**ANALYSIS OF GULLY DEVELOPMENT IN KADUNA SOUTH LOCAL GOVERNMENT AREA OF KADUNA STATE NIGERIA**

**Abstract**

This study assessed the extent of gully development in the planned and unplanned areas of Kaduna South Local Government Area of Kaduna State. Gully erosion sites numbering eighty eight (88) were identified in planned and unplanned areas, coordinates of all the spatial locations of gullies are collected using hand held GPS Garmin 78s and the area was mapped using ArcGIS 10.5. Shape files were used to generate Base Map for the period of 20 years (2001-2020) at 5 years interval. Data on gullied areas were obtained from places where gullies are more prevalent like Kurmin Mashi, Kakuri Gwari, Tudun Nupawa and Kabala West through survey, interviews, measurements and ground trothing exercise. The highest number of gullies identified was 21, Kabala West having the most of the gullies and Makera having the lowest. Several roads identified to be affected by gully erosion like Kajuru road and Alagbado Street in Kabala West as well as Birnin Kudu Road in Tudun Nupawa were investigated, While building infrastructures were also affected by gully development at Tudun Nupawa LEA, River close in Kurmin Mashi, Lungu (pipeline) in Kakuri Gwari which eventually became a criminal hiding points. Base Map of Kaduna South LGA for the years 2005, 2010, 2015 and 2020 was obtained with the coordinate of the gully locations superimposed. From the Base Map, the year 2005, 2010, 2015 and 2020 had 33, 18, 20 and 16 gullied points respectively. Mean length, Width, Depth and year of formation for each gullied site was obtained and the rate of advancement per annum was calculated. Kajuru and Alagbado roads in Kabala have the highest rate of advancement of 6.6m per annum which is due to slope and inadequate drainage. Captain Road in Kurmin Mashi has the lowest rate of advancement of 0.2m per annum which is due to community effort put in place by using sacks of sand as a way to mitigate and reduce the effects of the gully. There was community participation in different areas in trying to mitigate the effect of gully in their communities, as evidenced at Abuja road, Kurmin Mashi and Kajuru Road at Kabala West, where residents use old car tires and sacks filled with sand across the gullied region to stop further advancement of the gully on the road side. An action that helped in ameliorating the advancement of gully overtaking the available access roads. From the results obtained it can be concluded that gully formation can occur in any area whether planned or unplanned. Factors discovered to be responsible for the development of gullies in the study areas clearly shows that the socio economic status of the residents contributed in their formation where residents were found to have abandoned their houses because they cannot remediate the effect of gully presence. However, relevant government authorities need to enlighten the communities about the dangers of gullies in the society and finding lasting solutions to gully effects. Also, state and local government authorities need to provide required engineering solutions to the places affected by the gully(s) like retaining walls, embankments and proper drainages.

**INTRODUCTION**

The impacts of gully erosion in Nigeria are significant and comparable to those experienced in other parts of the world. Gully erosion occurs due to a combination of various factors that act individually or concurrently to detach, transport, and deposit soil particles in different locations from where they originated. This phenomenon leads to the formation of deep cuttings and bulges that dissect the entire land surface. Earth scientists have established that both environmental and human-related factors, known as anthropogenic factors, influence the extent of soil erosion worldwide (Mbaya, 2013).

While humanity has contributed positively to reshaping and conserving the earth's surface, it has also played a role in causing ecological instability and the rapid proliferation of environmental issues like soil erosion. Anthropogenic factors primarily include technical elements such as land use and tillage methods, the choice and distribution of crops, and the nature of agro-technology. Activities like vegetation clearance, intensive harvesting, and over-grazing leave the soil bare and promote soil erosion. Moreover, soil compaction resulting from heavy machinery reduces the soil's capacity to absorb water, leading to excessive water runoff and erosion (Simpson, 2020).

Classical modeling works on soil erosion prediction and estimation by various researchers have identified topography/relief, rainfall, and soil factors as the main agents determining the extent of gully erosion hazard. The soil factor represents soil erodibility, which is a product of geological and soil characteristics (Poeson, 2011). .

In Nigeria, erosion is an active and widespread geomorphic process, particularly in the south-eastern and some parts of the guinea savanna. These areas experience phases of intense rainfall combined with non-cohesive soil structure, making erosion a severe environmental hazard. The savanna region, in particular, is affected by erosion in a broad east-west belt stretching from the eastern highland of Taraba state to the Sokoto basin. Headwaters of major drainage systems have been extensively eroded in these regions.

Every state in Nigeria suffers from some form of erosion, with the southern states experiencing higher incidences. As a response to the severity of the issue, the Kaduna state government approved construction works for soil erosion control projects in various locations across the state. These projects aim to combat erosion and prevent further damage to the environment. For instance, the construction of the Rigasa Erosion Control project in Igabi Local Government was funded by the Ecological Fund and overseen by the Kaduna state government in 2015.

The significance of understanding gully erosion and its impacts on primiparous mothers lies in the potential to develop targeted interventions and support systems. By recognizing the factors that contribute to erosion and its implications on environmental stability, healthcare providers can address the health and well-being of primiparous mothers more effectively. Moreover, awareness of the social and informational support available to these mothers can help healthcare providers offer tailored guidance, resources, and assistance during the postpartum period. Ultimately, improving the support systems for primiparous mothers can lead to better maternal and infant health outcomes, fostering a positive start to motherhood and nurturing the well-being of both mothers and their newborns (Mbaya, 2013). .

Gullies are evident signs of physical land loss, and for a long time, efforts have been directed towards controlling them. As early as the 1930s, the colonial government in Nigeria initiated a tree-planting campaign to combat erosion, especially on steep slopes in the South Eastern region. Over the years, researchers have extensively studied the causes of these catastrophic erosions, attributing them to environmental factors such as vegetation, geology, geomorphology, aggressive rainfall patterns in the region, and soil characteristics. The consequences of soil erosion are severe, leading to the loss of arable land and inhabitable areas (Simpson, 2001).

The critical state of gully erosion problems in Nigeria necessitates a comprehensive soil conservation program to mitigate the hazards posed by these erosions. Soil conservation measures should focus on sustainable soil productivity while striking a balance between the ecosystem and human-induced influences. Gully occurrences have resulted in the destruction of several properties, particularly houses, with some areas losing multiple buildings in a single event of gully erosion. For instance, in the Auchi area of Edo State, about ten houses were lost to gully erosion (Poeson, 2011). In another incident, over 450 buildings were reported to be lost in Edo State due to erosion The problem of gully development poses a significant threat to land use, sustainable agriculture, and infrastructural development in the Kaduna South Local Government Area. In light of this situation, this study aims to assess the extent of gully development in both planned and unplanned communities within the Kaduna South Local Government Area. By understanding the severity of gully erosion and its impact on the region, this study seeks to inform effective strategies for mitigating the erosional hazards and preserving the environmental and socio-economic stability of the area.

Gully erosion represents a significant component of land degradation that requires careful consideration in the planning of urban centers. It occurs when water flows through unprotected land, washing away soil along drainage lines (Ibrahim, 2014). In the Kaduna South Local Government Area, gully erosion has emerged as a serious problem affecting both planned and unplanned localities. Examples of its impact include the washing away of toilet blocks at Tudun Nupawa Primary School and the encroachment on access roads in Kurmin Mashi due to gully development. Similar situations are observed in areas like Kabala west, Barnawa, Television, and Tudun Wada.

Various measures have been implemented to address gully occurrences in these affected areas. Communal efforts during the rainy season aim to mitigate the effects of gullies, while the Local Government Authority works on de-silting drainages to allow for the free flow of water and prevent further gully development. The State Ministry of Environment also takes action to tackle gully erosion in the region. Additionally, the Federal Government has partially addressed one gully site in Tudun Wada through the ecological funds. Despite these efforts, the problem of gully development persists.

Gully erosion poses several problems, including the threat of displacement, destruction of road and communication infrastructure, loss of lives and properties, and the disruption of existing drainage systems, among others. To address these challenges, the research in question investigates the spatial distribution of gully erosion in planned and unplanned areas of Kaduna South Local Government Area. Utilizing ArcGIS 10.5, the study aims to identify and map out areas affected by gully erosion, analyze potential causes, and propose solutions to mitigate its effects.

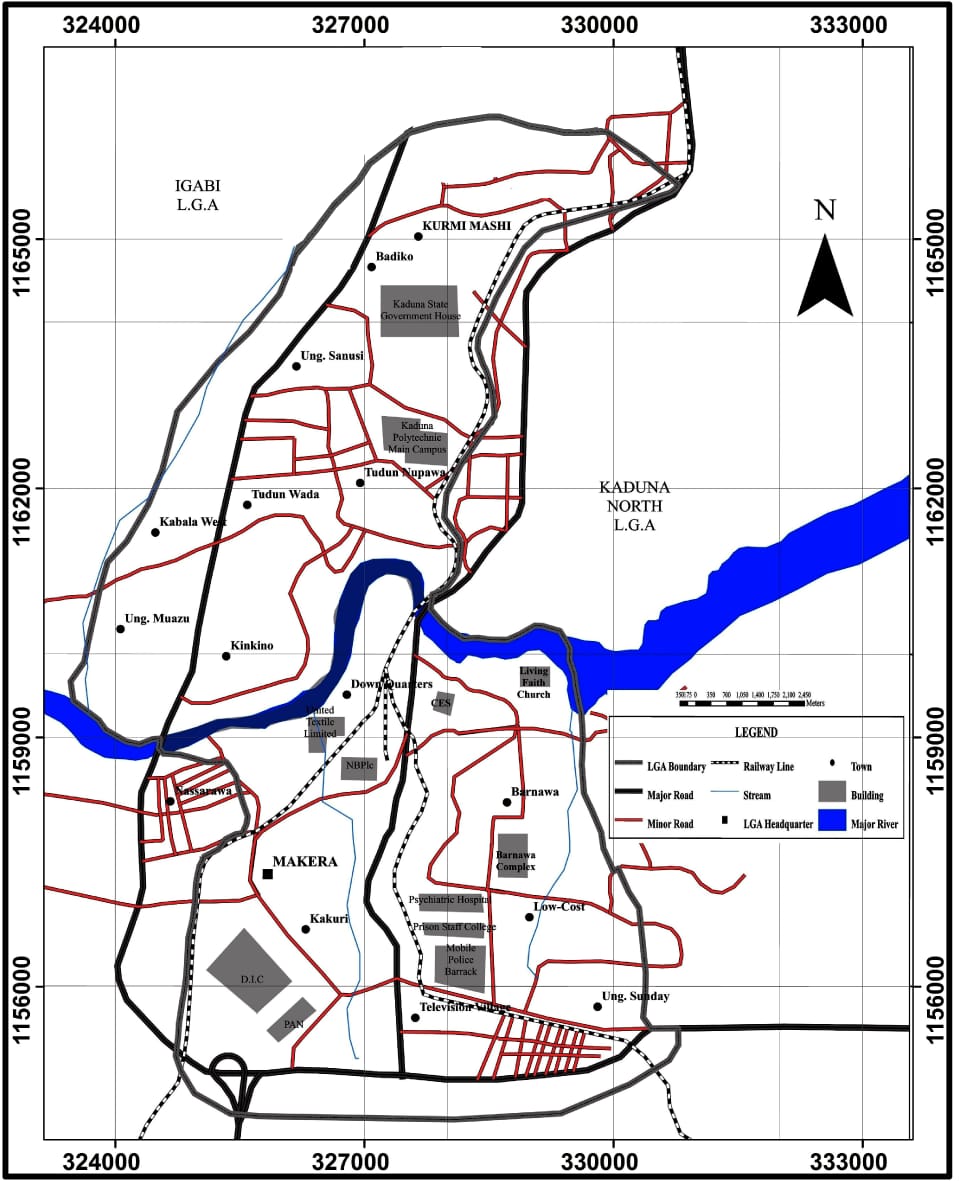
In conclusion, gully erosion represents a pressing issue in the studied region, impacting both planned and unplanned areas. Despite various efforts by different authorities, the problem persists, causing significant disruptions and risks to the community. The research endeavors to shed light on the extent and characteristics of gully erosion, offering valuable insights to develop more effective strategies for its prevention and mitigation.

The aim of this study is on the assessment of the extent of gully erosion in both planned and unplanned areas of Kaduna South Local Government Area. This aim was achieved via the following actions

1. Identification of the planned and unplanned areas within the study area.
2. Identifying the gully erosion sites and the level of their development.
3. Examining the causes of gully erosion in the study sites.
4. The determination of the effects of gully erosion on available infrastructure.

**Materials and Methods**

**Study Area**: The study is limited to Kaduna South Local Government situated within the Kaduna Metropolis and falls in the ecological zone of Northern guinea Savannah.. The area is geographically located between Latitude 100 24' 00''and 100 28' 00'' North and Longitude 700 20' 00'' and 700 28' 00'' East as shown in figure 1.

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**Figure 1: The Study Area**

**Source: Cartography Department, Kaduna Polytechnic (2021)**

The elevation of Kaduna South varies between 575 to 650 meters above sea level. Kaduna South experiences a typical tropical continental climate with distinct seasonal patterns, alternating between hot dry and humid wet season. This variations are influenced by the presence of tropical continental and equatorial maritime air masses that sweep over the entire country. The climate is characterized by a pronounced seasonality, with cool and dry season. The localities surrounding Kaduna South are characterized by a peneplain that has developed under Precambrian basement complex, consisting of igneous and metamorphic rocks with varying compositions, including quartzite. Overtime, weathering, erosion, transportation and deposition processes have shaped the land forms. Some areas in Kaduna South have protruding hard and resistant granite rocks that have resulted from the weathering process. (Dantudu 2015). Moving on the relieve of Kaduna South, the land primarily comprises of rolling hills with elevation ranging from as low as 600m

The study area is cited in the central.part of Kaduna State Nigeria, covering a total land area of 1152km2 and estimated to be inhabited by 588,766.8 people. The terrain is predominantly flat, with gentle undulations found in the northern part. The soils in Kaduna South Local Government Area primarily consists of Sandy and laomy soils. Sandy soils are composed of medium, coarse and particle, promoting good drainage and lacking organic matter. The prevalent soil type I of Kaduna South Local Government Area is sandy loam, which combines soil texture with varying promotions of silt ,clay and organic materials.sandy laomy generally offers excellent water holding capacity and fertility compared to pure sandy soils ensuring favorable conditions for crop cultivation due to their effective drainage conditions.

**Data Collection**

The study employed a descriptive survey method, which involves collecting data to describe and interpret existing conditions, prevailing practices, attitudes, and procedures related to the research objectives. The data were presented using maps, plates, and tables, and subsequently analyzed and presented using graphs, tables, figures, and charts.

Before initiating the main study, a reconnaissance survey was conducted to gain a better understanding of the gully locations and to identify the planned and unplanned areas. This preliminary survey laid the groundwork for scoping the study and setting its boundaries.

Gully locations were obtained through ground truthing, where researchers physically visited the sites and used a hand-held GPS device to accurately record the exact locations of the gullies in the study area. Additional attribute data, such as the gully's proximity to infrastructures like roads and buildings, and specific characteristics of each gully, were also recorded.

A base map of the study area was obtained, covering the period from 2000 to 2020, with intervals of 5 years. This base map served as a reference for understanding the spatial changes over time.

Topographic maps and land use maps of the study area were also acquired, providing valuable information about the terrain and how the land is being utilized.

Oral interviews were conducted with individuals directly affected by gullies, gathering valuable insights and experiences from the local community. Additionally, a field survey was conducted to gather on-site information.

The following software’s are used for the studies: -

i ArcGIS 10.5 software for mapping, vectorization and analysis purposes,

ii Microsoft words for data storage and processing,

iii Microsoft Excel for data entry and graphic display.

The following hardware’s are used for data collection and analysis: -

i GPS (hand held Garmin 78s) for the collection of coordinates of gully locations.

ii HP Laptop for typing, data analysis and storage of soft copy.

iii Coloured printer for conversion of soft to hard copies

iv Digital camera for capturing photographs of the affected locations

v Measuring tape for measurements of the gully length and width

The sample used in this study was determined based on the desired level of research. The entire relevant field data was gathered through a series of steps, including Reconnaissance Survey, field Observation, Measurements, oral interviews, Ground Truthing, and Inventory Survey, to ensure comprehensive and validated data.

Observation played a crucial role in conducting this research; areas affected by gullies were carefully observed and recorded for analysis.

All geographic data collected underwent meticulous scrutiny and were converted into compatible

formats for computer systems. The following processes were undertaken: Geo-referencing,

Digitizing, Creation of layers, and Data Base Creation.

The analysis was conducted to achieve the research objectives. Descriptive statistics were utilized to summarize the data gathered from field observation, measurements, and interviews. The relevant data were presented using tables, plates, figures, and maps. Furthermore, GIS Analysis involved overlaying the gullies' locations on the base map generated for the period 2000-2020.

**Data Analysis and Discussion**

The designated planned areas under the Kaduna State Geographic Information System (KADGIS) is presented in Table 1. Investigation reveals that communities in Kaduna South Local Government were planned during the period from 1976 to 2014. Among these planned settlements, Barnawa Residential Layout stands as the oldest, while Makama Road Low Density Residential Layout represents the most recent planned area, as the result presented in table 1.

**Table 1**: List of Planned Areas under the State Planning Authority

|  |  |  |  |
| --- | --- | --- | --- |
| **S/No.** | **Planned Areas** | **TPO’s** | **Year of Approval** |
| 1 | Barnawa residential layout GRA B | 463 | 1976 |
| 2 | Bye Pass Light Industrial Estate K/Mashi A,B and C | 460 | 1985/1998 |
| 3 | College Road Residential Layout (Governor Road) | 428 | 1985 |
| 4 | Bus Terminus, Residential and Commercial Layout, Badikko | 630 | 1991 |
| 5 | Kakuri Industrial Layout | 451 | 1994 |
| 6 | Tudun Wada Lodge Layout | 640 | 1991 |
| 7 | Challawa Crescent residential lay out | 635 | 1996 |
| 8 | Unguwan Muazu old market site Development  Layout extension | 668 | 1997 |
| 9 | AliyuMakama road redevelopment scheme | 655 | 1996 |
| 10 | Low density residential lay out at Barnawa North | 1064 | 2014 |
| 11 | Unguwan Television high density residential layout | 5598 | 2000 |
| 12 | Tudun Wada and Kinkinau medium density residential layout | 996 | 1996 |
| 13 | Makama road, Barnawa GRA, Low density residential layout Barnawa north | 636 | 2014 |

\*TPO Town planning ordinance

***Source:*** KADGIS, KASUPDA 2021

Table 2 provides evidence of the existence of planned areas in Kaduna South Local Government under the native authority before the establishment of the Local Government system in Nigeria. The oral interview with the deputy director of lands in Kaduna South Local Government reveals that people applied for lands and were allocated them under the native authority as far back as the 1950s, as clearly indicated in Table 2 above

**Table 2**: Planned Areas under the Local Government and Colonial Authority

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Area** | **L.G.A. Planning Authority** | **Native Authority** | **Years of**  **Establishment** |
| 1 | T/Wada | - | Native | 1930s-1963 |
| 2 | Sabon/Gari | - | Native | 1963 |
| 3 | Makera | - | Native | 1950s-1962 |
| 4 | Kakuri | - | Native | 1950s-1962 |
| 5 | T/Nupawa | Kaduna L.G.A Authority | - | 1962 |
| 6 | K/Barchi | Kaduna L.G.A Authority | - | 1972 |
| 7 | Barnawa | Kaduna L.G.A Authority | - | 1972 |
| 8 | K/Mashi | Kaduna L.G.A Authority | - | 1974 |
| 9 | Badikko | Kaduna L.G.A Authority | - | 1974 |
| 10 | Kabala West | Kaduna L.G.A Authority | - | 1976 |
| 11 | U/Sanusi | Kaduna L.G.A Authority | - | 1976 |
| 12 | Shagari Low-cost Barnawa | Federal Ministry of Works | - | 1979 |

***Source:*** Kaduna South L.G.A, 2021

Results obtained in Table 3 showcases the unplanned areas within the Kaduna South Local Government area, encompassing 12 different localities. Oral interviews with village heads and residents revealed this outcome. The earlier settlers were permitted to continue residing in their respective areas while planning initiatives were being implemented. According to the research findings, Kakuri Gwari stands as the oldest settlement, with a history of over 200 years of existence.

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**Table** 3: Unplanned Areas (Old Settlements) Presentation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Area** | **L.G.A. Planning Authority** | **Customary Authority** | **Year of Establishment** |
| 1 | T/Wada | Nil | Nil | Over 120 |
| 2 | U/Sanusi | Nil | Nil | Over 100 |
| 3 | Kabala West | Nil | Nil | Over 150 |
| 4 | Barnawa | Nil | Nil | Over 100 |
| 5 | K/Mashi | Nil | Nil | Over 150 |
| 6 | Badikko | Nil | Nil | Over 150 |
| 7 | K/Barchi | Nil | Nil | Nil |
| 8 | T/Nupawa | Nil | Nil | Over 120 |
| 9 | Kakuri-Gwari | Nil | Nil | Over 200yrs |
| 10 | Makera | Nil | Nil | Over 150 |
| 11 | Barnawa | Nil | Nil | Over 120 |
| 12 | Kakuri | Nil | Nil | Over 150 |

***Source:*** Author’s Field Work, 2021

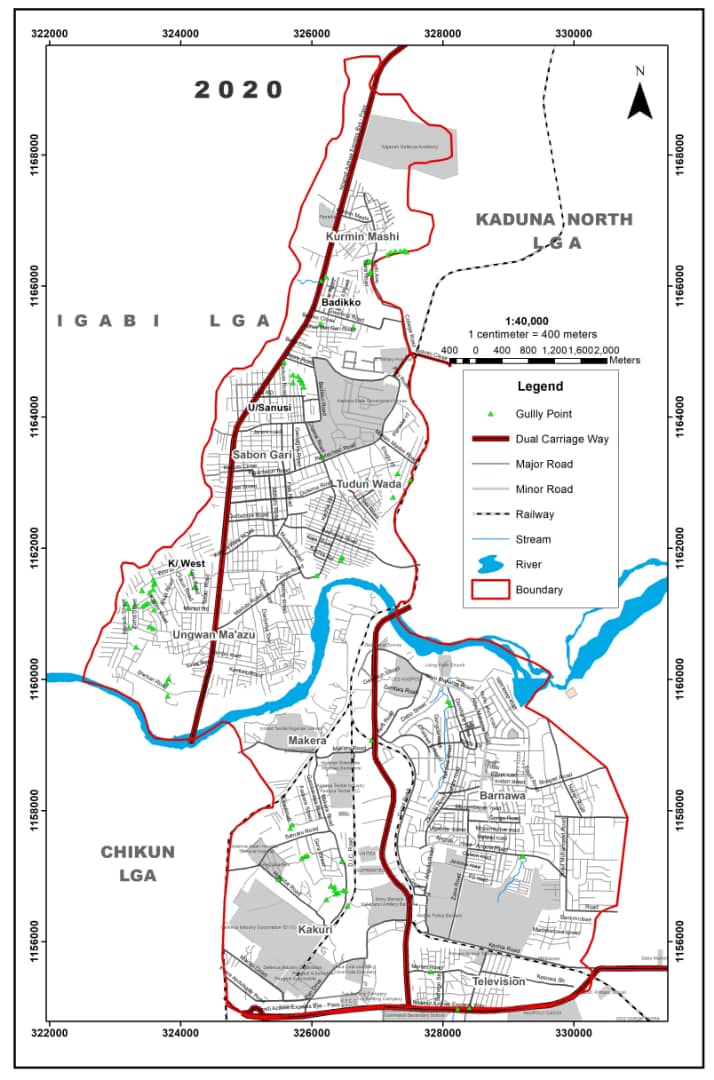
The identified gully locations and their developments over a period of twenty (20) years is presented in Table 4 with their respective location as shown by Figure.2.

**Table 4**: Identified Gully Locations and Development over a 20-Year Period

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S/No** | **IDENTIFIED AREAS** | **Ref No.** | **2005** | | **2010** | | **2015** | | **2020** | |
|  |  |  | NO | EO | NO | EO | NO | EO | NO | EO |
| 1 | Kurmin Mashi | 1 | 327294 | 1166426 | 327447 | 1166524 | 326218 | 1166144 | 326831 | 1166358 |
|  |  | 2 | 327241 | 1166451 | - | - | 326147 | 1166080 | 326856 | 1166370 |
|  |  | 3 | 327126 | 1166217 | - | - | 327399 | 1166496 | 326880 | 1166384 |
|  |  | 4 | 327121 | 1166241 | - | - | 327324 | 1166464 | - | - |
|  |  | 5 | - | - | - | - | 327156 | 1166478 | - | - |
| 2 | Badikko | 6 | 326137 | 1165429 | 325576 | 1164841 | 326635 | 1165372 | - | - |
|  |  | 7 | 324163 | 1161620 | - | - | - | - | - | - |
| 3 | Unguwan Sanusi | 8 | 325839 | 1164559 | 325789 | 1164630 | - | - | 326150 | 1163396 |
|  |  | 9 | 325855 | 1164528 | 325876 | 1164463 | - | - | - | - |
|  |  | 10 | 325816 | 1164577 | 325713 | 1164529 | - | - | - | - |
|  |  | 11 | 325711 | 1164647 | - | - | - | - | - | - |
| 4 | Kabala West | 12 | 325576 | 1164841 | 324163 | 1161620 | 324231 | 1161409 | 323591 | 1161452 |
|  |  | 13 | 323579 | 1161376 | 324212 | 1161409 | 323604 | 1161478 | 323413 | 1161356 |
|  |  | 14 | 323463 | 1161146 | 323583 | 1161527 | 323611 | 1161193 | - | - |
|  |  | 15 | 323423 | 1161120 | 323593 | 1161064 | 323528 | 1161322 | - | - |
|  |  | 16 | 323495 | 1161166 | 323175 | 1161165 | 323181 | 1161152 | - | - |
|  |  | 17 | - | - | 323206 | 1161084 | 323206 | 1161084 | - | - |
|  |  | 18 | - | - | 323305 | 1161130 | 323305 | 1161130 | - | - |
| 5 | Unguwan Mu’azu | 19 | - | - | 323522 | 1160809 | 323209 | 1160790 | 323321 | 1160495 |
|  |  | 20 | - | - | - | - | - | - | 323582 | 1160779 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 21 | - | - | - | - | - | - | | 323782 | 1159947 |
|  |  | 22 | - | - | - | - | - | - | | 323815 | 1160016 |
|  |  | 23 | - | - | - | - | - | - | | 323802 | 1159751 |
| 6 | Tudun Nupawa | 24 | 327248 | 1163026 | 326840 | 1163048 | - | - | | 327348 | 1162938 |
|  |  | 25 | 327240 | 1162784 | - | - | - | - | | - | - |
|  |  | 26 | 327223 | 1162936 | - | - | - | - | | - | - |
|  |  | 27 | 327505 | 1163039 | - | - | - | - | | - | - |
| 7 | Tudun Wada | 28 | 326075 | 1161586 | - | - | - | - | | - | - |
|  |  | 29 | 326441 | 1161824 | - | - | - | - | | - | - |
|  |  | 30 | 327310 | 1163140 | - | - | - | - | | - | - |
| 8 | Television | 31 | 328226 | 1154977 | 328406 | 1154992 | 328517 | 1155373 | | 327824 | 1155542 |
| 9 | Barnawa | 32 | 328114 | 1159610 | 329208 | 1157305 | - | - | | - | - |
|  |  | 33 | 328077 | 1159671 | 329217 | 1157305 | - | - | | - | - |
| 10 | Kakuri Gwari | 34 | 326365 | 1156731 | 326223 | 1156647 | 325493 | 1156952 | | 326547 | 1156548 |
|  |  | 35 | 326402 | 1156748 | - | - | 325516 | 1156991 | | 326478 | 1156783 |
|  |  | 36 | 325847 | 1157280 | - | - | 326457 | 1157223 | | 326519 | 1156779 |
|  |  | 37 | 325897 | 1157304 | - | - | 326289 | 1156847 | | - | - |
|  |  | 38 | 325932 | 1157321 | - | - | 325700 | 1157786 | | - | - |
|  |  | 39 | 326349 | 1156784 | - | - |  |  | | - | - |
| 11 | Kakuri Hausa | 40 | 326349 | 1156838 | - | - | - | - | | - | - |
|  |  | 41 | 325672 | 1157732 | - | - | - | | - | - | - |
| 12 | Makera | 42 | 326912 | 1159074 | - | - | - | | - | - | - |

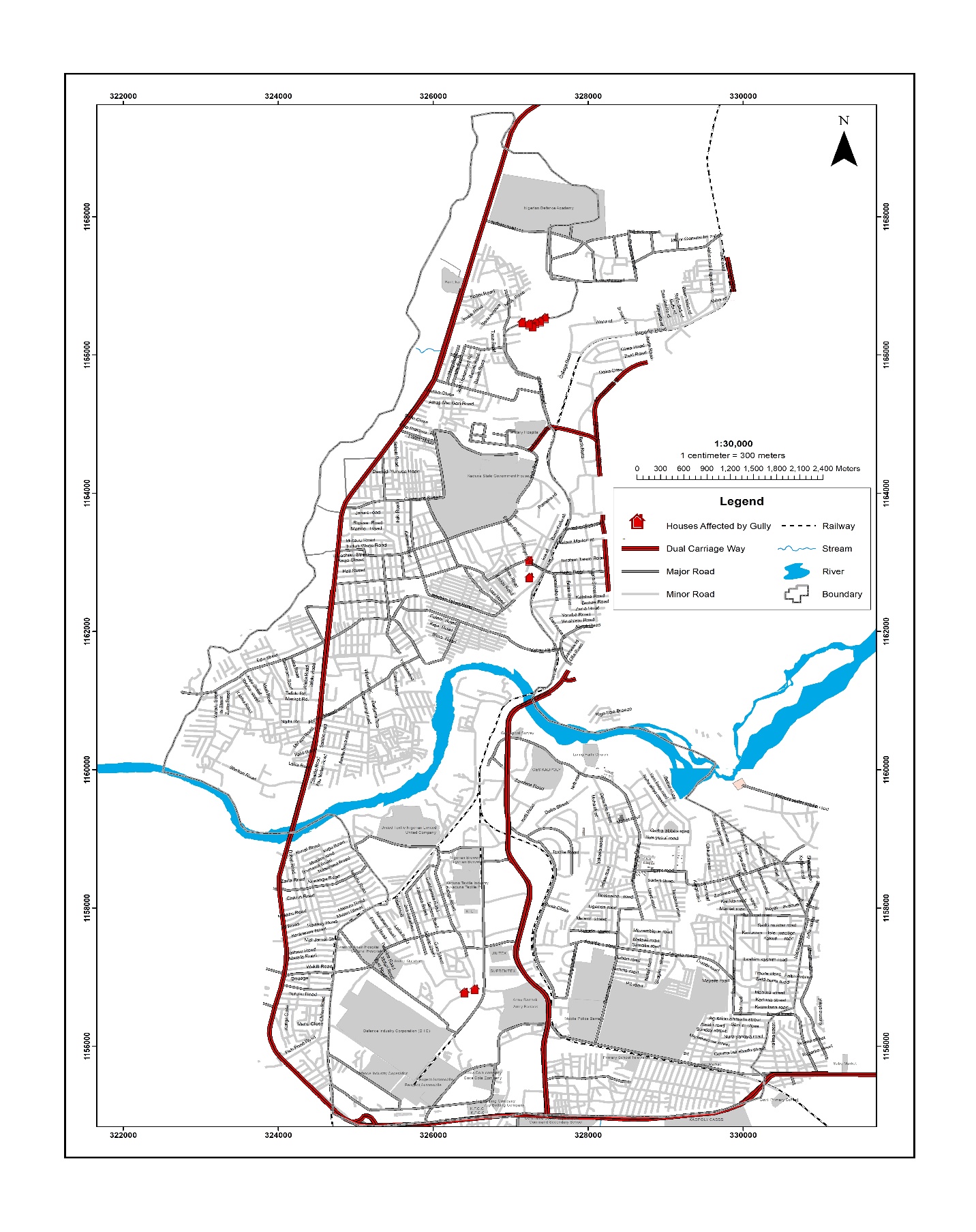
***Source;*** Author’s field work 2021



es**Figure 2:** Gully Locations in the Study Area

Authors Field Work, 2021

The outcomes of gullies and their impact on houses in regions of high gully prevalence particularly in Kurmin Mashi area is observed in Plates I, II and III. In this areas, numerous residents have been compelled to evacuate their homes and relinquish their possessions to allow the gully to persist in its development. Notably, River Close has experienced such effects. Additionally, Plates III and IV depict the alarming situation at the Local Education Authority Primary School in Tudun Nupawa, where the gully's advancement poses a severe threat, encroaching closely upon the classrooms and fully engulfing two blocks of toilet facilities used by the students. In these areas, numerous houses have been destroyed, leading to the area becoming a hub for criminal activity involving the sale and consumption of various sedative drugs during daylight hours. This perilous situation has also resulted in the recruitment of many unsuspecting young individuals into these illicit activities. The gullies in these regions have become conspicuous symbols of land degradation, necessitating an immediate response to salvage the affected environment.

**Figure 3.:** Houses affected by gully developments

***Source:*** Author’s Field Work, 2021



*Plate I****:*** Gully development approaching a classroom in LEA, Primary school, T/Nupawa

***Source:*** Authors Field Work, 2021



Plate II**:** Gully development that consumed 2 Toilet facilities in LEA, T/Nupawa

***Source:*** Authors Field Work, 2021



*Plate III****:*** Houses at River Close Kurmin Mashi, where residents forfeited and evacuated their belongings because of gully development.

***Source:*** Authors Field Work, 2021

**SUMMARY, CONCLUSION AND RECOMMENDATIONS**

Gullies represent visible signs of land degradation, and the research findings provide evident support for gully erosion occurring due to various factors. It is crucial to implement mitigation and remediation measures to address gully development and ensure a sustainable and healthy environment. Thus, this study focused on conducting a comparative analysis of gully development in the planned and unplanned areas of Kaduna South Local Government Area. The study identified the locations of planned and unplanned areas, with Table 1 displaying the planned areas approved by the Kaduna Urban Planning Development Authority (KASUPDA) and Table 1 presenting the planned areas under the Kaduna Local Government and Customary (Native) authority. Additionally, Table 2 illustrates the unplanned areas (old settlements).

During the assessment of the existing planned and unplanned areas, it was discovered that certain parts of Kaduna South Local Government area were planned before Nigerian independence, as evidenced by records from Kaduna Geographic Information Systems (KADGIS) and Kaduna State Urban Planning Development Authority (KASUPDA) in Table 1. This table indicates the names of the areas, Town Planning Orders (TPOs), and the years of establishment, which vary across different locations. These planned areas are spread across the study area and feature diverse land uses such as residential, industrial, and commercial. According to the records, Barnawa Residential Layout and G.R.A. B 1976 stand as the oldest and low-density residential layouts, while Barnawa North 2014 represents the most recent layout established by KADGIS in the study area. Table 4 also reveals planned areas under the Local Government and Customary (Native) authorities, with certain areas like Tudun Wada, Makera, Kakuri, and S/Garin Tudun Wada planned and approved by customary authorities between the 1930s and 1960s. Moreover, Table 4 provides clear information about areas that were not planned by State, Local government, or customary authorities, and they are regarded as old settlements. The planning authorities adopted the integration concept to incorporate these areas instead of the resettlement concept, which involves demolishing all existing structures to create new settlements.

The locations of eighty-eight (88) gullies were identified, and their coordinates were recorded using GPS Garmin78s, as displayed in Table 4. These points were then superimposed on Figure 4., revealing areas with a high prevalence of gullies, namely Kabala West, Kakuri Gwari, Kakuri Hausa, and Kurmin /Mashi.

Investigating the causes of gully erosion in the study area, it was found that in Kurmin Mashi, gullies primarily form due to water channels or streams that pass through the area, carrying a large volume of rainwater, especially during high-intensity periods, as shown in Figure 4. This situation is also evident in Plate V, where it remains consistent in Tudun Nupawa, where two blocks of toilet facilities were washed away at LEA Tudun Nupawa Primary School. This finding aligns with Stocking (1987) and Lal (2016), which suggest that the kinetic energy of the storm and the highest intensity of rainfall during the first 30 minutes significantly contribute to soil loss and gully erosion on field plots. Rainfall distribution, intensity, and quantity, along with other environmental factors, play a role in accelerating the rate of inter-rill and gully erosion development.

The level of gully development significantly impacting many roads in Kabala was found to be a result of steep slopes. According to the relief of the study area, Kabala West and Unguwan Muazu have the lowest relief at 565 meters above sea level. This aligns with Hudson, N.W. (2011), as steep lands are more vulnerable to water erosion due to increased erosive forces such as splash, scour, and transport.

The study also revealed that the level of government intervention in tackling gully development is inadequate. However, community efforts in some areas play a vital role in addressing the ongoing development of gullies, as demonstrated in Plate VI and VII.

**Conclusion**

The findings of this study indicate that various factors contribute concurrently to the development of gullies in the study area, including socio-economic status, poor development control, slope size and inclination, inadequate drainage systems, soil type, and rainfall.

The research emphasizes that gullies can form in both planned and unplanned areas, with socio-economic status being a major contributing factor, as evidenced in high gully prevalence areas like Kurmin Mashi, Kabala West, Kakuri Gwari, and Tudun Nupawa. Residents from disadvantaged socio-economic backgrounds often remain in such areas due to their struggle for daily survival, vacating their homes only when it becomes unavoidable for the gully to continue its development, as seen in Kurmin Mashi.

Furthermore, slope influences the quantity of runoff, with long slopes collecting more water and generating larger volumes of runoff. Steep and long slopes tend to cause the most erosion due to high velocity and mass of runoff, as observed in Kurmin Mashi and Kabala West, which are part of the high-prevalence gully occurrence areas.

**Recommendations**

Based on the field findings and obtained results, the following recommendations are proposed to effectively address and control the development of gullies in the study area:

**i Implementation of drainage and culvert construction**: Constructing proper drainage systems and culverts will assist in mitigating and preventing the concentration of water before it flows down steep slopes, ultimately halting gully formation.

**ii Utilization of lateritic soil for backfilling gullies**: In areas where gullies have already formed, backfilling with lateritic soil should be employed. Additionally, for deeper cuts, permanent engineering gully remediation techniques, such as constructing channels, embankments, and retaining walls, should be utilized.

**iii Strict adherence to development control measures**: It is essential to comply strictly with development control regulations to avoid building developments in close proximity to water channels, especially at the tributaries of River Kaduna. Adequate provisions for water channels where necessary must also be addressed by the Local and State governments.

**iv Public awareness and education**: The government should collaborate with relevant authorities to raise awareness among gully-affected communities about the detrimental effects of gullies. This will help discourage building development in gully-prone areas and encourage residents to take preventive measures

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