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Review of Gully Erosion in Nigeria: Causes, Impacts and Possible Solutions

I. A. Abdulfatai[1,*], I. A. Okunlola[1], W. G. Akande[1], L. O. Momoh[1], K. O. Ibrahim[2]

[1]Geology Department, Federal University of Technology, Minna, Nigeria
[2]Department of Geology and Mineral Science, University of Ilorin, Ilorin, Nigeria
*Corresponding author: geoadavize@yahoo.com

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Abstract Gully erosion, the most impressive and striking erosion type, has been recognized as one of the major global environmental problems. Many States in Nigeria are currently under the threats of this phenomenal process, south-eastern part of the country being the most affected. It has numerous causes; and these causes can be both naturally and artificially-induced, but the underlying geology and the severity of accompany surface processes play a key role. Observations have shown clearly that gully erosion is more prevalent in sedimentary terrain than in the basement complex of Nigeria. This erosion activity at various scales has resulted in the loss of lives and properties almost on a yearly basis. Solutions that have been proffered include public awareness campaign, improved farming techniques, cultural method of gully control, enactment of laws against any activities that favour gully growth, and thorough implementation of suggested solutions.

Keywords: *Nigeria, gully erosion, geology, environmental problems, sedimentary terrain*

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1. 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). However, gully is visually the most impressive of all types of erosion (El-Swaify, 1990). Gully erosion is a well-defined water worn channel (Monkhouse and Small, 1978). It is a recently extended drainage channel that transmits ephemeral flow, steep side, steeply sloping or vertical head scarf with a width greater than 0.3 m and a depth greater than 0.6 m (Brice, 1966). It is a V or U-shaped trench in unconsolidated materials with a minor channel in the bottom, but not necessarily linked to a major stream (Graf, 1983). Similarly, 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). Gullies can be active (actively eroding) or inactive (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. The causes of gully erosion are poorly understood but the processes and factors involved in its growth and degradation are well-known (Bettis III, 1985). The research has shown that gully processes had happened in the past even without human influence or interference. Thus, the phenomenon of gully erosion is either naturally-induced or artificially-induced, or both. Like in other parts of the world, gully erosion is one of the major environmental challenges facing Nigeria. The available literatures on the subject show that this menace is more predominant in the eastern half of the country compared to the western half. South-eastern part of Nigeria is more affected than its north-eastern counterpart. Soil erosion in the former has been identified as the most threatened environmental hazards in the country (Albert, *et al.* 2006). Anambra State is the most affected of all the states in Nigeria where Agulu, Nanka and Oko communities of the state are the worst hit.

Available literatures have clearly reiterated the fact that the underlying geology exerts a major of control on gully development and, more often than not, the process is rock type dependent as some rocks are more susceptible to erosion than the others. There is therefore a need to briefly review the geology of Nigeria with a view to recognizing why the phenomenal gully erosion is more prevalent in one part of the country than in the other.

2. Geology of Nigeria

Nigeria is endowed with diverse of rock types, both crystalline (igneous and metamorphic) and sedimentary rocks. The former forms what is commonly referred to as the Basement Complex of Nigeria where the latter forms the sedimentary terrain (sedimentary basins). Numerous

workers have worked extensively on different aspects of these rocks and only the key authors will be cited in this paper.

2.1. The Basement Complex

The Basement Complex of Nigeria is made up of crystalline (igneous and metamorphic) rocks which are sometimes referred to as hard rocks. The Nigeria basement is part of pan-African mobile belt and it is located between Congo and West African cratons. The Basement Complex rocks are exposed in almost equal proportion as the Nigerian sedimentary basins, thus covering nearly half of the total surface area of the country. Thus, because of its diverse nature and areal extent, various researchers have concentrated and worked on different parts of the country where the basement outcrops. For instance, McCurry (1976) reviewed the geology of the northern Nigeria and he divided the Paleozoic and Precambrian rocks of the region into four major groups namely:

i) The Basement Complex (*sensu stricto*), otherwise referred to as Older Metasediments
ii) Younger Metasediments
iii) The Older Granite Series
iv) Volcanic Rocks.

Later work by Ajibade *et al.* (1987) resulted in the subdivision of the basement complex rocks of Nigeria into four blocks as follows:

a. The North-Western Basement Complex
b. The North-Central Basement Complex
c. The South-West Basement Complex
d. The Eastern Basement Complex.

Similarly, Rahaman (1976) reviewed the basement geology of the south-western Nigeria and he summarised the Precambrian rocks of the region into five major groups, namely:

i) Migmatite-gneiss complex which comprises biotite and biotite hornblende gneisses, quartzites and quartz schist and small lenses of calc-silicate rocks.
ii) Slightly migmatised to unmigmatised paraschists and metaigneous rocks which consist of pelitic schists, quartzites, amphibolites, talcose rocks, metaconglomerates, marbles and calc-silicate rocks.
iii) Charnochitic rocks
iv) Older Granites which comprise rocks varying in composition from granodiorite to true granites and potassic syenites.
v) Unmetamorphosed dolerite dykes believed to be the youngest.

The mode of occurrences, evolution, tectonic and geological history, and phases of metamorphism, deformation (folding) and igneous activity (igneous intrusions) of these basement rocks have been discussed extensively by Rahaman (1996) and other studies.

2.2. The Sedimentary Basins

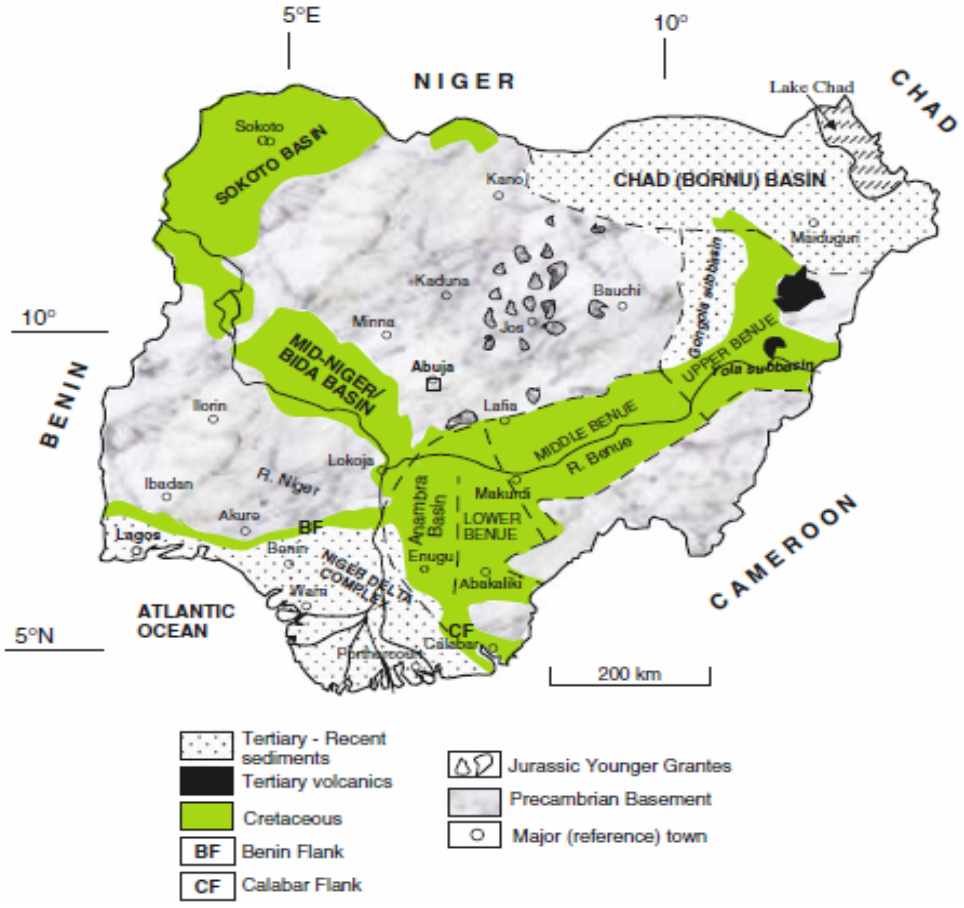

Figure 1. Geological Map of Nigeria (Obaje, 2009)

The sedimentary basin consists of sedimentary rocks which were derived from pre-existing rocks (igneous or metamorphic rocks, or even sedimentary rocks) deposited within the depressions in the crust of the Earth's surface. The Nigerian sedimentary basins (Figure 1), like the Basement Complex, cover roughly fifty percent of the

total surface area of the country. They, both inland and coastal basins, are grouped into seven relatively small basins and these are:

i) Anambra Basin
ii) Benue Trough
iii) Bida (or Mid-Niger or Nupe) Basin
iv) Chad (or Bornu) Basin
v) Dahomey Basin
vi) Sokoto Basin
vii) The Niger Delta Basin

The origin and tectonic evolution, stratigraphy and sedimentology, basin fill, lithofacies and economic potentials of these basins have been extensively studied by various authors (e.g. Adeleye, 1971; Ojo and Akande, 2002; Nwajide and Reijers, 1986; Nwajide, 1990; Obaje, 2011, Short and Stauble, 1967).

3. Causes of Erosion

Because of more prevalence of gully erosion in the southeastern part of the country as earlier noted, the region has attracted more attention of a number of researchers to unravel the causes of gully erosion. Therefore, the works from this area are overwhelming in the literature.

Gully erosion can be caused in a number of ways, having different mechanisms, modes and conditions of formation; some of which are directly related to the underlying geology and the severity of the surface processes operating on the surface geology and soil cover. Ezechi and Okagbue (1989) summarized the types of gully erosion with respect to their modes and conditions of formation, and common advance mechanism (Table 1). Their study indicated that the nature of the underlying bed (or geology) has a bearing on the initiation and propagation of gullies. Observations have also shown that gully erosion, in Nigeria, is more predominant in the sedimentary terrains and perhaps in the basement/sediment contact areas. This accounts for why its occurrences is more skewed to the south-eastern Nigeria where most of the gullies take the advantage of the loosely consolidated and sometimes friable rocks such as the Ajali Sandstone in Auchi area of Edo State of Nigeria (Nwajide, personal communication). The causes of gully erosion with respect to the geologic settings as suggested by the earlier studies are numerous. Some of the identified natural causes include tectonism and uplift, climatic factors, geotechnical properties of soil, among others. Anthropogenic causes include farming and uncontrolled grazing practices, deforestation, and mining activities.

Table 1. Gully types, modes and conditions of formation and common advance mechanism (Ezechi and Okagbue, 1989)

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.

4. Impacts of Gully Erosion

The impacts of gully erosion in Nigeria are enormous and similar to that obtainable elsewhere in the world and they include:

i) **Loss of Farmland**: A vast area of farmlands has been lost due to the menace of gully erosion while others are at their various stages of destruction leading to drastic decrease in agricultural productivity and ultimately food shortage that can lead to famine.

ii) **Treat to Vegetation**: The gully erosion in Nigeria has resulted in loss of vegetation as its continuous expansion encroaches into areas that are hitherto forest leading to falling of trees and exposure of more surface areas to gully activities. The phenomenon if allowed to continue and remains unchecked may ultimately lead to climatic changes locally or globally.

Figure 2. Umuaka Gully site Enuvie (Akpokodje, *et al. 2010*)

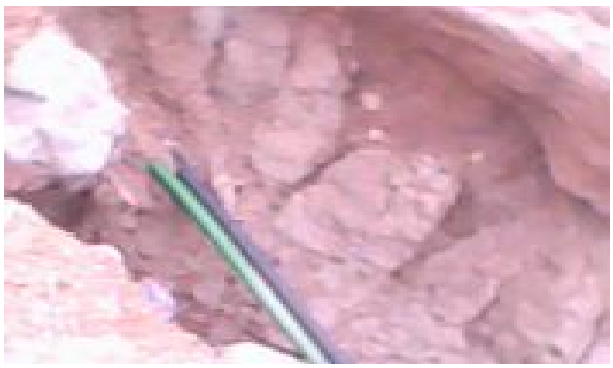

Figure 3. Exposure of utility cable by gully erosion, Minna, Niger State of Nigeria (Personal photo taken by the leading author, 2012**)**

Figure 4. A Gully Site in Umuchiana, Aguata, Anambra State (Igbokwe, 2008)

Figure 5. A three-storey building about to be swallowed by gully erosion at Omabge Estate, Onitsha (News Agency of Nigeria, 2011)

iii) **Effect on Properties**: Several properties whose value cannot be quantified accurately here have been destroyed and others are under treat by this menace especially houses and other properties located on the floodplain. About 10 houses have been lost in a single event of gully erosion in Auchi area of Edo State. Besides, it was reported recently that over 450 buildings are lost in Edo State of Nigeria as a result of erosion (NTA News, Sunday 6th July 2013). On a separate note, Committee on Erosion and Ecological matter recently discovered 15 gully sites in Bida, Niger State of Nigeria (NTA Minna News, Wednesday 17th July 2013). Apart from untimely evacuation from these gully sites, infrastructural facilities such as pipelines, utility cables, roads and houses also suffer from these hazardous events (Figure 2 – Figure 5).

iv) **Effect on Life**: Many lives have been lost as a result of the problem of gully erosion. Some either fell into these gullies and sustained various degrees of injury or died. Some instances have also been reported where people are drowned in some of the gully sites. About 23 people have been reported in the past few years to have lost their lives in a single event of gullying activities in Ibori, Ugbalo, Ewu-Eguare, Idogalo and Oludide communities of Edo State, Nigeria. Millions of people have been displaced and evacuated their homes following the gully incidences. The gully erosion in Oko community in Anambra State has created a deep gully and wide crater, threatening to sweep away the homes of about 826 families as this channel is continuously expanding at an alarming rate.

Figure 6. Road hazard resulting from gully erosion at Orlu/Mgbee road (imostateblog, 2012)

v) **Isolation of Villages and Towns:** Gully erosion has resulted in the separation of adjacent villages and towns as it may involve collapse of the bridges linking them together. This has had negative impacts on such areas since some facilities such as schools, hospitals and water supplies shared by the affected neighbouring communities may become inaccessible. Transportation of farm produce has also been affected and this also often leads to loss of agricultural products especially the perishable ones. Traders who also go to these areas for their trade are also cut off from their normal day-to-day business (Figure 6).

vi) **Bad Land:** Gully erosion has given rise to infertile and barren land that may need to be reclaimed. This usually brings untold hardship to the inhabitants if the land is still inhabitable but has been severely affected. Anambra State has lost over 30 percent of her land, and over 40 percent of the total area of land and homes are being threatened by the menace according to the Anambra State Ministry of Environment.

5. Proposed Solutions to Gully Erosion in Nigeria

Prevention is better than cure, they say. Thus, prevention of the processes or mechanisms that result into or advance to gully erosion should be of paramount importance to all the stakeholders in environmental management in the country. Control measures to stem gully erosion that are incipient are most effective when erosion is still at an early stage (Obidimma and Olorunfemi, 2011). Organic carbon, chemical properties, textural characteristics and moisture content of the soil have been suggested as the most useful factors to be considered in a detailed survey and control of gully (Osadebe and Enuvie, 2008). Thus, these factors and others should be carefully examined in the erosion-prone regions of the country in a bid to better design preventive measures. Other measures that could be used to curb the menace of gully erosion are suggested as follows:

i) As earlier mentioned, poor farming techniques were found to be a contributing factor to the growth of gully erosion. Improved farming practices that reduce the gully erosion processes to the barest minimum therefore should be encouraged.

ii) Refuse dump along the river courses impede the flow of water leading to flooding especially during heavy rainfall. Therefore, dumping of refuse on the river channels and floodplains should be prohibited. Government at all levels should enact and enforce laws to deter such activities.

iii) Cultural method (also called vegetative techniques by Simpson, 2010) of erosion control has been found to be a cheap and effective method. Planting of plantain and banana on the floodplains have also been found to be effective in controlling erosion. Grasses species such as *Eulaliopsiss binata* (Babiyo), *Neyraudia reynaudiana* (Dhonde), *Cymbopogon microtheca* (Khar), *Saccharum pontaneum* (Kans) and *Thysanolaena maxima* (Amliso), *Arunduella nepalesis* (Phurke) and *Themeda species* have been suggested by Ojha and Shrestha (Ojha and Shrestha, 2007) as suitable especially for slope stability.

iv) Inadequate awareness of effects of human activities on both floodplain and river channels contribute to misuse of these areas. Therefore, there should be

general enlightenment campaign on the dangers posed by gully erosion and human activities that promote them.

v) Efforts should also be made by relevant authorities to enact a law against location of engineering structures on waterways.

vi) The government at all levels in Nigeria should take it as matter of urgency to yield to addressing issues relating to erosion especially gully erosion at an early stage so as to avoid loss of lives of Nigerian people and their properties.

6. Conclusions

Nigeria and elsewhere in the world suffer from the havocs of gully erosion. The causes of gully erosion in Nigeria include both natural and anthropogenic sources. The impacts include loss of human and animal lives, loss of properties and land resources. Some of the solutions that are proffered include improved farming techniques, cultural method of gully control, and enactment of laws against any activities that favour gully growth. The government at all levels in Nigeria and the stakeholders in environmental management such as State Ministry of Environment and Federal Ministry of Environment should also sensitize Nigerians on the causes, impacts and problems of gully erosion. However, poor or lack of implementation of research findings and recommendations seem to hinder complete evaluation of proposed solutions. For instance, in some cases where an effort is made, poor quality of work usually lead to even greater erosion, as in the case of road construction probably due to poor supervision, poor funding and corruption.

Though we have little or no control on the natural causes of gully erosion especially those related to the underlying geology, the individuals and relevant stakeholders should discourage all practices that are capable of initiating or speeding the phenomenon in Nigeria. If all the suggested solutions are carefully looked into, it is believed that the incidence of gully erosion in Nigeria would be drastically reduced and the security of the lives of Nigerians and their properties will be guaranteed.

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