrated gullies. The generation of gully characteristic map revels that the gullies vary from area to area in relation to their lithology. The characteristic map (in meters) was classified into three parameters with 2.00-6.06 as Low, 6.06-8.89 as Medium, and 8.89-13.77 as High. The gullies with the highest depth are in GbeganuKpakungu, the highest width is in Bosso and Fadipke, and longest length in Bosso, Fadipke and eastern bypass. The research result indicate the need for incorporation of gully vulnerability, the areas require dire attention to arrest the menace of the erosion trait.

Key words: Assessment, Gully Erosion, GIS, Minna

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I. INTRODUCTION

Gully erosion is a world-wide phenomenon. It is enormous types of environmental degradation which leads to loss of valuable land used for agricultural, domestic, industrial and aesthetic purposes, as well as loss of property and even human lives (Obiadiet al. 2011).Istanbulluoglu et al. (2003) defined gullies are unstable channels formed at or close to valley heads, sides and floor.Poesen et al. (2003)on the other hand defined gully erosion as the process whereby runoff water accumulates and also receives in narrow channels and over short periods removes the soil from this narrow area to considerable depth. Gullies have three dimensional nature affected by varied factors and processes including surface hydrology, soils, topography, land use among others. Many gullies grow initially rapidly to large dimensions making effective control technically difficult (Thomas et al.,2004;Valentin et al.,2005). Gully processes has for sometimes been neglected because gully processes are difficult to study and control. This is why studies in gully processes and their modeling are scarce (Gomez et al., 2003; Sidorchuk, 2005) Gully erosion is an important sign of land degradation(Poesen et al.,2003).Studies have been carried out in different part of the world by researchers such asSzabó et al. (1998) and Nwiloet al. (2011)they use GIS/RS to assess gully erosion. Nigeria however have also attract pretty much attention in gully study, southern Nigeria states like Abia, Anambra have always experience devastating gully erosion base on the study carried out by Nwiloetal.(2011) who also use GIS as an approach to assess and map gully erosion hazards in Abia State, they were able to identify the distribution of gullies in the study area using GIS and also examine the cause of erosion and spotting affected areas. However they recommended that more practical approach at the local level is required. Over the years substantial progress have been made with respect to modeling water erosion process, but many issues still remain unresolved. These unresolved issues are little concentration on accurate and substantial data of the depth, length, width and risk assessment lacking in Minna. It is not only important from a scientific or geomorphological perspective, but also to enable land managers and stakeholders to develop sustainable planning strategies for appropriate utilization of land, that include both stabilization of gullies as well as prevention of gully formation in areas that are considered sensitive. The aim of this research is to assess gully erosion using Geographical Information System (GIS) techniques with the following specific objectives:Identify the distribution of gully in Minna, determine the length, width and depth of the gullies in Minna and produce gully characteristics map of Minna

II. MATERIALS AND METHODS

2.1 Study Area

Minna, the capital city of Niger State, one of Nigeria's 36 federal states, and is the headquarters of Chanchaga Local Government Area. Minna covers a landmass of 72km^2, Minna lies on latitude $9^0$3'E and longitude $6^0$33'N, on a geographical base of undifferentiated basement complex of many gneiss and magnetite situated at the base of prominent hills in an undulating plain. The whole surrounding of Minna is very rocky, presently, Minna enjoy a climate of typical middle belt zone. The rainy season starts around April and last till October, it has a mean annual rainy of 1334mm (52 inches) with September recording the highest rain of 300m (11.7 inches), the mean monthly temperature is highest in March at 30-50^{0}C (83^{0}F) and lowest in August at 33.3^{0}C (27.9^{0}F).

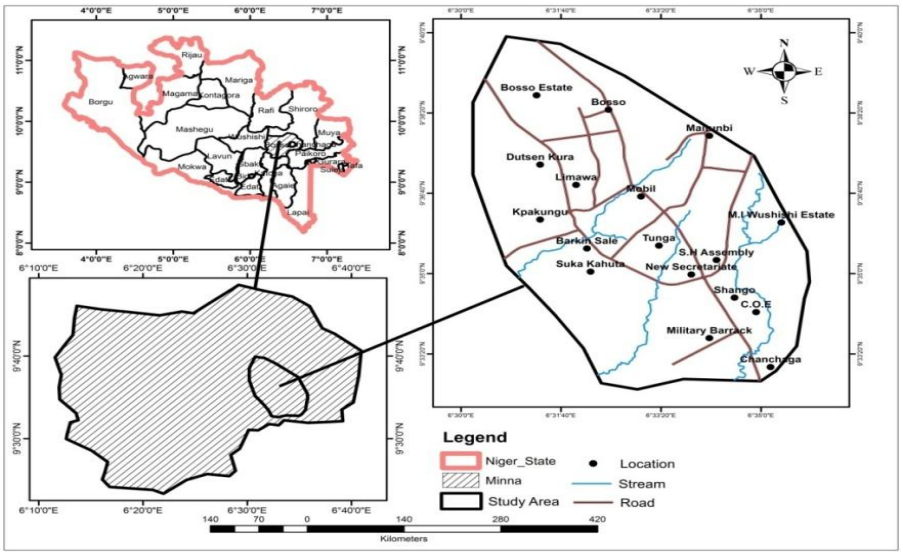

Figure 1: Study Area

2.2 Geology of the study area

The available literature have clearly reiterated the fact that the underlying geology exerts a major control on gully development and more often than not, the process is rock type dependent as some rocks are more susceptible to erosion than others (Abdulfatai et al., 2014). Ezechi and Okagbue (1989) indicated that the nature of underlying bed (or geology) has a bearing on the initiation and development of gullies. Overlaying the study area on the geological map of Niger state and digitizing it out revels that the study area is laying three bed lithology namely: porphyritic and biotite hornblende granite, fine grain biotite granite, and undifferentiated schist.

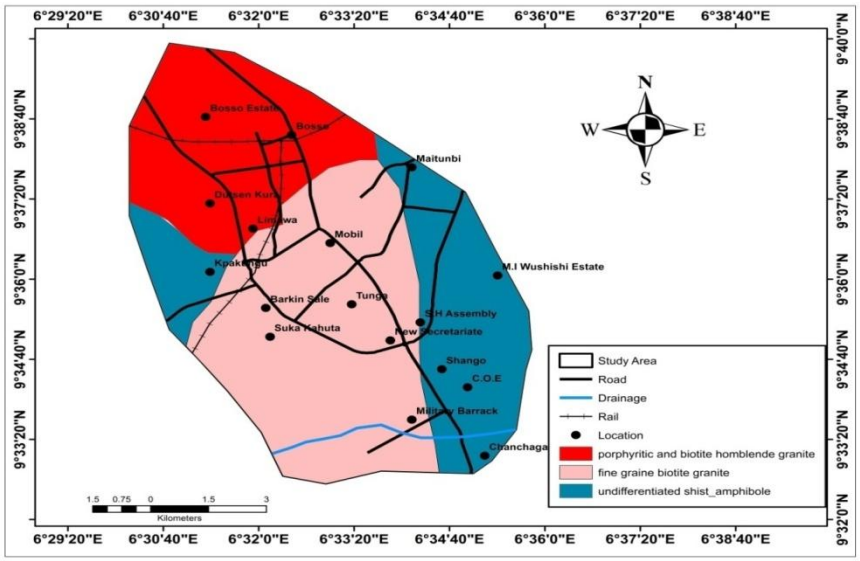

Figure 2: Geology of the study area

3. Types of data

This research is mainly based on field information; therefore most of the data required are collected from field work. However it entails both primary and secondary data collection sources. The primary data are attributes data recorded and coordinates of already existing gully sites obtained from GPS observations during reconnaissance survey of the gully areas, and secondary data sources are base map; geological, drainage, land use; relief and rainfall maps of the study area.Based on the data required for this research, three data set were used, they include surface data (topographical features), point data (coordinates) and attribute data (width, length and depth of gully sites)

Table 1: Data sets used in this research

S/N	Data type	Detail	Data format	Extracted info	Data Source
1	Map	Geological Map	Soft copy	Geology of the study area	NGSA
2	Map	Drainage Map	Soft copy	Traverse	NIHSA
3	Map	DEM	Soft copy	Digital Elevation Map	NASRDA
4	Map	Soil Map	Soft coy	Soil map of the study area	
5	Attribute	Field readings	Soft copy	Gully width, length and depth	Field work
6	Point	Coordinate	Soft copy	Coordinate of the gully sides	Field work

Source: Authors fieldwork, 2017

3.1 Data acquisition

The length, width and depth of the gullies were obtained used of tape and ranging pole to measure them in meters and coordinates was taken using GPS.

3.2 Data analysis

This involves the process of analysis and generation of result in relation to the stated objectives. Identifying the distribution of gully erosion; the data acquired (coordinates) was imputed into excel and converted to Base file (a format ArcMap can understand) using access. This data was further added to ArcMap, overlaying it on the map of the study area to show the distribution. The measured length, width and depth of the gully and the coordinates were used to generate a data base using excel. Producing gully characteristic map; the generated database was added to ArcMap and a density of each parameter (length, depth and width) was generated using the following tools in Arctools box; 3D analyst→Rater interpolation→IDW and then Data management tools→Raster processing→Clip.The Geological map of Niger State wasgeoreferenced; the study area wasoverlayed on it and the digitized to show the soil type.

3.3 Data presentation

Base on all the Data acquired, a database were generated using Microsoft excel, and imported to ArcMap thereby generating a database management in a table format having all the information collected. This database can be processed, analyzed and updated**.**The various data in this research were presented in text and maps to show visual contrast between the findings and enable easy understanding.

III. RESULTS AND DISCUSSION

4.1Distribution of Gully Erosion in the study area

Nineteen (19) gully sites were identified and coordinated. Overlaying the gully sites on the study area map shows that the distribution of gullies in the study area is dispersed. Figure 2, shows the distribution of the gullies. The gullies are more clustered in GbeganuKpakungu area, it's moderately clustered in Chanchaga, Mandela, and Tunga area, and less in areas of Bosso this is due to the underlying granite rock.

Figure 3: Gullies distribution in the study area

4.2 Gully Characteristic of the Study Area

4.2.1 Gully width

The gullies width also was characterized in three parameters as depicted in figure 4, 2.00-6.06 are areas of low gully with. They represent a large portion of the characteristic in width except gullies in areas of mechanic junction Bosso and opp. Kure market which have high width parameters between 8.89-13.77; field observation shows that the settlements close by are in danger of being collapsed if no action is taken. Majority of gullies in the study area have low width, this point out that they are not at a mature stage and can be easily controlled.

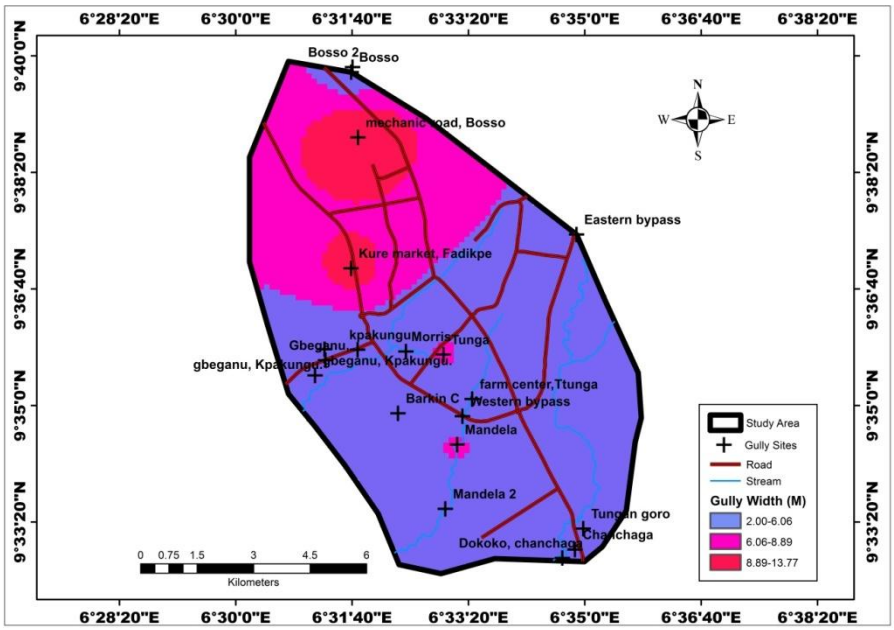

Figure 4: Gully Width characteristic

4.2.2 Gully Depth

As depicted in Figure 5, the deepest gully encountered was in GbeganuKpakungu with the highest parameter of 8.89-13.77. This area is underlained by schist amphibole which is moderately resistant to erosion. The medium parameter is between 6.06-8.89 in areas such as Kpakungu, Barkin sale C, western bypass and Mandela. These areas are underlain by fine grain biotite and the lowest depth parameter between 2.00-6.06m is underlain by porphyritic and biotite hornblende granite, this explain why the area is least dug by erosion because granite are resistant to erosion, the areas include Chanchaga, Tungagoro, opp. Kure market, Bosso 1 and 2, and eastern bypass. Much attention is needed to the Gully located in GbeganuKpakungu; field observation shows that the gully is by a road side which put this road in bricks of collapse any time soon if action is not taken.

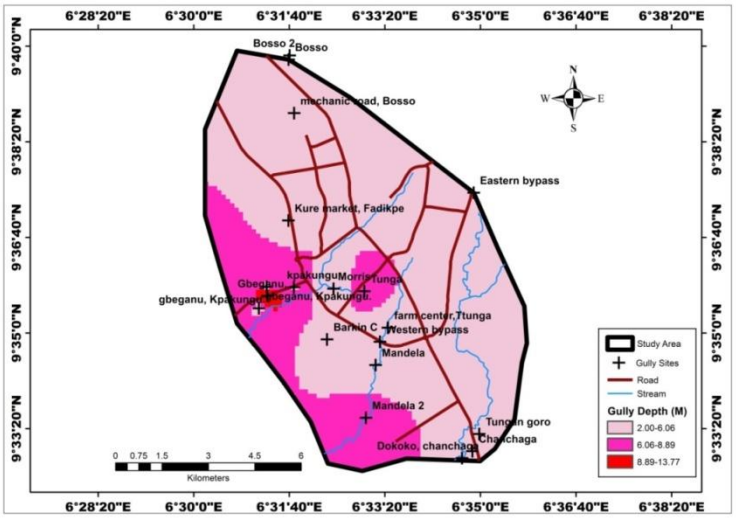

Figure 5: Gully Depth characteristic

4.2.3 Gully Length

Figure 6 below, gives a visual interpretation that gullies located in areas such as mechanic road Bosso, opp. Kure market and eastern bypass (close to 3 arm zone) have the longest length with the highest parameter between 8.89-13.77m. Tunga (Niteco road), Kpakungu, Mandela2, the areas of Tungagoro, and Chanchaga all have medium length parameter of 6.06-8.89m. The rest of the areas namely Bosso, Mandela 1, western bypass, GbeganuKpakungu, and so on, all have very low length density between 2.00-6.06.

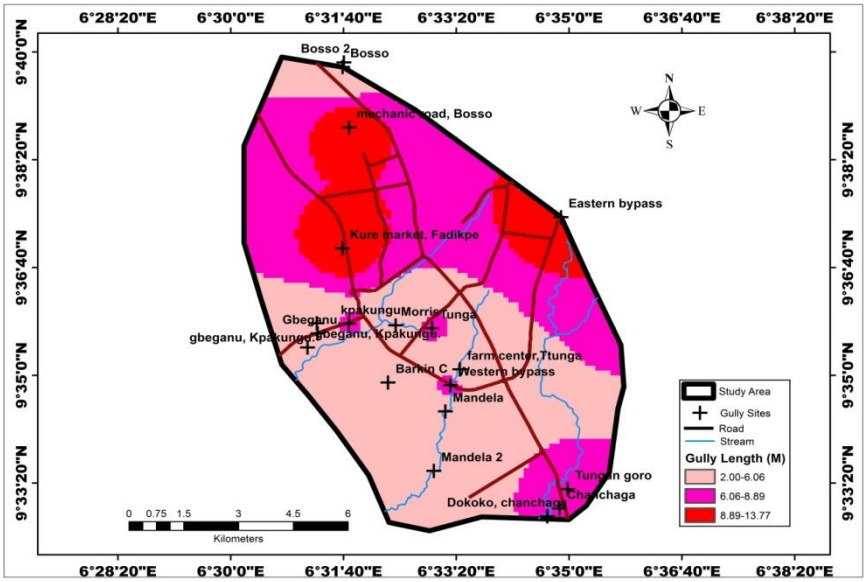

Figure 6: Gully Length characteristic

IV. CONCLUSION

Although the distributions of gullies are dispersed, the areas of Gbeganu have more concentrated gullies compared to areas of Bosso and Chanchaga which are less concentrated. The study area lies on granite and schist amphibole bed rock which are quite resistance to erosion. Generating gully characteristic map revels that GbeganuKpakungu, Bosso, Fadipke and eastern bypass have the highest gully depth, width, and depth in relation to their lithology respectively. The research find out that all the gullies were aided by anthropogenic activities primarily un-channeled drainage system or collapsed erosion drainage that was abandon. Some of the gullies are close to major road (i.e. those of western bypass and GbeganuKpakungu) they are among the gullies that have the deepest depth.

Recommendations

Further study should adopt high resolution aerial imageries to detect gully erosion in the study area. New models should be developed for the study of gully erosion using remote sensing and GIS techniques. Action should be taken to repair this sites before it eats up to the main road and cause road block. Drainages should be created alongun-channeled water channel and were necessary and collapsed drainages should be repaired.

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