A SURVEY OF GULLY EROSION SITES IN CALABAR METROPOLIS, CROSS RIVER STATE- NIGERIA

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Abstract
The study assessed and severity of gully erosion in Calabar Metropolis. Geographic Information System (GIS) and cross sectional survey were employed to identify spatial location of gully sites as well as understand residents' perception of the gullies, Data were also collected on the gully parameters (depth, length) using measuring tape. A total of 383 copies of structured questionnaires were distributed and 382 were retrieved. The study revealed that 35 per cent of the sampled population attributed the cause of the gullies to deforestation, 30 per cent claimed that poor drainage system was the root cause, 22.5 per cent traced it to urbanization while the remaining 12.5 per cent linked it to heavy rainfall. The result also revealed that the largest gully site was that of Ikot Awatim which covered a total of 65089sqm with 59m depth followed by Mbaccoc with a dimension of 59112sqm and depth of 34m. Rapid urbanization, inadequate drainage systems and improper land use practices were identified to exacerbate the problem of erosion perturbation, leading to significant environmental degradation and posing serious threats to infrastructure and human settlements in the area. The study recommends improved drainage systems and sustainable urban planning practices to mitigate future erosion risks.

Keywords: Calabar Metropolis; Urbanization; Drainage Systems; Gully Erosion

Introduction

Erosion is the process by which soil and stones of various sizes, including other surface materials are driven away and transported by water, wind, or ice depending on the geographical location. It is a significant environmental issue leading to land degradation, loss of fertility, and ecosystem disruption (Hossain, Krupnik,Tiimsina, Mahboob, Chaki, Farooq,& Hasanuzzaman 2020). The main types of erosion include water erosion, wind erosion, and glacial erosion. Water erosion occurs when rainfall or surface runoff dislodges and transports soil particles. Subtypes include sheet erosion, where thin layers of soil are removed, rill erosion, characterized by small channels formed by water (Peter, Oruk, Brian, Benjamine & Chritopher, 2023), and gully erosion, which involves the creation of large, deep channels by intense water flow (Beilicci, & Beilicci, 2024). Wind erosion is prevalent in arid regions where strong winds blow loose, dry soil, (Wei, Wu, Wang, Wu, Li, Hu, & Dashtseren, 2023). Human activities, such as unsustainable agriculture and urbanization, often exacerbate the severity of erosion process (Prăvălie, 2021).

Gully erosion is considered the most threatening form of erosion globally due to its rapid and destructive nature, causing severe land degradation and loss of fertile topsoil. It is particularly problematic in developed countries like U.S.A. and others (Shaheb, Venkatesh, & Shearer, 2021), in Australia (Dadzie, Egedi, Stewaft, Eldridge, Molesworth, Singh, & Munoz-Rojas, 2023), and in Europe, (Ferreira,

Keesstra, Destouni, Solomun, & Kalantari 2024). Gully erosion is so threatening in view of its capacity to advance rapidly (Akanwa, Iko-ojo, Ezeomedo, Ikegbunam, Igwe, Muoghalu,& Obidiegwu, 2024).

In developing countries, especially in Africa, countries like Nigeria, Ethiopia, and Uganda, gully erosion is prevalent in areas where deforestation, overgrazing, and unsustainable agricultural practices are predominant. Food and Agricultural Organization (2019) decried the loss of 1.3 million hectares of land due to soil degradation. Soil susceptibility to erosion is facilitated by soil texture, bare land surface, slope and areas of subsidence or gully (Egbai, Ndik, Uquetan, Ewa, Okeke, 2011). And once the conditions like loosed soil texture, bare land surface, and sloppy land terrain, are prevalent, soil loss and gully initiation become inevitable in the event of heavy rainfall. Southern Nigeria is characterized by humid tropical condition presupposing severe rainfall possibility, hence the initiation and establishment of gullies. For instance, in southeastern Nigeria, gully erosion is rampant, with thousands of hectares of land lost each year (Fagbohun, Aladejana, Okonye, & Tobore, 2024). As far back 1991, over 1000 hectares of land was said to have been lost to gully erosion in the Agulu-Nanka gully site (Nigeria Environmental Study Team (NEST) (1991)). Recent report about the gully site proved that it covers a width of 100 meters and several meters deep (Okenmuo, Ibeh, & Obalum, 2023).

The socio-economic implications of gully erosion are profound, Woldemariam, Yasin, & Iguala, (2023) emphasized the effect on economic livelihood, infrastructure and arable land. In Nigeria alone, it is estimated that over ₦80 billion ($200 million) is spent annually on gully erosion management and repairs (Croitoru, Miranda, Khattabi, & Lee, 2020). Specifically, in Enugu and Imo States, gully erosion has rendered vast tracts of agricultural land unusable, threatening food security (Udokporo, Anikwe, & Chukwu, 2015). Most worrisome is the fact that it is deepening and widening by several meters annually (Itu, Njoku, & Erahabor, 2017).

Cross River State, particularly, Calabar Metropolis, gully erosion is primarily concentrated in areas such as Ikot Ansa, Ikot Effanga, and Edim Otop, where poor drainage systems, deforestation, and unregulated urban expansion are prevalent. Eni and Udoh (2020) decried the effect of erosion menace on infrastructure in Calabar Metropolis, This study aimed to provide insight into spatial distribution of gully erosion sites with a focus on identifying and understanding areas that are prone to soil erosion and the associated impact.

Material and methods

Study area

Calabar Metropolis lies between longitudes $8^0$18'00"E to $8^0$24'00'E and latitudes $4^0$54'00"N to $5^0$04'00'N, bounded by Calabar River, at west, Kwa River towards the East, Odukpani L.G.A on the North, its creeks empty into the Atlantic Ocean through south. The Metropolis has land area of 406 square kilometers (Fig.1).

Methods of data collection

The study adopted a cross-sectional survey design and Geographic Positioning System (GPS) to assess the spatial distribution and impact of gully erosion in Calabar Metropolis. The population of the study included residents of erosion-prone areas in Calabar, such as Ikot Awatim, Atakpa, Edim Otop, Nyahasang, Ikot Uduak and Mbacoco. The six (6) erosion sites are found in six (6) major wards (Table.1) in the Metropolis covering both Calabar Municipal and Calabar south LGAs (Fig.1). The selection of these sits was based on severity of the gullies (Fig.3) as well as their strategic locations, harboring a population of well over 35,000 residents whose properties, economic livelihoods, including infrastructure are implicated. The fact that previous studies did not holistically capture the extent, areal coverage and associated impacts of these gullies makes the study inevitable.

Target population/sample size

The current population of Calabar Metropolis in 2023 is 657,000, a 4.12% increase

from 2022. Meanwhile, six communities are affected with an estimated population of 36,000 residents. Atakpa, 10,000; Edim Otop, 8000; Nyahasang, 6000; Ikot Anwatim, 4000; Ikot Uduak,5000 and Mbacoco, 3000 (Table 1). Therefore, the sample size was drawn through generation on the population as proposed through statistical formula proposed by Sanunders, Lewis and Thornhill (2007). To this end, sample size at 95 per cent of confidence level varies base on population and margin of error. At 5 per cent margin of error, in a sample population between 10,000 and 100,000, it is advisable to adopt a sample size of 383. So, this study adopted 383 as sample size base on Sanunders, Lewis and Thornhill (2007). Therefore, a total of 383 respondents were selected using a simple random sampling technique to ensure a representative sample of the population. A total of 382 were retrieved. Data was gathered through structured questionnaires administered to residents to assess their perceived knowledge on the effects of gully erosion on infrastructure, livelihoods, and the environment. The study used measuring tap to ascertain the real dimension of the gullies and to practically involve the members (field assistants) of the affected communities in the process of measurement of the gully sites. The involvement of the members of the communities was to enhance awareness of the enormity of the gullies as this is capable of dissuading them from conducting practices that promote soil degradation. However, attempt to employ geospatial tools in the determination of the dimensions of the gullies would constitute the bulk of subsequent study on the affected gully sites.

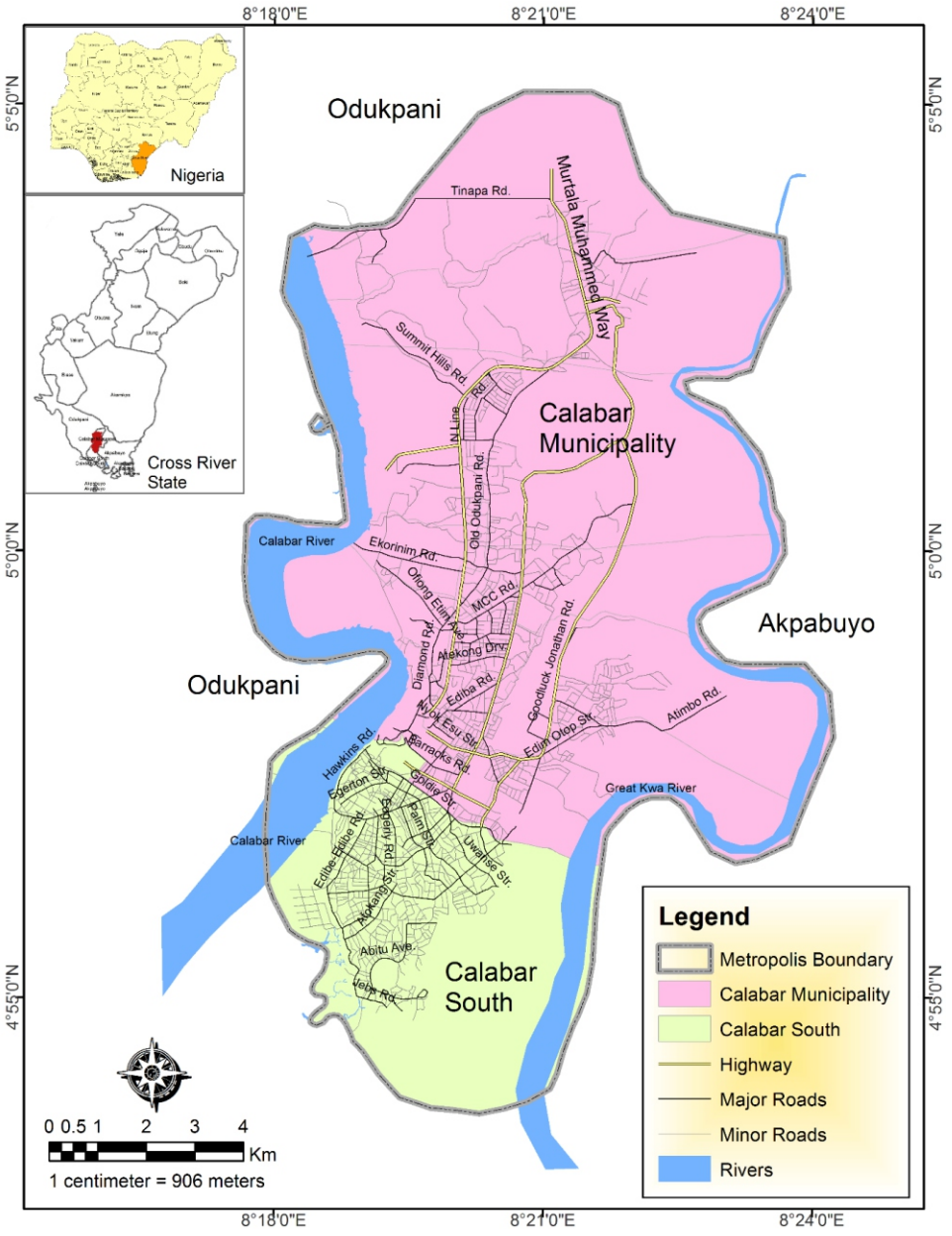

FIG. 1: Map of Calabar metropolis
Source: Surveyor General Office Cross River State (2024).

Result

Table 1 consists of the locational pattern and characteristics of the various gully erosion sites in the Metropolis. The wards, population, coordinate, extent of damage and the depth of the gullies are featured in this table. It is necessary to know the length, depth and other characteristics of each gullies in other to determine the impact on humans and the environment.

Table 1: Locational pattern and characteristics of gully erosion sites in Calabar

S/N	Ward/Cal South	Population of affected area	Gully Erosion site	Coordinates of the sites	Extent of coverage	Gully Depth
1.	Ward 1/ Calabar South	10,000	Atakpa gully site	4057'45"E 8019'12"E	18177 sqm	19 metres
2.	Ward 2/ Calabar Mun	8,000	Edim Otop	4057'46"E 8021'23"E	23019 sqm	25 metres
3.	Ward 3/ Calabar Mun	6,000	Nyahasang	4058'45"E 8021'30"E	19723 sqm	29 metres
4.	Ward 7/ Calabar Mun	4,000	Ikot Anwatim	500'12"E 8019'57"E	65084 sqm	39 metres
5.	Ward 8/ Calabar Mun	5,000	Ikot Uduak	5008'8"E 8021'2"E	13458 sqm	25 metres
6.	Ward 10/ Calabar Mun	3,000	Mbacoco	503'33"E 8021'44"E	59112 sqm	34 metres

Source: Author fieldwork (2024).

Table 2, highlights the perception of the residents on the various forms of soil erosion in the metropolis. The humid tropical environment is characterized by sufficient rainfall, undulating landscape and in most cases fragile soil condition which makes the soil inherently susceptible to all forms of water erosion example; sheet, rill, gully and stream bank erosion.

Table 2: Types of Erosion Prevalent in Different Areas of Calabar Metropolis

Type of Erosion	Frequency (n)	Percentage (%)
Gully Erosion	145	37.5
Sheet Erosion	115	30.0
Rill Erosion	76	20.0
Riverbank Erosion	46	12.5
Total	382	100

Source: Author fieldwork (2024).

This table innumerates the various environmental and human induced factors that contribute to gully establishment with a view to knowing people's perception.

Table 3: Environmental and Human Factors Contributing to Erosion in Calabar Metropolis

Contributing Factor	Frequency (n)	Percentage (%)
Deforestation	135	35.0
Poor Drainage Systems	115	30.0
Urbanization and Construction	86	22.5
Heavy Rainfall and Climate Change	46	12.5
Total	382	100

Source: Author fieldwork, 2024

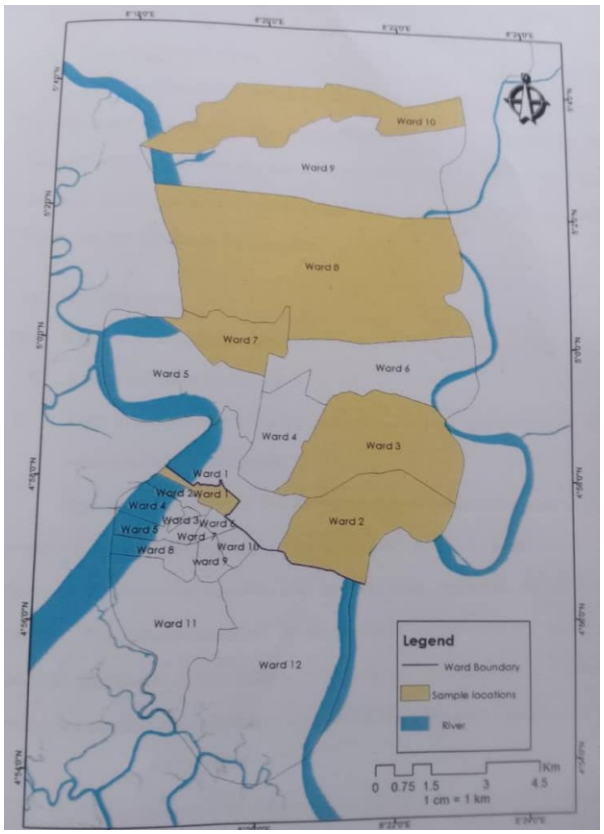

FIG. 2: Communities plagued with gully erosion
Source: Author fieldwork (2024).

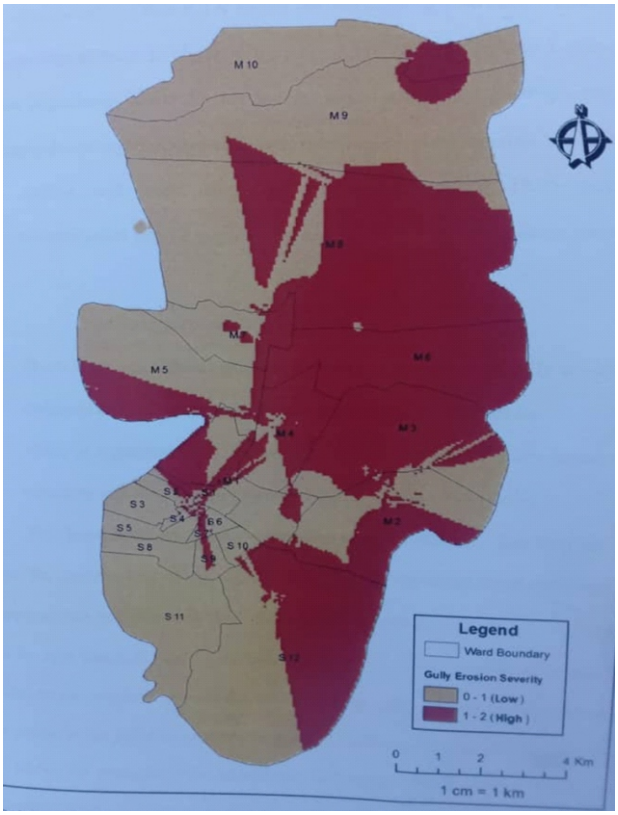

FIG. 3: Severity of gully erosion perturbation in Calabar Metropolis
Source: Author fieldwork, (2024).

Figure 2, consists of geospatial locations of the various gully sites. It is important to consider spatial proximity of gully sites in other to guide against devastating seismic related activity in the area.

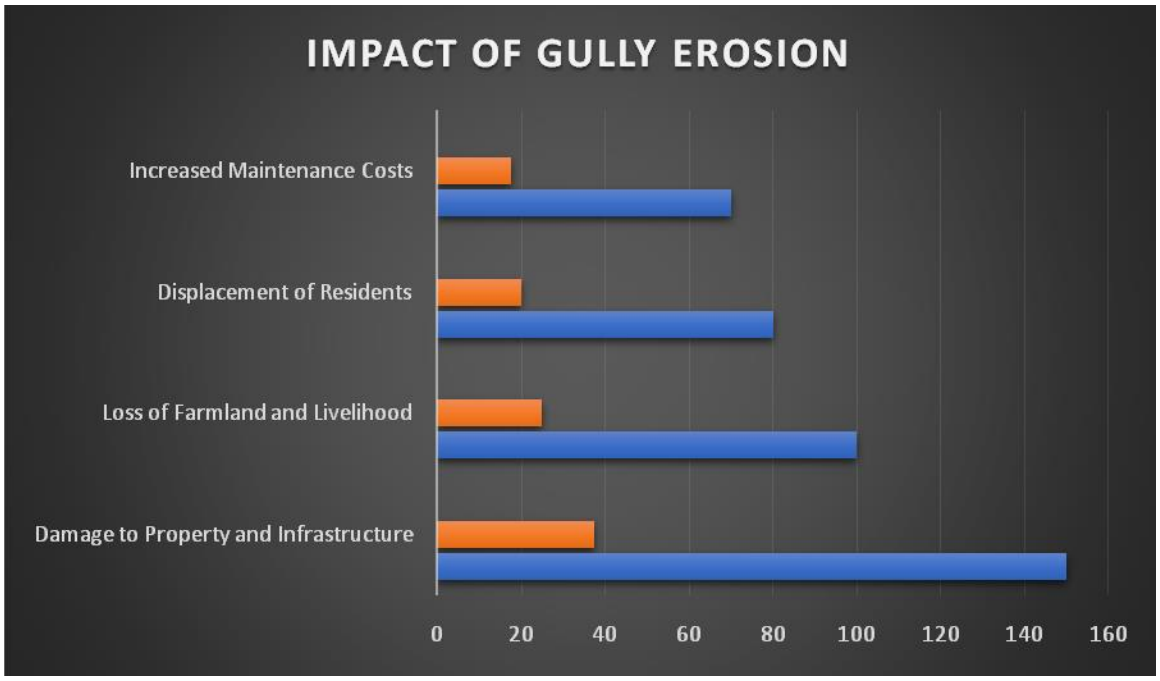

Fig. 4: Impact of gully Erosion on residents of Calabar Metropolis.

This figure presents Impact of gully erosion on residents of Calabar Metropolis. It important to consider the socio-economic and environmental impacts of erosion on residents and infrastructure in Calabar Metropolis. Impacts include; displacement of residents, financial implication, lost of farmlands and livelihoods and damage to properties and infrastructure.

Discussion

Locational pattern of gully erosion-prone sites in Calabar Metropolis

Result in Table 1 revealed that the following communities in Calabar Metropolis were in close proximity to gully erosion sites: Edim Otop, Nyahasang, Ikot Anwatim, Ikot Uduak, Mbacoco, and Atakpa. These areas are severely affected by gully erosion, which pose significant threats to both the environment and local infrastructure. Hossain et al (2020) stressed on ecosystem disruption of gully sites while Woldemaram et al (2023) talked about its impact on infrastructure. In this study, key gully characteristics such as the exact location of the gully sites, their geographic coordinates, areal extent/coverage, and the depth of the gullies were carefully examined. Itu et al (2017) decried the issue of gully expansion in Calabare Metropolis. It is important to measure extent of gully in order to get insight into the enormity as to contemplate adequate further expansion and damage. Okenmuo et al (2023) measured Agulu Nanka gully and found that the level of expansion is of serious concern. Measurement of length, width and other parameters of the gullies provided a detailed understanding of the spatial extent and severity of the erosion in each the affected communities, contributing to the overall analysis of erosion risks in Calabar Metropolis. Meanwhile Fig 2 and Fig 3, show the spatial location of gully sites and the severity in Calabar Metropolis

Prevalent erosion in different areas of Calabar Metropolis.

The result in Table 2, showed the distribution of various types of erosion prevalent in Calabar Metropolis. Gully erosion is identified as the most dominant type of erosion,

with 37.5 per cent of the respondents citing it as a major problem. This was followed by sheet erosion, with 30.0% of the responses, while riverbank erosion was the least widespread. The most ravaged community was Ikot Awatim with a gully depth of 39 meters and coverage of 65084sqm. The result proved that gully erosion is a significant issue in Calabar Metropolis, necessitated by poor urban planning and ineffective drainage systems. Sheet and rill erosions are also prevalent, reflecting the susceptibility of the area's topography to surface water runoff (Egbai, Ndik, Uquetan, Ewa, Okeke, 2011). Riverbank erosion, while less frequent, may be attributed to proximity to rivers and waterways (Watene et al., 2021).

Environmental and human factors contributing to the occurrence of erosion in Calabar

Result in Table 3 outlined the major environmental and human factors contributing to gully erosion in Calabar Metropolis. According to respondents, deforestation (35.0per cent) was the leading factor, followed closely by poor drainage systems (30.0per cent). Urbanization and construction activities accounted for 22.5per cent, while heavy rainfall and climate change were responsible for 12.5per cent. The findings suggest that deforestation, driven by agricultural expansion and land clearing, significantly contributes to erosion. Poor drainage systems, often a result of inadequate infrastructure maintenance, further exacerbate the problem. Urbanization, coupled with improper construction practices, adds to soil destabilization, while extreme weather events linked to climate change intensify erosion risks. The findings corroborate that of Pravalie (2021) who attributed unguided human activities as the major cause of soil erosion.

Socio-economic and environmental impacts of erosion on residents and infrastructure. Fig. 4 shows Impact of gully Erosion on residents of Calabar Metropolis. This figure highlights the impact of gully erosion on residents of Calabar Metropolis. It is important **to consider** the socio-economic and environmental impacts of erosion on residents and infrastructure in Calabar Metropolis. Impacts include; displacement of residents, financial implication, lost of farmlands and livelihoods and damage to properties and infrastructure. The highest percentage (37.5per cent) of respondents reported that erosion leads to significant damage to property and infrastructure. The loss of farmland and livelihoods was also a major concern, affecting 25.0 per cent of the population. Additionally, 20.0 per cent of respondents indicated that erosion caused displacement of residents, while 17.5per cent complained of increased maintenance costs. This is in agreement with the findings of Croitoru (2020) who discovered that a huge financial implication is involve in gully repairs and rehabilitation. This simply means that erosion in Calabar Metropolis, not only disrupts infrastructure but also impacts livelihoods, particularly for those reliant on agriculture. The displacement of residents reflects the severe consequences of unchecked erosion, particularly in low-lying areas

Conclusion

The study has evidently shown that gully erosion is a significant environmental threat to Calabar Metropolis. The locational pattern of gully erosion-prone sites, such as Edim Otop, Nyahasang, Ikot Anwatim, and others, highlights the spatial distribution of these sites in areas with varying geospatial locations. The study reveals that certain areas are more susceptible to erosion than others. Unguided human activities and poor drainage systems are among the major drivers of erosion perturbation.

The outcome of this study shows the need for targeted interventions to mitigate the ongoing erosion crisis. Already, socio-economic impacts of gully erosion on residents and infrastructure are profound. As erosion continues to worsen, it led to the displacement of families, destruction of property, and loss of agricultural land, which directly affects livelihoods. Furthermore, the environmental degradation caused by erosion threatens the

sustainability of the ecosystem in the affected areas. Infrastructure such as roads and buildings are also at risk, increasing the financial burden on the government and local communities. This study therefore provides critical insights into these challenges, offering a foundation for future policies and practical solutions aimed at addressing erosion in Calabar Metropolis. The findings call for holistic action plans that incorporate both preventive and corrective measures to mitigate the devastating effects of erosion in Calabar.

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