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Comparative Analysis of Erosion and Sedimentation Challenges in Efon-Alaaye and Idah Towns in Nigeria

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Abstract:
Efon-Alaaye and Idah have been reported to be the most critical cases of erosion in South-Western and North-Central Nigeria respectively. The aim of this research is to compare the erosion and sedimentation features in the two towns. It conducted on-site physical surveys, examined the type and causes of erosion in the communities, reviewed intervention efforts of statutory agencies, and recommended efficient control measures. Information was obtained through interviews, questionnaires, archival data and on-site evaluation. Respondents were selected through purposive and random sampling techniques and data analysed using bar charts, percentiles and mean ranking. It was observed that gully erosion is the most predominant in Efon- Alaaye, whilst in Idah, it is the sheet and rill type. The causes of erosion in Efon-Alaaye are mostly natural (i.e., topography and rainfall pattern), while in Idah, they are mostly due to indiscriminate human activities (e.g., poor town planning regulation, indiscriminate refuse disposal, uncontrolled land development and use and poor drainage), largely aided by the physiographic setting. The research work revealed that Efon-Alaaye witnessed a few cases of interventions by relief agencies, but in Idah most intervention mechanisms have been initiated by property owners and the inputs of statutory agencies have been extremely poor. Recommendations were offered to residents of both communities on implementing efficient, economic measures to control erosion spread; for statutory agencies to enforce necessary legislation to control indiscriminate human activities; and for intervention agencies to be alive to their responsibilities of disaster control and management.

Keywords: *Efon-Alaaye, erosion, erosion control, Idah, sedimentation*

1. Introduction

1.1. Background

Efon Alaaye and Idah have been reported as the most severe cases of soil degradation arising from the exposure of the lands surface to agents of erosion in the South-Western and North-Central Regions of Nigeria respectively (Ikhile, 2015; Julius & Adekunle, 2015; Jimoh, 2013; Ibitoye & Adegboyega, 2012; Jeje, Ogunkoya & Oluwatimilehin, 2011; UNAAB-IFSERAR, 2010; OnlineNigeria, 2003).

Efon-Alaaye (Ekiti State, South-Western Nigeria) is located on 7 ^{0}40$^{'}$N, 4 ^{0}55$^{'}$E (Jeje, Ogunkoya & Oluwatimilehin, 2011) and is situated on an elevation of 600m above sea level. It has an area of 232sq. km and a population of over 100,000 in 1983 (Wikipedia, 2010). It is a mountainous town with several hills, hillsides, plains and valleys (Ekiti State of Nigeria, 2017; Wikipedia, 2009). Early settlers enjoy security advantage from the hilly terrain but in recent times, due to development and destruction of the vegetation for the purpose of expansion and construction, the area has become susceptible to the risk of soil erosion, with devastating gullies easily observed within the town (Ekiti State of Nigeria, 2017). The town is underlain by major rocks of the Ife-Ilesa schist belt which comprises of Amphibolite Complex Schists and Quartzite sequence, including ferrogenous tropical soils (Adediji & Ibitoye, 2013). Julius & Adekunle (2015) observed that the lithology of the rocks underlying the area varies in type and composition and thus, their resistance to weathering varies.

Idah (Kogi State, North-Central Nigeria) is an old river port town located on a sandstone cliff on the east bank of River Niger. It is located on 7 ^{0}05$^{'}$ N, 6 ^{0}45$^{'}$ E in the North Central region of Nigeria. (Wikipedia, 2015). It occupies a land area of approximately 36 sq. km with a population of 79,815 (2006 population census). It lies on a relatively flat level plain with an altitude of 62 meters above sea level. (The Leadership Newspaper, 2015).The flood plains of the Niger River valley, where Idah is located, have hydromorphic soils which contain a mixture of coarse alluvial and colluvial deposits. The alluvial soils along the valleys of the river are sandy, while the adjoining laterite soils are deeply weathered and grey or reddish in colour, sticky and permeable. (OnlineNigeria, 2003). The most predominant soil type on Idah is ferralsol.As a result of the predominant soil type and the altitude, ecological problems manifest in the town and they include leaching, erosion and general impoverishment of the soil. Flooding is common in the flood plains during the rainy season and aridity is experienced in other locations farther from the river during dry season. The predominant soil type existing on Idah, is

soft and susceptible to erosion and collapse. This is aided by the sparse vegetation cover and soil composition.The erosion problem in Idah is a menace already approaching unbearable proportions. Many roads, drainage courses, farmlands, buildings and other public and private infrastructure have been lost to deep and wide gullies which have become an almost common feature of the landscape. This has resulted to huge financial losses to the owners of these facilities and even in some cases, loss of life.

Against this background, this study aims to compare the erosion and sedimentation features in the two towns. It conducted on-site physical surveys, examined the nature and causes of erosion in the communities, reviewed intervention efforts so far put in place, and recommended efficient control measures.

2. Conceptual Framework and Relevant Literature

Environmental issues are receiving increasing attention globally. Jimoh (1995) & Obarezi (2015) observed that soil erosion as a form of environmental degradation is a hydrological process with negative consequences the world over and that one of the most urgent problems confronting African cities today is how to plan and manage the environment. The process may be a slow process that continues relatively unnoticed or happen at an alarming rate causing terrible damage and loss of soil, especially top soil and vegetation.

It has been estimated that each year, more than 10million hectares of crop land are degraded or lost as rain and wind sweep away topsoil. An area big enough to feed Europe – 300million hectares, about ten times the size of the United Kingdom has been so severely degraded it cannot produce food. (Ogundare, 2016).

Many factors have been identified as responsible for erosion in Nigeria. According to Onuigbo (2004), urban development aggravates some erosion problems such as when housing projects are carried out on unsuitable soils that are subject to landslides. Ogundare (2008) observed that one major human activity that can result in soil erosion is poor agricultural practices such as over cropping and overgrazing of domestic animals. He also observed that deforestation; roads, anthropogenic climate change and urban sprawl are amongst the most significant human activities in regard to their effect on stimulating erosion. According to Ojo (1993), the activities of man have tended to promote erosion such as indigenous farming methods which encourages deforestation by bush clearing and burning while the rising demand for food for the teeming population does not allow the land enough time for full recovery and vegetal cover. Ojo pointed out that unplanned location of buildings and road networks as well as their constructions give little consideration to drainage or blockage of the existing ones.

2.1. Erosion

The word erosion, according to the Northern Rivers Catchment Management Authority (n.d), is derived from the Latin *'rodere '*meaning to 'gnaw'. The main agents of erosion are water, wind and gravity. Erosion is a natural process but is often intensified by human land use practices.

Erosion is defined by Gaffney & Dickerson (2005) as the gradual wearing away of the land surface as a result of uncontrolled wind and water energy. The report views erosion as a three-step process involving the detachment, transport and deposition of soil particles.

2.2. Sediment/Sedimentation

According to the United States Department of Agriculture (2008), sediment is the result of erosion. Once soil particles have detached from the surface, they are transported from their site of origin and come to rest on other ground surfaces or in lakes, ponds, watercourses, or wetlands, such deposits are referred to as sediment. The process of soil particles being transported from their site of origin and deposited on foreign ground is known as sedimentation.

Gaffney & Dickerson (2005), describes sedimentation as the result of transport and delivery of eroded soil particles, deposited at some point remote from their original location.

2.3. Ferralsol

Ferralsol is described by *britannica.com* (2016) as a red and yellow weathered soil whose colour results from an accumulation of metal oxides, particularly iron and aluminum (from which the name of the soil group is derived). They are technically defined by a fine-textured subsurface layer of low silt – clay ratio, high contents of kaolinitic clay and iron and aluminum oxides; and low amounts of available calcium or magnesium ions. Because of the residual metal oxides and the leaching of mineral nutrients, they have low fertility and require additions of lime and fertilizer if they are to be used for agriculture.

Ferralsol is the predominant soil type existing on Idah and surrounding communities.

3. Nature and Causes Of Erosion

3.1. Types of Erosion

The Northern Rivers Catchment Management Authority (n.d.) opined that erosion is a naturalprocess but is often intensified by human land use practices.

There are many kinds of erosion; sheet and rill erosion, gully erosion, stream bank/bed erosion and wind erosion are the primary concerns. Each of these types of erosion involves the detachment and transport of soil and downstream/downwind deposition of sediment. (Gaffney & Dickerson, 2005).

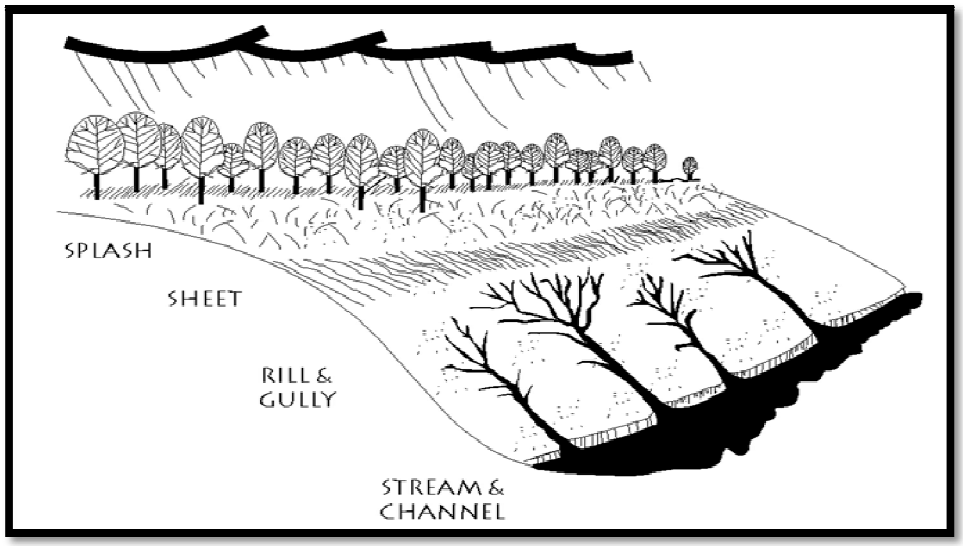

Figure 1: Illustrates the Gradual Development of Erosion on a Sloping Site
Bin (2016) Identified the Following Categories of Erosion

3.1.1. Hydraulic Erosion

Hydraulic erosion, consisting of raindrop, surface, rill and gully erosion,

3.1.2. Wind/Artificial Erosion

Wind/artificial erosion, caused by human activity, frequent quarrying, mining and crop cultivation on slopes, and,

3.1.3. Gravitational Erosion

Gravitational erosion features include debris flow, collapse, landslide and tunnel erosion. The United States Department of Agriculture (2008) categorized erosion into the following types;

3.1.4. Sheet and Rill Erosion

Sheet erosion is the uniform movement of a thin layer of soil from sloping, bare, unprotected land. Falling raindrops detach soil particles which go into solution as runoff occurs. Detached particles are transported down slope/grade to a point of deposition. Rills form with longer, harder rains when runoff volumes accelerate. Erosion increases as slope/grade becomes steeper and with longer slope length.

3.1.5. Gully Erosion

Rill erosion evolves into gully erosion as runoff increases, from one heavy rain or a series of storms over time. A gully is generally defined as a scoured-out area that is not crossable with tillage or grading equipment.

3.1.6. Streambank and Streambed Erosion

This type of erosion is the scouring away of stream banks. Degrading or downcutting streambeds and/or repeated high flows for extended duration causes bank erosion. Streambank and streambed erosion are a significant contributor of sediment loads to surface water resources.

3.1.7. Wind Erosion

Wind erosion is similar to sheet erosion in that detachment, transport, and deposition of soil particles occur, except that wind is the transportation mechanism rather than water.

The Northern Rivers Catchment Management Authority (n.d.) in its study identified Splash erosion and Tunnel erosion.

Splash erosion has been described as the first stage of the erosion process. It occurs when raindrops hit bare soil. The explosive impact breaks up soil aggregates so that individual soil particles are splashed onto the soil surface (Ogundare, 2016). The splashed particles can rise as high 60cm above the ground and move up to 1.5 metres from the point of impact. The particles block the spaces between soil aggregates, so that the soil forms a crust that reduces infiltration and increases runoff.

Tunnel erosion occurs when surface water moves into and through dispersive subsoils which are poorly structured and can erode easily when wet. The tunnel starts when surface water moves into the soil along cracks or channels or through rabbit burrows and old tree root cavities. Dispersive clays are the first to be removed by the water flow. As the space enlarges, more water can pour in and further erode the soil. As the tunnel expands, parts of the tunnel roof collapse leading to potholes and gullies.

For the purpose of this report, erosion types shall be categorized under four headings, namely, gully, sheet and rill, streambank/bed and wind types.

3.2. Causes of Erosion

Adediji & Ibtoye (2013) and Ibitoye & Adegboyega (2012) observed that causative agents for erosion spread can be broadly categorized into two, i.e., natural and manmade. Natural causes include the physiographic setting and geology of the area. Julius & Adekunle (2015) opined that physiographic features include the climate, drainage pattern, topography and vegetation, while site geology refers to the rock formation and soil pattern of the area. Manmade sources of erosion generally refer to all human activity that tends to threaten the ecosystem. They include, among others indiscriminate land use, overgrazing, mining and quarrying, bush burning, poor or lack of drainage, indiscriminate waste disposal, etc. In most cases, a combination of most of these factors is responsible for the occurrence of erosion on any typical site.

4. Materials and Methods

Data for the study were obtained through site visits to observe critical cases, questionnaire administration and oral interviews. Through a combination of purposive and random sampling techniques, respondents were selected to provide responses to enquiries presented in a well-structured questionnaire on the causes of erosion and intervention efforts undertaken within the areas.

A total of seventy-eight (78) responses obtained from residents in the most critical areas in both communities were analysed using bar charts, percentiles and mean ranking. The breakdown consisted of thirty-six (36) respondents from Efon-Alaaye and forty-two (42) from Idah.

The objective of the analyses is to compare the erosion features in both communities with regard to the types of erosion in the communities, factors responsible for their occurrences and intervention efforts conducted to control their spread.

5. Results and Discussion

5.1. Nature and Types of Erosion in Efon-Alaaye and Idah

As shown in the preceding sections, erosion manifests itself in different forms. Attempts were made to identify the types of erosion predominant in the two communities. For the purpose of the analysis, erosion types were categorized under four headings, namely, gully, sheet and rill, stream bank/bed and wind types.
Figure 2 below presents a chart comparing the erosion types in the two communities.

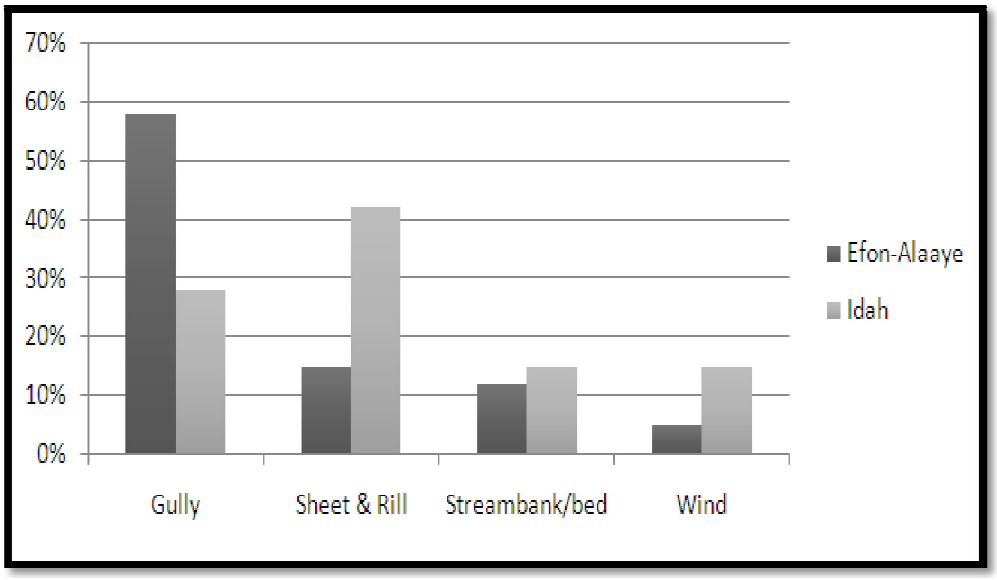

Figure 2: Comparison of Erosion Types in Efon-Alaaye and Idah
Source: Field Survey (2017)

From the responses obtained as analysed in Figure 2 above, the most predominant erosion type in Efon-Alaaye is gully erosion which constitutes 58% of the report, followed by the sheet and rill type, 15%, while streambank/bed type constituted 12% of the cases and wind erosion least of all at 5%. In Idah, sheet and rill erosion represent 42% of the cases of erosion observed, gully erosion constitutes 28% and stream bank/bed and wind erosion both constitute 15% each.
In comparing the two towns, gully erosion cases in Efon-Alaaye far supersede that of Idah, whereas sheet and rill cases are more predominant in Idah. Although relatively less occurring, streambank/bed and wind erosion is more in Idah than in Efon-Alaaye.

5.2. Causes of Erosion in Efon-Alaaye and Idah

Respondents were implored to indicate their opinions using a 5-point Likert scale; 1 representing the least significant factor and 5 representing the most highly significant factor, as shown below.

Factor Responsible for Erosion	Mean Scores		Average
	Efon-Alaaye	Idah	
Uncontrollable natural forces	4.58	3.65	4.12
Indiscriminate land development and use	2.88	4.67	3.78
Indiscriminate waste disposal	3.02	3.97	3.50
Poor town planning regulation	2.72	4.03	3.38
Lack/non-availability of adequate drainage	2.48	4.01	3.25
Poor vegetation cover	2.46	3.56	3.01
Overgrazing	1.62	2.81	2.22
Bush burning	2.04	1.85	1.95

Table 1: Causes of Erosion in Efon-Alaaye and Idah
Source: Field Survey (2017)

Respondents reported that in Efon-Alaaye, uncontrollable natural forces constitute a very highly significant cause of erosion with a mean score of 4.58. Indiscriminate waste disposal, with mean score of 3.02, indiscriminate land development and use (mean = 2.88) and poor town planning regulation (mean = 2.72) are perceived to be significant factors causing erosion spread, while lack/non-availability of adequate drainage (mean score of 2.48), poor vegetation cover (mean score of 2.46) and bush burning (mean = 2.04) are considered less significant factors and overgrazing with a mean score of 1.62 is considered to be the least significant factor causing erosion. In Idah, indiscriminate waste disposal with mean score of 4.67 is considered very highly significant. Other very significant factors are lack/non-availability of adequate drainage (mean = 4.03), indiscriminate land development and use with mean of 4.01, and poor town planning regulation (mean = 3.97). Also, of high significance are factors like uncontrollable natural forces (mean of 3.65), poor vegetation cover (mean = 3.56) and overgrazing (mean = 2.81), while bush burning with a mean of 1.85 is considered as less significant.

5.3. Erosion Prevention Initiatives in Efon-Alaaye and Idah

Concerted efforts have been executed to prevent erosion damage in Efon-Alaaye and Idah. Four groups were identified as stakeholders in ensuring erosion control measures are put in place to control the spread, these are individuals, i.e.,

- private owners of properties in erosion prone areas,
- the community, which are sometimes mobilized to pull resources together to control the spread,
- the government (federal, state and local) and,
- international agencies (e.g. USAID, DFID, World Bank, etc.).

Respondents assessed the performance each of these groups. Figure 3 presents the respondent's opinions on the contribution of these groups to erosion prevention and control initiatives in the two towns.

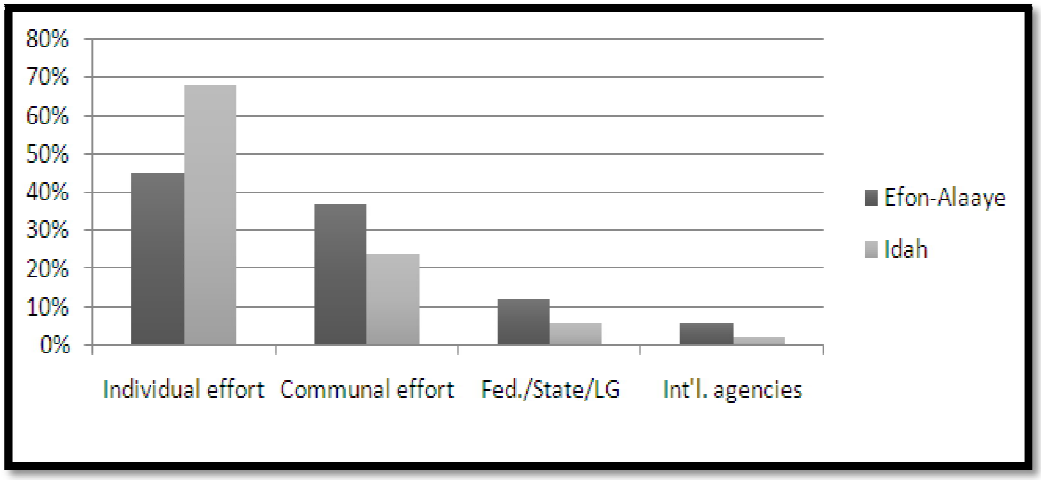

Figure 3: Interventions for Erosion Prevention and Control in Efon-Alaaye and Idah
Source: Field Survey (2017)

Efforts to control erosion spread in the two towns have been majorly undertaken by property owners as shown in Figure 3. In Efon-Alaaye, 45% of intervention efforts were carried out by individuals while communal efforts were employed in 37% of the cases. Government intervention was just 12% and international agencies were 6%.

In Idah, individual efforts predominate at 68%, communal efforts at 24%, government intervention recorded a poor 6% and international agencies were involved only in 2% cases.

The above analyses present many welfare implications; the erosion problem will certainly continue and worsen if the current trend is not reviewed.

6. Conclusion and Recommendations

The study has revealed that natural features like geology, surface slope, subsurface structural trend and vegetation patterns have significant influence on the erosion crisis in both Efon-Alaaye and Idah. Poor town planning, indiscriminate construction practice and poor waste management have also contributed significantly.On-site evaluations of conditions around the two towns were carried out on severely affected locations. In almost all cases, the gradual process leading to what currently exists was only controlled by individuals whose property is at risk with very little or no intervention by statutory agencies. However, these individual interventions are grossly inadequate to curtail the powerful effect of the erosion. In many cases, especially in Idah, property owners and occupiers have had to abandon their properties when the erosion damage became life threatening.Over time, the cases of sheet and rill erosion were carelessly managed and have developed into serious gullies scattered around the town.

The input of Government and other agencies responsible for rural and urban infrastructural development efforts have largely been unimpressive. While Efon-Alaaye witnessed some intervention from these agencies in the past, their impact in Idah has been extremely poor.

Environmental degradation is bound to continue to threaten us. This reality ought to advise us not to degrade but rather to embrace environmental improvement options.

Thus, the following economic measures are proposed to private residential owners and farmers within the study areas: provision of buffer strips, crop rotation, conservation tillage, cultivation of cover crops, contour bounding, mulching, cultivating perennial crops to avoid frequent soil disturbances, reforestation efforts, strip farming, vegetating water ways, terracing, planting of trees to serve as wind breakers in wind erosion prone areas alone and the planting of grasses over eroded surfaces in all areas as they have the powers to break the impact of rainfall at ground level and adoption of environmental education among others.

There is urgent need for the enforcement of laws to guide the conduct of man in his interactions with the environment. Such laws should spell out in part to encourage forest regeneration and also the associated penalties for the defaulters. Such penalties for defaulters should cover reasonable fines and /or jail terms if necessary.

The onus rests on the government to use the political will to put into operation erosion control interventions in the study area especially along roads and foot of the hills to reduce this menace.

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