GULLY EROSION IN ANAMBRA STATE: CAUSES, EFFECTS AND MANAGEMENT APPROACH

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ABSTRACT

The aim of this paper is to identify the existing gullies in Anambra State, examine the causes and effects of gully erosion in the study area and proffer solutions. To achieve the above objectives, both primary and secondary sources of data were collected using questionnaires, online and desk searches respectively. Data analyses were done using statistical and descriptive techniques. The study also identified major causes of gully erosion in the State as high rainfall and lack of good drainage system, while the major effect was observed as Loss of farmland/ Reduction in soil nutrient and agricultural productivity. Various measures proffered to control the menace of gully erosion in the study area include: preparation of geo-referenced survey template for baseline information, with all the existing gullies inclusive, sensitization and awareness campaign on the serious need for massive afforestation, and the Establishment of local works committee/task force to monitor the movement of storm water. This paper also recommends that government should ensure that ecological funds are properly used for ecological purpose.

Keywords: *Gully Erosion; Soil; Land forms; Runoff*

INTRODUCTION

Erosion is one of the surface processes that sculpture the earth's landscape and constitutes one of the global environmental problems. Soil erosion is perhaps the most serious mechanism of land degradation in the tropics (El-Swaify, *et al.,* 1982), and one of the most striking features on the land surface of South-Eastern Nigeria, especially in Anambra(Ofomata, 1964). Only rare occurrences of the phenomenon are recorded in some other States of the Federation. Gully erosion is visually the most impressive of all types of erosion (El-Swaify, 1990), with the

highest concentration of its severity in five Eastern States of Anambra, Enugu, Abia, Imo, and Akwa Ibom. Anambra State is the most affected of all the states in Nigeria with Agulu, Nanka and Oko communities of the state, the worst hit.Almost all communities in the state are affected by one form of erosion or the other. Over 70 percent of the land of the state is ravaged or threatened by erosion at various levels (Oranye, 2013). Available statistics indicates the presence of about 500 gully erosions spread across the rural communities. Notable areas include: Aguata/Orumba L.G.A's with about 78 gullies, Nnewi 60, Njikoka/Aniocha 50 gullies, Idemili 46, Ihiala 40, Awka 30, Onitsha 22, Anambra/Oyi 16 gullies (Obi and Okekeogbu, 2017). This paper examines the causes and effectsof gully erosion in Anambra State. It is structured intofive (5) sections. Following the introductory section is the location and physical characteristics of Anambra State. Section two (2) centres on methodology. Section three (3) focusses on the review of relevant literature on the definition, types, causes and effects of gully erosion. Section four (4) hinges on the review of past government efforts to ameliorate gully erosion problems in Anambra State, while section five (5) concludes the paper.

Location, Vegetation and Geology of Anambra State

The Anambra State lies within longitudes 06^0 31′ and 07^0 03′E and latitudes 05^0 45′ and 06^0 46′Nand covers an estimated surface area of 7200km^2. It is located in the transition area between the sub-equatorial climatic and the tropical hinterland climatic belts of Nigeria.

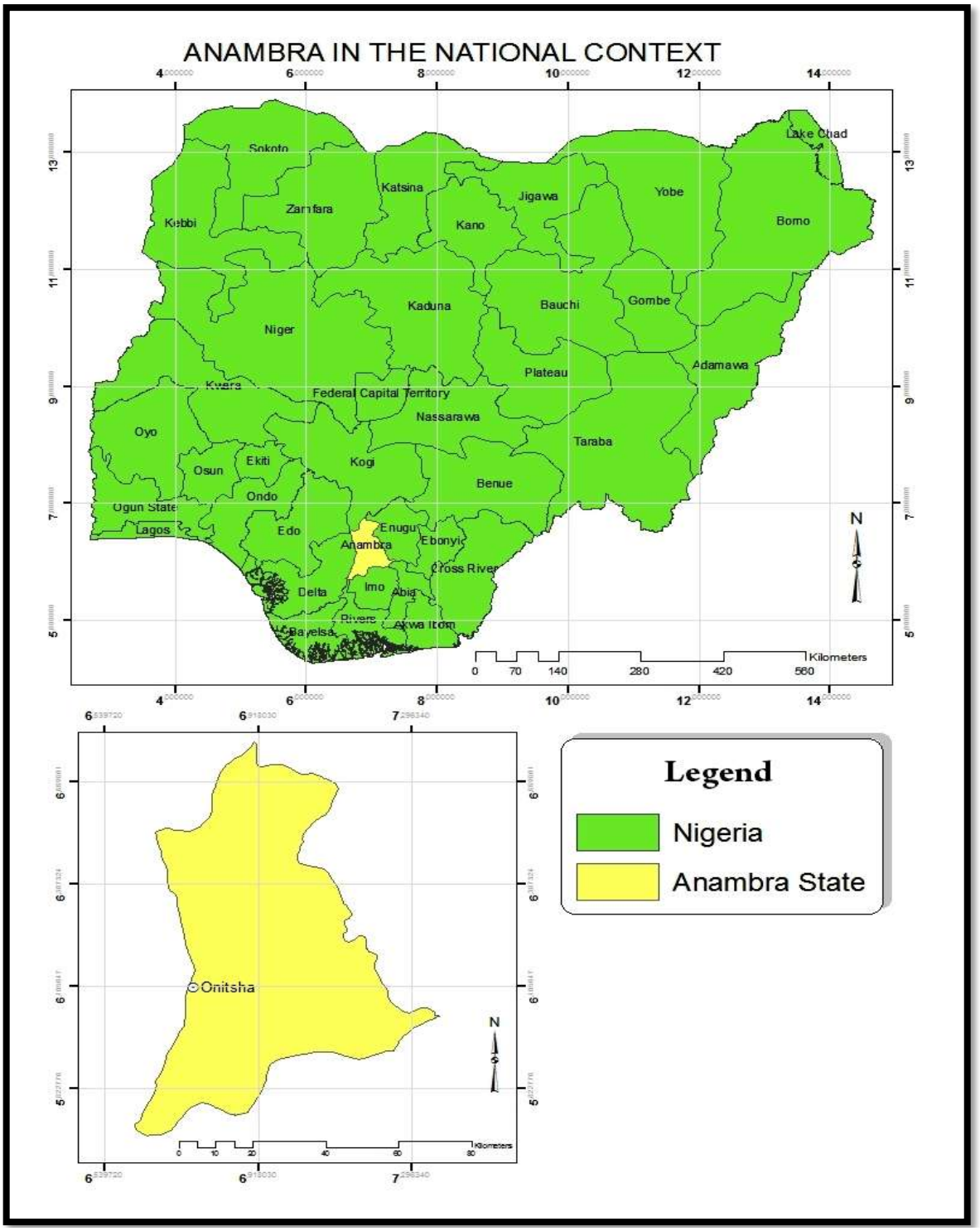


Figure 1: The Study Area within National and Regional Context
Source: Digitised by Toyonscape Consultants, 2013.

The climate of Anambra is influenced by two major trade winds: the warm moist Southwest Trade Winds during the rainy season (April – October) and the North East Trade Winds during the dry and dusty harmattan (November – March).Although, annual rainfall is high in Anambra State, ranging from 1,400mm in the north to 2,500mm in the south, it is concentrated in one season, with about four months of dryness, November to February.

The natural vegetation of Anambra is tropical dry or deciduous forest, which in its original form, comprise tall trees with thick under growth and numerous climbers. Because of the high population density, most of the forests have been cleared for settlement and development. What exists now is secondary regrowth, or a forest savannah mosaic, where the oil palm is predominant, together with selectively preserved economic trees.

Anambra State falls into two main landform regions: highland region of moderate elevation that covers much of the state, south of the Anambra River, and low plains to the west, northand east of the highlands (OnlineNigeria, 2003). The highland region is a low asymmetrical ridge or cuesta which is highest in the southeast (about 410m above mean sea-level), and gradually decreases in height to only 33m in the northwest on the bank of the Niger River.

The Anambra area is underlain by Cretaceous and sedimentary formations of varying aquifer potentials. The alluvial soils are pale brown loamy soils and are found in the lower plains of southand north of Onitsha. The soils are fine loamy, with lower layers faintly mottled; while the subsoil layers are strongly mottled and spotted, containing stiff grey clay. They are also easily eroded into gullies, and the underlying impervious clayey shales cause waterlogging of the soils during the rainy season.

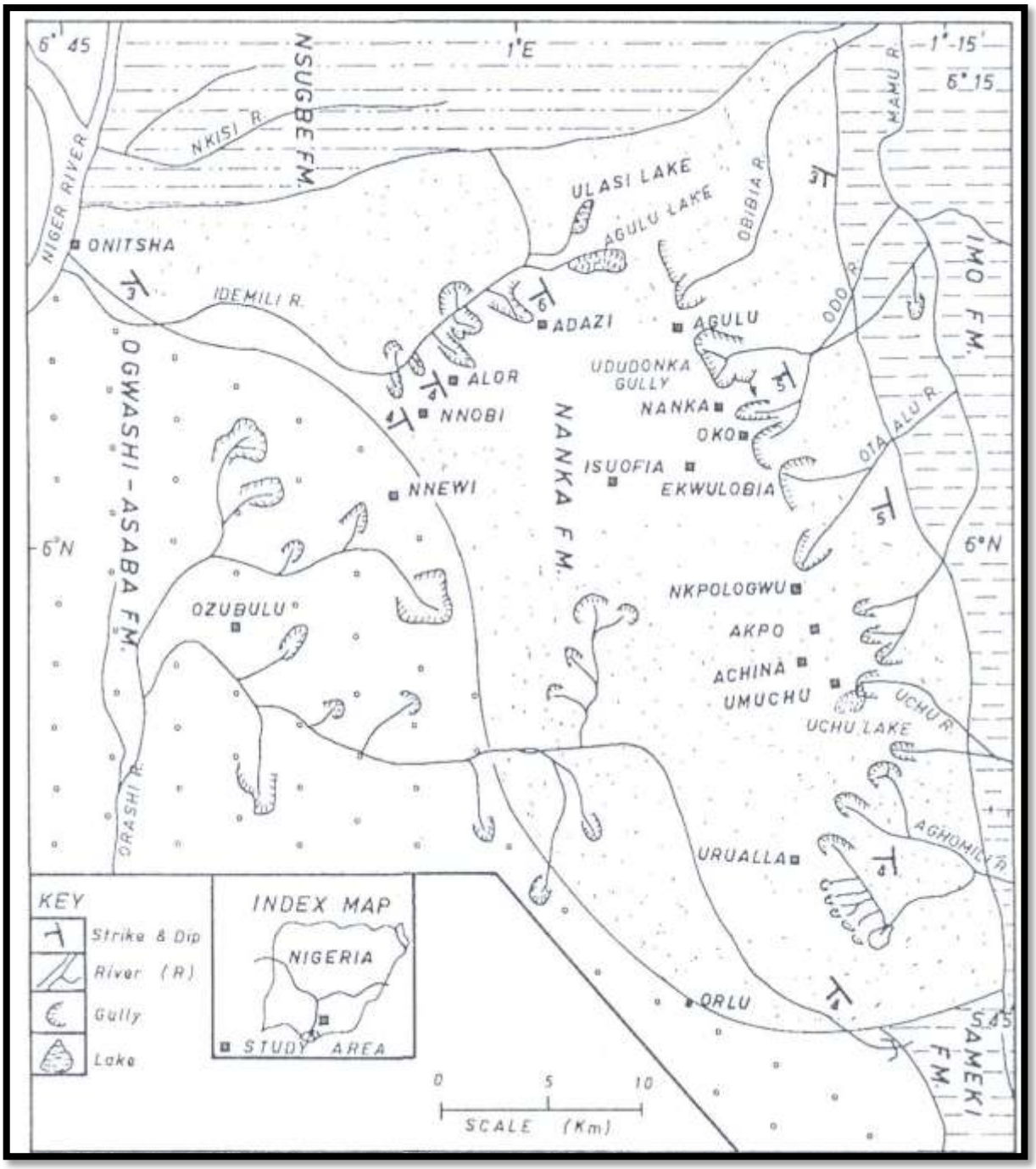


Figure 2: Geologic map of Anambra State showing areas where gully erosion is common
Source: Egboka and Okpoko, 1984.

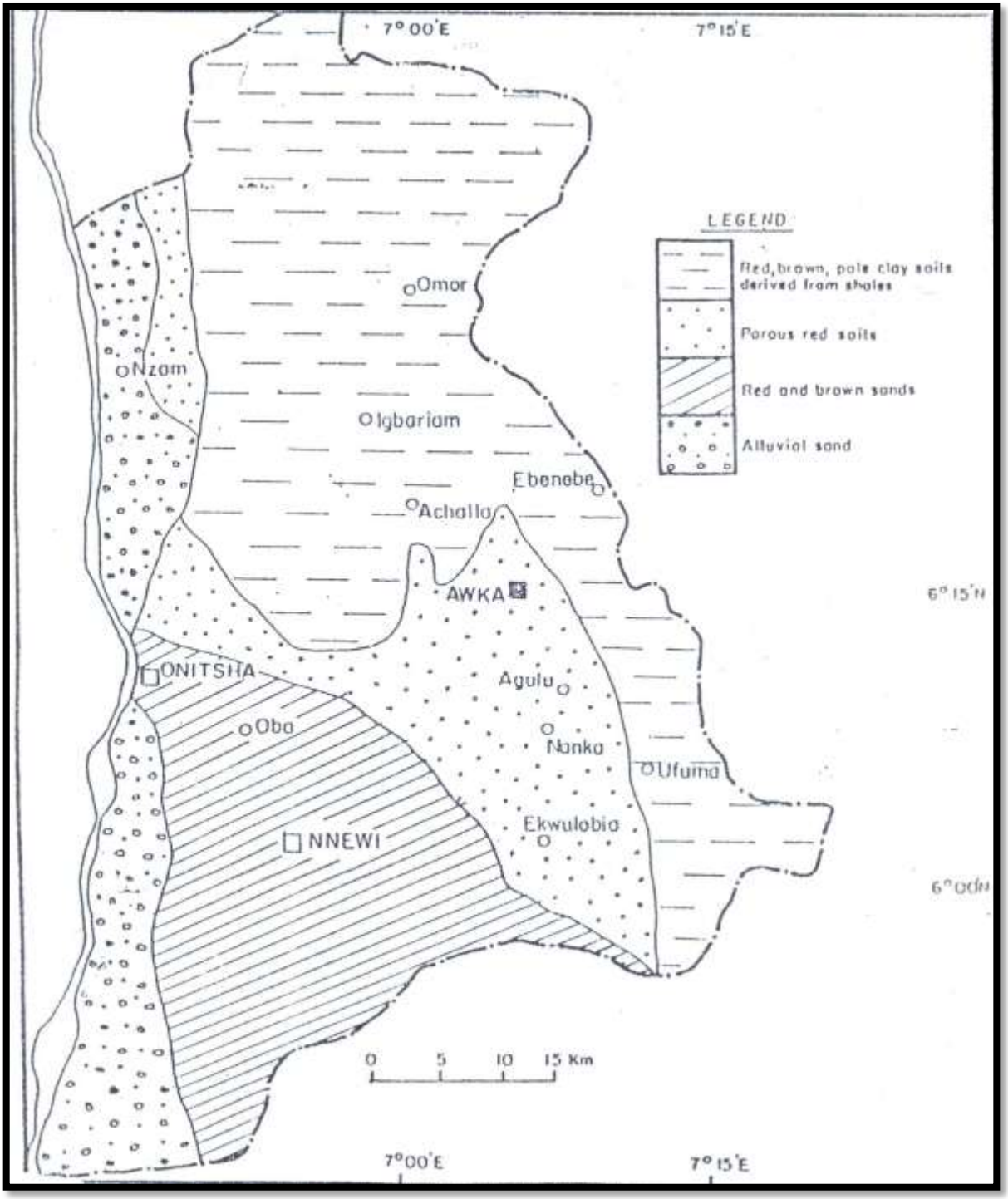


Figure 3: Distribution of soil types in Anambra State. Source:Obiadi. I.I, et al, 2011.

Methodology

Three methods of data collection were adopted in this study. They are the remote sensed data, data obtained from field/ground observations and semi-structured interviews/questionnaires.

Remote Sensed Data

The remote sensed data were downloaded (through Google Earth Pro), geo-referenced and digitised in Arc GIS.

Field/Ground Observation

The investigation utilized personal observation methods and some pictures were taken to demonstrate the reality of erosion menace in Anambra State, and are presented in Plates 1 and 2 respectively.

Data Acquired from Semi-structured Interviews/Questionnaires

Semi-structured interviews/questionnaires were administered to selected residents in the affected areas. The questions were structured mainly to reflect the scope of this study which is, to establish the causes, effects and management of gully erosion in Anambra State. Information from published and unpublished literatures were also used to analyse the causes and effects of gully erosion in Anambra State. The outcome of the questionnaires have been summarised in Tables 3and 4.

LITERATURE REVIEW

Definition of Gully Erosion

Bettis III (1985) defined gully as a relatively deep, vertical walled channel, recently formed within a valley where no well-defined channel previously existed. Gully erosion is an advanced stage of rill erosion where surface channels have been eroded to the point where they cannot be smoothened over by normal tillage operations (Hilborn, 1985). Sheet and rill erosion are the forerunners of gully erosion representing the incipient stage of the development of gully erosion. Gully erosion is understood by the processes that caused the landforms to undergo a progressive change and degenerate into sheet and rill erosion. Gullies are steeper and deeper than sheet and rill erosion put together, and can be actively eroding or stabilized. The former, according to

Poesen*et al*. (2003), can occur where the erosion is actively moving up in the landscape by head-cut migration. Brice (1966) avers that the width and depth of gullies are greater than 0.3m and 0.6m respectively, while Ezechi and Okagbue, (1989) states that gullies in Anambra State would modestly be described as catastrophic with many of them having depth and width exceeding tens of kilometres, they would better be called canyon.

Types of Gullies

Ezechi and Okagbue (1989) summarized the types of gully erosion sites in Nigeria with respect to their modes and conditions of formation, and common advance mechanism in Table 1.1 below. Their study also indicated that the nature of the underlying bed (or geology) has a bearing on the initiation and propagation of gullies.

Table 1: Gully types, modes and conditions of formation and common advance mechanism

Gully Type	Modes and Condition of Formation	Common Advance Mechanism
Base level	Groundwater flow	Slope undermine, sliding and slumping
Scarp	Runoff and slope change	Slope undermining, sliding/slumping, toppling
Fracture	Runoff and shrinkage fracture	Collapsing, also block failure
Incidental	Runoff concentration and vulnerable soil exposure by man	Common sliding/slumping.

Source: Ezechi and Okagbue, 1989.

Obiadi. I.I, et al (2011) categorised the severity of some notable gully erosion sites in Anambra State in Table 1.2below.

Table 2: Quantitative Analysis of Gully Erosion Sites in Anambra State.

Gully Site	Coordinates	Elevation (m)	Trend	Depth (m)	Length (m)	Width (m)	Stage/Geometry
Umuchiana	$N6^0$1.34'; $E7^0$ 4.5'	278	160^0	18	1010	70	Active/U-Shaped
Achina	$N5^0$57.2'; $E7^0$7.3'	275	143^0	10	155	2	Active/V-Shaped
Umuchu (A)	$N5^0$56.6'; $E7^0$8.1'	222	252^0	10	1500	12	Active/V-Shaped
Nanka	$N6^0$2.4'; $E7^0$ 4.6'	249	275^0	66	2900	349	Active/U-Shaped
Nkpologwu	$N5^0$59.1'; $E7^0$5.5'	210	105^0	25	1800	73	Active/U-Shaped
Agulu-Ezechukwu	$N6^0$0.1'; $E7^0$6.6'	144	152^0	12	1200	23	Active/V-Shaped
Ezinifite	$N5^0$58'; $E7^0$3.3'	260	165^0	3	900	8	Active/V-Shaped
Akpo	$N5^0$57.2'; $E7^0$6.4'	200	300^0	17	25	18	Active/V-Shaped
Agulu	$N6^0$6.5'; $E7^0$3'	190	330^0	20	2100	86	Active/U-Shaped
Umuchu (B)	$N5^0$56.2'; $E7^0$8.1'	200	280^0	12	165	12	Active/V-Shaped
Ekwulobia	$N6^0$1.8'; $E7^0$5.6'	748	****	60	1010	42	Active/V-Shaped

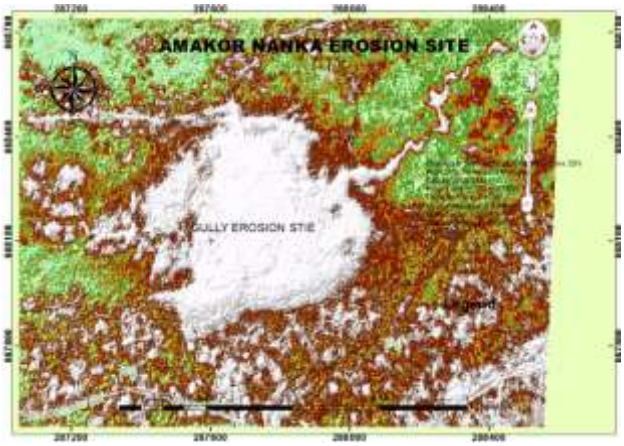
Source: Obiadi. I.I. et al, 2011.

Causes of Gully Erosion

Researches have shown that gully processes happened in the past with or without human influence or interference, or that the phenomenon of gully erosion is either naturally-induced or artificially-induced, or both. Several workers have attributed the development of gullies in Anambra State to the influence of human activities on natural and geologic processes while others suggested that gullies are linked with concentrated runoff processes. Uchegbu(2004) opined that human activities such as removal of vegetative cover, deforestation, diversion of runoff into drainage channels, blockages of channels for housing developments, use of burrow pits for quarrying of building sands and stones, and farming activities are factors that accelerated erosion.

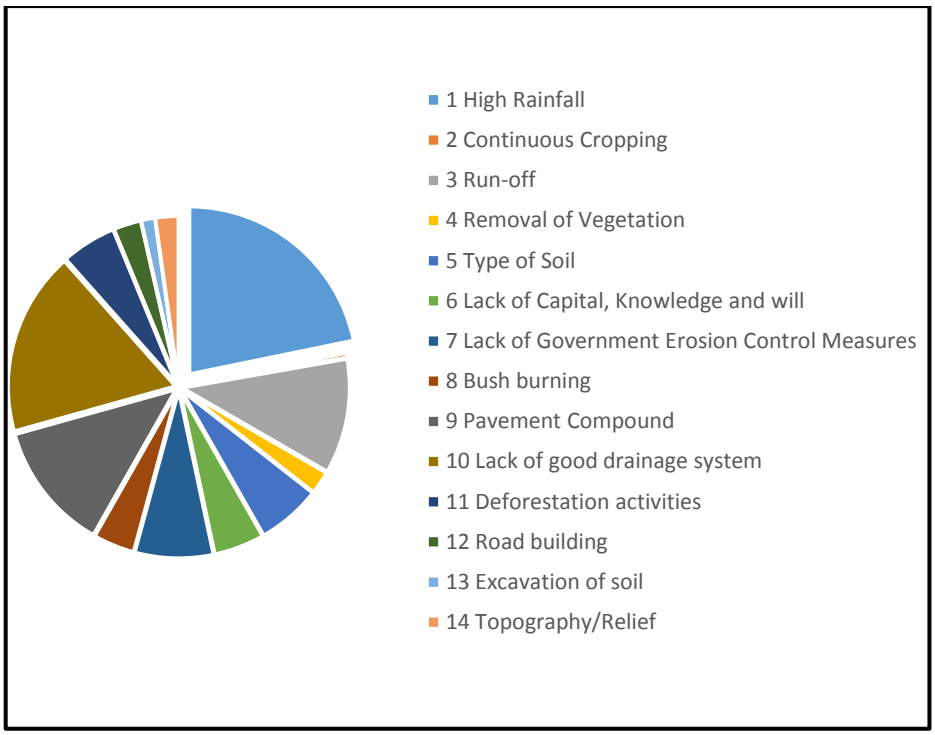
Nwajide and Hogue (1979) attributed the causes of gullies to the combination of physical, biotic and anthropogenic factors, while Egboka and Nwankwor (1986), Okagbue(1986), Uma and Onuoha (1986)uphold that gullies are caused by hydrogeological, hydro-geochemical and geotechnical properties of the rocks in the affected area. Ofomata (1985), introduced a systems model in the discussion of soil erosion and highlighted physical and human components as factors of gully erosion from which other factors viz; surface configuration, earth materials, climate and vegetation, etc. emanate. Muoghalu and Ikegbunam (1997), abstracted population pressure, surface configuration or relief, rainfall, vegetation and surface materials as factors of soil erosion in Abagana. All these strictly affirm that topography, geology, vegetation, climate, geographical location, channel characteristics and land use are factors that determine gully erosion.

The World Bank Task Leader lamented that over 80 per cent of gully erosion sites in Anambra State were caused by poorly terminated drains resulting from road construction (The Sun, November, 2017), while Okonkwo C.O. (2002) argued that the factors which led to gullying in the State include the erodibility of the soil and topography of the areas within the Anambra Basin of which Nanka Sandstone plays a critical role. According to him, in most parts of the State when sheet erosion are neglected, fluvial erosion and mass washing or the combination of all, wash away the top soil and once Nanka Sandstone is exposed, it disaggregates easily leading to gullying. At this stage, the erosion becomes intractable and so rapid that control measures becomes too expensive and most times overwhelming and thus erosion sites abandoned.

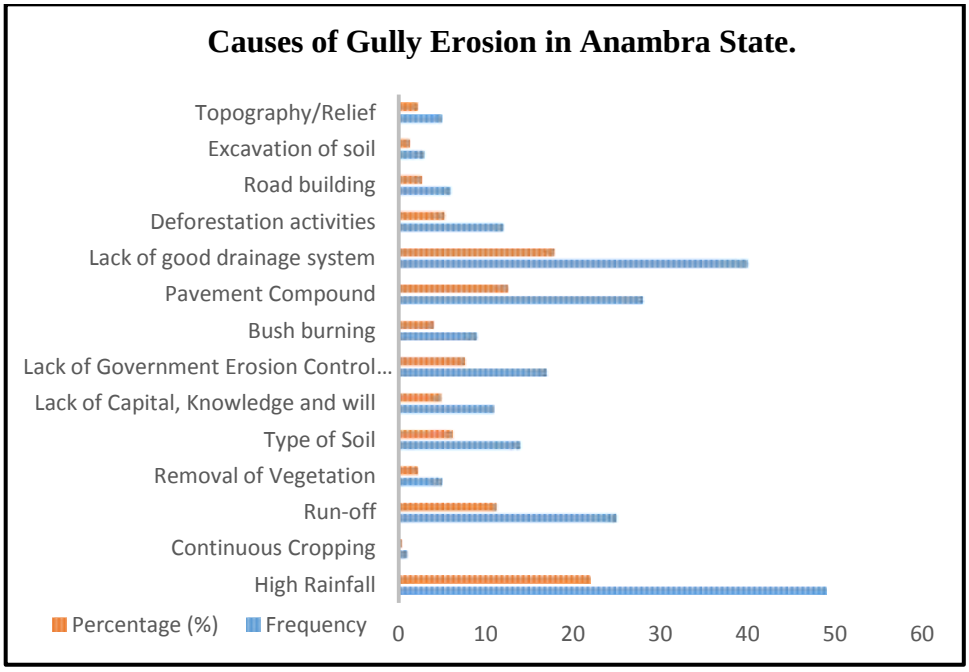


1	High Rainfall	49	21.9
2	Continuous Cropping	1	0.4
3	Run-off	25	11.2
4	Removal of Vegetation	5	2.2
5	Type of Soil	14	6.2
6	Lack of Capital, Knowledge and will	11	4.9
7	Lack of Government Erosion Control Measures	17	7.6
8	Bush burning	9	4.0
9	Pavement Compound	28	12.5
10	Lack of good drainage system	40	17.8
11	Deforestation activities	12	5.3
12	Road building	6	2.7
13	Excavation of soil	3	1.3
14	Topography/Relief	5	2.2
Total		224	100

Source: Researchers' Survey, 2018.



Pie Chart Representation of Table 3.
Source: Researchers' Analysis, 2018.



Bar Chart Representation of Table 3.
Source: Researchers' Analysis, 2018.

However, the major causes of gully erosion from the survey were high rainfall (21.9%), lack of good drainage system (17.8%), self-effort by residents towards erosion control like pavement of their compounds (12.5%), run-off (11.2%), lack of government erosion control measures (7.6%), lack of capital, knowledge and will (4.9%), etc. In addition to the responses from semi-structured questionnaires, field observations also revealed that there is a serious poor land use planning in the State. Extant literature on the history of gullies in Anambra revealed that gully areas lie on sloppy land and are distressed from land use activities.

Slope failures in the State go through four stages of flowage, gilding, tumbling and falling over. The rate of the failures are more pronounced during heavy precipitation than during the dry season. During the peak of rainy season, much of the rainfall flows as runoff, causing remarkable damages to regions with lose sands towards the foot of the slope. This is because of the rise in volume of the flood and its increased velocity and density as it moves downward the slope, below the clay top strata found in the upper regions of the site. Such type of evidences abound in other parts of the world and have been presented in the works of Bargali et al (2007;2008) and Joshi et al (1997).

From the field observations and semi-structured questionnaires, runoff was established as the main contributor of gully erosion in Anambra. Field observations also showed that local geology, runoff as encouraged by the residents of community in the affected areas, nature of the soil porosity and loose sands, as well as the condition of groundwater at the sites were prominent contributors to the rates and magnitude of gullying in parts of the State. These observations confirmed earlier results by Uchegbu (2004) and Okonkwo (2002).

Effects of Gully Erosion

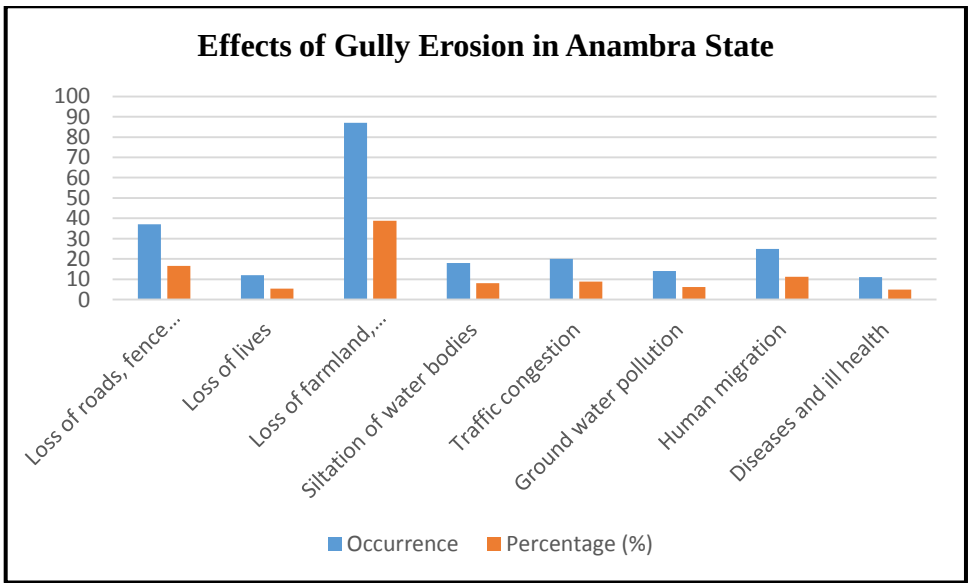
Gully erosion is a highly visible form of soil erosion that affects soil productivity, restricts land use and can threaten roads, fences, buildings and human life. It enthrones deprivation in its process and affects soils in many parts of the world (Le Roux et al, 2012).The Nation Newspaper (2011) reported that erosion has destroyed 13 homes and properties worth millions of naira in

Amachalla Village near Awka, the Anambra State Capital in July, 2011. The gorge which swallowed the houses and rendered the occupants homeless, measured about 300 metres deep and 300 metres wide. After the Amachalla incident, 500 people were rendered homeless, while 12 more houses, schools, churches, farmlands and cash crops were anticipated to be destroyed if nothing serious is done. Anambra State is currently one of the most ecologically damaged states in Nigeria with erosion still threatening to eat-up the 4844km^2 area of the state. In the highlands of Ethiopia for instance, wide and deep gullies are common features, significantly affecting land used for agriculture (Yitbarek et al, 2012). Gully erosion often indicates extreme land degradation. It reduces agricultural productivity by destroying valuable land resources, increases sediment concentrations, reduces water quality, and fills up reservoirs; its rehabilitation has proven to be challenging especially in the high rainfall areas (Ayele et al, 2015). The sizes and volumes of natural water bodies in some of the erosion prone communities of Anambra State, have been reduced as a result of siltation, a situation where soil particles are washed away by flood and other agents of denudation, and are deposited at the natural water bodies. This scenario has endangered the lives of most aquatic organisms, and is one of the reasons most crocodiles resort to terrestrial habitat, most fishes died of de-oxidation and most aqua-related activities are becoming more difficult to practice. In the work of Frankl et al (2014), multiple on-site and off-site effects of gully erosion threaten sustainable development which is especially evident in dry land environment.

Table 4: Effects of Gully Erosion in Anambra State.

S/N0	Variable	Occurrence	Percentage (%)
1	Loss of roads, fence and building properties	37	16.5
2	Loss of lives	12	5.4
3	Loss of farmland, Reduction in soil nutrient and agricultural productivity	87	38.8
4	Siltation of water bodies	18	8.0
5	Traffic congestion	20	8.9
6	Ground water pollution	14	6.2
7	Human migration	25	11.2
8	Diseases and ill health	11	4.9
Total		224	100

Source: Researchers' Survey, 2018.



Bar Chart Representation of Table 4.
Source: Researchers' Analysis, 2018.

Table 4 revealed that gully erosion in the State has seriously led to loss of farmland, soil fertility and agricultural productivity (38.8%), loss of building and fenced properties (16.5%), involuntary human migration (11.2%), traffic congestion (8.9%), siltation of water bodies (8.0%), ground water pollution (6.2%) and loss of lives (5.4%). this observation is in line with the views of Yitbarek et

al (2012) and Le Roux et al (2012) on the effects of gully erosion. Field observation revealed that majority of those affected by gullies are rural dwellers whose occupations are predominantly subsistence farming. It may be difficult for them to devise another means of livelihood or survival, following the disappearance of their farmlands which will have adverse effects on their farm produce.

Plate 2: Photo Gallary of Gully Erosion Menace in some parts of Anambra State, Nigeria.

Past Government Efforts to Ameliorate Gully Erosion in Anambra State.

In 2009, the Senate Committee on Environment and Ecology called on the Federal Government to declare a state of emergency on Anambra erosion sites. The Federal Government therefore spent ₦3.7b on Anambra erosion sites out of the ₦11b earmarked for the South-Eastern region (The Nation, 1st December, 2011), while the World Bank pledged the sum of $450

million for erosion control, assuring that the menace would soon be a thing of the past (Daily Trust, 2nd December, 2011), and is currently handling about six (6) erosion sites in the state which include; Amachalla in Awka, Saint Thomas Aquinas, Uruokpala in Abagana, Omagba in Onitsha, Madonna in Agulu and Igboukwu/Umuona/Aguluzigbo Road. Anambra State Government has also submitted a list of 62 critical erosion sites to Abuja with their cost estimated at ₦17b in 2008, and has also allocated about ₦1.5b for ecological problem every year (The Nation, September 29th, 2011).

The erosion sites contracted by the Federal Government in 2009 are; Nanka, Sakamori/Nwangene in Onitsha, Alor and Nnobi erosion sites in Idemili South, and Nkisi in Onitsha, and those already tackled by the Peter Obi administration are; Umuchiana Ekwulobia, Ebenebe, New Tarzan, Nnewi Ichi and Omagba, while those in process of control by the state government are: Nimo, Nnewi-Okigwe highway, Inyaba Umudim Nnewi, Utuh/Osumenyi, Umuchu-Uga-Igboukwu highway, Umueze-Uga, Nawfija, Obieze, Ifite-Dunu and Ndiagu-Ogidi erosion sites.

Despite efforts by the federal government, state government, local government, towns/community unions as well as individuals, gulling have persisted. In towns like Nanka, Nkpologwu, Agulu-Ezechukwu, Ekwulobia and Agulu, the gully extends for kilometres with width and depth in tens and hundreds of meter. Generally, most of the gully sites investigated are still very active despite the control measures already in place. The implication will be disastrous and some will eventually develop into erosion monster in the next ten to fifteen years.

In June 24th, 2008, the Anambra State Commissioner for Environment, Dr. Ifedi Okwenna said; "last year, we did not receive any grant for ecological problem, what we did was that we used our internally generated revenue and part of the Federation Account to solve the problem" (FocusNigeria.com, May, 2017).The Nation Newspaper also reported that; "immediate step however is needed to return Ecological Fund to its constitutional purpose. It should no longer be a slush fund for party politics. It should be strictly for ecologically challenged

states, and specifically to address ecology problems. The notion of giving it to party faithful or as a presidential largesse to governors who are in good standing with the president should seize"(The Nation, September 29th, 2011).

Drawing from the foregoing, one can understand why the State still records about 62 critical erosion sites, 550 very active erosion sites and 1,000 erosion sites. These pockets of 1,550 minor gullies have seriously spread across the state landscape, with majority of the minor gullies existing within the built up areas. By implication, some of them have been forecasted by the researchers' to develop into serious gullies in the next two decades. This issue needs urgent attention considering the risks it pose to the State urban and rural environment.

RECOMMENDATIONS

Control measures to gully erosion that are incipient are most effective when erosion is still at the early stage (Obidimma and Olorunfemi, 2011). Geo-scientist and other Earth scientists working on the gullies in South East Nigeria suggested that the control of gully should be scientifically and systematically implemented rather than the common and general practice of channelization and embankment construction. As such, Osadebe and Enuvie, (2008) stated that organic carbon, chemical properties, textural characteristics and moisture content of the soil should be considered in detailed survey and control of gully. Egboka and Okpoko (1984) asserted that detailed geological, hydro-geological, geo-technical and hydro-geotechnical characterization of the region threatened by gullies be done as a prerequisite for adoption and design of the most efficient control method to be employed. Drawing from the foregoing, this paper therefore recommends the following:

i. All gully erosion sites in Anambra State should be properly located, geo-referenced and integrated in the regional plan as disaster prone areas. After which a proper sensitization and awareness campaign programmes, through regular workshops, electronic and print media billboards, to enlighten the people on the pre-management approach to erosion problems, should be done by the State Governments.

ii. There should be deliberate efforts by the Ministry of Environment to refill and construct a proper drainage system that will be channelled to a safe discharge points down stream. Soil excavation for laterite, stones, sand and other solid minerals exploration and exploitation should be prohibited in erosion prone areas of the state, while farming and other human activities 30 meters away from the gullies, should be avoided.
iii. Extensive afforestation program/campaign should be introduced to help protect the soil from direct impact of raindrops and runoff as well as maintain the moisture content of the soil at responsible level during the dry season.
iv. Establishment of local works committee/task force to monitor the movement of flood waters from upland villages to lowland villages, communities and towns, with a view of checking indiscriminate human activities that aid erosion.
v. Above all, government should ensure that ecological funds are properly used for ecological purpose, and devise stringent rules to punish those who syphoned such funds.

CONCLUSION

Anambra State, South East Nigeria can be said to have an unfair share of gully erosion. Field studies show that this environmental hazard has remained active and has continued to defy control measure put in place to checkmate it. The effects of this menace has been enormous ranging from loss of access roads, farmland, and crops, ancestral homes, livestock and properties, and even human lives. Government, communities and individuals have continued to combat this monster with little or no success. This is attributed to the peculiar geology of the area and non-specific control method employed in combating gully erosion. Therefore, the recommendations contained in this paper should be extensively applied for effective gully erosion control.

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