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Causes, Effects and Potential Health Risk of Gully Erosion Menace in Calabar Municipal: Residence Perspective

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Abstract

Purpose: The present study sought to investigate the potential health risk associated with gully erosion in addition to environment effect which is commonly investigated upon by researchers. The prevalence of gullies in Calabar Municipal was also a unique factor in this study.

Methodology: Data were gathered from both primary and secondary sources. The main instrument for gathering primary data was the questionnaire design by the researcher and validated with a reliability coefficient of .76. Descriptive statistics of mean, and graphs were used to answer the research questions while the hypotheses were tested using dependent t-test at .05 level of significant.

Findings: The findings revealed that human activities such as farming, intensive and short-period rainfall, improper land use, improper irrigation design, improper discharge of water in the channels¸ soil characteristics where the cause of gully erosion in the study area; while open grassing was not part of the cause of gully erosion in the study area. it was further discovered that effect of gully erosion included, Loss of farmland, threat to vegetations and biodiversity, loss of properties, increase poverty and famine, expansion of degraded land, increase surface runoff, low agricultural production, environmental destruction with significant health implication $p<.00<.05$.

Unique Contribution to Theory, Practice and Policy: The study concluded that there is need for adequate funding, committed political will (not lip-service) and well-articulated sustainable policies are required in other to solve the problems of gully erosion in Calabar municipal.

Keywords: *Gully Erosion, Causes, Effects, Health Risks*

INTRODUCTION

Our diverse and interdependent world are plague with diverse environmental problems among which includes global warming, pollution, escalated desertification, oil pollution, food shortage, soil and land degradation, massive extinction of flora and fauna, wanton destruction of our forests, burning of fossil fuels, gas flaring, flooding, erosion and other unwholesome activities which have overtime significantly defaced the earth's surface of which soil is the major constituent. Among other natural resources found on the earth surface, soil is one of the most important natural resource available everywhere. This is because, soil is the major determinant of physical activities on the earth surface; for instance, farmers consider its types, fertility and texture among others for site suitability in lieu of crops. Despite the paramount important of soil to the well-being of the physical and socio-economic activities of man, erosion and other man-made activities listed above remains a threat to soil quality and quantity (Mbaya, 2013 and Okpiliya, Itu, Njoku, and Erahabor, 2017).

One of the surface processes that sculpture the earth landscape is the soil erosion, and this constitutes one of the global environmental problems. It is perhaps the most serious mechanism of land degradation in some part of Nigeria. Most recently, soil erosion has reached a very threatening height in Nigeria and Calabar, Cross River State in particular. Loss of topsoil under the action of water or wind is referred to as soil erosion. During rainfall or flooding, Water runoff carries the topsoil away; thereafter, the loss of topsoil reduces fertility because as the soil becomes denser and thinner, it is less penetrable by growing roots and may become too shallow for them; the capacity of soil to retain water and make it available to plants is reduced; and plant nutrients is wash away with soil particles. Subsequently, the washing away of the top soil leads to the formation of sheets, rills and gullies. Sheet erosion is the first stage in the process of gullies formation, it occurs when soil particles are easily transported in a thin layer, or sheet, by flowing water. If allowed unchecked, it concentrated and subsequently gain velocity, cutting rills and gullies as it detaches more soil particles. As the erosive force of flowing water increases with slope length and gradient, gullies become deeper and deeper channels and finally, it gorges (Poessen, 2011).

As a result of the threat post by gully erosion, it has become a subject of discussion among soil scientists, geographers, geologists, engineers and social scientist. As gully continue to cut with the depth of more than 30 centimetres deep into the ground, it becomes more visible and it leaves remarkable impression on the surface of the earth. Rădoane and Rădoane (2017) noted that definition of gully erosion landforms has always been a controversial issue, depending on the scientific field approaching the subject. For the agronomists and land improvement professionals the main focused is on landforms occurring in noncohesive rocks (i.e., ravines), for foresters and forest soil preservation professionals their interest is on gullies occurring in cohesive rocks (i.e., torrents). For the purpose of this study, gully erosion is defined as the terminal phase of a four-stage erosion process involving splash, sheet, rill, and gully. It is also defined as steep-sided channels, often with steeply sloping and actively eroding head scarp landscape usually ranging from 30cm to 30m deep, caused by the intermittent flow of water, usually during and immediately following heavy rains (Poessen, Nachtergaele, Verstraten, and Valentin 2003, Amangabara, 2012). it 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. Gullies can be active (actively

corroding) 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 passage

The datum of gully-erosion as a pronounced environmental problem in Calabar is worthy of note. With the population growth of Calabar, more houses have been built leading to high level of storm collection along unpaved channels, which gradually leads to gully-erosion. There has also been the question of exposed land surface owing to clearance for construction and excavation of sand by the residents for buildings even along the same gully route. Gully erosion is one of the most disparaging soil/land erosion processes; within a short period of time the topsoil and the underlying unconsolidated rock substrate are removed by runoff, resulting in the formation of a steep-sided channel deeper than 2 m, with an abrupt gully head-cut and numerous thresholds in the channel thalweg. This landform is known as a ravine (gully).

Gullies could be well-thought-out as signals of disturbances and accelerated erosion brought about by climate or land-use change. Abdulfatai, Okunlola, Akande, Momoh, and Ibrahim (2013) maintained that in the past, gully processes had happening even without human influence or interference according to research, hence concluding that the causes of gully erosion are poorly understood but the processes and factors involved in its growth and degradation are well-known. Putting the view of Abdulfatai, et al (2013) and Poesen et al. (2003) together, it can therefore be said that, the phenomenon of gully erosion is either naturally induced or artificially-induced, or both. Naturally induced gully erosion has been identified as the most threatened environmental hazards in the Nigeria. Available literatures Albert, Samson, Peter, and Olufunmilayo, (2006) 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.

Problem Statement

Bank gullies and large gullies have received great attention from researchers with respect to their morphology, factors influencing past and current head cut retreat. Data acquisition, processing and management using GPS, GIS and remote sensing has had a profound consequence on the studies of Ephemeral Gullies. These equipment's and techniques have proved very useful in ascertaining gully morphology, volumetric computations, head cut and side walls retreat rates etc. However, it is not possible to have a common and systematic compilation of the morphological characteristics, causative parameters including topography, soil types, land use and hydrology for all the gullies in a community, state or a Country as these parameters will vary from place to place and their effects will be different for different locality. Different methods have been adopted for gully erosion control in various studies, there is still need for more research on the effectiveness and cost efficiency of gully control measures adopted in various areas. control of the gully erosion site showed that the control measures did not work because new gullies developed in the area leading to further degradation and more land loss than the original problem. A lot can be learned from past failures when applying existing gully control techniques and there is need to document these studies and the result thereof. The emergence and stretch of gully erosion in Calabar Municipality had reached a very threatening dimension, and the displacement associated with gully erosion in the area calls for urgent attention and intervention from the government, cooperate organizations,

nongovernmental organization, religious and traditional institutions, individuals etc. to tackle the current expanse before it sweeps major fragments of the municipality.

Objective of the Study

The main objective of the study is to examine the causes, effects and health implication of gully erosion menace in Calabar Municipal of Cross River State. in specific terms, the study sought to;

1. Determine the prevalent causes of erosion in Calabar Municipal
2. Determine the prevalence effect of gully erosion in Calabar Municipals
3. Assessed the potential health risk of gully erosion in Calabar Municipal

Research Question

The following research questions were formulated to guide the study

1. What are the prevalence causes of erosion in Calabar Municipal?
2. What are the prevalence effect of gully erosion in Calabar Municipal?
3. Is there significant health risk post by gully erosion in Calabar Municipal?

Statement of Hypothesis

1. There is no significant health risk post by gully erosion in Calabar Municipal

Study Area

Municipality of Cross River State city lies geographically along longitudes $08^0$18'E and $08^0$26'E Greenwich meridian and latitudes $04^0$55'N and $04^0$58'N of the equator. The city is located is bounded in the North by Odukpani and Akamkpa Local Government Areas, Great Kwa River by the East and Calabar River and Calabar South Local Government by the South. Calabar municipality has an area of 331.551 square kilometres. During the last population census as at 2006, Calabar municipality has a population of 179,392.

Calabar Municipal have a tropical monsoon climate with a lengthy wet season spanning ten months and a short dry season covering the remaining two months. The harmattan, which significantly influences weather in West Africa, is noticeably less pronounced in the city. Temperatures are relatively constant throughout the year, with average high temperatures usually ranging from 25 to 28 degrees Celsius. There is also little variance between daytime and night-time temperature, as temperatures at night are typically only a few degrees lower than the daytime high temperature. Calabar averages just over 3,000 millimetres (120 in) of precipitation annually.

Calabar Municipality is characterized by a double maxima rainfall regime which occurs in June and September. It has an annual rainfall of 3000mm and a harmattan wind blowing over the area in December and January respectively. The annual temperature is 280 C with a high evapotranspiration and an average humidity of 90%.

The soil is composed of coastal plain sand which belongs to tertiary deposits. The alluvial deposits are used for construction with light brown and grey colour. According to Cross River Basin Authority Cross River State Hydrological Province are grouped into four units namely: basement and intrusive rocks, sandstone, shale and alluvial deposits. The lithology is characterized by an underlying aquifer. The surface and ground water bodies are recharged by high precipitation. The

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aquifer is confined with few aquicludes made up of silt, clay and sandstone. The soils of the area are derived from coastal plain parent materials overlying the tertiary coastal plain sand geological formation usually referred to as 'acid sand' and the soil type is classified as Kandiudults according to USDA soil Taxonomy (AkpanIdiok et al., 2012).

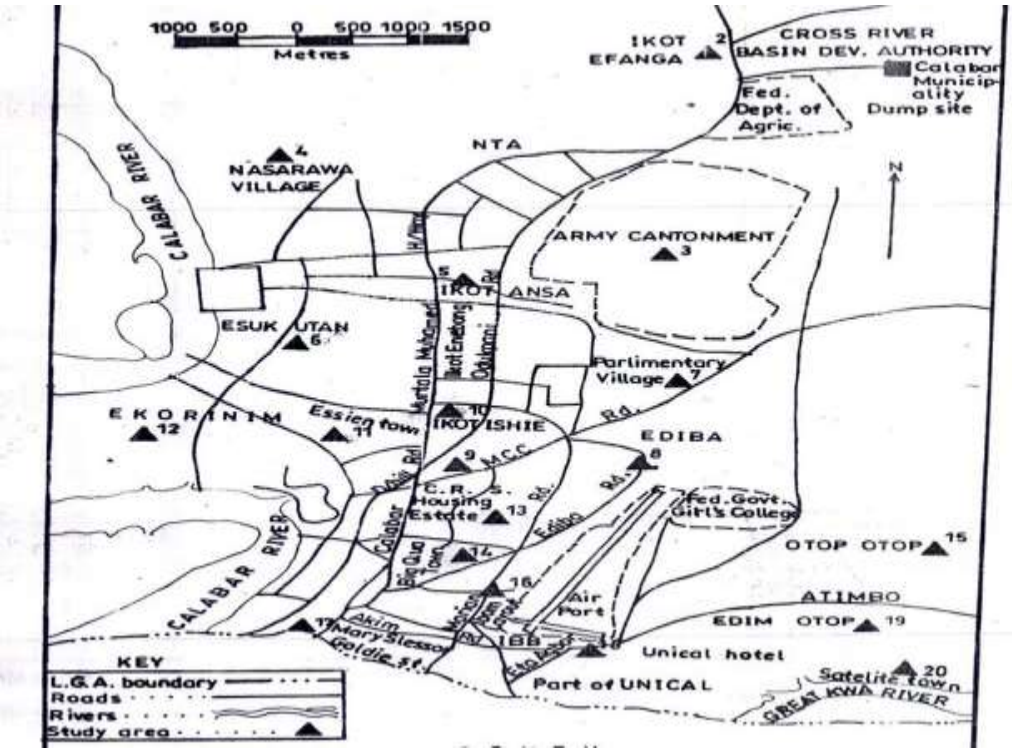

Figure 1: Study Area

LITERATURE REVIEW

Gully erosion is an advanced stage of rill erosion where surface channels are eroded to the point where they become a nuisance factor in normal tillage operations. There are farms that are losing large quantities of topsoil and subsoil each year due to gully erosion. (http://en.wikipedia.org/wiki/soilerosion). Surface water runoff, causing gully formation or the enlarging of existing gullies, is usually the result of improper outlet design for local surface and subsurface drainage systems. The soil instability of gully banks, usually associated with seepage of groundwater, leads to sloughing and slumping (caving-in) of bank slopes. Such failures usually occur during rainy seasons when the soil water conditions are most conducive to the problem (and Eng, 2012).

Studies and research on gully erosion are necessitated by the threat and hazard associated with it. Over the years, study on the gully initiation, morphology and control have been conducted in difference areas Calabar municipality included. Bank gullies and large gullies have received great attention from researchers with respect to their morphology, factors influencing past and current

head cut retreat (Oostwould Wijdenes, Poesen, Vandekarckhove, and Ghesquiere 2001; Martinez-Casanovas, 2003, and Martinez-Casanovas, Ramos, and Poesen, 2004)

According to Mbaya, (2013), the World Bank Country in 2009 reported that gully erosion is one of the top five hazards threatening Nigerian environment. Other main environmental degradation according to world bank as recorded by Agagu (2009) are; soil degradation and loss, water contamination and deforestation. Analysis of the mentioned problem indicate that gully erosion is the subset of each of them. Due to soil texture and structure in Calabar municipality, gully erosion is active and at alarming rate. Mbaya (2013) maintain that other significant characteristics of the area include slopy land, rainfall; Human activities such as deforestation, over grazing, excessive cultivation, bush burning and construction works amongst others. Gully erosion occurs where surface water flow has become trapped in a small concentrated stream, and begins to erode channels in the ground surface, making it wider and deeper. Uncontrolled progress of gullies results in 'bad land' topography and destroys the ecology and economy of the affected areas (Cavey, 2006).

Amadi et al (2014) carried out a study on the effects of Agulu Nanka erosion (one of the most appalling gully devastations in Nigeria) on the socio-economic life of Agulu and Nanka communities of Anambra state. Result from the study showed that 35 percent of the sampled respondents were displaced by the landslide, 2 domestic rivers silted, 235 Hectares of farmland gulped, 80 houses collapsed and 13 rural roads cut off. Aliyu and Ray (2014) also assessed the socio-economic effects of gully erosion on land-use in Gombe Metropolis, Gombe State, Nigeria. The researchers obtained data from field administration of questionnaires and focus group discussion. Their findings showed that several buildings, farmland/plots and other properties worth millions of Naira as well as human lives were lost due to effect of gully erosion in the study area. Abdulfatai, Okunola, Akande, Momoh and Ibrahim (2014) also emphasized the causes and impacts of gully erosion, case studied in Edo state, Nigeria. They reiterated that many lives have been lost as a result of the problem of gully erosion. Some fall into the gullies and sustain various degree of injury while some instances were also reported where people drowned in some of the gully sites. About 23 people were reported in the past few years to have lost their lives in a single event of gully activity in Ibori, Ugbalo, Evou-Eguare, Idogalo and Oludide communities of Edo state, Nigeria.

In China, Ming (2016) performed a research on partitioning the contributions of sheet and Rill erosion. They made use of environment radio-nuclides, as sediment 51 tracers on small erosion plots. Their result showed that both rill erosion and sheet erosion were responsible for the changes in sediment quality being eroded away. In Nigeria, Nest (2011) assessed the extent of Gully erosion in South-Eastern Nigeria using questionnaire. He noted that gully erosion prone areas have become bad land environments as people are usually forced to relocate in Gully erosion.

In a study on soil erosion control and damage costs in Nigerian small farms: implications for farm growth and sustainability, Chukwuemeka (2009) tried to establish a relationship between soil erosion and reductions in crop value and also sought to establish a policy guiding document that would assist policy makers in economic development. The study used an empirical assessment to determine the impact of soil erosion on farm land crop production. The study area was Enugu North Local Government Area (LGA), Enugu State, South Eastern Nigeria. Randomly selected

from the wards followed by a random sample of 12 farmers from each community to make a total of 72 farmers. Structured questionnaires, personal interviews and participant observation were used to collect data. The researcher recommended that designated monitoring stations should collect information regularly on average small farm owners and corporate companies that are engage in farming as the basis of advice on level of targeted assistance required by farmers in specific locations.

METHODOLOGY

Data used in decision making pertaining to this study were derived from primary and secondary sources, while the study was primarily a survey type. The primary data which was used for data analysis were obtained through questionnaire only. The questionnaire was administered to people living in the communities (living around the gully sites). The relevant literature reviewed on the subject matter – published and unpublished books, textbooks, maps and photographic forms the secondary data used in the study. There are several gully erosion sites within the different land use in the study area. However, the major ones which have been measured in terms of severity, depth and other factors by Itu, Erhabor, and Njoku (2017) were of interest to the current researcher. Table 1 shows the details of those gully erosion site.

Table 1: Gully Erosion Characteristics in the Metropolis

S/N	Ward/LGA	Gully erosion site	Coordinates of the site	Year and Area Coverage	Gully Depth
1.	Ward 1/Calabar South	Atakpa gullysite	4° 57' 45''E 8° 19' 12''E	2004-3650.1 sqm 2010-13911 sqm 2015-16087 sqm	17 metres
2.	Ward 2/Calabar municipal	Edim Otop	4° 57' 46''E 8° 21' 23''E	2004-14613 sqm 2010-15735 sqm 2015-20229 sqm	22 metres
3.	Ward 3/Calabar municipal	Nyahasang	4° 58' 45''E 8° 21' 30''E	2004 – 0 sqm 2010-15735 sqm 2015-18735 sqm	27 metres
4.	Ward 7/Calabar Municipal	Ikot Anwatim	5° 0' 12''E 8° 19' 57''E	2004-21973 sqm 2010-120565 sqm 2015-63098 sqm	37 metres
5	2015-63098 sqm	Ikot Uduak	5° 08' 8''E 8° 21' 2''E	2004-16610 sqm 2010-20545 sqm 2015-115317 sqm	23 metres
6	Ward 10/Calabar Municipal	Mbacoco	5° 3' 33''E 8° 21' 44''E	2004-9611.4 sqm 2010-19981 sqm 2015-57008 sqm	31 metres

Source: Itu, Erhabor, and Njoku (2017)

For questionnaires administration, only the adult resident within each gully erosion area who have spent at least a decade in the community were used for the study. 10% of the population is considered as the sampling size for the different land-use areas within the metropolis, random sampling techniques were used to determine the individual respondent.

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RESULT AND DISCUSSION

Prevalence Causes of Erosion in Calabar Municipal

Graph 1 present the result of the results of the questionnaires administered residents within the vicinity of the sampled gully sites. The findings showed that most of the gully site emerges over ten years prior to this study, while some, though severe emerges in less than ten years. However, the respondent feels that, human activities such as farming, intensive and short-period rainfall, improper land use, improper irrigation design, improper discharge of water in the channels¸ soil characteristics where the cause of gully erosion in the study area; while open grassing was not part of the cause of gully erosion in the study area.

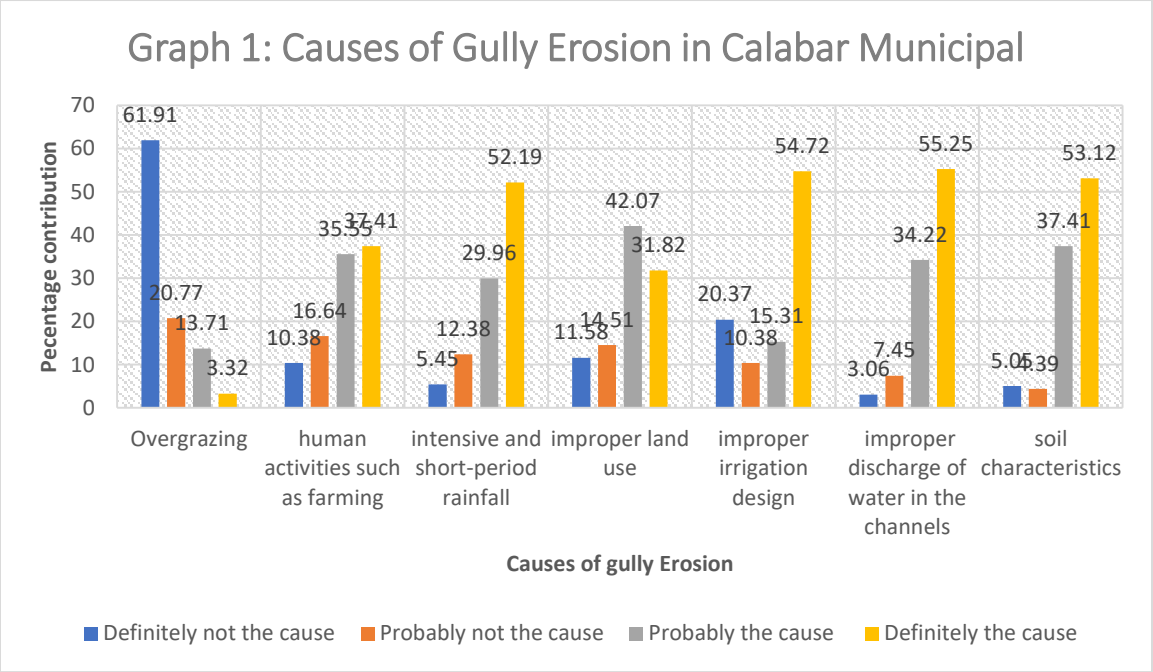

Figure 2: Causes of Gully Erosion in Calabar Municipal

From the resident view, open grassing does not contribute to emerging and escalation of gully erosion in the study area. Succinctly, it is observed that open grassing is rarely practice in Calabar municipality, as livestock farming is intermittently practice in this area. It is also worthy of note that the effect of open grassing may be overlooked due to the peculiar characteristics of people living in Calabar and its environment. With this item, majority of respondent (61.91%) definitely disagree that open grassing is the cause of gully erosion in the Calabar. Conversely, human activities such as farming unanimously agreed by the respondents as one cause of gully erosion in the study area. As opposed to open grassing, must of the residents engaged in farming as a means for survival. No doubt, activities such as tillage, and other land use increase run off thus washing away of the top soil which is always to root of gully erosion. It is also noted the amount and intensity of rainfall result in excess run off vis-à-vis gully erosion. The respondent observed that intensive rainfall contributed to formation of gully erosion (52.19%). All the factors responsible for gully erosions as seen in the study suggested that menace of gully erosion is controllable if

both the government and the resident jointly tackle the incident from inception before escalation. This finding of the study was fully supported by previous studies such as Mbaya (2013); Favis-Mortlock (2005); and Poesen, (2011).

Effect of Gully Erosion in Calabar Municipal

Table 1 present the results of the questionnaires administered the resident in Calabar Municipals withing the vicinity of the gully sites the effects of gully erosion. The findings showed that gully erosion has caused over Loss of farmland, threat to vegetations and biodiversity, loss of properties e.g houses, bridges, roads etc, increase poverty and famine, expansion of degraded land, increase surface runoff, low agricultural production, increase migration from village to cities, increase socio-economics problems, environmental destruction among other problems. The respondent further revealed that over the years, houses, roads and bridges/ culverts etc have all been destroyed by gully erosion, additionally, land values have been depreciated as some people lost their agricultural and/or residential lands dues to gullies. For most families in in the communities understudied, land has remained a traditionally inheritable commodity, and is passed on from one generation to another. The problem with gully erosion is it's difficult to fully reclaim the lost land.

Table 1: One-Sample Test Showing Significant Effect of Gully Erosion in Calabar Municipal

Test Value = 3

s/n	Effect of gully erosion	N	Mean	Std. dev.	t	df	p-value	Remarks
1	Loss of farmland	751	4.75	.538	89.154	750	.000	Sig. Effect
2	Threat to vegetations and biodiversity	751	4.62	.644	68.981	750	.000	Sig. Effect
3	Loss of properties e.g houses, bridges, roads etc.	751	4.28	.659	53.268	750	.000	Sig. Effect
4	Increase poverty and famine	751	4.27	.899	38.698	750	.000	Sig. Effect
5	Expansion of degraded land	751	4.34	.881	41.628	750	.000	Sig. Effect
6	Increase surface runoff	751	4.05	.768	37.605	750	.000	Sig. Effect
7	Lower quality and quantity of water	751	4.28	.738	47.635	750	.000	Sig. Effect
8	Low agricultural production	751	4.28	.675	51.772	750	.000	Sig. Effect
9	Increase migration from village to cities	751	4.44	.971	40.662	750	.000	Sig. Effect
10	Increase socio-economics problems	751	4.49	.803	50.936	750	.000	Sig. Effect
11	Environmental destruction	751	4.14	1.041	29.933	750	.000	Sig. Effect

All the variables conceptualise by the researcher as being the effect of gulley erosion were statistically significant at .05 level. This signify that all the mentioned items are the significant effect of gully erosion in Calabar Municipal.

Significant Health Risk Post by Gully Erosion in Calabar Municipal

Gully erosion and it associated effect further have a negative effect to human health. Although there is no direct health related impact, however, the associated socio-economic, cultural, environmental etc effect of gully erosion relatively affects the health (which is not a mere absent of disease) of the citizen. The result of the analysis presented in table 2 using the scores derived from the administered questionnaire indicate that there is a significant health effect of gully erosion to the community.

Table 2: One-Sample Test Showing Significant Effect of Gully Erosion in Calabar (T-Value = 15)

Variable	Mean	S	N	t	df	p-value	Remarks
Effect of gully erosion	19.15	1.169	751	97.338	750	.000	Sig.

Result of the analysis in table 2 is significant at .05 level with 750 degrees of freedom and the t-value of 97.338. From the instrument, it was gathered that gully erosion contributed to ecosystem degradation leading to biodiversity loss and, can pose considerable threats to human health. Biodiversity system which is often destroyed by gully erosion is responsible for supporting human and societal needs**,** including food and nutrition security, energy, development of medicines and pharmaceuticals and freshwater, which together underpin good health (World health organisation (WHO), 2015). Additionally, many lives have been lost as a result of gully erosion, either by being drowned by gully water, falling inside the gully or seriously injured in the gully site. Gully erosion also increases the amount of dust carried by wind. Dust particle size is a key determinant of potential hazard to human health. Particles larger than 10 μm are not breathable, thus can only damage external organs – mostly causing skin and eye irritations, conjunctivitis and enhanced susceptibility to ocular infection. Inhalable particles, those smaller than 10 μm, often get trapped in the nose, mouth and upper respiratory tract, thus can be associated with respiratory disorders such as asthma, tracheitis, pneumonia, allergic rhinitis and silicosis. However, finer particles may penetrate the lower respiratory tract and enter the bloodstream, where they can affect all internal organs and be responsible for cardiovascular disorders. A global model assessment in 2014 estimated that exposure to dust particles *(escalated by gully erosion*) caused about 400 000 premature deaths by cardiopulmonary disease in the over 30 population (Giannadaki, et al., (2014) additionally, some infectious diseases can be transmitted by dust.

Conclusion

In Calabar municipal and its environments, Gully erosion has been on increased and advanced at alarming rates in the past few decades. This study discovered that gully menace resulted inharships, miseries, loss of houses, and other serious health implications including lost of life and other valuable properties. The conditions become deteriorated with the rise in urban land due to population increase. With the rise of deforestation for agricultural, residential and industrial

structures, the magnitude and frequency of gully erosion have been on the increase. This is in response to high storm water runoff and channel concentration, leading to more destruction of lives and properties as observed in the study area. Adequate funding, committed political will (not lip-service) and well-articulated sustainable policies are required in other to solved the problems of gully erosion in Calabar municipal.

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