Journal of Physical Science and Innovation
ISSN: 2277-0119
Volume 9, No. 2, 2017

ALGEBRAIC MODELLING OF THE INTERCONNECTION AMONG MORPHOMETRIC PARAMETERS IN ATA OBIO AKPA GULLY COMPLEXES, ORUK ANAM, AKWA IBOM STATE, NIGERIA.

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ABSTRACT

Gully as an endemic ecological issue have created uncalled-for geo-precarious topographic units that has over the years been a subject of modern geoscientists in different parts of the world. This work examined the morphometric parameters in Ata ObioAkpa gully complexes, OrukAnam, AkwaIbom State. The morphometric parameters such as Gully Width (W), Gully Depth (D), Cross sectional area (CS) and Slope angle (SA) were measured using measuring tape, ranging pole, Global Positioning System and Abney level. Interrelationship between gully morphometric parameters was analyzed using Pearson Product Moment Correlation Model (PPMCM) and the result revealed thatin gully site A, W & SA correlated strongly at $P<0.05$ and $r = 0.857$ and the relationship is significant; and SA & D, SA & CS, W & D, W & CS accounted for weak correlations at $P>0.05$ and r= -5.22, 0.196,-0.07 while W& CS and D & CS were moderate at $p>0.05$ and r=0.673 and 0.735. In gully site B, W, D & CS correlated strongly with SA at r= 0.917, 0.964 & 0.996; W and CS; D and CS also correlated strongly at r=0.880 & 0.983. In gully site B, the regression of slope angle and width is not significant at r^2=73.4% and $p>0.05$; slope angle will increase by 0.7073 units for every one unit increase in width. In plot A, since $r^2=0.9294$ and $p>0.05$, the relationship exists between SA and D but effect of D on SA is not significant; then slope angle will increase by 0.5537 units for every one unit increase in depth. In plot B, since $r^2=0.9864$ and $p>0.05$, the existing relationship is insignificant; slope angle will increase by 0.3842 units for every one unit increase in depth. The shape

of the gully in the stream catchment and gully size has been influenced by geomorphic processes and persistent hydrogeological events which has relative consequences on lithological, ecological, economic and geomorphic assets. Therefore, efforts should be geared towards approaching the phenomenon with adequate measures to controlling the magnitude of gully growth and expansion in the terrain for sustainable management of geo-hazards.

INTRODUCTION

Erosion as a crucial degradation phenomenon in past decades has been the subject of recent interest among geoscience and environmental management scholars, precedence of research has been given to rill and inter-rill erosion (Valentin, Poesen and Kun 2005). However, in recent times, gully erosion as a pervasive ecological problem becomes an area of growing interest among humid and sub humid regions of the world (Casali, Gimenez & Benneh, 2009; Sidorchuk, 2005; Udosen, 2008). Poesen (2011) observed that gullies are among the morphological indication of long periods of soil erosion revealing the effects of atmospheric adjustment e.g. heavy rainfall and land use practices in the landscape. The phenomenon is the principal geomorphic features readily observed in the human environment. Gully erosion is the most important factor responsible for generating of sediments, approximately about 10 and 95% of the overall sediments were produced at catchments level while a reduced amount of 5% of the entire catchment area of ten occupy by gully channel (Mansur, 2014).Hoshino (2006) proposed the possible mechanisms of gully erosion based on geological and geographical factors. Ehiorobo & Audu (2012) investigated gully erosion in an urban area and reported that gully erosion occur due to extreme overflow of fluid with a very high speed and energy to remove and transmit soil particle downhill slope. In Nigeria, several of the gullies that occurred in towns were due to inappropriate termination of drains and stream paths, the increase in gullies pool by the side of a few water courses resulting in land use practice which remained a source of worry

(Mansur, 2014). Gully erosion is one of the major devastating catastrophes that speed up soil erosion. This menace signifies a severe type of land degradation that deserves a very exceptional consideration. Gully erosion caused significant soil losses and water, decrease crop yield, degradation of ecosystem and bridges, farmlands as well as settlements (Consenti, Angileri, Cappadonia, Rotigliano, Agnesi and Marker, 2014). The works of Areola (1990), Jeje (1978, 1982 and 1991), and Ologe (1972, 1974 and 1988) in various parts of Nigeria have shown how gully processes are sustained in various ecological zones of Nigeria. Gully morphometric are the physical features of gully. Ebisemiju (1988); and Ebisemiju and Ado (1989) analyzed the morphology of 46 gullies in a laterite terrain, examined the nature of the interrelationships of the parameters, and related observed gully form or processes and controlling factors, he focused his attention to gully morphometric properties such as length, shoulder width, depth, slope etc. His study was conducted on laterite soil with poor structural conditions at the soil surface, high rainfall intensity, low infiltration rates, high runoff and the bunchy habit of the grass growth.

The result of the Pearson's product moment correlation analysis indicates that most of the gully morphometric proportions are strongly interrelated. This finding is important as it indicates that equilibrium conditions between the form elements of fluvial system that were established even at the youthful and early mature stages of their development. It also suggested that there is considerably redundancy in the morphometric parameters of gullies as widely reported for drainage basins. This means that it is possible to reduce the parameters to a small sub set that adequately simulate gully morphology. There are, however, some variables which have extremely low correlations with most of the morphometric properties. These are bed width, the ratio of the side slope to the bed slope, and gully length (Udosen, 2008). Recent scholars have made confirmations and detailed morphometry of delineated gullies using scientific and technological tools to fit into the current trend of

Geographic Information system in Geographic Information systems model. Ogundele, Odewumi and Ganniy (2013) discovered on the Coastal plain sand formations around Yewa South and Ipioka in Ogun State, South West Nigeria that more gully parameters were related in the morphometric description of gullies. Same findings were as well carried out by Enoleka, Iorkyar and Kweidzah (2013) on gullies inKastina-Ala. Udosen (2000) discovered exceeding values above threshold of gully erosion in his morphometric of gullies in Coastal Plain Sand of South eastern Nigeria. In 2004, a morphometric analysis of gullies in Ikpa River Basin and a multivariate approach for predicting gully initiation was examined and the result indicated gully erosion is a function of drainage basin parameters and that different basin has different gully frequencies and sizes (Udosen, 2004). In a humid tropical environment, gully morphometric indicate slope angle variation in comparison with the threshold values and that slope profiles affects sustenance of gully development. The morphometric of gully erosion is pivotal in examining geomorphologic dynamics in any ecological zone (Udosen, 2008; Abraham, 2010).

STUDY AREA

Ata ObioAkpa is one of the communities in OrukAnam Local government Area, AkwaIbom State, Nigeria lies between latitude $4^0$7'N and 5^0 49'E and longitude 7^0 40'E and $7^0$49'E. It is located in the south western part of the state, being a part of OrukAnam and at the extreme north of OrukAnam Axis bounded on the North by ObioNdot, on the North West by NungIkotOkusong, on the East byIbesitEkoi, on the south by ObioIbet, and on the west by NdotusungIdim. The Area is located within the humid tropical zone and the climate of Ata ObioAkpa is influenced by two marked seasons viz, the wet and dry seasons. Heavy rainfall spread over eight months of the year. The mean annual rainfall is between 2400mm to 3600 mm the rain season begins in March and last till October or early November. The clearest rainfall months are July and September. The dry season is marked by high temperature and sunshine. It is always very hot. It comes between Novembers to February. The two air masses influencing these seasons are tropical meantime and tropical contractual air masses. The former gives way to rain season and the later dry season. Temperature is high all year round with a monthly mean of about 26^{0}c. The area is on the gently undulating plain of South Easter Nigeria where sediments come from different drainage canals of Cross and KwaIboe River. The physiographic region of Ata ObioAkpa is underlain by the gently undulating plain sands, where geomorphic and metereologic factors had given rise to development of ferralsols with completely weathered soil consisting of resistant mineral such as quarts rich free iron low mineral.

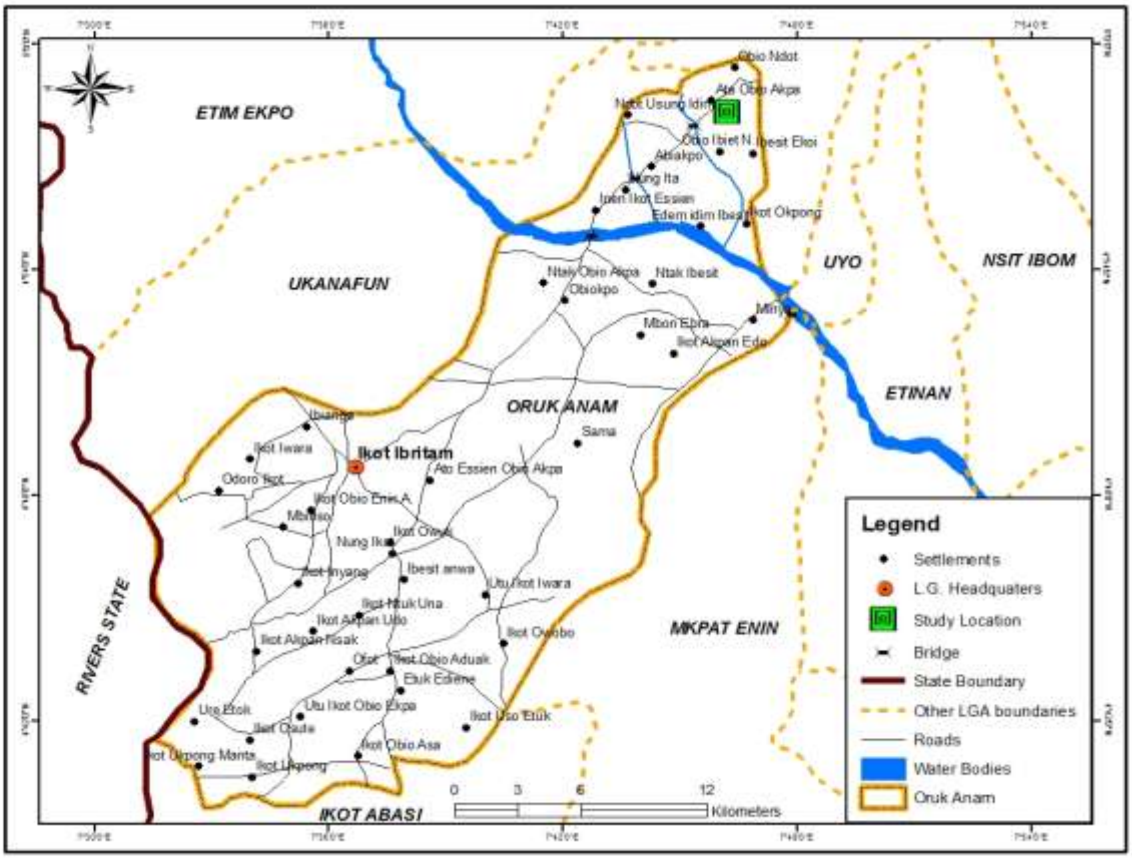


Fig 1: OrukAnam showing study area

MATERIALS AND METHODS

Data Sets and sources

The data collected consists of the following sets:

- Data on the gully impacted sites and the geographic coordinates
- Morphometric Data: Data on the geometry of the gully morphology(gully shape, depth, width, cross section and slope angle and distance)

Sampling Procedures

Ata ObioAkpa was delineated into two sections using stratified random sampling technique. The two sections were separated by stream direction of flow. In each of the sampled section, a single identified gully was mapped out. A transect was selected and divided into upper slope, middle slope and lower slope (valley bottom) segments on a sampling interval of 10m with a total elevation of 40m above sea level on the toposequence. These two gullies were under cultivation.

Table 1 Field Measurements

Equipment	Use	Quantity Required
GPS	Coordinates and elevation readings as well as location of sampling points; mapping out the sub-catchment	1
Measuring tape and rope	Measurement of gully dimension	1
Camera	Photography	1
Abney level	Angular measurement	1
Field book	To record observations	1

METHOD OF DATA ANALYSIS

Pearson Product Moment Correlation provides a means whereby two sets of variables are measured on the scale and it is possible to plot a graph. According to Udofia (2011), the strength of the relationship of two variables X and Y is measured by

$$r = \frac{n \sum XY - \sum X \sum Y}{\sqrt{n - \sum X^2 (\sum X)^2} \sqrt{n - \sum Y^2 - (\sum Y)^2}}$$

Where

r = Correlational Coefficient

X = Dependent variable

Y = Independent variable

n = Sample size

Regression Analysis

Regression analysis was used to determine the significant effect of width on slope angle and depth on slope angle. This is able to investigate causal relationship between the variables, measure the effect of one variable on the other and predict values of the dependent variable and given values of the independent variables.

A linear regression equation is given by

Y● = a + bx

Y. = estimated value of dependent variable

X_n = the value of independent variable

a = rate intercept, i.e. where the regression line touches the y – axis

b = the regression coefficient or slope

e = the residual or random error term

RESULTS AND DISCUSSION

In Ata Okpa Stream catchment, there were idiosyncratic features of the region that predisposed the area to serious gully scenario. The major processes were geomorphic and geological including valley retreat, slope wash, potholing, and disintegration of rock materials, solution and internal earth movements. These are caused by unethical land-use practices and hydrologic events such as flooding, water transportation and high humid flow (increasing humidity). The combining efforts of nature and anthropogenic have magnified the gullying scenario. Therefore, based on the GPS data, the elevations of gully sites decreased down the slope. The coordinates were not similar but they were close in values showing that the study area has proximate geographic identities (see table 2). That is to say that the area being on analogous latitude and longitude as well as topographic extent at the upstream and downstream fall under similar geographic conditions of climate, geology, soil and lithology.

Table 2 Gully Impacted Sites and Geographical Coordinates

SAMPLES SITES	POSITION	LATITUDE	LONGITUDE	ELEVATION
SITE A	US	N 0468.421	007^0 48.331’	40m
	MS	N 0457.593	007^0 45.531’	33m
	LS	N0462.409	007^0 48.358’	22m
SITE B	US	NO 4^0 60.515	007^0 45.271’	41m
	MS	$N04^0$ 61.248	007 ^{0}46.184’	34m
	LS	$N04^0$60.420	007^0 43.234’	26m

Source: Author’s Field Survey, 2016

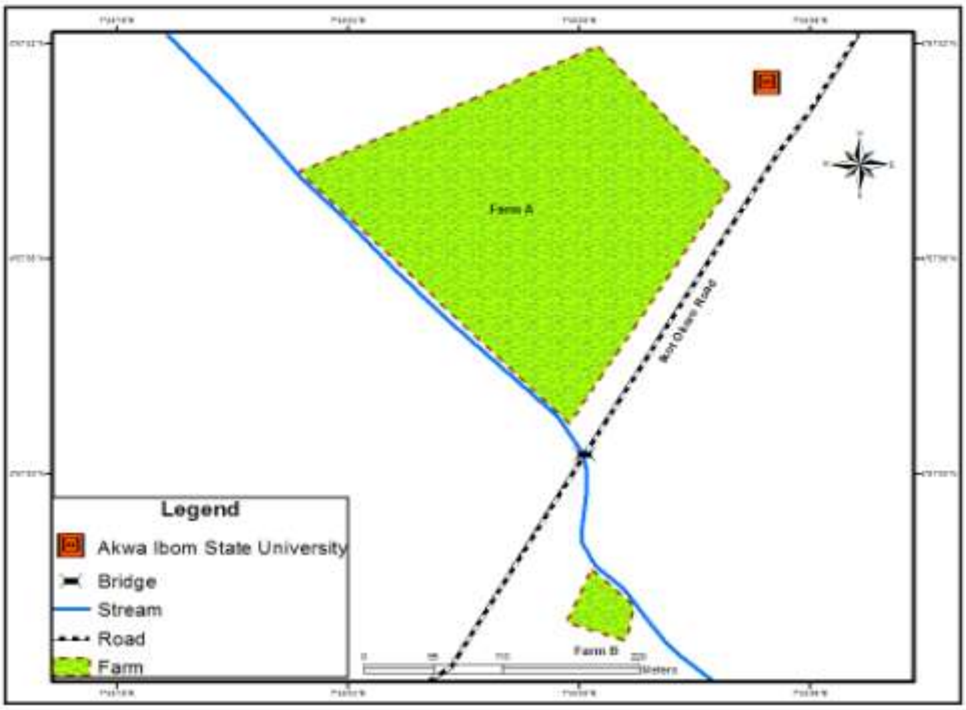


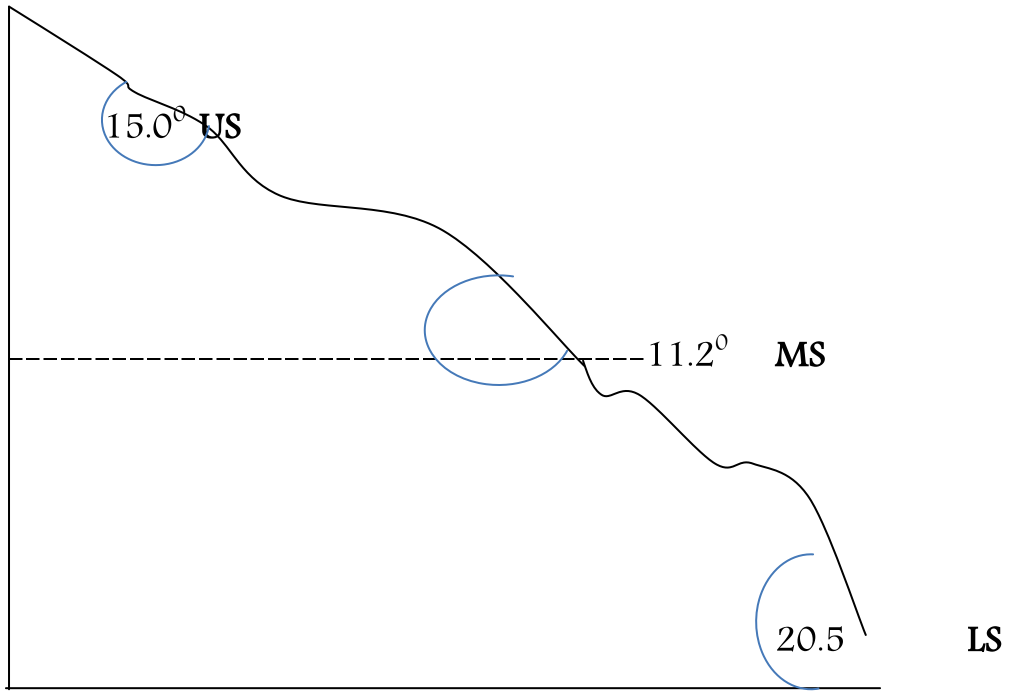
Fig 2 Gully Sites under cultivation at Ata Obioakpa Stream Catchment
Source: Author’s Field Mapping, 2016

Table 3 Geo-morphometric and Geographic Characteristics of Gully Complexes in Farmlands of Ata Obio Akpa Stream Catchment

GULLY DIMENSIONS	Site A	Site B
Shape	V- Shaped gully	V-shaped gully
Width	99m	29m
Depth	18.40m	16.70m
Upper Slope Angle	11.2^0	10^0
Middle Slope Angle	15^0	10.5^0
Lower Slope Angle	20.5^0	19.7^0
Cross Section	1821.6 m^2	484.3 m^2
Land-use Type	arable crop farming	arable crop farming
Drainage condition	Well drained by Obio Akpa Stream	Well drained by ObioAkpa Stream

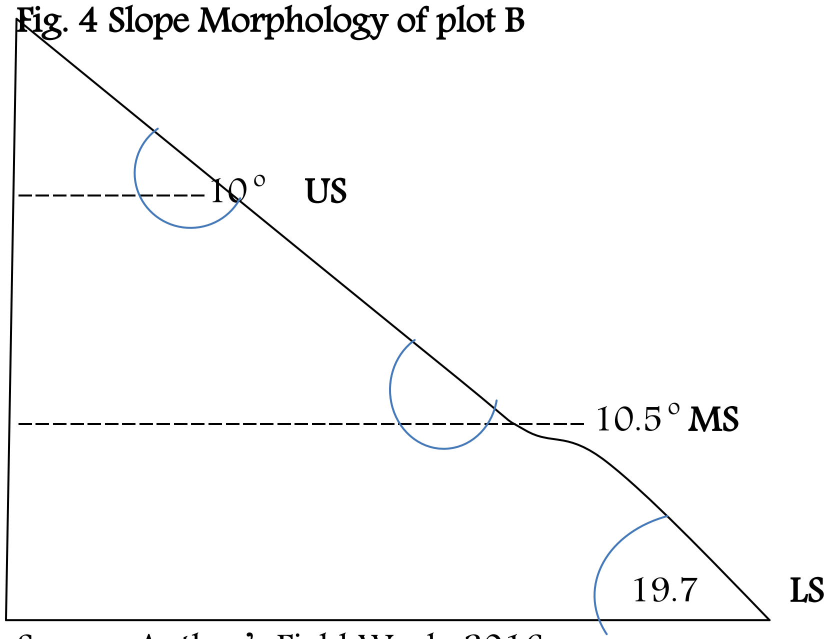
Source: Author's Field Work, 2015

Fig. 3 Slope Morphology of Site A



Source: Author's Field Work, 2016

Fig. 4 Slope Morphology of plot B



Source: Author's Field Work, 2016

Correlational Modeling of the Gully Morphometric Parameters

In gully site A, W & SA correlated strongly at P<0.05 and r = 0.857 and the relationship is significant. SA & D, SA & CS, W & D, W & CS accounted for weak correlations at P>0.05 and r= -5.22, 0.196,-0.07 while W& CS andD &CS. were moderate at p>0.05 and r=0.673 and 0.735.

Table 4 Correlation Matrix of Morphometric Parameters of Gully Site A

	SA	W	D	CS
SA	1	.857*	-.522	.195
W		1	-.007	.673
D			1	.735
CS	.			1

In gully site B, W, D & CS correlated strongly with SA at r= 0.917, 0.964 & 0.996; W and CS; D and CS also correlated strongly at r=0.880 & 0.983.

Table 5 Correlation Matrix of Morphometric parameters of Gully Site B

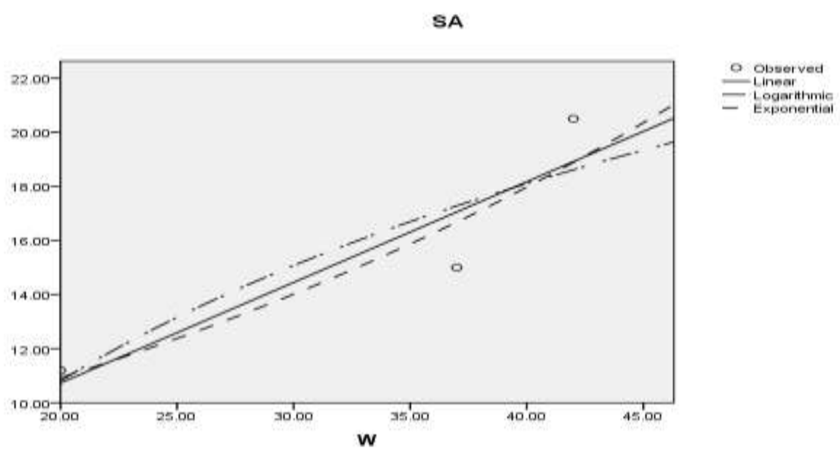
	SA	W	D	CS
SA	1	.917*	.964*	.996*
W		1	.778	.880*
D			1	.983*
CS				1

REGRESSION MODEL OF THE RELATIONSHIP BETWEEN SLOPE ANGLE AND WIDTH & SLOPE ANGLE AND DEPTH

The model attempts to quantify therate at which the slope angle is predicted by width and depth. At what extent do they contribute to the position of the slope angle? Then one can draw inference at the units of estimation.

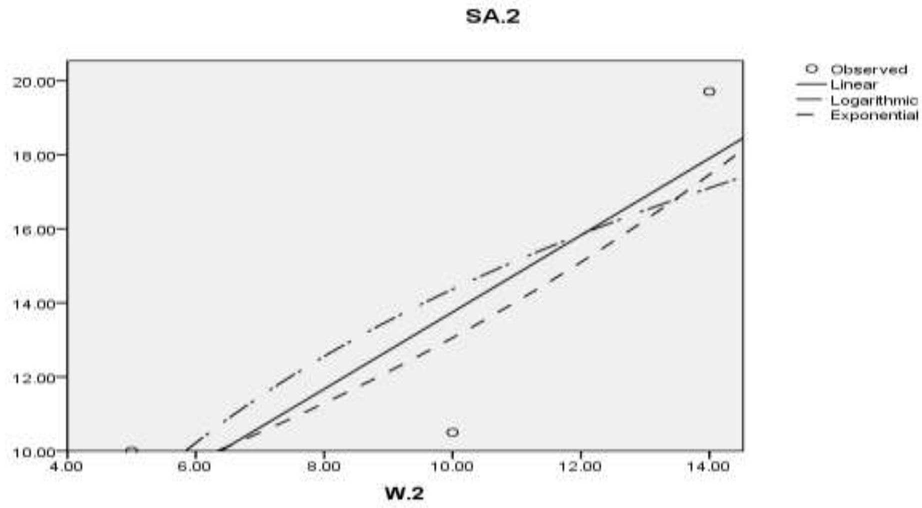
From the result analyzed in Gully Plot A, the effectat r^2 of 0.84% with P>0.05 is not significant; Slope angle will increase by 2.2618 units for every one unit increase in width. That means there is relationship but the effect of Width on SA is insignificant.

Fig 4.Regression of Slope Angle and Width in Gully plot A.



In gully site B, the regression of slope angle and width is not significant at r^2=73.4% and p>0.05; slope angle will increase by 0.7073 units for every one unit increase in width.

Fig 5 Regression of slope angle and width in gully plot B



Regression Of Slope Angle and Depth

In plot A, since r^2=0.9294 and $p<0.05$, the relationship exists between SA and D but effect of D on SA is not significant. Slope angle will increase by 0.5537 units for every one unit increase in depth. In plot B, since r^2=0.9864 and $p>0.05$, the existing relationship is insignificant. Slope angle will increase by 0.3842 units for every one unit increase in depth.

Fig 6 Regression of slope angle and depth in gully plot A

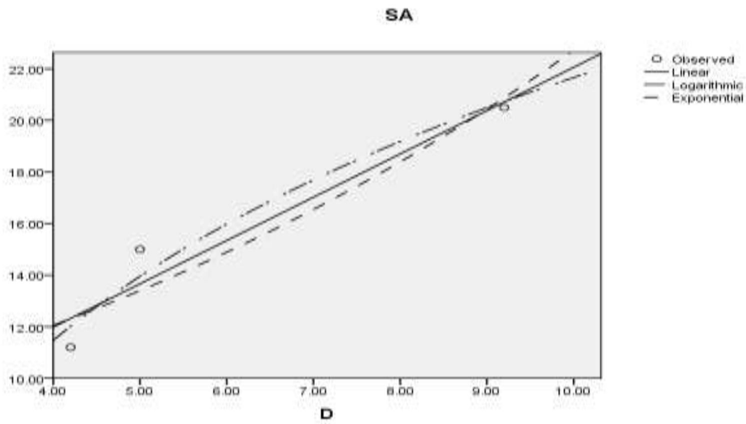
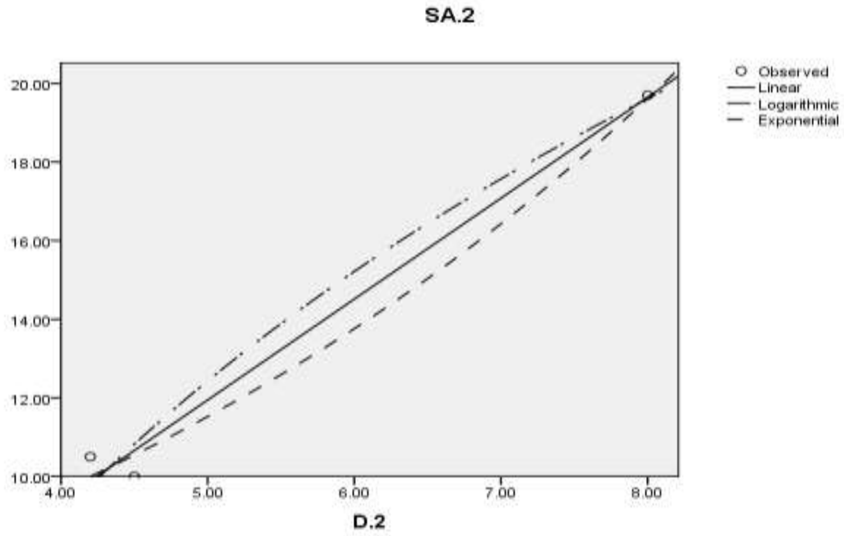


Fig 7 Regression of slope angle and depth in gully plot B



GEOMORPHIC ASSETS AND ECOLOGICAL EVENTS IMPACTED BY GULLY

The growth of gullies in Ata ObioAkpa Stream catchment has predisposed the area to loss of geomorphic assets and ecological events are obstructed. Thetwo plots are under recent cultivation and planting on the large gully have helped in widening and deepening the gully size where the shape is not ecologically appreciative. Many useful flora and fauna with soil quality are under serious degradation in the watershed. So, the impact on the entire environment is enormous and therefore the need to address further gully-associated hazard is based on the available baseline which this work have provided on the geometrical algebraic modeling of the gully parameters. The knowledge on the expanse of gully lands and topography would enable adequate environmental planning and management of geo-hazards.

CONCLUSION AND RECOMMENDATION

The algebraic modeling of the interconnection between morphometric parameters in gully complexes in Ata ObioAkpa, Oruk Anam, Akwa Ibom State has been explored in this work. The work revealed the differing relationship among the gully morphometric parameters across the studied plots and that some correlations were significant while some were insignificant. The study showed that width and depth predicts the angular position of the slope at different levels. These widening and deepening of gully structures have exposed the environment to extreme degradation and ecological distortion. Farmlands and useful ecological products have been threatened in the terrain. Therefore, it is recommended that the pervasive depression and losses caused by the hydro-geomorphic scenario of gully development should be broadly studied towards controlling the provocative expansion of gullies and curbing the geo-hazard, thereby rendering the landscape appreciable and sustainably productive.

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