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APPRAISAL OF SOIL EROSION IN ZURU METROPOLIS, ZURU LOCAL GOVERNMENT AREA, KEBBI STATE NIGERIA.

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Abstract

Soil erosion and sedimentation pose significant threats to environmental sustainability, food security, and economic development in Zuru Metropolis, Nigeria. This study investigates the causes, effects, and mitigation measures of soil erosion and sedimentation in the area. Using a combination of field observations, laboratory analysis, and community surveys, the research reveals that heavy rainfall, deforestation, poor land use practices, and urbanization are major drivers of soil erosion and sedimentation. The impacts of these processes include loss of fertile land, water pollution, infrastructure damage, and increased risk of flooding. The study recommends [redacted] reforestation, conservation agriculture, drainage management, and community education as effective mitigation measures. The findings of this research contribute to the development of sustainable land management strategies and policy interventions aimed at reducing the risks associated with soil erosion and sedimentation in Zuru Metropolis. The results of this study indicated that previous authors whose works were reviewed have a

Keyword: Soil Erosion, Sedimentation, Nature of Soil, Zuru metropolis, Land use practice, Reforestation.

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convergent view that the use of vegetative approach, an aspect to landscape design, must be practiced for effective control of gullies., however, previous authors have divergent views on the use of structural approach, another aspect to landscape design, for control of gully erosion. Other recommendations of this study include: Planting of a combination of woody trees and grasses; Use of some locally accessible structures for example, sieve structures.

Introduction

Background of the study

Gully erosion causes severe damage to human settlements and agricultural lands, including soil loss, increase in surface runoff, lower soil water-holding capacity, lower quality and quantity of water, lower groundwater table, and lower agricultural production. Gully erosion within settlements requires peculiar attention because of the risk and hazards it poses to buildings and other structures that could endanger human lives. The gully erosion in Rikoto community in Zuru town has posed numerous threats to the inhabitants of the area. It has caused many residential buildings and worship centers to collapse, destroying road networks and other infrastructure, and degrading land for commercial and agricultural purposes. It has been observed that more buildings are perching precariously on the edge of the gully channel.

Therefore, mitigating soil loss through improved land use management practice and conservation of natural resources is important to maintained the function of the soil and contribute to food security now and for future generations.

Statement of Research Problem

Rikoto Community area is about two thirds of the Zuru township. It is densely populated because it cannot expand due to the problems posed by the gully erosion. The area and the sub-communities affected by the erosion stretch

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over ten (10)kilometers from Rafin Mosee, Shada Wanka, Mangorori to the Masallacin Juma'a area of the community. The gulley started around 1974 to 1976 when the town started to develop and people begun to cut down trees to build houses and road along water ways without proper drainage and as such the water no longer spread over, it started to gully the areas little by little until it got to the terrible and devastating stage it is now. Various community efforts were done to control the problem through community development projects (Ismail Adebayo 2017). The community will be required to give out its labour and 10 percent of the cost of any project that is embarked on by the association. The federal government made effort to control the menace by awarding the Rikoto erosion control project to a construction company, Zoha Enterprises Limited at the cost of N119,587371,75k about ten (10) years back. The company started work in the community, but abandoned the project midway into its completion

Objectives

The objective of this study is to access:

i. the nature of Soil Erosion and Sedimentation in Zuru Metropolis

Conceptual Frame work

This research review will provide an extensive literature on past and present initiatives of mitigating soil erosion and sedimentation, focusing on agronomic soil conservation strategies, soil management strategies and mechanical methods. Application of this strategies will improve the management of the devastating impact of the erosion and also conserve the soil resources in the livelihood of Rikoto community of zuru local government area.

A livelihood comprises the capabilities, assets (financial, natural, social, and physical, human) and activities required to provide a means of living. A livelihood is sustainable when it can cope with and recover from stress and

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shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation. It also contributes net benefits to other livelihoods at local and global levels in the short and long term (Krantz, 2001:5)

Soil erosion

Soil erosion is a physical process of soil degradation and the most widespread form of land degradation Lal as quoted by Argaw (2005:20). It is the detachment and transportation of soil particles from one place to another with a degree ranging from splash erosion to the alarming stage of gully formation. Shaxon et al. (1997:11) and Miller and Donahue (1997:437) describe the process as a loss of nutrient rich clay and organic matter in rain- drop splashes, impoverishing the upper top soil and while subsequent erosion peels-off the upper soil layers. Tripathi and Singh (2001:10) state that soil erosion that can be called the creeping death is a worldwide problem.

Montgomery (2007:13288) is of the opinion that the recognition of the detrimental influences of accelerated soil erosion on agrarian societies dates back to Plato and Aristotle. Several classic studies have attributed the bare rocky slopes of the classic world to soil erosion in current times. Furthermore, Pimentel, et al. (1995:1117) states that soil erosion is a major environmental and agricultural problem worldwide. Although erosion has occurred throughout the period of agricultural activity, it has intensified in recent years.

Soil erosion is a complex process that involves soil properties, ground slope, vegetation rainfall and intensity (Montgomery, 2007:13288). Soil erosion occurs when soil is exposed to water or wind energy. Rain drops hit exposed soil with great energy and launch soil particles along with the water in to the air. Rain drop splash and resulting sheet erosion remove the thin film of soil from the land surface (Pimentel and Kounang, 1998:417). Soil erosion therefore impacts agricultural production negatively by depleting nutrients

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needed for plant growth. Hartemink (2006:1614) reports that in tropical regions where many soils have inherent low fertility that is concentrated in the top soil, loss of top soil by soil erosion results in a serious reduction in soil chemical fertility.

Types of Erosion

Erosion is often described as the detachment of soil particles by some force. This force may be due to rainfall, wind, or other forces. Once detachment occurs, the particles are transported. This is most often caused by water action, although wind can also be a major contributor.

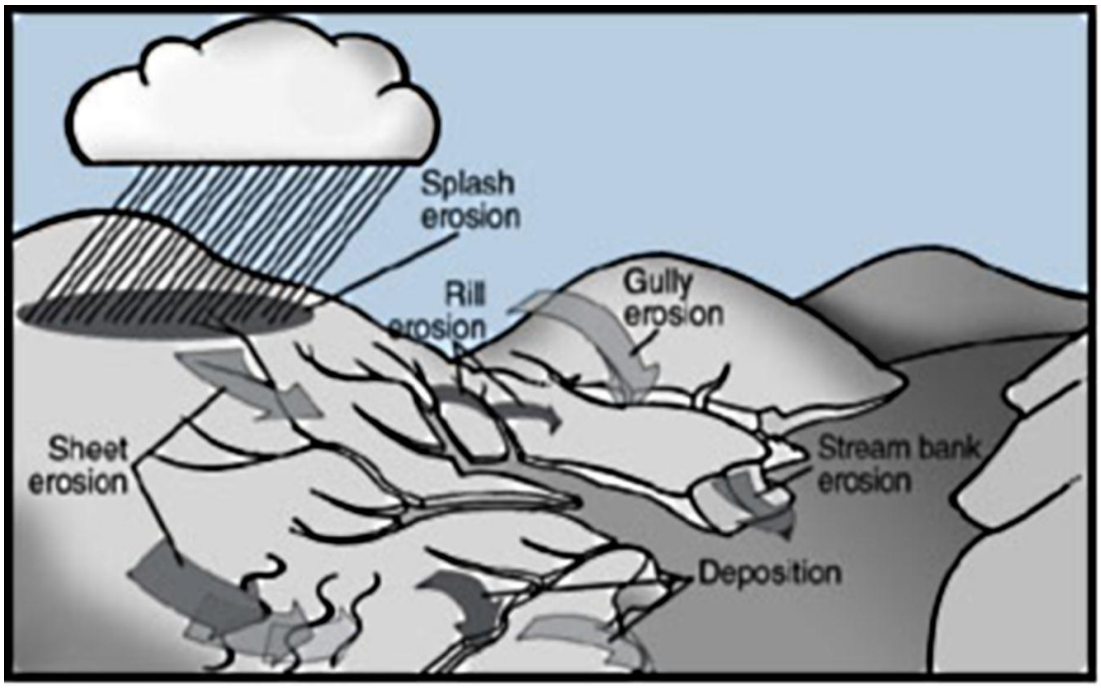


Figure 1: Image of different forms of erosion (Broz et al. 2003)

During the entire erosion process six types of erosion take place at different stages. It starts with splash erosion as the raindrops are falling from cloud at high velocities and detach the soil from surface. Once the raindrop hits the soil surface, it compacts the soil directly under the drop and disperses the detached soil particles that are on the side. These soil particles can travel as

far as 2-3 feet vertically and up to 5 feet horizontally. On a sloppy surface over half of this material travels down the slope. Hence, as one can imagine in a heavy storm millions of these raindrops hit the slope and millions of soil particles moves towards downstream.

Detachment or losing of soil particles caused by raindrop impact begins to flow in the overland flow. As the rain continues, the raindrops continue to pummel the soil into smaller and smaller particles. If the particle size is smaller than the other, it moves faster in the runoff. Because of the raindrop splashes, particle transport downhill to result in the next stage of erosion. Effect of sheet erosion is relatively slow and uniform therefore it may go unnoticed.

After some time, sheet erosion deteriorates to form small grooves on the slope, this starts a new type of erosion called rill erosion. Creation of small channels due to the runoffs called rills. As the runoff velocity increases, it's transport capacity increase. It means it can carry large amount of detached particles.

The next form of the erosion is gully erosion, which is an extremity of rill erosion. Large channels allow more amount of water to move swiftly and these large amounts of water can pick up even more soil.

When the runoff reaches the main channel, the erosion process does not stop and the next form of erosion starts. Erosion along the bank of the channel happens, because of which channels start meandering. The water cuts into the bank and erodes the soil.

The last stage of erosion is deposition of soil particles. Deposition usually happens in the lakes, reservoirs, ponds, estuaries and deltas. As the channels bed slope decreases, the velocity of the water decreases, this leads to the settlement of the soil particles. As the channel effectively decreases its own slope, then slower the water velocity, more the sediment deposits. This cycle intensifies the settling process.

Rates of soil erosion mainly depend upon the soil properties and its characteristics. Some soils are extremely vulnerable and sensitive to erosion while some are not. The main factor affecting the soil erosion is texture, organic matter content, structure, and permeability (Steiner, 1987). In the clay soil, the particles have the property to adhere to themselves in such a way that they reduce the erosion susceptibility. In general, smaller soil particles, travel longer distance than bigger one.

Sedimentation

The entrained soil materials carried in water or air is known as sediment. The main sources of sediments are soil erosion of upland areas or river channel, mass movement due to landslides, soil creeps etc, and from mining or dumps lefts as waste material.

Sediment transport is a direct function of water or wind movement. With respect to water movement in a river, during sediment transport, sediment particles become separated into three categories: suspended material which includes silt + clay + sand; the coarser, relatively inactive bedload and the saltation load. Suspended load comprises sand + silt + clay-sized particles that are held in suspension because of the turbulence of the water. The suspended load is further divided into the wash load which is generally considered to be the silt + clay-sized material (< 62 µm in particle diameter) and is often referred to as fine-grained sedimentǁ. The wash load is mainly controlled by the supply of this material (usually by means of erosion). The amount of sand (>62 µm in particle size) in the suspended load is directly proportional to the turbulence and mainly originates from erosion of the bed and banks of the river. In many rivers, suspended sediment (i.e. the mineral fraction) forms most of the transported load. Bed load is stony material, such as gravel and cobbles that moves by rolling along the bed of a river because it is too heavy to be lifted into suspension by the current of the river. Bed load is especially important during periods of extremely high discharge and in

landscapes of large topographical relief, where the river gradient is steep (such as in mountains). It is rarely important in low-lying areas such as lower parts of river Juba and Shebelle in south Somalia. Saltation load is a term used by Sedimentology's to describe material that is transitional between bed load and suspended load. Saltation means —bouncing‖ and refers to particles that are light enough to be picked off the river bed by turbulence but too heavy to remain in suspension and, therefore, sink back to the river bed. Saltation load is never measured in operational hydrology.

Sediment transport is facilitated when there is sufficient energy to carry the sediments. The mass rate of transport is known as —sediment discharge‖. If at any point during the transport the velocity of the water is reduced, some sediment will be deposited. The process is known as sedimentation. Sediment yield is the amount of eroded soil that is delivered to a point in the catchment.

Sedimentation and its consequences

Sedimentation is the process whereby detached soil particles transported by runoff are deposited elsewhere on the land or in lakes, reservoirs, streams, and wetlands. Sediment deposition in reservoirs is a reflection of catchment erosion and deposition processes, which are controlled by terrain form, soil, surface cover, drainage networks, and rainfall- related environmental attributes (Renard and Foster, 1983; Walling, 1994). Soil erosion is the first step in the sedimentation processes which consist of detachment, transportation and deposition of soil particles in reservoirs or channels downstream. Sedimentation downstream leads to water quality degradation (sediments may carry pollutants into water systems and cause significant water quality problems), reduces the capacity of rivers and retention ponds, enhances the risk of flooding and muddy floods and shortens the design life of reservoirs (Clark, 1985; Boardman et al., 1994; Verstraeten and Poesen, 1999).

STUDY AREA

Location of the Study Area

The study was conducted in Zuru Local Government Area of Kebbi State. It is one of the twenty-one (21) Local Government Areas of Kebbi State. Geographically, it is located within latitudes 110 35' to 110 55' N and longitudes 40 45' to 50 25' E of the equator (KBSG, 2003), at the extreme south eastern part of Kebbi State and covers an area of approximately 32, 626 square kilometre. This location is on a hilly terrain and is bordered in the north by Gummi Local Government Area of Zamfara State, to the Northwest by Fakai Local Government Area, to the Southwest by Yauri Local Government Area, to the Northeast by Sakaba Local Government Area and to the South by Rijau Local Government Area of Niger State (Girma, 1998).Zuruland is an enormously endowed agricultural hub with long standing reputation in various agricultural activities. The area has complex vegetation that is suitable for the production of a variety of crops and other agricultural products. Even though the area is located in Kebbi state, substantial part of its vegetation is akin to that of guinea savannah. It is thus suitable for growing of crops mostly found in both the southern and northern Nigeria.

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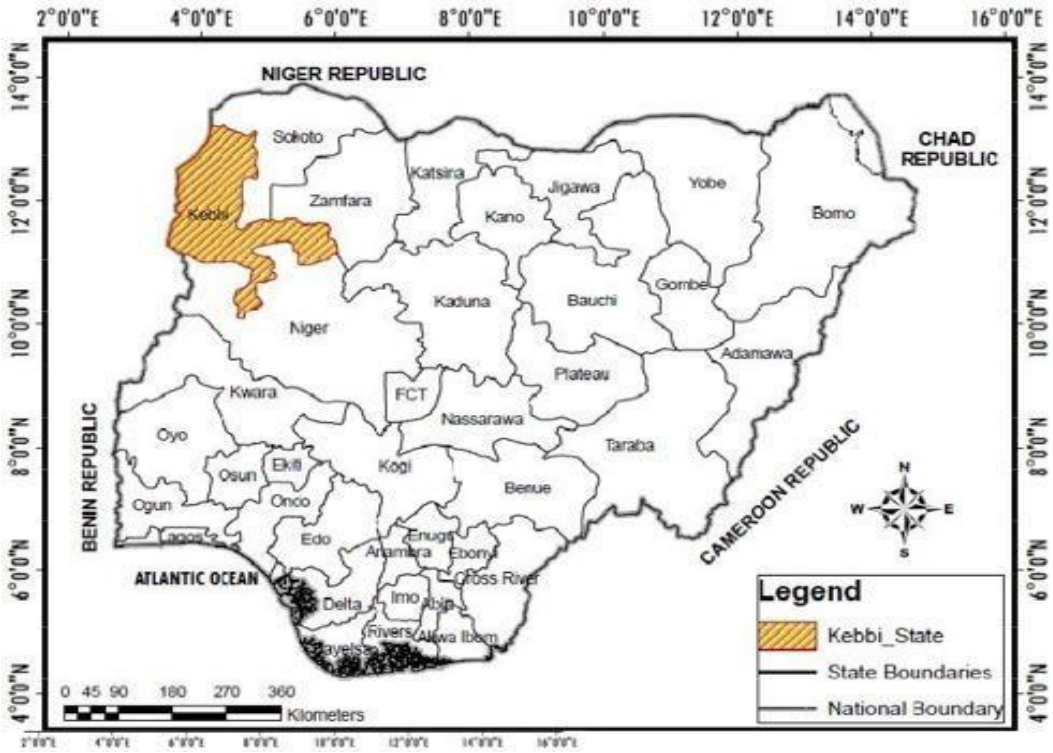


Fig. 2: Map of Nigeria Showing Kebbi State that Harbors the Study Area

Source: GIS Analysis

Materials Used

i. GPS / Total Station; was used to map and create the profiles of the gullies.

ii. Drone; was used for reconnaissance survey and characterization of the gullies.

iii. Survey, was carried out to determine the existing situation along the affect gully site in the study area.

Fieldwork

Preliminary Fieldwork

The preliminary fieldwork consisted of a reconnaissance survey of the study area and the collection of basic information on the soil erosion processes and it is effects in the study area. It also involved the collection of other ancillary data like topographic map, political map for the delineation of the study area.

Detailed Fieldwork

Two districts in Zuru metropolis were selected for this study and sampling of respondents through simple random sampling using a structured questionnaires. Interviews were conducted to gather information from community representatives on the erosion menace. Field observation and expert judgment also formed part of the research fieldwork. The structural questionnaires seek to stabilize the links between soil erosion and sedimentation, and how it affect the livelihoods of the people living in the study area.

Sampling procedures

The research covered two districts of Zuru L. G. A; Rikoto District, and Rafin-Zuru district. The two district areas were purposively selected based on the concentration of soil erosion and sedimentation which has posed numerous threat to the inhabitants of the areas. Since it is not possible to use all the population in Zuru town for this research work, stratified random sampling was adopted. The study area was divided in to three zone A, B and C. Zone A & B represent Rikoto district while Zone C represent Rafin-Zuru district all the selected areas are based on the affected gully areas. Zone A which comprises: Jarkasa, Mangorori, Lenna Hotel, Izala mosque one (1) and Tudun Wada. While Zone B comprises: Rikoto area, ShadaWanka, GRA, Rafin Mose. Zone Comprises: Rafin bumbum, Umu Musa, Danbu Gomo, Zango area, Kalfu area, Rafin Marna, Unguwan Zuru, Mayanka, Road Block, and also pass behind the Zuru airstrip then link with Rikoto gully and then empty to Zuru Dam. The respondents were randomly selected from each of the district giving a total sample size of 250 respondents. Data were collected through the use of structured questionnaire and oral interview especially with respondents who are not literate enough to complete the questionnaires.

Interviews

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The researcher interviewed community leaders to obtain information on the nature of soil erosion in the study area. Also ask on the possible hazards and risks associated with communities around the study area as a result of the gully erosion. Data generated from the responses were analyzed and use to validate some of the information obtained from State Ministry of Environment and Sokoto River Rima Basin Development Authority (SRRBDA).

Focus Group Discussion (FGD)

Focus Group Discussion were conducted with relevant stockholders within the communities. The Focus Group Discursion were used to obtain information on people's perception on the nature of soil erosion and the type of mitigation measures taken by both Federal, State and Local government to address the problems.

Questionnaire Administration

Semi-structured interviews/ questionnaires were administered to selected residents in the affected areas under study. The questions were structured mainly to reflect the scope of this study which is, to establish the nature of soil erosion in Rikoto and Rafin Zuru communities of Zuru town. Other people familiar with the study area such as Union leaders, traditional leaders, some retired civil servants as well as politicians were interviewed separately for added information. Information from published and unpublished literatures were also used to analysis the nature of soil erosion in the study area. The outcome of the questionnaires has been summarized while the variable, occurrence and representative percentage of the respondents to administered questionnaires.

A total of 250 questionnaires were administrated to the households by the researcher with the help of two research assistants who know the study area very well. The questionnaires were both close and open ended and were administered within the period of one month.

The Simple structured questionnaires were used to obtain information on the perception of the people of Zuru metropolis' on nature of soil erosion and

how it has influenced their livelihood; and nature of soil erosion and sedimentation in Zuru metropolis; the type of mitigation measures taken both by Federal, State and Local Government to address the problems; the major causes and control/mitigation measures being taken on the erosion and sedimentation problems on the affected areas; and likely impact of climate change on the gully erosion and sedimentation.

Data Analysis

Statistical Analysis

Data obtained from the questionnaire administration and FUDs will be subjected to simple descriptive statistics such as mean and percentages in addition, the result of the GIS analysis were also represented using simple description statistics.

Data Presentation

The nature of Soil Erosion and Sedimentation in Zuru Metropolis

The objective of the study was to identify the nature of soil erosion and sedimentation in Zuru metropolis. The predominant causes of soil erosion are either related to naturally-occurring events or influenced by the presence of human activity. The main causes for the initiation and development of gullies in the study area were noted. One of the primary root causes of the soil erosion and sedimentation in Rikotto and Rafin Zuru district stems from the run-off water from the top Hill of Jarkasa that links to Dabai known as Zuru Dakitakwas road, it also move from Jarkasa to Gadanzango known as Zuru Kwantagora road. In addition with runoff water from the roof top of residential development in the study area in 1976 to 1978 major drainage was constructed in view of collecting the run-off water but presently during our site investigation and site analysis human activities block 70% of the main drainages in the study area. All this come together and curse flooding on the Federal high way that passes through Zuru metropolis which links three (3) state: Niger state, Zamfara state and Kebbi State. In addition to improper supervision of development control from the appropriate authority.

The Effects of Slope of the land in the study area

The physical characteristics of the land also contribute to soil erosion. In the study area for example, the high hill slope which perpetuate the process of rainwater or runoff saturation in the area, particularly due to the faster movement of the water down a slope along Zuru-Mahuta road. Flowed by urban development. Habitat replacement often results in an increase in the amount of impervious surface such as roads, parking lots and building construction.

Gully Characterization of the study area

A transect of the slope across the Zuru Metropolis from the Zuru hill is shown in Figure 1.3 the slope profile shows (from west to east) a very steep slope by the hillsides, moderately steep slopes through the Metropolis to a gentle slope in the outskirts of the metropolis (Figure 1.3). The profiles shows the direction of overland flow from the hills through the town which also affects the degree of soil loss and gully development in the study area because most of the gullies are found in the upper sections of the town which are upslope and progress downslope out of the settlement.

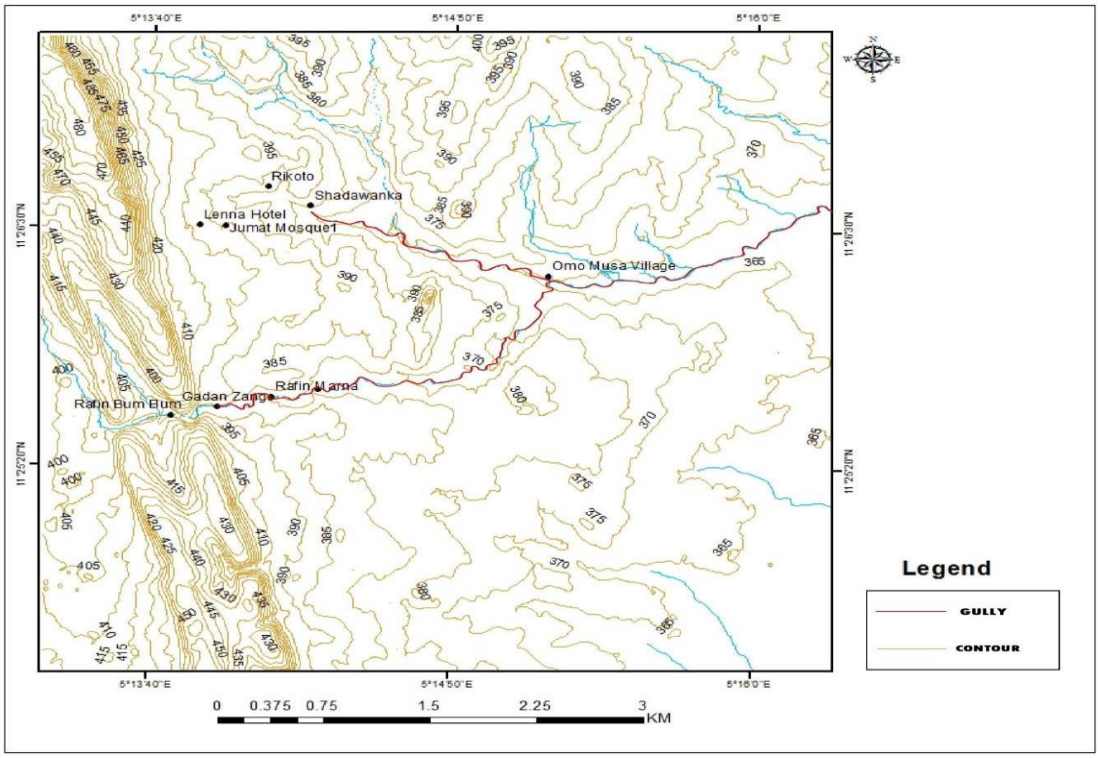


Figure 3: Topographical map of the Study Area showing the gully affected area in Rikoto and Rafin Zuru districts. Sources (NASRDA)
(Source: NASRDA)

Table 1: Land Use and Land Cover of the Study Area

Landuse	Area(Sqrkm)
Farmland	**23.51**
Shrubland	**0.25**
Woodland/Forest	**1.48**
Plantation	**0.09**
Settlement	**13.64**
Orchard	**0.24**
Total	**39.21**

(Source: GIS Analysis)

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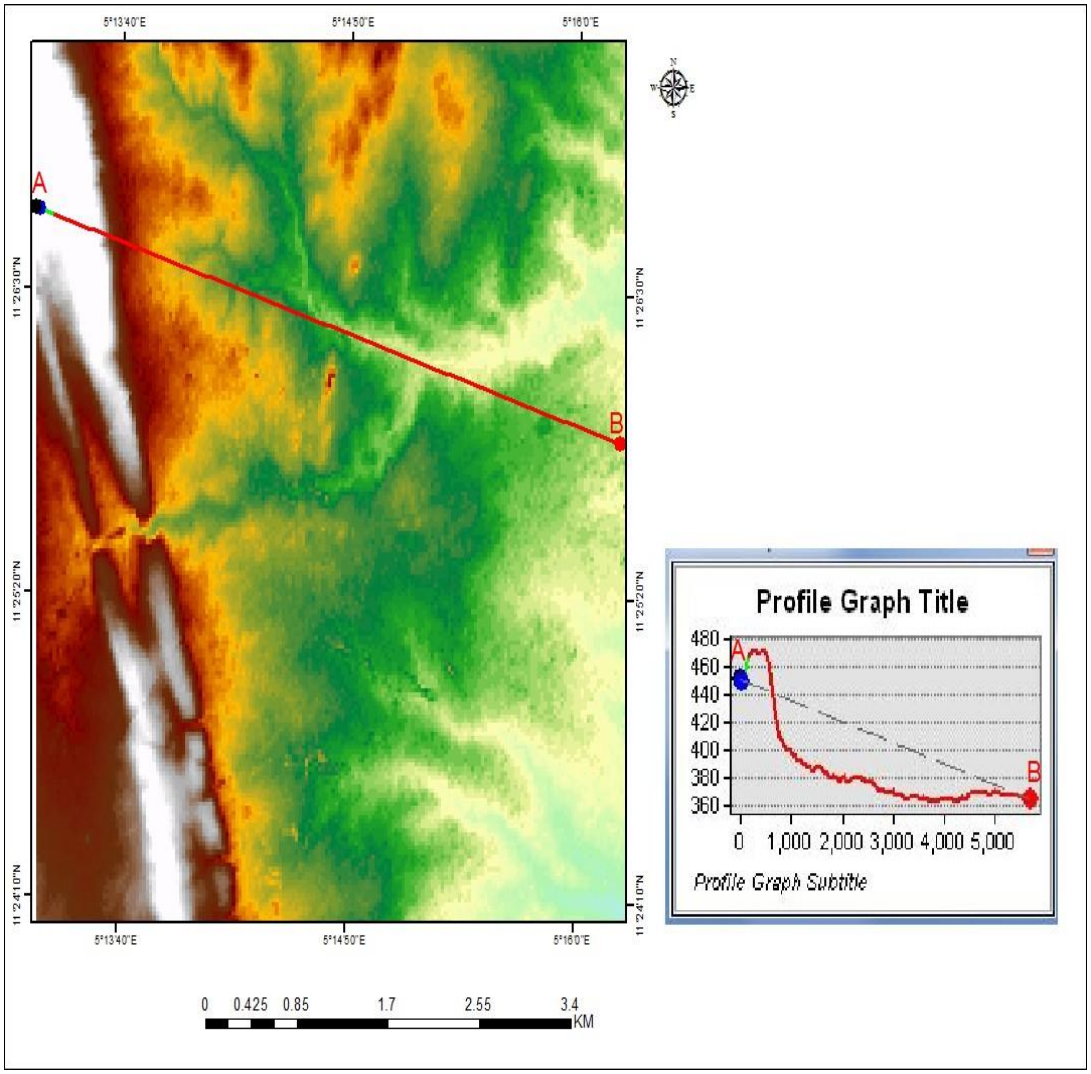


Figure 4: Slope Profile across Zuru Metropolis (East – West) (Source: GIS Analysis)

Some gully cross files were created using the digital elevation model at different gully sections within the study area. These gully cross-sections were used in conjunction with field assessment for the description and characterization of the gullies.

The cross-section downstream of the Jumaat Mosque One in Rikoto just before Shadawanka, is depicted in Figure 5 The profile shows a wide U-

shaped gully shape profile which indicates that the gully is a fully developed one.

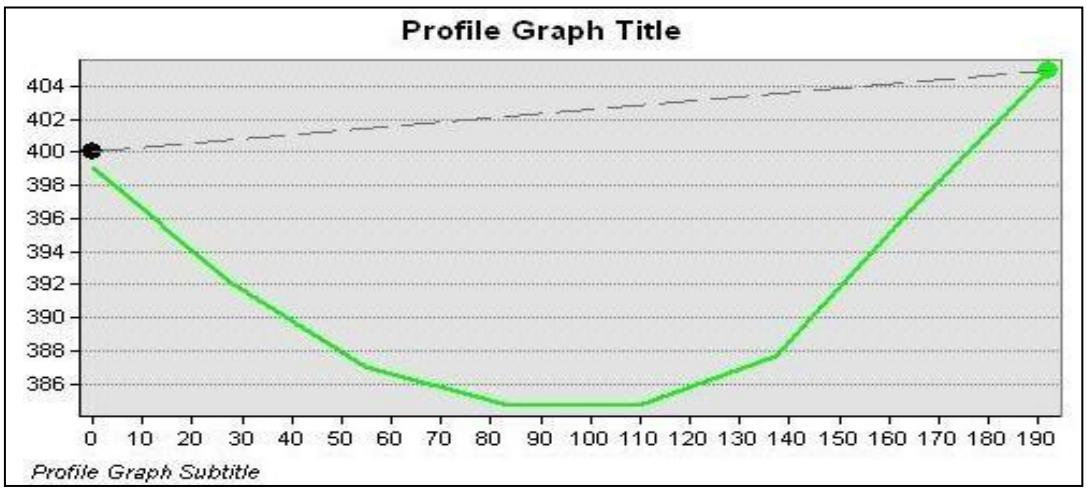


Figure 5: Cross-Section Profile downstream Masalacin Jumaat one. (Source: GIS Analysis)

The cross-section at the confluence of the two rivers downstream of the town at Omo- Musu settlement is depicted in Figure 6. The profile is within the middle course of the basin and is also a wide U-shaped gully. The profile also indicates that the gully is a fully developed one.

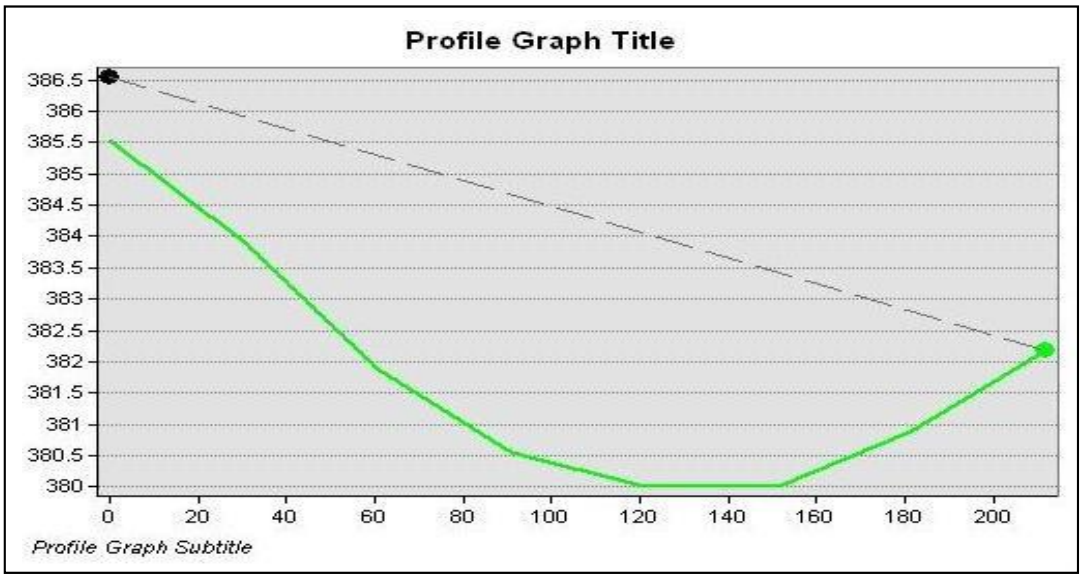


Figure 6: Cross-Section Profile at Confluence of the Rikoto and Rafin Zuru Rivers (Source: GIS Analysis)

The cross-section along Rafin Bumbum is depicted in Figure 6. The profile shows a V- shaped gully. The profile which is upstream of the River indicates that the gully is still a developing one. Developing gullies such as this are characterized by steep slopes and deep incision. The steepness of the gully at this section is a result of the steep slopes in addition to other human activities such as farming activities and in proper development along the water way.

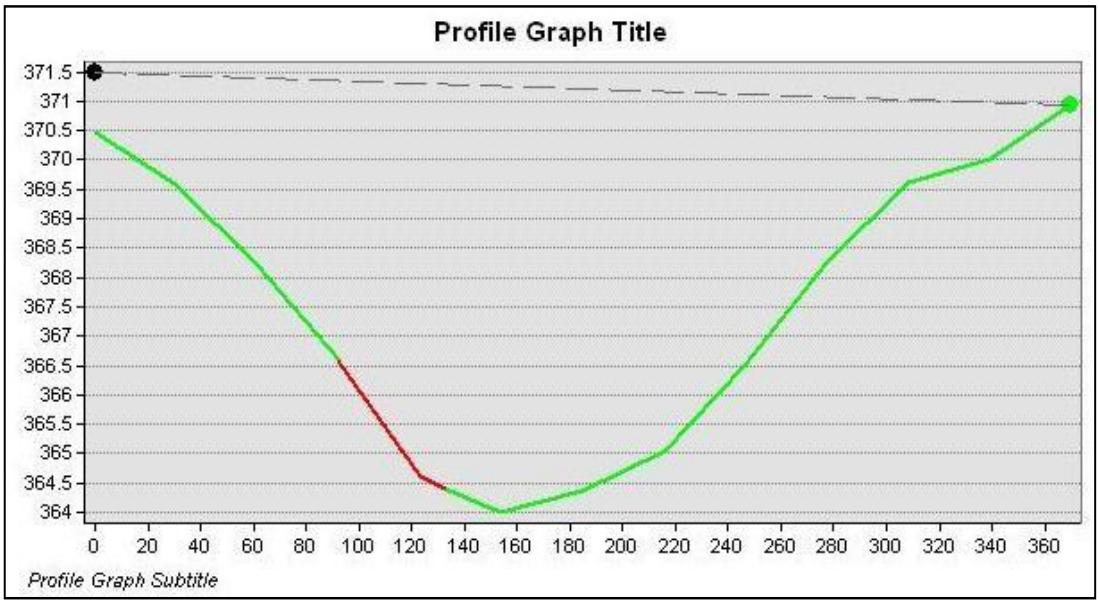


Figure 7: Gully Profile 6(Source: GIS Analysis)

Normally, vegetation would slow surfaces water flow, while impervious surfaces increase water flow. On this situation water travel faster and in greater quantities. This action causes water to overflow stream banks triggering erosion in vulnerable parts of the study areas. Also in the order way some of the most likely courses are:

A history of poor ground cover due to clearing, high stocking rates, repeated cultivations, decimation by fire. Concentrated runoff, from steep lands, flowing into cleared drainage depressions.

Unstable soil in drainage lines. Intense rainfall. Elevated runoff caused by factors such as low levels of free cover and poor soil infiltration.



Plate 1 showing loss of houses

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Plate 2 showing loss of farm land due to gully erosion

Conclusion

The causes and impacts of gully erosion in Zuru metropolis had been investigated using various techniques highlighted in the study area, It was observed that both anthropogenic and the human-induced factors were responsible for the phenomenal, which has resulted in devastating impacts on the residents, property and their environment.

Field observations by this research had shown the run-off water from the top Hill of Jarkasa that links to Dabai known as Zuru Dakitakwas road, it also move from Jarkasa to Gadanzango known as Zuru Kwantagora road. In addition with runoff water from the roof top of residential development in the study area. All this come together and curse flooding on the Federal high way that passes through Zuru metropolis. By way of proffering tangible measures that would help in tackling the menace of gully erosion in Zuru metropolis, Governments at all levels should collaborate to find a lasting solution to the phenomenal by adopting recommendations contained in this research. If the recommendations advanced in this work are fully and carefully implemented, it is hoped that the incidence of gully erosion in parts of Zuru metropolis

would be drastically reduced and the security of the lives of residents and their properties will be guaranteed.

Recommendation

i. To encourage people to adopt Best Management Practices (BPM) that canpreventor minimized pollution. If these are successfully employed on the study area the measures will not transfer pollutants downstream.
ii. Reforestation, conservation agriculture, drainage management, and community education as effective mitigation measures
iii. People should be encouraged to provide paved drainages around their homes or along the gutters to reduce the amount of soil loss.
iv. Relevant Government agencies should encourage residents to plant trees and grasses in the environment to reduce soil loss and urban heat.
v. Contour Farming by planting along the contours of the land to slow water runoff and reduce soil loss.
vi. Constructing terraces on slopes to reduce the speed of water flow and capture sediment.
vii. Growing cover crops during fallow periods to protect the soil and improve its structure.

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