# Soil Erosion in South Eastern Nigeria: A Review

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Abstract- The development of gullies and other forms of erosion have become the greatest environmental hazard and disaster rampant in southeastern Nigeria. Agricultural productivity, sustainability and management for food security/sustenance in this region has been undermined and greatly limited by the menace posed by soil erosion while the availability of farmlands for agricultural production and construction activities have been greatly reduced by losses caused by the attendant issues of soil erosion. Through productive review of existing research and field observation this paper presents a comprehensive review of the causes and effects of soil erosion as well as control measures aimed at reducing and mitigating the threats posed by soil erosion within the region. From the study the major causes of soil erosion within the study area were narrowed down to human interference, climatic factors (rainfall), poor geology, undulating topography and soil nature while control measures such as cultivation of vegetative cover, proper soil and water conservation practices, proper crop management techniques and intensive community based campaigns were advised to minimize and control soil erosion and maintain soil quality.

Index Terms- soils, soil erosion, causes of erosion, southeastern Nigeria

## I. INTRODUCTION

Soils play an essential role for mankind because they provide the fundamental ecosystem services required for human life primarily for the production of food by providing the environment for plant growth (Sebastian *et al.*, 2014). Soils provide the pathways through which water and nutrients move to the roots of plants, they are the matrix for nutrient transformations and environment for micro-organisms and fauna (Powlson *et al.*, 2011). According to Dominati *et al.*, (2010) soils provide provisioning, regulating and cultural services; presumably the most important provisioning service for human life supplied by soils through food production. As reported by FAO (2011), agriculture uses 11 % of the worlds land surface for crop production. Though soils are a non-renewable resource its capacity to meet required outputs, agricultural productivity and sustenance of food security is threatened as a result of continuous human exploitation thus causing soils to be degraded and deteriorated with all the natural species/ecosystem being endangered to destruction. Soil degradation which is a decline in the quality of soils to meet up with expected demands is greatly caused by problems like soil erosion, deforestation, desertification, poor crop management/agronomic practices and harsh climatic conditions.

Soil erosion is considered to be a major environmental problem since it seriously threatens natural resources and the environment (Rahman et al., 2009). Soil erosion diminishes soil quality and reduces the productivity of natural, agricultural and forest ecosystem (Pimentel, 2006). To further buttress the strength of soil erosion according to Quinton (2014) soil erosion is a globally significant environmental process which degrades the soil upon which we rely on for food, fuel, clean water, carbon storage and substrates for building and infrastructure. As reported by Aksoy et al., 2009; Asdak 2009; Hacisalihoglu et al., 2010 and Gunawan et al., 2013, soil erosion is a natural process of soil material removal and transportation through the action of erosive agents such as water, wind, gravity and human disturbance. It is becoming clear that the transport of eroded material from land to water by overland flow via runoff is an important environmental problem promoting the eutrophication of surface waters, damaging freshwater ecosystems and causing microbial contamination of surface water sources (Sender et al., 2002). Soil loss by runoff is a severe ecological problem occupying 56 % of the worldwide area and is accelerated by human induced soil degradation (Bai et al., 2008; Gelagay and Minale, 2016). On a global scale erosion by water affects 1.1 billion hectares of soil worldwide thus representing 56 % of the total degraded land area while wind erosion affects 28 % of total degraded land area (Humberto and Lal, 2008). Soil erosion is a single major process responsible for the loss of billions of tones of soil worldwide (Ibitoye and Adegboyega, 2012) and it remains the world's largest environmental problem threatening both plants and animals (Abegbunde et al., 2006). According to Okin (2002) over 65 % of the soil on the earth is said to have displayed degradation phenomena as a result of soil erosion, salinity and desertification. Soil erosion is a serious

environmental, economic and social problem which not only causes severe land degradation and soil productivity loss but also threatens the stability and health of society in general and sustainable development of rural area in particular (Tang, 2004; Zheng *et al.*, 2004; Jing *et al.*, 2005).

This paper therefore presents a comprehensive review of the causes, effects and control measures towards soil erosion in southeastern Nigeria based on past studies carried out within the study area of consideration.

# II. SOIL EROSION IN SOUTHEASTERN NIGERIA

The situation of erosion is particularly pronounced in t he ecologically vulnerable areas of southeastern Nigeria where population densities and least land per capita ranks among the highest in rural Africa, (Onu, 2006; Eboh and Lemchi, 1994). The menace of soil erosion especially gully in no doubt represents a major ecological challenge facing most states in Nigeria especially Anambra, Imo, Ebonyi, Abia and other states in the humid tropical regions of southern Nigeria, (Ume et al., 2014). Soils of the southeastern Nigeria have high soil erodibility and are classed as structurally unstable, (Idowu and Oluwatosin, 2008), therefore erosion forms a major type of soil degradation in the area. In southeastern Nigeria the soils are naturally prone to erosion due to their fragile nature and ease of leaching being mainly ultisols and alfisols, (Oguike and Mbagwu, 2009). Both physical, socioeconomic and anthropogenic factors as well as deficient agricultural production practices are believed to have aggravated and exacerbated the high erodibility of the soils in the region. According to Ofomata, (1985), the presence of gully sites is one of the hazardous features that characterize the southeastern zone. The formation of gullies have become one of the greatest environmental disasters facing many towns and villages in southeastern Nigeria, (Adekalu et al., 2007; Okpala, 1990). The type of erosion that is predominant in the southeastern zone is gully. Chiemelu et al., (2013) concurred that gully erosion is most predominant in the region and is considered an environmental degradation with a lot of disastrous consequences caused mainly by flood as a result of high precipitation, which is a fall out of climate change. The development of gullies causes the loss of a great amount of soil and can be considered as one of the principal causes of geo-environmental degradation in the Southeastern Nigeria. Researches previously conducted in Imo, Abia and Anambra States show that gully incidences generate between 4.2 and 10 m  $^{3}/ha/year$ of sediments, which constitute about 45-90 % of total sediment production on agricultural lands (Ogbonna and Ijioma, 2010). Erosion predominates in areas which have been subjected to bush burning, continuous cultivation and mining on hill side slopes, all of which are common and long-term traditional practices in southeastern Nigeria, (Nwachukwu and Onwuka, 2011). Asiabaka and Boers, (1988) had estimated over 1970 gully sites in Imo and Abia states. A conservative assessment shows the distribution of known gully sites in different stages of development as follows; Abia (300), Anambra (700), Ebonyi (250), Enugu (600) and Imo (400), (Igbokwe et al., 2003; Egboka, 2004), the statistics are not exhaustive enough as new sites are developing during each rainy season due to

flooding and torrential rainfall. Of all the states in the southeastern region, Anambra has the highest concentration of active gully sites; in fact every community in the state has tales of woe as a result of expanding gullies, (Igbokwe et al., 2008). The massive soil loss in the Southeastern Nigeria results in severe ecological damages, soil fertility depletion, loss of soil structure, reduction of soil biodiversity, soil compaction, decline in agricultural productivity, low farm income, poverty, food insecurity and social disorder (Junge, et.al., 2008; Lal, 2001; Eswaram, et al., 2001). A number of studies have shown that the southeastern region of Nigeria is susceptible to gully erosion due to the nature of soil, topography and geology, (George et al., 2008; Okagbue and Uma, 1987; Onu, 2005; Osadebe and Akpokodje, 2007). The southeastern region lies within Awka-Orlu uplands and Enugu-Awgu-Okigwe escarpment where gully erosion is a general problem, (Chiemelu et al., 2013). The area is also predominantly covered by Awka-Orlu Cuesta which is an area subject to ground surface cracks and landslides during the rainy season. The soils have low silt/clay content which decreases with depth making the sands cohesionless, very permeable with high infiltration rates, thus making control of gullies difficult after soils have been cut through by climatic factors. According to Eze (2007) soils especially in Enugu are loose sandy ferallitic with loamy-clay mixture having poor soil cover and highly susceptible to erosive actions. Also the rise in groundwater table due to heavy rainfall in the rainy season contributes to an increase in hydraulic head, high subterranean flow rate and the enhancement of gully formation, (Egboka et al., 1990; Ezezika and Adetona, 2011). There are three geopolitical zones in Imo State namely Orlu, Owerri and Okigwe zones respectively. Out of all the zones Orlu zone has the highest number of active gully erosion sites. The major erosion sites in Imo State are all situated in Orlu zone, this is basically as a result of anthropogenic interference by human activities, geological formation of the soil and the variation in slope/topography of the zone. According to Ume et al., 2014 the average depth of gullies existing in Ideato North and South L.G.A ranges between 15-35 m, with a cross-sectional area of about 80metres in some places and covering a distance of about 3 km. According to Ogbonna, (2012), the erosion rate in Orlu zone between 1984-2008 has progressed from 6.58 km<sup>2</sup> to 31.07 km<sup>2</sup> and it is projected to reach 34.07 km<sup>2</sup> by 2018. Abia State is equally not left out from the menace of soil erosion as catastrophic gullies occur at Amucha, Isuikwuato, Ohafia, Abriba and Arochukwu Local Government Areas respectively resulting in dissection of major roads and loss of productive lands for agriculture. According to Umeugochukwu et al., (2012) at least 10 % of Anambra state is occupied by gully erosion of all types and due to increased environmental and human activities the gullies are still on the increase. At least 1600 gully erosion sites exist in southeast region (Egboka 2004; Ogbonna, 2009) thus occupying within 36.4 km<sup>2</sup> of areas that would have been used for agriculture. Food security and agricultural productivity within southeastern Nigeria has been adversely affected because of the prevalent occurrence of soil erosion. A conservative report on gully erosion distribution in southeastern Nigeria is shown in Table 1.

<b>S</b> /	States	No. of	Condition	Control
Ν		Gully		Measures
0		Sites		
1	Anambr	700	Mostly active	Not
	а			successful
2	Abia	300	Some	Not
			active/some	successful
			dormant	
3	Ebonyi	250	Mostly minor	No records
			gully sites	
4	Enugu	600	Some active /	None
			some dormant	
5	Imo	450	Some active /	Not
			some dormant	successful

Table 1: Distribution of Erosion sites in Southeastern Nigeria

(Source: Igbokwe et al., 2003; Egboka, 2004)

### III. MATERIALS AND METHODS

#### i. Study Area Description

#### *ii. Position, Climate and Vegetation*

Southeastern Nigeria is located within latitudes 4° 47' 35" N and 7° 7' 44" N, and longitudes 7° 54' 26" E and 8° 27' 10" E and is made up of five (5) States namely; *Abia, Anambra, Ebonyi, Enugu* and *Imo* (Anejionu *et al.*, 2013). The area covers about 29095 km<sup>2</sup> which is about 3.19 % of the total area of Nigeria. The region has a tropical climate with humidity and rainfall decreasing from the coast inland, and characterized by uniformly high temperature and a seasonal distribution of bimodal rainfall (Anyadike, 2002). The mean minimum and maximum temperatures ranged from 21-30°C in the coast and 29-33°C in the interior or inlands (Chukwu, 2007). According to Igwe, 2012; Ezemonye and Emeribe, 2012 the rainfall of southern Nigeria generally is heavy and ranges from over 2500 mm in the

southern most region towards the Atlantic to about 1500 mm annually around River Benue in the northern borders. The vegetation stretches from the mangrove swamp in the coast through to the derived savanna in the interior (Chukwu *et al.*, 2009) but the region lies in the lowland rainforest natural vegetation belt with evergreen trees in the south and gradually gives way northward to rainfall-savanna forest characterized by trees interspersed with grass.

#### iii. Geology and Soil

The underlying geology consists of heterogeneous materials namely basement complex, beach sands, coastal plain sands, mangrove swamp deposits, sandstones, shale, sombrero Warrideltaic deposits, recent and sub-recent alluvium (FDLAR, 1990). According to Egede (2013), the soils of the southeastern Nigeria is heterogeneous in nature comprising of loose red-earth with sands, sandstones, clayey-loam with or without ferric properties underlain by shale formation. Also reported by Ezemonye and Emeribe (2012) the soils are derived from shale and sandstone parent materials which are deep, porous, and acidic with low organic content as a result of leaching from rainfall activity. Ogbonna et al., (2011) also described that at least ten soil classes exist in southeastern Nigeria and they are Eutric fluvisols, hystic fluvisols, dystric fluvisols, rhodic ferrosols, lithosols, dystric gleysols, eutric gleysols, eutric nitosols, dystric cambisols and glevic cambisols. According to Ufot et al., (2016) southeastern soils are low in organic matter content, base status and water storage capacity with high susceptibility to accelerated erosion and land degradation. Ezezika and Adetona (2011) further states that the soils have low silt/clay content thus resulting in a sandy soil which is cohesionless, very permeable and very high infiltration rates. Presented in figure 1 is a comprehensive soil map of southeastern Nigeria.



Fig. 1: Soil Map of Southeastern Nigeria (Source: FDLAR, 1990)

# <u>Key/Legend</u>

- A- Shallow Pale brown soils from acid crystalline rock.
- **B-** Shallow brown soils from sandy shales of deposited materials.
- C- Pale brown loamy alluvial soils
- *D* Dark grey mangrove soils
- *E* Brownish yellow fine sandy soils from beach deposits of tropical soils
- *F* Red clayed soils from basalts
- G- Red gravel brown sandy soils from acid crystalline rocks
- H- Yellowish red gravel and brown soils from acid crystalline rocks
- I- Deep porous red soils from sandy deposits
- J- Deep porous brown soils from sandy deposits
- K- Red and brown soils frm sandstones and shales hydromorphic soils
- L- Redish brown gravel and pale clayey soils from shale

# **IV. RESULTS**

**Causes of Soil erosion in the Region**: From field observation, productive works and reports of other researches carried out within the southeastern region of the country the major causes of soil erosion in southeastern Nigeria is summarized as follows;

i. Climatic Factors: FAO (1990) concluded that gully erosion results from the action of heavy rainfall on surface earth materials under reduced or altered vegetative cover. According to Igwe (2012), the rainfall of southern Nigeria is heavy and aggressive and the nature of the rainfall regime contributes significantly to erosivity of rainfall (potential, ability and strength of raindrops to cause soil disturbances that result in soil erosion) thus generating large volumes of runoff that initiate the development of waterways and channels that result in gullies. Egede (2013), Ezeabasili *et al.*, (2014) and Abdulfatai *et al.*, (2014) collectively reported

that soil erosion in the southeastern region of the country heightens, elevates and increases during the rainy season as a result of streams of runoff generated within this period. Salako (2006) also reported that land degradation in many tropical regions occur because of high rainfall erosivity and poor soil conservation practices within the rainy season especially.

- ii. Soil Nature and Topography: According George et al., (2008), Osadebe and Akpokodje (2007), Onu (2005) and Teme and Youdeowei (2004); the southeastern region of Nigeria is susceptible to gully erosion due to the nature of the soil, topography and geology. The formation of gullies in the southeast is directly related to the underlying geology and severity of surface processes operating in the surface geology and soil cover (Ezechi and Okagbue, 1989). Observations have also shown that gully erosion in Nigeria is predominant in sedimentary terrains and this accounts for why gully occurrences is more skewed to southeastern Nigeria where the soil formations are loosely consolidated (Abdulfatai et al., 2014). The nature of the soils in the southeast is red earth with sandstones loose surface that is easily prone to damages y torrential rainfall and flood (Egede, 2013). Ezezika and Adetona (2011) states that the Imo/Anambra basin is predominated by the Awka-Orlu cuesta which is an area susceptible to ground surface cracks, landslides, mass movement, and tectonic movements during the rainy season that results to all kind of land degradation and soil erosion predominantly.
- iii. Human Factors: According to Egede (2013) soil/land has been subjected ti intensive pressure from human uses that induce degradation, soil loss and erosion; such human factors include overgrazing, excessive farm activities, tillage, clearing of bushes, extractive industries, road construction, bush burning, over-population, lumbering, residential development buildings, of urban centres, fumigation industrialization, with pesticides, mining (open cast and soil excavation) e.t.c. Ibitoye and Adegboyega (2012) quipped that human activities such as construction works involving haphazard erection of buildings on steep terrains, ineffective or uncompleted drainage projects encouraged concentration of runoff and gullies. In Ukpor, Nnewi-South L.G.A (Anambra) land use patterns and practices like arable farming, clean weeding, housing, bush burning, tree felling, sand and stone quarrying which are human induced are the major causes of soil erosion and decreased soil quality (Ubuoh et al., 2013). In most states within the southeastern region of Nigeria human environment interference with the through continuous excavation of borrow-pits and anthropogenic activities result in distortion/removal of soil vegetative cover are pivotal to soil erosion.

# IV. EFFECTS OF SOIL EROSION

Soil erosion in southeastern Nigeria is a major environmental problem and according to Abdulfatai *et al.*, (2014), Anejionu *et al.*, (2013), Ogboi and Odeh (2012), Umeugochukwu et *al.*, (2012), Ogbonna *et al.*, (2011), Obiadi *et al.*, (2011), Ezezika and Adetona (2011), Akpokodje *et al.*, (2010), Igbokwe *et al.*, (2008) and Pimentel (2006) the effects/impacts of soil erosion in the study area is summarized as follows;

- Reduced agricultural productivity and outputs/yields due to degraded lands/soils.
- Unavailability of land area for agricultural production due to continual dissection from gully formations.
- Reduction to removal of plant nutrients and organic matter content of the soil resulting in elevated soil infertility.
- Destruction of soil structure and biota to support plant root development and eventual growth.
- Depletion of soil volumes and quantities due to large volumes of surface runoff caused by high/heavy rainfalls which are synonymous to the region.
- Deposition of debris and pollution/contamination of aquatic ecosystem through direct runoff from farmlands.
- Eutrophication of rivers and streams resulting from fertilizer/manure runoff flows from agricultural farmlands.
- Siltation and sedimentation of water reservoirs thus reducing the life expectancy of dams and storage dams which will lead to eventual failure.
- Distortion, destruction and breakage of major road networks example of such roads include Uturu-Isuikwuato road at Mgbelu Umunnekwu, Abia State, Orlu-Mgbee/Eziama road, Imo State, Nkporo-Oso/Amasiri road at Edda, Ebonyi State, Nanka-Ekwulobia road Anambra and so many other roads.
- Decreased agricultural sustainability due to unavailable fertile lands for agriculture.
- Destruction of life and property for example in *Oko* community of Anambra deep gullies have widened into craters threatening to sweep away 826 families.
- Loss of vegetation and soil cover which exposes the soil to further environmental devastation.
- Reduction of lands available for erection of residential buildings, industries, and other structures.
- Siltation and sedimentation of existing channels resulting in over-flooding.

## VI. CONTROL MEASURES

Soil erosion is a continuous process accelerated by climatic and human activities and as such can be managed through the following methods;

- Cultivation of close-growing vegetation/grasslands such as carpet grass (*Axonopus Compressus*), Bahama grass (*Cynodon Dactylon*) e. t. c and trees such as oil palm (*elais guinensis*), *Gmelina Arborea*, *Acacia Albida* and other shed growing trees to serve as vegetative cover to reduce kinetic energy of raindrops, intercept runoff and induce infiltration on bare soils. According to Okorafor *et al.*, (2017) soils in Imo State require intensive revegetation and afforestattion activities to reduce the tendencies of erosion by water and rainfall erosivity.

- Practice of proper soil and water conservation methods: Depending on the nature of soils and topography of area certain soil and water conservation methods should be adopted to prevent further soil erosion occurrences. Such practices include use of terraces on steep sloped farmlands to reduce soil movement along slopes, creation of proper drainage channels to conduct large runoffs to safe outlets, slope stabilization and protection using wire-meshes, rip-rap, wood-chips, gabions e. t. c, use of mulches to reduce root zone evaporation, intercropping with legumes to ensure nitrogen fixation in the soil to maintain soil organic matter content and other proper practices.
- Proper crop management practices such as contour and strip cropping techniques on undulating farmlands, use of crop rotation practices to always provide soil cover on farmlands, manuring and use of organic fertilizers to sustain nutrient levels of soils, use of mulches to encourage decomposition and organic matter content replenishment and proper tillage practices are encouraged to sustain soil quality.
- Bad cropping techniques such as bush burning, clean weeding, over-grazing, continuous cropping, overcropping and deforestation should be avoided so as to reduce dryness of the soil, soil compaction and breakages that will ensure movability and transportability of soil particles by agents of denudation.
- Reduced human activities such as bush clearing, clean weeding and tree felling/lumbering that will initiate deforestation and removal of soil cover and expose the soils to uncontrolled climatic influence that will degenerate into land degradation and soil erosion.
- Use of sensitization campaigns through workshops, seminars, agricultural extension workers, and farm cooperative units to elucidate and educate rural farmers on the influence/impact of soil erosion of agricultural productivity and yield as well as simple cultural method(s) which can be of use in reducing the menace erosion poses.
- Government assistance through repairs of existing erosion sites, establishment of soil erosion research centers, provision of proper climate data especially rainfall characteristics and support of forest regeneration can also help reduce and control the effects of soil erosion.

# VII. CONCLUSION

The present study leads to the following conclusions:

Soil erosion within the southeastern region of Nigeria is caused predominantly by climatic factors especially rainfall, human interference and activities, poor nature of the soils, topography and geology of the area.

Soil erosion affects the region through reduced agricultural activity, unavailability of land for agriculture

and construction, destruction of major road networks, loss of vegetation and other adverse effects.

Soil erosion can be managed and controlled through cultivation of vegetative cover, application of proper soil and water conservation practices, proper crop management techniques, reduced human interference on the environment, government assistance and public awareness activities/campaigns through agricultural extension workers.

Soil erosion is a continuous natural phenomenon which cannot be stopped entirely but can be managed and minimized to retain soil nutrient level, fertility and ensure continued cultivation to sustain agricultural productivity.

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