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ANALYSIS OF SEVERITY AND MAGNITUDE OF GULLIES ON ARABLE LANDUSE IN LAFIA LOCAL GOVERNMENT AREA, NASARAWA STATE, NIGERIA

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Abstract
The study investigates and examines the effects of gully erosion on arable land use in Lafia LGA, Nasarawa State, Nigeria. It is aimed at understanding the extent to which gully erosion affected agricultural land use in the study area. Data for the study were sourced from both primary and secondary sources. The primary data were through collection of soil samples and field observation, while the secondary data were collected from consulting official documents, journals, past student projects, textbooks, dictionary, newspapers, encyclopedia, seminar papers and books which are most relevant to the study. Soil sample of each identified gully in the area were collected from a depth of 50 to 100m for particle size analysis. Measurement of Base with, total top width, depth, receded top width, length, slope and the volume of soil eroded in each of the identified gully in the study area were determined. The statistical techniques adopted for this work were descriptive statistics to test farmers perception on gully erosion and inferential statistics were adopted for particle-size analysis while spearman rank correlation coefficient were employed to get the inter relationship between the characteristics of the gullies in the area. The dominant grain-size is sand and clay in the area. The grain-size range also implies a high index of detachability. A total volume of 7032.92m soil were eroded from all the gullies in the study area. It appears that in order to retard or completely stop the process of gullies in the study area (and in similar environment), the cyclical

process chain must be broken. The most appropriate point to intervene is the removal stage. Runoff reaching the gullies should be slowed down and reduced in volume through the creation of grass bands and other obstacles around the gullies. If this is not done, increased infiltration will do more harm than good in the type of structure in the area. Also, the gullies walls should be treated to produce gentler slope, especially in urban setting in the manner described in Olofin (1985). Man must also improve on his land management in the area.

Keywords: *Severity, Magnitude, Gullies, Arables, Land use,*

Introduction

Today's society often times focuses on sensational news and short crises which surround us. By constantly dwelling in the present, many people ignore the long term problems that compound slowly until they reach a crisis level, and may then be very difficult or impossible to correct. Soil erosion is a continuing long term problem.

Natural processes such as the formation of soil occur at an alarmingly slower rate than soil can be lost. It is estimated that over 3 billion metric tons of soil are eroded off of our field in the world and pasture each year by water erosion alone (Rattan *et al*, 2010). The main variables affecting water erosion are precipitation and surface runoff. Rain drops, the most common form of precipitation, can be very destruction when they strike bare soil. With impacts of over 20mph, raindrops splash grains of soil into the air and wash out seeds. Overland flow, or surface runoff, then carries away the detached soil, and may detach additional soils and then sediment which can be deposited elsewhere.

Sheet and interrill erosion are mainly caused by rainfall. However, some of the more severe erosion problems such as rill erosion, channel erosion, and gully erosion all result from concentrated overland flow (Brown, 2012). Other types of erosion by water include landslides.

When fertile soil is removed, along with it go the nutrients and organic matter which are significant to the growth of plants and crops. Without soil, plant and crops will not survive. Thus, it is easy to see that a reduction in this protective cover will only expose more soil to the detrimental effects of wind and water erosion (Brown, 2012). In addition to the use of conservation tillage to control sheet and rill erosion, soil erosion can also be formed by wind.

As the world population increases and the demand for food and other agricultural commodities grow, it is inevitable that more demand will be placed on marginal land for agriculture. Much of the world marginal land is on medium to steep slope and prone to water erosion (Sanders, 1990). Agriculture is the main economic activity in Nasarawa State and Lafia Local Government in particular. The State is endowed with fertile agricultural land, rivers, streams as well as a large active population that can sustain highly productive and profitable agricultural sectors.

Nasarawa State has three senatorial zones which include: Nasarawa North, Nasarawa South and Nasarawa West zones respectively. The categories of crops being grown in Lafia include, cereals, tubers and vegetable (Aboki, 2002). A Food and Agricultural Organization (1981) report estimated that between 5 and 7.1 million hectares of land are at present being lost annually to soil erosion and hence affect and reduces food productivity.

Soil erosion is a worldwide phenomenon caused by wind or water in arid and humid environments and is accelerated by the removal of vegetation cover (Asthana *et al* 2005). Soil erosion threatens agricultural production capacity which is also one of the major sources of damaging sediments in rivers, lakes and estuaries (John, 2004). Global environmental problems range from pollution (air and noise to biological bosses, deforestation, gully erosion, flooding and atmospheric contamination) (Smart, 2002). Each particular problem has a linkage effect with another, which tends to exacerbate the effects of the other thus, creating waves of anxiety, worry and concern for users of the environment (Smart, 2002).

The problem of erosion is a worldwide phenomenon that has serious implication on farmlands and settlements leading to lots of agricultural land, productivity and displacement, urbanization, poor land use management, municipal and industrial waste (Smart, 2002).

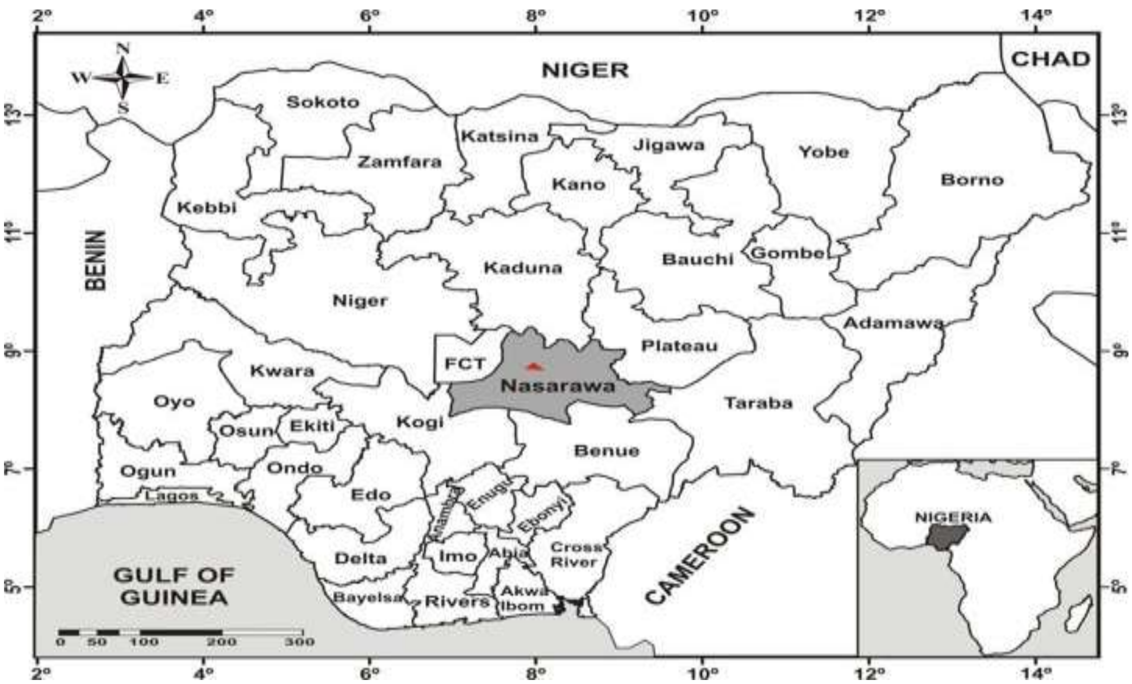
Materials and Methods

Study Area

The study was conducted in Lafia Local Government Area of Nasarawa State where gully erosion has affected agricultural land use.

Lafia is located between latitude 8^0 20'N-8^0 38'N and between longitude 6 34'E-7^0 30'E.

The area has a tropical type of climate. The two seasons of the year are wet and dry seasons that roughly coincide with summer and winter season of the Northern Latitudes.



Source: NAGIS, 2014

Fig 2.1: The Location of Nasarawa State in Nigeria.

The major soil units of the region belong to the category of Oxisols or Tropical Ferruginous soils. The soils are derived mainly from the Basement Complex formation and other sedimentary rocks.

Lafia falls within the Benue valley, and in this part of the region, little is known about the geology

The area is surrounded within the Mada River Basin of the Benue valley platform. The area is drained by the Benue River, River Mada of Guma and Ankwe River (Binbol, 2006).

Methodology

Nature of Data Required

In order to achieve the objectives of this study, information on the causes and effects of gully erosion on agricultural land use in Lafia LGA were needed from both primary and secondary sources. These include the measurement of identified gullies, soil physio-chemical properties, causes of gullies, the effects of gullies and ways of combating gully erosion in the study area.

Sources of Data

Data for this study were sourced from both the primary and secondary sources. The primary data were through field observation and soil samples of the study area while the secondary data were collected from consulting official documents, journals, past student projects, textbooks, dictionary, newspapers, encyclopedia, seminar papers and books which are most relevant to the study.

Field Measurement of Gullies

Instrument such as tape, compass, Abney level and ranging poles were used to determined the base width, total top width, total depth, top width, length of each of the identified gully site under the study. Clinometers were used to measured the angle of the slope of each identified gully in the area. First, the researcher observed measurements through a straight-line distance D from an observation point 0 to the gully. The measurement were start from angle a between 0 and the top of the gully. The sample measurement were carried out for the angle b between 0 and the bottom of the gully. D was multiply by tangent of a gives the height of the gully above the researcher, and by the tangent of b the depth of the gully bellow the base. At the end of the study, the volume of eroded soil in each of the gully site in the study area were determined. Field book were used to record the figure from the measurement.

Collection of Soil Samples from Selected Gullies

The soil samples from the identified gullies were obtained from the field using a soil auger. The soil samples were collected from a depth of 50 to 100cm for particle size analysis.

Laboratory Analysis of Soil Samples

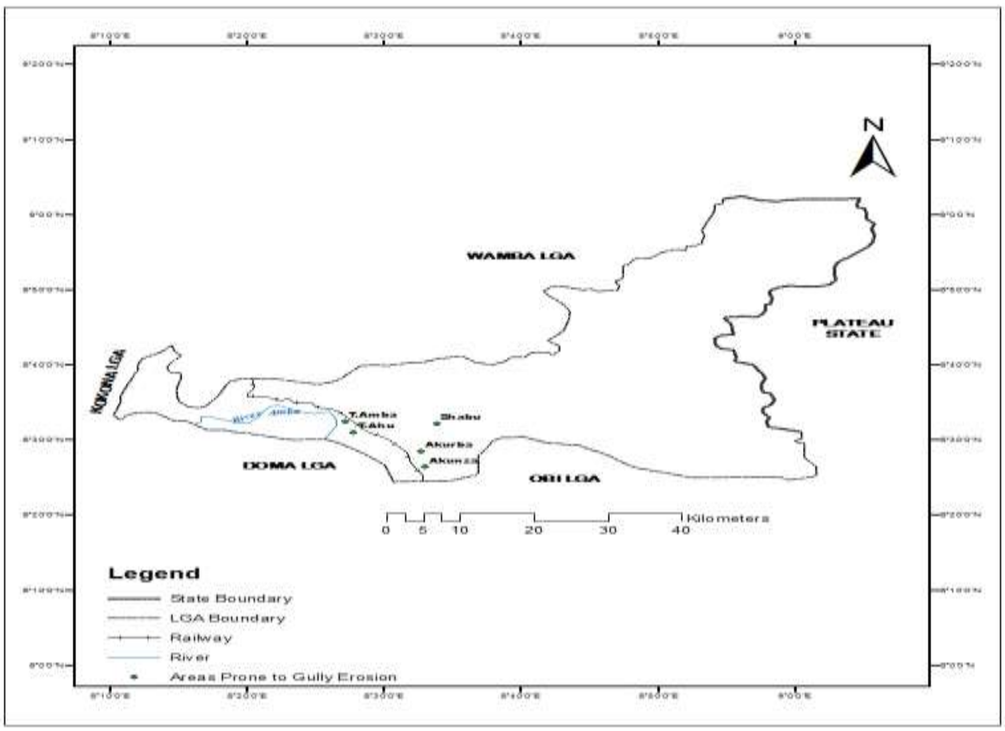
Laboratory analysis of soil samples were carried out in Agronomy Department of Faculty of Agriculture, Nasarawa State University, Lafia Campus. Particle size analysis was determined by using hydrometer method. Organic matter was determined by wet oxidation method

Statistical Techniques

The statistical techniques adopted for this work is descriptive statistics to test farmer perception in the area, descriptive and co-variance were used for particle size analysis, Spearman rank correlation coefficient were employed to get the relationship among the characteristics of the gullies in the area, while Students t-test were used to test the hypotheses.

Results and Discussion

Identification and Mapping of gully erosion site



Source: NAGIS, 2014

Fig 4.1: Map of Lafia Local Government Area showing areas prone to gully erosion

Fig. 4.1 indicates areas prone to gully erosion in the study area. These area include Tudun-Amba, Shabu, Akurba, Tudun – Allu and Akunza respectively. Areas within the above listed vicinity were very prone to impact of gully erosion. This is because, the dominant grain-size in the area is sand and clay and they easily crumples once it is saturated (Field and Laboratory observation). The grain-size range also implies a high index of detachability especially under high rainfall intensity.

Clay textured still have small pores more like narrow that do not allow water to soak into the soil fast. Clay soils are known to have poor infiltration and drainage (Olofin 1985).

The potential for gully erosion increases in the study gully site because of little vegetation cover of plants in the area. Plant and residue cover protects the soil from rain drop impact and splash, tends to slow down the movement of runoff water and allows excess surface water to infiltrates (Olofin, 1985).

Volume of eroded soils in the study gully sites

Determination of erodibility factor and predicted soil loss:

K (%) = (%sand + %silt) x 100(% clay)

The predicted soil losses for the various areas were done using revised universal soil loss (RUSLE) equation.

A = 2.24 RK

Where A = Soil loss converted to ton/ha/yr by multiplying by 2.24

R = Rainfall factor and given as 0.5H

H = Mean annual rainfall

K = Erodibility factor

Table 4.2 volume of soils loss in the study gullies sites

Gullies	Volume eroded (tons)
Akunza	618.1
Tudun Allu	2215.5
Tudun Amba (1)	1472.1
Tudun Amba (2)	1674.3
Shabu	664.9
Akurba	388.02
Mean	1172.2
S.D	630.2
CV %	53.8

***Source**: Field and laboratory work April 2014.*

Note: Total volume of soil eroded from all the gullies = 7032.92 (tons)

Table 4.2 presents information on the volume of soil loss in each of the identified gully site in the study area. The results revealed that Tudun –Allu of Makama ward recorded the highest volume of soil loss in the area (2215.5tons), followed by Tudun-Amba (2) which recorded the volume (1674.3m) of soil loss in the area, Tudun – Amba (1) (1472.1tons), Shabu (664.9tons), Akunza (618.1m) while Akurba recorded a least of (388.02m) soil loss in the area. The total volume of soil loss from all the gullies = 7032.92m. The implication here is that since a large area of arable land is seriously eroded, there will be shortage of land for cultivation. This will lead to migration of rural population to the cities in search for other alternative job. And it will result to food scarcity in the area.

Plate 1: Shabu Gully
Source: Fieldwork, 2014

Plate 2: Tudun Allu Gully
Source: Fieldwork, 2014

Plate 3: Use of sand in sacks as means of controlling soil erosion in the area
Source: Fieldwork, 2014

Plate 4: Tudun amba gully site showing severity of the gully.
Source: Fieldwork, 2014

Severity and magnitude of gullies in the study area

Table 4.4 severity and magnitude of gullies in the study area

Gullies Variables	Base Width	Total Top width (m)	Total depth	Receded Top width (m)	Length (m)	Slope
Akunza	5.4	6	4	5	50.00	40^0
Tudun Allu	4.5	5.00	5	3.50	80.00	50^0
Tudun Amba (1)	3.5	4.00	3.00	3.00	30.40	30^0
Tudun Amba (2)	2.00	3.50	2.00	3.50	25.6	25^0
Shabu	3.00	3.40	1.5	3.60	40.50	10^0
Akurba	3.8	4.00	2.00	3.00	75.00	30^0
Mean	3.7	4.3	2.9	3.6	50.3	30.8^0
S.D	1.1	0.9	1.2	0.7	20.8	12.4^0
CV%	29.7	20.9	41.4	19.4	41.4	40.3

Source: Field work, 2014

Table 4.4 shows the severity and magnitude of gullies of each of the identified site in the study area. The high CV% and low values indicate that the characteristics of the gullies in the area are not the same.

The table reveals that the gully found in Akurba recoded the highest length of 80m while, Akurba 75.00m, Tudun-Allu in makama ward 50m, shabu 40m, Tudun-Amba 30m, Tudun Amba (2) 25m.

From the above, Akurba has a steeper and longer slope. The slope length seems increases due to the greater accumulation of runoff that pass through the gullies after rainfall and the velocity of water, which permits a greater degree of scouring (carrying capacity for sediment).

Tudun Allu gully of Makama Ward is more severe and have more impact. This is because its recorded the highest volume of soil loss from all the gullies. It also has the highest depth of 5m, this contribute significantly to the sediment output in the area (2215.5m) (Field work, April 2014).

Table 4.5: Spearman rank correlation Coefficient of selected gullies

Sample Variables	Base Width & Total Top Width	Total Depth & Length	R_X	R_Y	D	d^2
Akunza	11.4	54.0	1	3	-2	4
Tudun Allu	9.5	85.0	2	1	1	1
Tudun Amba (1)	7.5	33.4	4	5	-1	1
Tudun Amba (2)	5.5	27.6	6	6	0	0
Shabu	6.4	42.0	5	4	1	1
Akurba	7.8	77.0	3	2	1	1

$$r = \frac{1 - 6\Sigma d^2}{n^3 - n}$$

where n = 6

$d^2 = 8$

$$r = \frac{1-6\ (8)}{6^3 - 6}$$

$r = \underline{1 - 48}$

$$r = 1 - \frac{\frac{216-6}{48}}{210}$$

r = 1 – 0.22857143

r= 0.77142857

r = 0.77 approximately

On the correlation line, the calculated value (0.77) tilt towards a positive one (+1)

-1 0 +1

This signifies that there is a positive variation between base width and total top width and total depth and length of the sample variables.

The T- value for these sample variable read off from the t distribution tale with 5% confidence level is 0.02

Since the r-value is greater than the t-value, we accept that there is a significant degree of relationship between the Base width and total depth of sample variables.

Table 4.5 displays the inter-relationships among the characteristics of the gullies in the area. Although the sample size is small, the relationships can be accepted as indicative because allowances have been made for the small size by using n-2 degrees of freedom in testing.

Two variables stand out in their pattern of relationship. One is the base width and total top width which is positively related to total depth and length which are significant at, at least 5% level. The r-values is 0.77 indicating that with a larger sample size, this relationship could be valid. Other relationships are easily read off table 4.5

Particle Size Analysis of selected gullies site in the study area

Table 4.6: Particle size distribution of selected gullies in the study area

Locations/Site	Sand %	Silt %	Clay %	Silt Clay
Akunza	70	3.4	26.6	30
Tudun Allu	89.4	1.4	9.2	10.5
Tudun Ambai	85.5	1.4	13.2	14.6
Tudun Ambaz	86.8	1.4	11.8	13.2
Shabu	71.4	3.4	25.2	28.6

Akurba	60.2	3.2	36.6	39.8
Mean	77.2	2.4	20.4	22.8
S.D	10.7	0.1	9.8	10.7
CV %	13.9	4.2	48.0	46.9

NOTE: The low CV% values show that the material is approximately the same in texture in the area.
Source: Fieldwork April 2014

Table 4.7 present information on the particle-size of selected gullies in the study area. The dominant grain-size is sand and clay and the material easily crumbles once it is saturated and undercut (field observation). The grain-size range also implies a high index of detachability especially under the high rainfall intensity. But the infiltration capacity is somewhat reduced under high intensity rainfall which enhances capping (i.e the blocking of pores), and the generation of a large runoff (Olofin 1985). The large run off leads of rapid slope wash on, and at the base of steep slopes. The organic matter contents of each gullies in the study area is very low because of subsurface wash. The lower content level often associated with subsoil contribute to lower crop yield (field observation).

Conclusion

The study has shown the extent to which gully erosion has affected Agricultural land use in Lafia L.G.A of Nasarawa State. The significant effects of soil erosion in the area have led to losses of soil organic matter, fertility of the area. The effects however are on the increase despite remedial measures taken by farmers to prevent, control and curtail the occurrence of the phenomenon. Social problems associated with the persistent erosion in the area result in low standard of living of the farmers as there is low yield per hectare of land, gully sites serve as breeding ground of mosquitoes and the pollution of the downward as well as the presence of some diseases such as cholera, dysentery, typhoid and high fever on the contaminated water bodies.

Social conservation measures are important because the natural soil with its organic matter, nutrients and its well developed horizon are non-renewable natural resources importantly; soil supports life and is essential for man’s existence and survival. Therefore, man has to be very conservative in order to keep, protecting and even improve soil quality as much as possible. The solution of these challenges lies in developing strategies based on understanding the nature, properties and process of soil dynamics of the life support processes of soil resources which same as primary mechanism for food production (Abaje, 2002).

Recommendations

From the foregoing discussion it has been established that gully erosion in the study area has caused destruction to farmland and consequently decrease crop production in the area. It is thus recommended that:

1. Areas that are very liable and vulnerable to gully erosion could be allocated to special uses. For example such vulnerable area could be used for wild life and recreational purposes.
2. Run off reaching the gullies should be slowed down and reduced in volume through the creation of grass bands and other obstacles around the gullies in the area in order to reduce the volume of soil loss.
3. The gullies walls and head scarps should be treated to produce gentler slope, in order to reduce base width, total top width, depth receded width and length of the affected gullies in the areas in the manner described in olofin (1985). Man must also improve on his land management in the area.
4. Some farming practices such as mono-cropping and over cultivation that are likely going to accelerate erosion should be discouraged by the soil conservation board. The board should establish field experimental station for research purpose ecological analysis and practical demonstration. It should also classify land according to its capabilities and the extent to which it is susceptible and vulnerable to erosion.
5. Voluntary organization likes the United National Development Programme (UNDP), Food and Agricultural Organization (FAO), the World Bank should in conjunction with the Nigeria Government mobilize the real populace (farmers) and train them on ways and measures of combating gully erosion.
6. Surface water should be diverted above the gully area.
7. Structural process such as re-planting of tress should be done in order to avoid the development of new gullies in the area.

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