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THE NEXUS BETWEEN ENVIRONMENTAL DRIVERS AND ANTHROPOGENIC MITIGATING MEASURES IN SHAPING THE CONTEMPORARY LANDSCAPE OF SOIL DEGRADATION IN SOUTHERN KEBBI, NIGERIA

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Abstract

This study examines the nexus between environmental drivers and anthropogenic mitigating measures in shaping the contemporary landscape of soil degradation in Southern Kebbi, Nigeria. Soil erosion has emerged as a critical environmental challenge in the region, driven by a combination of natural factors particularly high-intensity rainfall, soil texture, topography, and climate variability and human-induced pressures such as deforestation, unsustainable agricultural practices, overgrazing, mining, and rapid land-use transformation. Using respondents' perceptions, field measurements, and spatial evidence, the study establishes rainfall as the dominant natural driver of erosion, while deforestation and inappropriate land management practices constitute the most significant anthropogenic contributors. The consequences include loss of fertile topsoil, declining soil productivity, landscape instability, and increased vulnerability of rural livelihoods that depend largely on rain-fed agriculture. The study adopted a mixed-methods approach, integrating qualitative and quantitative techniques. Primary data were obtained through interviews, focus group discussions, structured questionnaires, and field observations, while soil sampling, GIS and remote sensing analyses, and land use/land cover (LULC) change detection for a 20-year period (2004–2024) provided quantitative and

Keywords: Soil Degradation, Deforestation, Anthropogenic, Land Use/Land Cover Change, Gully Erosion

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spatial evidence. Findings reveal that rainfall is the dominant natural driver of soil erosion (75%), while deforestation (45%), unsustainable agricultural practices (25%), and overgrazing (15%) are the leading anthropogenic causes. Gully erosion is the most prevalent form (38.57%), followed by rill (33.10%) and sheet erosion (28.33%). The area is dominated by sandy loam and loamy sand soils, with a mean soil pH of 5.90 and mean drainage of 36.2 mm/hr, conditions that increase erosion susceptibility. Vegetation cover declined from 409,274.22 ha in 2004 to 252,315.07 ha in 2024, while agricultural land expanded to 875,797.34 ha. The study recommends integrating indigenous management practices—such as agroforestry, contour farming, crop rotation, mulching, and controlled grazing with modern soil conservation measures and effective land-use policies to curb erosion, restore degraded landscapes, and promote sustainable agricultural livelihoods in Southern Kebbi, Nigeria.

Introduction

Soil erosion represents a critical environmental and agrarian challenge in numerous regions across Nigeria, significantly compromising agricultural productivity, ecological stability, and local livelihoods. Kebbi State, situated in the semi-arid northwestern geopolitical zone of Nigeria, exemplifies this vulnerability. The region's economy is predominantly agrarian, sustained by extensive tracts of sandy and loamy soils, which are intrinsically highly susceptible to fluvial and aeolian erosion processes. In particular, catastrophic gully and sheet erosion have become more frequent in the southern geopolitical demarcation, often known as Southern Kebbi. According to Oluwasina and Oladosu (2022) and Lawal and Anyaku (2025), the indigenous tribes have experienced severe socioeconomic hardships, reduced food yields, and quantified land forfeiture as a result of this deterioration.

Kebbi State is ecologically situated within the Sudan Savanna zone, characterized by a marked bimodal climate with a distinct dry season and a concentrated rainy season spanning typically from May to October. The inherent fragility of the soil structure, when compounded by accelerating anthropogenic factors—including rapid land use transformation, intensive deforestation, unsustainable overgrazing, and inappropriate farming methodologies—substantially exacerbates the susceptibility of the land surface to erosive forces (Yahqub *et al.*, 2024). Recent empirical investigations confirm that pervasive soil degradation in Southern Kebbi has resulted in the loss of fertile topsoil, a decline in soil organic matter and fertility indices, and heightened sedimentation rates in contiguous water bodies, thereby negatively impacting both agricultural viability and aquatic ecosystems (Muhammad *et al.*, 2024).

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Indigenous Management Practices (IMPs) refer to locally derived, culturally-embedded, and historically-proven strategies employed by communities for the sustainable management of land and natural resources (Obiefuna and Okeke, 2018; Kom *et al.*, 2024). These practices are fundamentally rooted in indigenous knowledge systems, transmitted inter generationally, and meticulously adapted to specific local ecological and socioeconomic contexts.

Consequently, there is an urgent epistemological and practical imperative for a comprehensive, scientifically validated investigation to rigorously document existing IMPs, objectively evaluate their effectiveness against measurable erosion parameters, and explore systematic modalities for their integration into broader land-use planning and policy frameworks. A robust understanding of IMPs in Southern Kebbi is fundamentally vital for the development of sustainable, culturally resonant, and community-driven soil conservation solutions. This study is thus strategically designed to address these critical knowledge deficits by systematically assessing the spectrum of indigenous practices, quantitatively evaluating their efficacy, and identifying the principal socio-ecological and governance factors that influence their adoption and long-term sustainability, thereby providing an informed foundation for policymakers and development agencies.

Southern Kebbi, an agricultural enclave encompassing seven Local Government Areas within the Yauri and Zuru Emirates (specifically Danko/Wasagu, Fakai, Sakaba, Zuru, Shanga, Ngaski, and Yauri), is fundamentally reliant on rain-fed agriculture for both subsistence and commercial farming practices. The region is characterized by accelerated soil erosion rates, principally driven by anthropogenic factors such as indiscriminate deforestation, fragmented land-use planning, and the intensifying impact of climate change. The severity of this degradation has reached such alarming proportions that it has been officially acknowledged as a disaster-level menace (National Daily Trust Newspaper, 11th April 2017). The annual regime of torrential rainfall significantly alters the geomorphological landscape, instigating the formation of extensive and deep gullies which progressively enlarge, transporting substantial volumes of material from the sloping terrain and leading to pervasive landscape alteration (Adebayo, 2017).

Materials and Method

Study Area

The Southern Kebbi [comprising of Zuru and Yauri Emirates], is in the Kebbi State, north-western Nigeria. It borders Sokoto State to the north, Zamfara State to the east, Niger State to the south and Benin republic to the west. The area has a wide land area of 11,580.7 sq km which has a diverse topography of plains, hills and valleys. The climate in the region is semi-arid with clear wet and dry season. The area is located between 11° and 12° North and 4° and 5° East of the equator. Agriculture, animal rearing, fishing and trading are the

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occupations of the people in the region. The big crops that are grown in the area are the millet, maize, sorghum, cowpea, and rice.

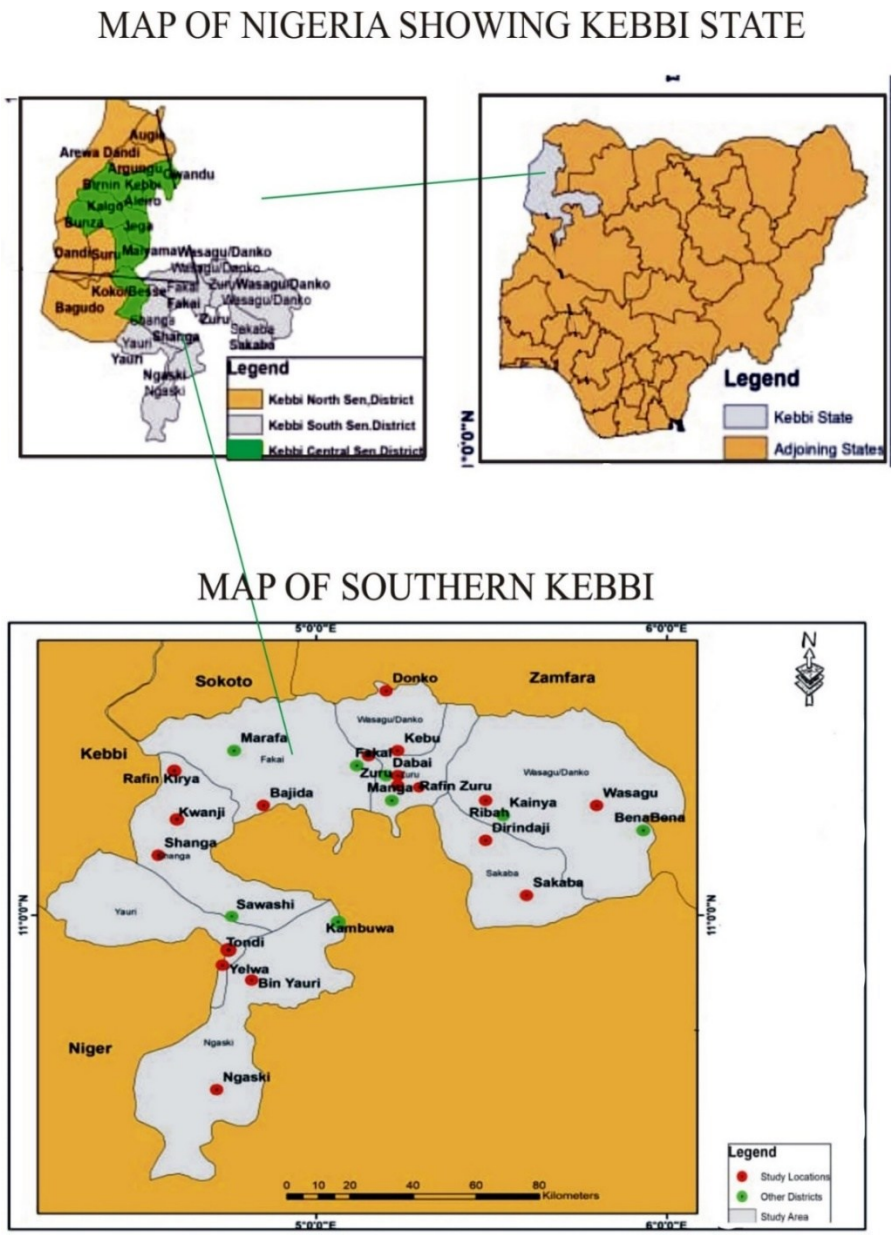

Figure 1: Study Area Location
Source: Political Map of Nigeria (2019)

The study adopts a mixed-methods approach by integrating both qualitative and quantitative research techniques to achieve a comprehensive understanding of indigenous land management practices and soil erosion. Qualitative data were obtained

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through interviews with local farmers, community leaders, traditional authorities, and agricultural experts, as well as focus group discussions aimed at exploring indigenous knowledge, beliefs, and practices related to soil conservation. Purposive sampling was used to select key informants and discussion participants based on their experience and depth of knowledge. Primary qualitative data were further supported by field observations, while secondary data were sourced from existing literature, governmental and non-governmental organization reports, and academic institutions to strengthen contextual understanding and triangulate findings. Quantitative data collection involved the use of GIS and remote sensing techniques to map and analyze the spatial patterns of soil erosion and the distribution of indigenous management practices across the study area. Field surveys and structured questionnaires were administered using stratified random sampling to ensure adequate representation of different land management practices and erosion-prone zones. Data analysis combined descriptive statistics—such as means, frequencies, percentages, and standard deviations—with spatial analysis using GIS to identify patterns and relationships. Qualitative data from interviews and discussions were analyzed thematically, while quantitative and spatial analyses provided empirical evidence on erosion rates, land use dynamics, and the effectiveness of indigenous soil conservation practices.

Results

Natural Drivers of Soil Erosion in Southern Kebbi

The research paper has explored the natural factors that contribute to soil erosion in Southern Kebbi and found out that soil erosion is majorly contributed to by Natural and Anthropogenic causes. Topography, Climate, Soil Characteristics, Vegetation Cover are all under the Key Natural Drivers. According to the survey information provided in Table 1, Rainfall which has 75% out of total responses is the most influential natural cause of soil erosion in Southern Kebbi, as indicated by the respondents. This very high percentage is a strong indication that the overpowering force of water, is the more powerful agent of nature that gets away with the topsoil. Heavy rainfall leads to erosion in two main modes the splash effect, which is the process in which individual raindrops sweep the soil particles away, and the runoff, which is the process whereby the sheer mass of water slipping away carries the dislodged particles, forming a sheet, a rill or even a gully erosion. Wind is mentioned by paradoxically 10% of the respondents meaning that although it can be a cause of erosion, it is considered to have a much less dramatic impact on it, compared to water. The 15% of those who gave this response identified the cause as Other Factors which may include natural factors such as the natural nature of the soil (Like., erodibility), terrain steepness, or geological action. However, the numerical data takes a very clear view of high intensity rainfall as the major natural hazard to the soil stability and fertility

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in the study field. Climatic conditions in the region which are characterized by heavy rainfall and wind during rainy season also contribute to erosion. The absence of contour farming, insufficient terracing, and poor land management practices also make the problem worse Yilmaz, S., Demir, G., and Kaya, M. (2023).

Table 1: Respondents View to the Natural Causes of Soil Erosion in the Study Area

Respondents	Frequency	Percentage %
Rainfall	315	75
Wind	42	10
Other Factors	63	15

Source: field work, 2024

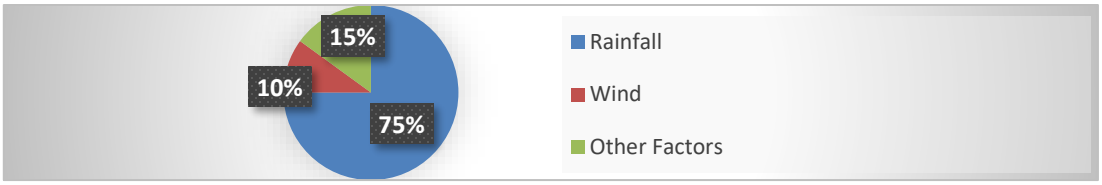

Figure 2 Showing Respondents View to the Natural Causes of Soil Erosion in Southern Kebbi, Kebbi State.

Source: field work, /GIS 2024

Table 2: Summary of Natural Causes of Soil Erosion in Southern Kebbi

Natural Cause of Erosion	Percentage%	Mitigating measures
Rainfall **Impact: Heavy rainfall leads to surface runoff, which can wash away the topsoil. The intensity and duration of rain significantly contribute to soil erosion**	75%	**Agroforestry:** Planting trees and shrubs alongside crops can help intercept raindrops, reducing the impact on the soil surface. **Contour Farming:** Implementing contour plowing can enhance water retention and reduce runoff by following the natural contours of the land. Cover Cropping: Using cover crops during off-seasons can protect the soil from erosion and improve soil health.
Wind **Impact: Wind erosion is particularly prevalent in dry seasons, where loose topsoil can be lifted and carried away, especially in areas with sparse vegetation.**	10%	Windbreaks: Planting rows of trees or shrubs can serve as barriers to wind, reducing its speed and protecting the soil. Mulching: Applying organic or inorganic mulch can help protect the soil surface from wind erosion and maintain soil moisture. Proper Grazing Management: Managing livestock grazing to prevent overgrazing can help maintain vegetation cover that protects against wind erosion.

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Other Factors **Impact: This category includes factors such as human activities, land use changes, and natural events like landslides or floods that can also contribute to soil erosion.**	15%	**Terracing:** Constructing terraces on slopes can help reduce runoff and soil loss, particularly in hilly areas. **Indigenous Management Practices:** Encouraging practices such as crop rotation, reduced tillage, and organic farming can enhance soil structure and reduce erosion. **Community Education:** Raising awareness about sustainable agricultural practices and the importance of maintaining vegetation can help mitigate human-induced erosion.

Source: field work

Anthropogenic Drivers of Soil Erosion in Southern Kebbi

Based on the responses detailed in Table 3, the key anthropogenic drivers of soil erosion in Southern Kebbi are predominantly rooted in land use and agricultural practices.. The largest influence is the Deforestation that is characterized by 45 percent of the respondents. When the trees are cut off to make fuel, to build houses or to plough land, the wealth of topsoil, the canopy which collects rain and the roots which keep the soil in place, is washed away. This exposes the ground to the maximum erosion power of rain and wind. Unsuitable Agricultural Practices is the second major cause with 25%. This group generally includes a number of unsustainable agricultural practices, including mono cropping (planting the same crop each year), tilling processes which overly destroy soil structure, or tilling a steeply sloping land without proper terracing or contouring. Such activities erode the soil in terms of its organic matter and stability and leave the soil prone to being washed away easily by the water runoffs. The third significant cause is overgrazing, with 15% of the interviewees reporting the same. In over grazing, livestock will destroy too much of the vegetative cover and trample the ground with their feet. Compression of soil decreases water percolation resulting in more and quicker surface runoff, which erodes loose topsoil.

Lastly, Construction Activities and Other Factors contribute 10 and 5 respectively, which shows that the development of infrastructures and disturbance of natural scenery and soil are a contributing factor. All the mentioned data emphasize that the shift to sustainable land management and agroforestry is essential in reducing the most serious anthropogenic risks to soil fertility in the region.

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Table 3: Respondents View to the Anthropogenic Causes of Soil Erosion in Southern Kebbi

Respondents	Frequency	Percentage %
Deforestation	189	45
Unsuitable Agricultural Practices	105	25
Overgrazing	63	15
Construction Activities	42	10
Other Factors	21	5

Source: field work, 2024

The outcome of Table 3 indicated the Respondents perception to the Anthropogenic Causes of According to the research, Participation of the community in native soil management techniques reduces the adverse effects of these human activities in the research area which ultimately results in soil health and ecosystem resilience. The range of what was found by this study coincides with the range of what Pimentel, D., and Burgess, M. (2017) found. Soil erosion especially gully erosion is a major ecological problem in many states in the humid tropical regions of southern Nigeria, among them being Anambra, Imo, Ebonyi, Abia and other states of the humid tropical environment.

Table 4: Summary of Anthropogenic Causes of Soil Erosion in Southern Kebbi

Anthropogenic Cause of Erosion	Percentage%	Mitigating measures
Deforestation **Impact: The removal of trees leads to reduced canopy cover, which increases soil exposure to wind and rain, resulting in higher erosion rates.**	45%	**Agroforestry:** Integrating trees into agricultural systems can enhance soil stability and reduce erosion. **Community Tree Planting Initiatives:** Engage local communities in reforestation efforts to restore and maintain forest cover.
Unsustainable Agricultural Practices **Impact: Practices such as monoculture, excessive tillage, and the use of chemical fertilizers can degrade soil structure and fertility, making it more susceptible to erosion.**	25%	**Crop Rotation:** Implementing diverse crop systems to improve soil health and reduce erosion. **Conservation Tillage:** Promoting minimal tillage practices to maintain soil integrity and reduce disturbance.
Overgrazing **Impact: Excessive grazing pressure from livestock can lead to vegetation loss, which destabilizes soil and increases erosion risk.**	15%	**Controlled Grazing Practices:** Implementing rotational grazing to allow vegetation recovery and soil stabilization. **Fodder Cultivation**: Growing fodder crops to supplement livestock feed and reduce pressure on natural pastures.

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Construction Activities **Impact: Land clearing and earth-moving activities associated with construction can disturb soil layers and lead to sediment runoff.**	10%	**Erosion Control Measures:** Implementing silt fences and sediment traps during construction to limit soil displacement. **Site Restoration:** Rehabilitating disturbed areas post-construction with vegetation cover to stabilize the soil.
Other Factors **Impact: This category may include urbanization, mining, and industrial activities, which can also contribute to soil erosion.**	5%	**Sustainable Urban Planning** Incorporating green spaces and permeable surfaces in urban development to enhance water infiltration and reduce runoff. **Awareness Programs:** Educating communities about the impacts of various activities on soil erosion and promoting sustainable practices.

Source: field work

Result from Table 4 reveal that, effective mitigation of soil erosion in Southern Kebbi requires integrated approaches, which include contour plowing, terracing, and agroforestry also with traditional and modern methods that help reduce runoff and soil loss. Reforestation and afforestation projects are vital in restoring vegetative cover and stabilizing soil. Community-based soil conservation programs, supported by government and non-governmental organizations, promote awareness and active participation among farmers and local stakeholders. Additionally, introducing sustainable land management practices such as crop rotation, cover cropping, and controlled grazing can significantly reduce erosion risks. Policy frameworks that encourage land rehabilitation and environmental education are also necessary to sustain erosion control efforts, as documented by Ojo, O., Oladipo, A., and Akinboade, O. (2020). Modern Soil Erosion Control Technologies in Nigeria: Effectiveness and Challenges. Also, Ojo, A., Adeyemi, A., and Ojo, S. (2021), documented a study on the impact of human activities on soil erosion in Kebbi State, Nigeria, which has similar aspect for both natural and anthropogenic courses of soil erosion in southern Kebbi.

The integration of these indigenous management practices in Southern Kebbi State underscores the importance of leveraging local knowledge and resources to combat soil erosion effectively. By combining traditional ecological wisdom with contemporary agricultural techniques, the community not only enhances its resilience to soil erosion but also contributes to the sustainability of its agricultural systems. This multifaceted approach not only safeguards the environment but also supports the livelihoods of local farmers, ensuring a balanced relationship between agricultural productivity and

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ecological integrity. The indigenous management practices in mitigating soil erosion of the studied area as discovered from this study fall the range of the findings of Osei, Y., Mensah, J.,and Ofori, E. (2015). In Ghana, they practised traditionally, and indigenous famers grow pigeon peas, Mucuna, Dolichos, and stylosnthes, which shield the soil from erosion and weeds. Cover crops are long term agricultural tools that recover soil water dynamics and upsurge soil organic matter.

The findings from Southern Kebbi State underline the critical role of topography, soil drainage, and pH in driving soil erosion. This research provides valuable insights for local agricultural practices, emphasizing the need for tailored soil management strategies using indigenous management practices. In view of the above for achieving the effectiveness of indigenous management practices in southern Kebbi, the study intends to know how the soil drainage and soil pH of Southern Kebbi interplay, to enable good decision on the mitigation measures in the study area. In summary integrating indigenous management practices with modern smart farming techniques, in Southern Kebbi can effectively mitigate soil erosion while enhancing agricultural productivity. This approach not only preserves the environment but also empowers local communities, fosters resilience, and promotes sustainable land use. Collaboration among farmers, local governments, and NGOs will be crucial in driving these initiatives forward.

Respondents View on Drivers of Soil Erosion in Southern Kebbi

The results from Table 5 indicates that while all Local Governments Areas (LGAs) face soil erosion, the most critical drivers vary by location and topography:

i. **Danko Wasagu** (15%): The primary drivers here are a combination of human induced land degradation. Deforestation, Overgrazing, and Unsustainable Agriculture Practices. This suggests a landscape where the removal of protective vegetation and poor farming methods are intensifying erosion.
ii. **Fakai (20%):** This LGA's key drivers are predominantly physical and human environmental factors. Steep Slopes (a natural factor), Poor Drainage, and Deforestation. The high percentage indicates that the combination of challenging topography and the removal of trees is a severe problem, especially when coupled with heavy rainfall.
iii. **Sakaba (5%)**: Erosion here is attributed to industrial and urban activities, specifically Mining Activities, Construction Activities, and Soil Compaction. Although the lowest percentage, this profile suggests localized, intense soil disturbance related to development.
iv. **Shanga (10%):** The drivers are linked to intensive agriculture and urbanization. Monoculture Farming, Improper Waste Disposal, and Urbanization. These

indicate that modern land use practices and human settlements are major contributors to land degradation.

v. **Ngaski (15%):** This LGA points to systemic issues. Poor Land Use Planning, Soil Disturbance, and Climate Change. The reference to planning and climate change suggests that the respondents perceive erosion as a result of policy failures and broader environmental shifts.

vi. **Yauri (15%):** The main concerns are Illegal Logging, Soil Pollution, and general Land Degradation. This profile strongly emphasizes the role of illicit and unregulated human activities that directly diminish soil quality and protective cover.

vii. **Zuru (20%):** Erosion is driven by a critical mix of forces. Riverbank Erosion (suggesting a significant water body influence), Deforestation, and Poor Agricultural Practices. Tying with Fakai for the highest frequency, Zuru clearly faces severe water related erosion intensified by the removal of riparian and upland vegetation.

Table 5: Respondents Views on Drivers of Soil Erosion in the Study Area

Respondents	Frequency	%
DANKO WASAGU MAIN CAUSES OF SOIL EROSION:		
Deforestation	**63**	**15**
Overgrazing		
Unsustainable agriculture practices		
FAKAI MAIN CAUSES OF SOIL EROSION:		
Steep slopes		
Poor drainage	**78**	**20**
Deforestation		
SAKABA MAIN CAUSES OF SOIL EROSION:		
Mining activities		
Construction activities	**21**	**5**
Soil compaction		
SHANGA MAIN CAUSES OF SOIL EROSION:		
Monoculture farming		
Improper waste disposal	**42**	**10**
Urbanization		
NGASKI MAIN CAUSES OF SOIL EROSION:		
Poor land use planning		
Soil disturbance	**63**	**15**
Climate change		

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Respondents	Frequency	%
YAURI MAIN CAUSES OF SOIL EROSION:		
Illegal logging:		
Soil pollution	**63**	**15**
Land degradation		
ZURU MAIN CAUSES OF SOIL EROSION:		
Riverbank erosion		
Deforestation	**78**	**20**
Poor agricultural practices		
Total	**420**	**100%**

Source: field work, 2024

In summary, the most cited individual cause across the region is Deforestation (present in Danko Wasagu, Fakai, and Zuru), often combined with poor/unsustainable agricultural practices and physical factors like steep slopes or poor drainage. The LGAs with the highest perceived severity, Fakai and Zuru (both 20%), are those where deforestation and water related issues (steep slopes/poor drainage and riverbank erosion) are listed together. This variation suggests that effective mitigation efforts must be tailored to address the dominant local drivers, such as promoting agroforestry in Danko Wasagu, implementing erosion control on slopes in Fakai, and regulating land use near rivers in Zuru.

Mitigating Measures of Soil Erosion by the Respondents in the Study Area

Mitigating soil erosion in Southern Kebbi requires tailoring interventions to the specific drivers identified in each Local Government Area (LGA), focusing on sustainable land management, legislative enforcement, and infrastructure development.

i. **Danko Wasagu** (Deforestation, Overgrazing and Unsustainable Agriculture): The primary strategy here should be the aggressive promotion of agroforestry and reforestation programs to combat deforestation. To address overgrazing, the LGA needs to implement rotational grazing systems, establish designated grazing reserves, and enforce controlled animal stocking limits. Farmers must be educated and incentivized to adopt conservation agriculture techniques like minimal tillage and cover cropping to make agricultural practices sustainable.
ii. **Fakai** (Steep Slopes, Poor Drainage, Deforestation). Mitigation in Fakai, with its challenging topography, must focus on structural conservation measures. This includes the construction of terraces and contour bunds on steep slopes to break the speed of water flow and trap sediment. Addressing poor drainage requires constructing proper drainage channels (gutters/culverts) and gully reclamation

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works. Reforestation efforts must be concentrated on the steepest slopes and vulnerable catchment areas.

iii. **Sakaba** (Mining, Construction, Soil Compaction). Given the focus on industrial and construction activities, the LGA must enforce strict environmental regulations requiring mandated reclamation plans for all mining and construction sites. This involves leveling disturbed land, covering it with topsoil, and replanting vegetation immediately after work concludes. To relieve soil compaction, techniques like deep ripping or subsoiling should be employed, followed by the incorporation of organic matter.

iv. **Shanga** (Monoculture, Improper Waste Disposal, Urbanization). To counter monoculture, farmers should be encouraged to practice crop rotation and intercropping, which enhance soil structure and fertility. The local government must invest in improved waste management infrastructure and enforce penalties for improper waste disposal, as debris can block drainage systems and worsen runoff. Urbanization impacts should be mitigated through green infrastructure and strategic land use planning that preserves buffer zones and green spaces.

v. **Ngaski** (Poor Land Use Planning, Soil Disturbance, Climate Change). The crucial step is to develop and enforce a comprehensive, climate-resilient Land Use Plan that zones areas for agriculture, settlement, and conservation, preventing the cultivation of marginal lands. Public awareness campaigns are needed to explain the link between climate change and environmental vulnerability. All development activities must incorporate mandatory Environmental Impact Assessments (EIAs) to minimize soil disturbance.

vi. **Yauri** (Illegal Logging, Soil Pollution, Land Degradation). A strong emphasis on enforcement is necessary to stop illegal logging and timber harvesting, possibly through community-based forest monitoring. The local government must also develop programs for the safe disposal and regulation of agrochemicals and pollutants to counter soil pollution. Large-scale rehabilitation and afforestation projects are required to reverse existing land degradation.

vii. **Zuru** (Riverbank Erosion, Deforestation, Poor Agricultural Practices). The most critical measure here is establishing and protecting riparian buffer zones—strips of permanent vegetation along riverbanks—to stabilize the soil and prevent riverbank erosion. This must be complemented by renewed reforestation efforts and intensive extension services to train farmers in effective water harvesting techniques and sustainable tillage practices to minimize soil loss on their farms.

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Soil characteristics of Southern Kebbi

The results presented in Figure 3 illustrate the relationship between soil texture and erodibility in Southern Kebbi, Kebbi State. The findings reveal distinct patterns in how different soil textures influence the K factor values, which quantify the susceptibility of soils to erosion in the study area.

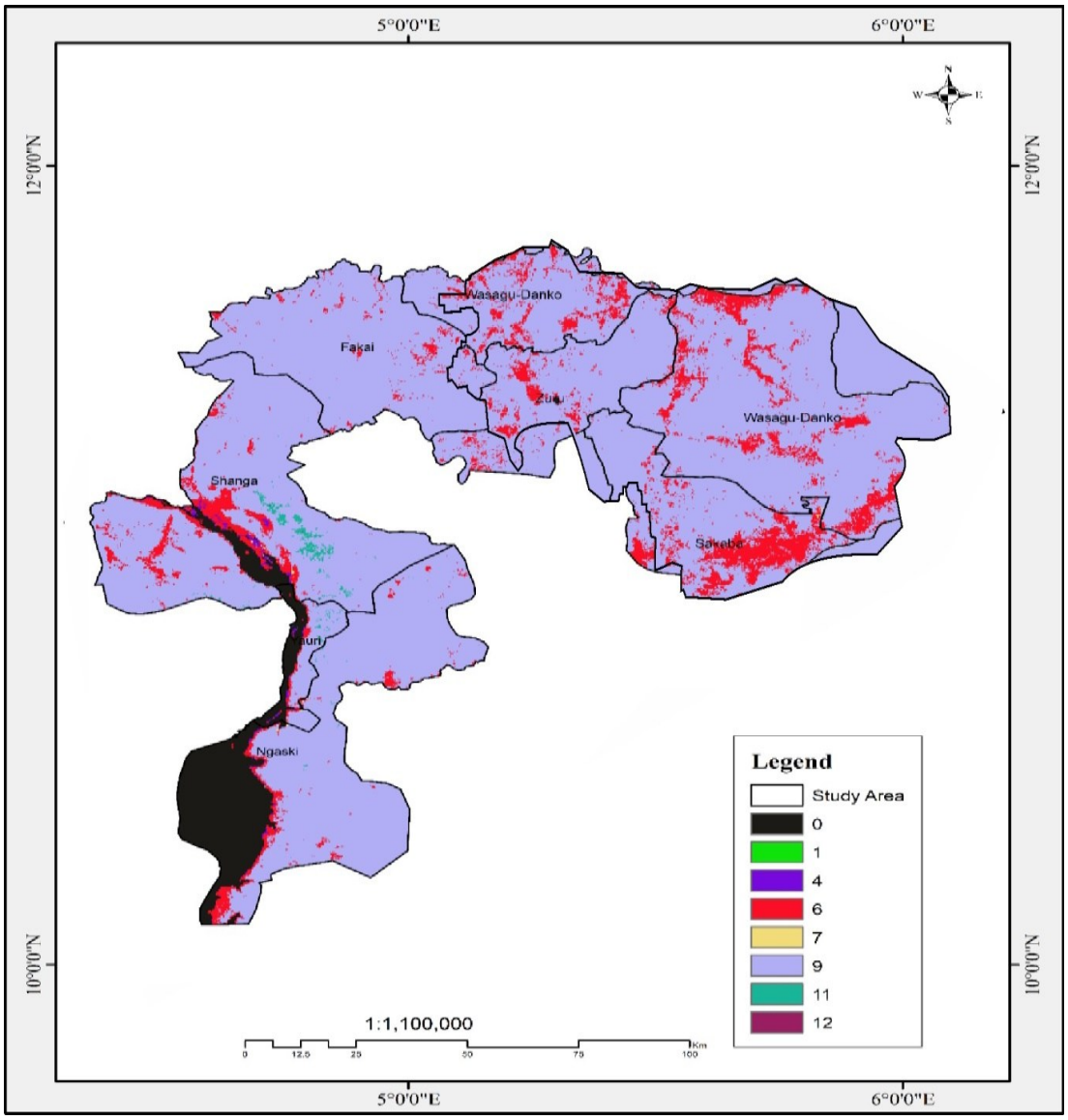

Figure 3: Soil Texture of southern Kebbi State

Source: Open Land Map/SOL/SOL_TEXTURE-CLASS_USDA-TT_M/v02 Resolution 250m (2024)

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Table 6: Description of the soil texture and K-factor of the study Area

Soil Texture	K Factor
Clay	0.0288
Silty Clay	0.0341
Sandy Clay	0.036
Silty Clay Loam	0.0394
Clay Loam	0.0264
Sandy Clay Loam	0.0394
Silt	0.0499
Silt Loam	0.05
Loam	0.045
Sandy Loam	0.017
Loamy Sand	0.0053
Sand	0.0053

Source: analysis from figure 3

The results derived from figure 3 and table 6 shows High erodibility in Silty Soils, Soils with higher silt content, such as silt and loam, exhibit elevated K factor values, indicating greater erodibility. The characteristics of these soils contribute to their vulnerability to erosion, the small particle sizes of silt lead to reduced cohesion, making these soils more easily dislodged by water or wind. While silty soils can retain moisture, their loose structure can lead to increased surface runoff during heavy rains, further exacerbating erosion risks. Lower Erodibility loamy sand and sandy textures, possess the lowest K factor values. This reduced erodibility are attributed to Coarser Particles. The larger particle size of sand provides greater structural integrity, reducing the likelihood of erosion. Sandy soils typically allow for rapid drainage, which minimizes surface runoff and erosion potential. Clay Soils and Cohesion Clay soils, despite having small particle sizes, demonstrate relatively low K factor values due to their strong cohesive properties.

The fine particles in clay bind tightly together, enhancing soil stability and reducing erosion susceptibility. Water Interaction: While clay can become slippery when wet, its cohesive nature helps maintain soil integrity. Silty Clay and Clay Loam Textures Interestingly, silty clay and clay loam textures have higher K factor values compared to pure clay. This highlights the influence of silt content on erodibility: Increased Vulnerability: The presence of silt in these textures can reduce overall cohesion, making them more prone to erosion than pure clay. These textures represent a balance between the cohesive properties of clay and the erodibility introduced by silt, resulting in an increased K factor.

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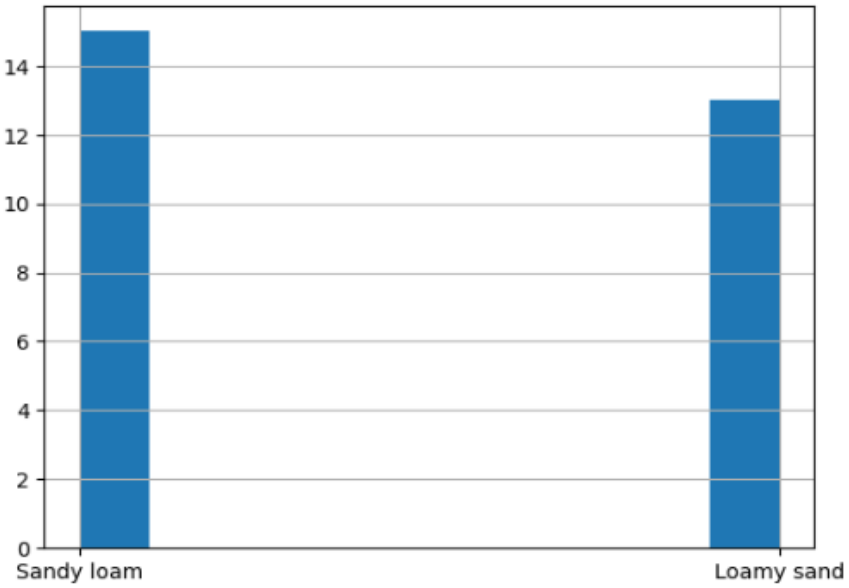

Figure 4: Histogram showings the soil texture is almost balanced between loamy sand and sandy loam

Source: analysis from *Figure: Soil Texture of southern Kebbi State*

The histogram above shows that the soil texture is almost balanced between loamy sand and sandy loam among the seven local governments studied. There were 15 and 13 samples of sandy loam and loamy sand respectively.

Table 7: Soil Properties of the Study Area in General

Sample		Parameters			
ID	**VILLAGE STUDIED**	**SOIL PH**	**SOIL DRAINAGE**	**TEXTURE**	**TOPOGRAPHICAL VALUE**
Shanga	Rafin kirya	5.51	35.7	Sandy Loam	
	Giro masa	5.48	33.8	Loamy Sand	
	Gebbe	6.19	29.3	Loamy Sand	
	Kwanji	6.32	36.6	Loamy Sand	
					74-217 Low
Ngaski	Kambuwa	5.67	32.7	Sandy Loam	
	Makurdi	5.40	37.6	Loamy Sand	
	Birnin yauri	5.48	30.2	Sandy Loam	
	Ngaski	5.51	30.2	Loamy Sand	
Fakai	Bajida	5.73	31.1	Loamy Sand	
	Mahuta	5.74	42.6	Sandy Loam	
	Fakai	7.43	59.0	Sandy Loam	

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ID	VILLAGE STUDIED	SOIL PH	SOIL DRAINAGE	TEXTURE	TOPOGRAPHICAL VALUE
	Marafa	7.22	47.0	Sandy Loam	
					217-336 Medium
Yauri	Yelwa	6.86	39.6	Sandy Loam	
	Tondi	7.53	44.8	Sandy Loam	
	Zamare	6.66	35.7	Sandy Loam	
	Bin yauri	5.66	35.7	Sandy Loam	
Danko/ Wasagu	Danko	5.59	33.8	Loamy Sand	
	Kyebo	5.41	35.7	Loamy Sand	
	Ribah	5.39	37.6	Loamy Sand	
	Wasagu	5.58	34.7	Loamy Sand	
					336-517 High
Sakaba	Dirin daji	6.09	33.8	Sandy Loam	
	Sakaba	5.67	35.7	Loamy Sand	
	Sabon Birni	5.82	40.6	Loamy Sand	
Zuru	Rafin zuru	5.47	42.6	Sandy Loam	
	Rikoto	5.53	32.0	Sandy Loam	
	Senchi	4.97	37.6	Sandy Loam	
	Dabai	5,06	31,1	Loamy Sand	

Source; Field Analysis, 2024

Soil pH and Soil Drainage of Southern Kebbi.

In Southern Kebbi State, soil pH and drainage were assessed to evaluate nutrient availability and hydrological constraints affecting crop production and erosion risk. Soil pH was measured in the field using a ratio 1: 2.5 soil to water suspension at 0 -15 cm and 15 - 30 cm depths, revealing an average topsoil pH of 6.1 (range 5.4 - 6.8) and a subsoil pH of 6.5 (range 5.9 - 7.1). The pH pattern showed more pronounced acidification in areas with intensive cropping and higher clay content, consistent with inputs from mineral fertilizers and organic matter dynamics.

The result from table 7 shows that the mean soil pH is 5.90, which generally falls into the slightly acidic category. While the pH exhibits a broad range, from a low of 4.97 (moderately acidic) in Senchi (Zuru) to a high of 7.53 (slightly alkaline) in Tondi and Bajida. The villages under Shanga, Ngaski, Danko/Wasagu, and Zuru predominantly show acidic soil conditions (most pH values <6.0). A notable shift occurs in Fakai and Yauri, where several samples show neutral to slightly alkaline conditions, with three villages (Fakai, Marafa, Tondi) recording pH ≥7.22. This is a significant spatial heterogeneity.

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Drainage assessment, based on field indicators and corroborated by laboratory measurements, classified about 45% of samples as well drained, with the remaining 55% ranging from moderately to poorly drained, particularly in low lying areas. The result from Table 7 shows that the mean soil drainage is 36.2 mm/hr. This is generally indicative of moderately high to high drainage rates, typical of the observed sandy textures. Drainage rates vary from a low of 29.3 mm/hr in Gebbe (Shanga) to a high of 59.0 mm/hr in Fakai (Fakai). There is no clear village level pattern showing drainage rates clustered around the mean. The highest drainage rates are observed in Fakai, Mahuta, and Marafa (Fakai), which correlates with the area also showing the highest pH values, but not consistently with texture (Like., Fakai and Mahuta are Sandy Loam, while other Sandy Loams have lower rates).

i. Soil Texture and Topography

The result from Table 7 shows that the dominant soil textures are Sandy Loam and Loamy Sand. Both indicate a high proportion of sand, which explains the generally high drainage rates. While the Topography shows that There is a general trend of increasing topographical value (from Low to High) corresponding with the administrative areas (Shanga to Zuru), suggesting a potential elevation or slope gradient across the study region.

From the result obtained in Table 7 the study observed pH and drainage data have significant implications for nutrient availability, agricultural practices, and resource management in the studied villages. Acidic Soils (pH<6.0 - Most of Shanga, Ngaski, Danko/Wasagu, Zuru). Acidity can reduce the availability of essential macronutrients like Phosphorus (P), Potassium (K), and Magnesium (Mg). It also increases the potential for Aluminum (Al) and Manganese (Mn) toxicity, which severely inhibits root growth and nutrient uptake.

These areas are best suited for acid-tolerant crops such as cowpea, sweet potato, cassava, or specific varieties of maize and sorghum bred for acid tolerance. Neutral to Alkaline Soils (pH ≥ 6.5 Fakai and Yauri). While toxicity is reduced, alkalinity can cause micronutrient deficiencies, particularly for Iron (Fe), Zinc (Zn), and Manganese (Mn), as these become less soluble and plant available. These soils are ideal for a wider range of crops, including most cereals, legumes (Like, groundnut), cotton, and vegetables, provided specific micronutrient deficiencies are addressed.

ii. Soil Amendments (Lime and Gypsum)

Villages with low pH (Like, Senchi, Rikoto, Ribah) require the application of agricultural lime ($CaCO_3$) to raise the pH and reduce Al toxicity. Liming is essential for sustainable production of acid-sensitive crops like maize and groundnut in these areas. Gypsum

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($CaSO_4 . 2H_2O$) is typically used to correct subsoil acidity (not directly addressed by this surface pH data) or to improve the physical properties of soils (high Na), which is not indicated here but could be relevant if Na is high. The high drainage rates suggest physical constraints are less of an issue, but poor subsoil structure is still possible.

iii. Drainage Improvements and Erosion Mitigation

The consistently high drainage rates suggest the soils are well-aerated but have a low water-holding capacity due to the sandy texture. This requires farmers to focus on irrigation (where available) and water conservation techniques like mulching and increasing Soil Organic Matter (SOM) to improve water retention. The combination of sandy texture, high drainage, and potentially increasing topographical values from Shanga to Zuru places the region at a high risk of wind and water erosion.

vi. Mitigation

Conservation tillage, contour farming on slopes, and the use of cover crops are crucial to protect the soil surface and bind the sandy particles.

v. Influence of Parent Material and Land Use:

The sharp pH gradient (acidic to neutral/alkaline) between administrative areas likely reflects a change in parent material (Like, from basement complex rocks to sedimentary or alluvial deposits rich in basic cations like Ca and Mg). Land Use (Like, application of different fertilizers or continuous cropping without proper residue management) can also significantly influence pH and SOM content, which, in turn, affects drainage. Influence of Soil Texture The dominance of Sandy Loam and Loamy Sand throughout the study area is the primary factor driving the high drainage rates. These coarse textures lead to a low Cation Exchange Capacity (CEC), making the soil less able to hold onto nutrients, especially in acidic conditions. Result in rapid leaching of applied fertilizers, requiring split application of N and K fertilizers to maximize efficiency. In conclusion, the study area is characterized by generally well drained, sandy soils with moderate acidity, requiring localized lime application and water/nutrient management strategies tailored to the specific pH and topographical conditions of each village compare to Soil Properties of the other Nigerian Regions as indicated in Table 8.

Table 8: Soil Properties of the other Nigerian Regions

Region	Soil Drainage (cm/hr)	Soil pH Range	Implications
North Central Nigeria (Like., Abuja, Kogi)	40 to 60 (Good to Excellent)	6.0 to 7.0(Neutral to Slightly Alkaline)	Favourable for diverse crops; low erosion risk
South East Nigeria (Like., Enugu)	20 to 35 (Poor to Moderate)	5.0 to 6.5 (Acidic to Slightly Acidic)	Higher erosion risk; limited vegetation cover
South West Nigeria (Like., Ibadan)	30 to 45 (Moderate to Good)	5.5 to 6.5 (Slightly Acidic to Near Neutral)	Moderate erosion risk; conducive for agriculture
North East Nigeria (Like., Borno)	15 to 30 (Poor to Very Poor)	4.5 to 5.5 (Strongly Acidic)	High erosion susceptibility; degraded soils

Source: ESA/World Cover/v100 Resolution**:** 10m

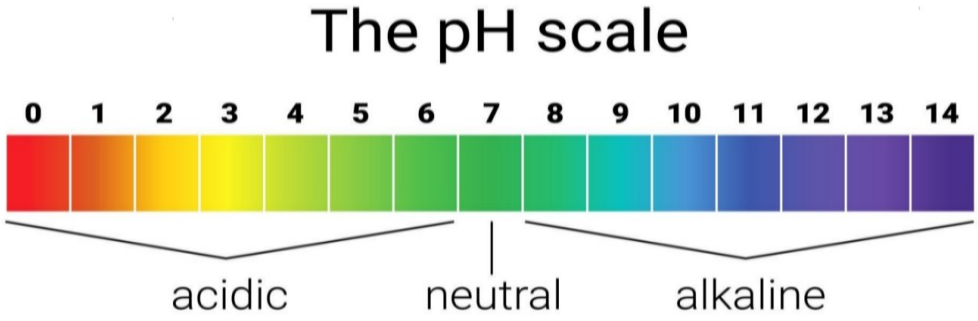

Figure 5: Soil pH: The Acidity Level
Source: ESA/World Cover/v100 Resolution**:** 10m

Soil Properties and Indigenous Practices of Southern Kebbi in relation to the Other Nigerian Regions:

The results obtained in Table 9 suggests that Southern Kebbi's local government areas (LGAs) have a mixed bag of soil characteristics, generally leaning toward poor drainage and acidic pH compared to the most favorable regional average (North Central). Kebbi's Acidity: Most LGAs in Southern Kebbi have a pH between 5.0 to 6.3 which falls in the Slightly Acidic to Strongly Acidic range. This is comparable to, or slightly less acidic than, the South East (5.0 to 6.5) and North East (4.5 to 5.5) regions. This acidity can limit the growth of certain crops without soil amendments like lime. The Exceptions: Ngaaki and Yauri trend toward Near Neutral to Alkaline (up to 6.8), mirroring the more Neutral to Slightly Alkaline conditions of North Central Nigeria (6.0 to 7.0), which is favorable for a diverse range of agriculture.

i. **Indigenous Practices:** The effectiveness of local farming methods is closely tied to the underlying soil quality. Practices in Yauri (Good to Very Good drainage, Slightly

Acidic to Alkaline pH) are rated as Highly Effective. This suggests that where the natural soil conditions are good, local knowledge thrives.

ii. **Limited Effectiveness:** Practices in areas with Poor to Very Poor drainage and Strongly Acidic pH (like Sakaba and Zuru) are rated as Limited Effectiveness. The data clearly shows that even the best traditional methods struggle to overcome severe soil constraints like poor water logging and high acidity. This mirrors the "degraded soils" implication noted for the North East. As shown in table 4.18

Table 9: Soil Properties and Indigenous Practices of Southern Kebbi in relation to the Other Nigerian Regions:

Region/LGA	Typical Drainage	Comparison Notes
North Central Nigeria	Good to Excellent (40 to 60 cm/hr)	This is the regional gold standard, offering great water movement and low erosion risk.
Southern Kebbi (Like., Danko Wasagu, Yauri)	Good to Excellent (35.0 to 50.0 cm/hr)	Danko Wasagu and Yauri match the quality of North Central areas, suggesting excellent conditions for many crops.
Southern Kebbi (Most other LGAs)	Poor to Very Poor (29.5 to 40.0 cm/hr)	Most of Southern Kebbi (Fakai, Sakaba, Shanga, Ngaaki, Zuru) struggles with drainage, similar to, or worse than, **North East Nigeria** (15 to 30 cm/hr) and **South East Nigeria** (20 to 35 cm/hr). Poor drainage often means waterlogging and less air for plant roots.

Source: ESA/World Cover/v100 Resolution**:** 10m

Land Used Land Cover (LULC) Change Detection of the Study Area from 2004 to 2024 (For the Period of 20years):

The Study further quantify the extend of soil erosion in the study area through Land Use Land cover change detection for the period of 20 years from (2004 to 2024) as shown in Figure 6, 7 and 8.

LULC 2004

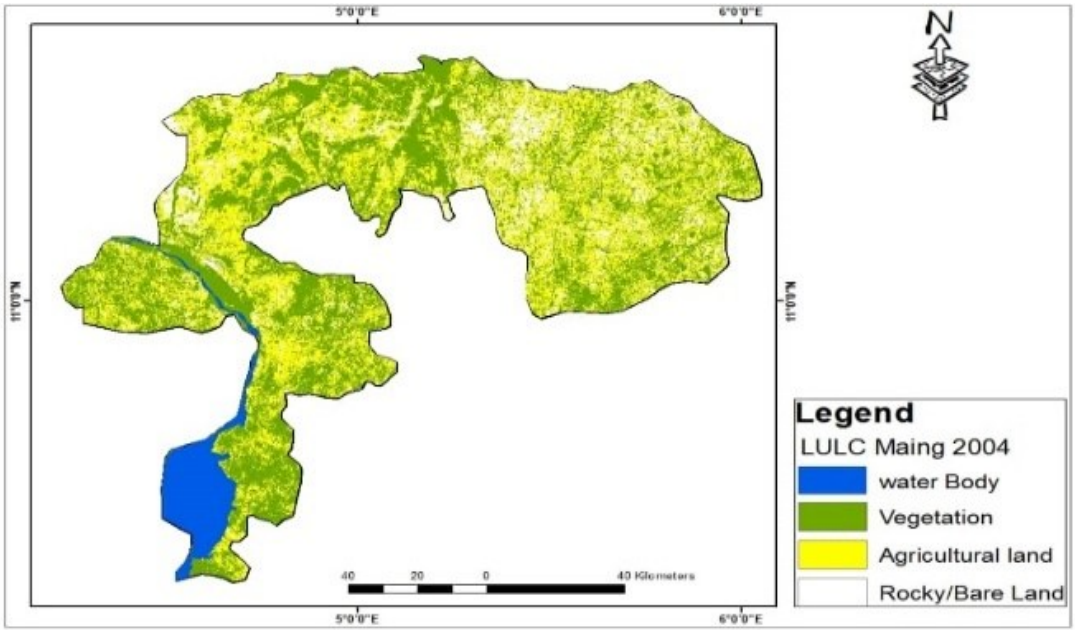

Figure 6 LULC Change Detection of the Study Area 2004

Source: ESA/World Cover/v100 Resolution: 10m

LULC 2014

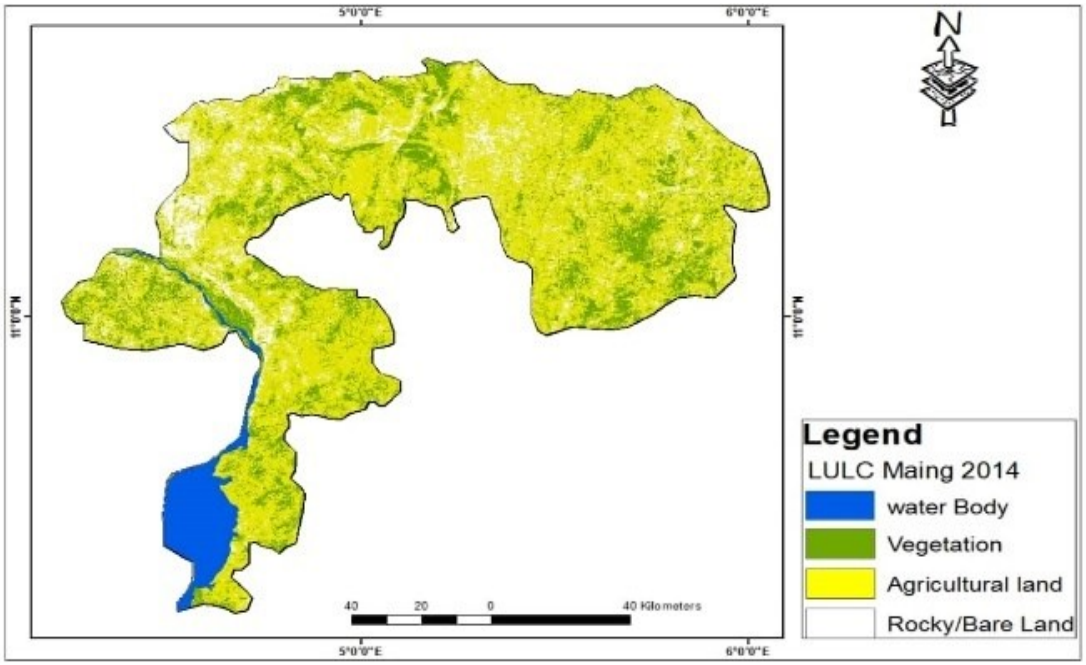

Figure 7: LULC Change Detection of the study area 2014

Source: ESA/World Cover/v100 Resolution: 10m

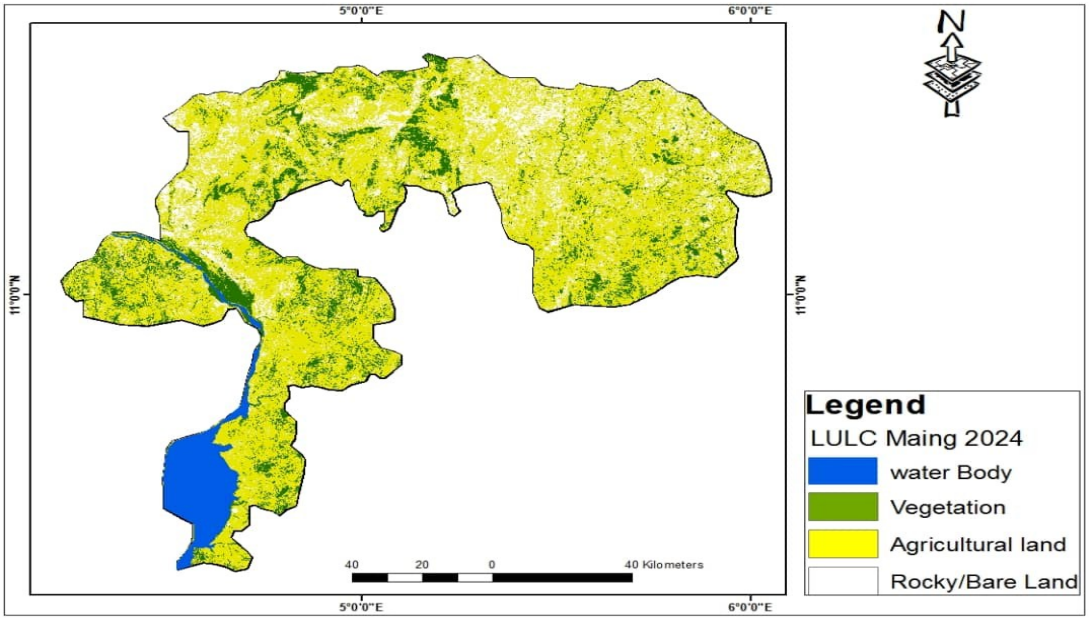

Figure 8: LULC Change Detection of the Study Area 2024

Source: ESA/World Cover/v100 Resolution: 10m

Table 8: Land Used Land Cover (LULC) Change Detection of the Study Area from 2004 to 2024 (For the period of 20years):

Years	Vegetation	Agricultural Land	Rocky/Bare Land	Water Body
2004	400,274.22	728,873.21	167,332.04	73,931.96
2014	298,548.45	829,446.77	167,695.03	74,721.18
2024	252,315.07	875,797.34	167,001.70	75,168.78

Sources: Land Used Land Cover (LULC) Detection of the study area from 2004 to 2024

The results obtained from Table 8 shown Land Used Land Cover (LULC) change detection of the study area from 2004 to 2024. Using ESA/World Cover/v100 Resolution: 10m that reveals significant transformations in the region's landscape. The transformation is measured in hectares (vegetation cover), agricultural land, rocky/bare land and water bodies. In 2004: Vegetation Covers 400,274.27ha Agricultural land 728,873.21ha Rocky/bare land 167,332.04 ha and Water bodies 73,931.96ha. According to the research, Southern Kebbi had a significant level of vegetation cover in 2004 which means that the ecosystem is relatively healthy. The agricultural land was much of the land use, as the region depended on farming as a means of economic support. In 2014 Vegetation Cover reduced to 298,548.45ha (reduction of 101,725.77ha) Agricultural Land was 829,446.77 ha (increase of 100, 573.56ha), Rocky/Bare Land was 167,695.03ha (some increase of 362.99ha) and Water Bodies was 74,721.18ha (increase this reduction implies more deforestation or conversion of land to agricultural activities as more land (over 100,000

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ha) was taken. The small change in rocky/bare land points to slight land degradation and the small change in water bodies points to the possibilities of having better water management or alterations in hydrology. Similar decline was witnessed in 2024 Vegetation Cover of 252,315.07 ha (further loss of 46,350.57 ha) Agricultural Land of 875,797.34 ha (further loss of 447.60 ha). The trend illustrates that the natural habitats are being constantly lost. The area of agricultural land was also growing with the latest agricultural area of 875,797.34 ha, which points to the constant demand of agricultural expansion, presumably, due to the population increase and economic dependence on agriculture. The rocky/bare land declined slightly indicating stabilization or recovery in part whereas the water bodies increased slightly.

The analysis has found out that the gradual loss of vegetation cover over the last 20 years is a cause of concern that may create a risk of biodiversity degradation, habitat loss, and soil erosion and desertification, unless it is controlled carefully. Agricultural Expansion: The massive growth in agricultural land use indicates an increasing agricultural activity in the region, which may cause soil erosion and desertification, unless well managed. Water Resource Management: The progressive rise in the water bodies, though small, is a pointer that there might be a rise in the water management practices, which may be very instrumental in sustaining agriculture and the local ecosystems. Policy and Management Strategies: With the trends being experienced, there is need to have effective land management policies that would ensure that sustainable agricultural practices are encouraged, reforestation and community participation in environmental conservation issues so as to strike a balance between the agricultural needs and ecological conservation.

Table 9: Evaluation of Land Used Land Cover (LULC) Change Detection of the Study Area from 2004 to 2024 (For the Period of 20 years):

Land Cover Type	2004 (ha)	2014 (ha)	2024 (ha)	Change (2004 2014)	Change (2014 2024)
Vegetation	409,274.22	298,548.45	252,315.07	-110,725.77	-46,233.38
Agricultural Land	728,873.21	829,446.77	875,797.34	+100,573.56	+46,350.57
Rocky/Bare land	167,332.04	167,695.03	167,001.70	+362.99	-693.33
Water Body	73,931.96	74,721.18	75,168.78	+789.22	+447.60

Source: ESA/World Cover/v100 Resolution: 10m

The results obtained from Table 9 For the period of 20years 2004 to 2024, Southern Kebbi experienced significant land cover changes characterized by a substantial decline in vegetation cover (27% from 2004 to 2014, and 15.5% from 2014 to 2024). This trend, driven by agricultural expansion and land clearing, has intensified soil erosion, leading to land

degradation, loss of productivity, and environmental instability. Implementing indigenous management practices, alongside community engagement and policy enforcement, can help mitigate these effects, promote sustainable land use, and restore ecological balance in the region.

Table 10: Forms of soil erosion prevalent in the study area

Village studied		latitude	longitude	Sheet	Rill	Gully	Total
Danko/Wasagu LGA							
Danko		11.72944	5.29889	**5**	**4**	**6**	15
Kyebo		11.5585	5.2257	**7**	**5**	**5**	17
Ribah		11.3971	5.4856	**5**	**6**	**8**	19
Wasagu		11.3739	5.8117	**4**	**5**	**6**	15
Fakai LGA							
Bajida		11.3999	4.9643	**5**	**9**	**7**	21
Mahuta		11.5518	4.9832	**7**	**5**	**7**	19
Fakai		11.5108	5.1035				21
Marafa		11.539	4.7724	**5**	**7**	**9**	17
Sakaba LGA							
Dirin daji		11.2449	5.4647	**3**	**5**	**4**	12
Sakaba		11.0655	5.5965	**3**	**4**	**5**	12
Sabon Birni		11.2449	5.4647	**3**	**2**	**4**	9
Shanga LGA							
Rafin kirya		11.4774	4.5934	**4**	**6**	**5**	15
Giro masa		11.1018	4.7248	**5**	**5**	**4**	14
Gebbe		10.9696	4.5418				16
Kwanji		11.14254	4.45948	**5**	**4**	**6**	15
Ngaski LGA							
Kambuwa		10.9401	5.0332	**6**	**4**	**5**	15
Makurdi		10.36407	4.83729	**5**	**5**	**5**	15
Birnin yauri		10.7868	4.8067	**3**	**4**	**6**	13
Yauri LGA							
Yelwa		10.837	4.7433	**6**	**5**	**6**	17
Tondi		10.8798	4.7504	**4**	**6**	**5**	15
Zamare		10.7302	4.7381	**5**	**5**	**7**	17
Bin yauri		10.7537	4.7783	**3**	**5**	**5**	13
Zuru LGA							
Rafin zuru		11.4273	5.2214	**5**	**7**	**9**	21
Rikoto		11.4496	5.2423	**4**	**8**	**11**	23
Senchi		11.3552	5.2311	**5**	**7**	**7**	19
Dabai		11.4384	5.2319	**3**	**6**	**6**	15
TOTAL							**420**

Source: field work, 2024

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From the result obtained in table 10 reveal that Forms of soil erosion prevalent in the study area and its Characteristics are Sheet Erosion, Rill Erosion and Gully Erosion. The data reveals a total of 420 recorded instances of erosion across the surveyed villages. The study analyzes the distribution of the three types of soil erosion in Southern Kebbi as shown in Table 11.

Table 11: percentage of Forms of soil erosion prevalent in the study area

S/no	Respondents	Frequency	percentage
1	Sheet Erosion	119	**28.33%**
2	Rill Erosion	139	**33.10%**
3	Gully Erosion	162	**38.57%**
	TOTAL	**420**	**100.00%**

Source: field work, 2024

The total counts for Sheet, Rill, and Gully erosion are calculated from the provided table, Gully erosion is clearly the most frequently observed and, typically, the most destructive form. This suggests that the erosive processes have advanced beyond the initial stages of sheet and rill erosion, indicating either prolonged exposure to erosive forces, high-intensity rainfall, or a combination of both. The dominant forms of soil erosion in Southern Kebbi are Sheet, Rill, and Gully erosion, with Gully erosion being the most prevalent and severe, closely followed by Rill and Sheet erosion. The overall high incidence of all three forms, points to a significant water erosion problem in the Study area.

Tackling Soil Erosion and Mitigation Measures for each of the Local Government Area L.G.A in the Study Area

The study aims to mitigate soil erosion and provide Solutions across the seven local government areas in Southern Kebbi. Each LGA, presents unique characteristics, including elevation, slope, and land use, which significantly affect erosion rates.

1. Danko Wasagu: People and Planet Partnership

The result obtained from table 12 shows that the causes at Danko Wasagu are largely driven by human activities that stress the land. The solution focuses on sustainable land management and restoring the natural environment. As indicated in Table 12

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Table 12: Tackling Soil Erosion in Danko Wasagu (High topographic elevation)

Cause	Detailed Mitigation Measure
Deforestation	**Terracing:** Constructing step like ridges across the slope to intercept runoff and convert the steep area into a series of smaller, level platforms for farming. Contour Plowing: Plowing along the natural contour lines of the slope, rather than straight up and down, to create small dams that catch water.
Overgrazing	**Rotational Grazing:** Implement a system where livestock are moved frequently to allow pasture land to recover. Establish carrying capacity limits for the land and use fencing to control movement. Introduce fodder crops to supplement feed and reduce reliance on natural pastures.
Unsustainable Agriculture	**Conservation Tillage/No Till Farming:** Minimize soil disturbance by planting directly into the residue of the previous crop. Use Cover Crops (like., legumes) during fallow periods to keep the soil covered, add organic matter, and improve soil structure. Practice Crop Rotation to break pest cycles and vary nutrient demands.

***Source*:** Fieldwork

2. Fakai: Mastering the Terrain

The results derived from Table 13 shows that issues in Fakai are a mix of natural challenges (steep slopes, poor drainage) and human activity (deforestation). The solutions focus on engineering the landscape and restoring vegetative cover. As indicated in Table 13.

Table 13: Tackling Soil Erosion in Fakai (Medium topographic elevation)

Cause	Detailed Mitigation Measure
Steep Slopes	Reforestation and Afforestation: Launch community based tree planting initiatives, focusing on indigenous species. Implement Agroforestry, integrating trees with crops and livestock to provide economic benefits while protecting the soil. Strictly enforce laws against illegal logging.
Poor Drainage	Subsurface/Surface Drains: Install or construct drainage systems (like ditches or French drains) to safely and quickly channel excess surface water away. Riparian Buffer Strips: Plant permanent vegetation along water bodies to filter water, stabilize banks, and slow down flow.
Deforestation	Establish Protected Areas: Designate parts of the steep slopes and fragile areas as protected forests, restricting human access and cutting. Bamboo Planting: Use fast growing, soil binding species like bamboo for rapid bank and slope stabilization.

***Source*:** Fieldwork

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3. Sakaba: Reclaiming the Ground

The results derived from Table 14 shows that the main causes in Sakaba involve heavy mechanical disturbance. The mitigation measures center on responsible industrial practices and rehabilitating damaged land. As indicated in Table 14.

Table 14: Tackling Soil Erosion in Sakaba (High topographic elevation)

Cause	Detailed Mitigation Measure
Mining Activities	Strict Reclamation Plan: Mandate and enforce that mining companies have a detailed plan to restore the site's topography, topsoil, and vegetation *before* they begin operations. Silt Fences and Sediment Ponds: Install temporary erosion control structures during operation to capture runoff and sediment before it leaves the site.
Construction Activities	Phased Construction: Limit the area of soil exposed at any one time. Mulching and Geo textiles: Immediately cover exposed soil with organic mulch or synthetic erosion control blankets (geotextiles) to protect it from rain and wind. Temporary Seeding: Plant quick growing grasses to stabilize disturbed areas not immediately under construction.
Soil Compaction	Deep Tillage (Sub soiling): Use specialized equipment to break up the compacted layers deep in the soil profile, allowing water infiltration and root growth. Add Organic Matter: Incorporate compost or crop residue to improve soil structure and resist future compaction. Restrict Heavy Machinery: Limit the movement of heavy vehicles to designated routes.

***Source*:** Fieldwork

4. Shanga: Planning for People and Soil Health

The result obtained from table 15 shows that Shanga's challenges are tied to modern land use and waste management. Solutions require changing farming practices and urban planning. As indicated in Table 15.

Table 15: Tackling Soil Erosion in Shanga (Low topographic elevation)

Cause	Detailed Mitigation Measure
Monoculture Farming	Diversified Crop Rotation: Implement a rotation that includes different crop types (cereals, legumes, root crops) to maintain soil health, break disease cycles, and vary the root structures that hold the soil. Inter cropping: Grow two or more crops in the same field simultaneously (Like., maize and beans) to provide more continuous ground cover.
Improper Waste Disposa	Integrated Waste Management: Establish formal waste collection and disposal systems, including recycling and composting. Public Awareness Campaigns: Educate the community on the link between illegal dumping (which destabilizes soil and contaminates runoff) and erosion/pollution.

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Urbanization	Permeable Pavement: Use porous materials for sidewalks, parking lots, and minor roads to allow rainwater to soak into the ground instead of running off rapidly. Rain Gardens and Green Infrastructure: Create small, planted depressions to capture and filter storm water runoff from impervious surfaces. Enforce Zoning Regulations that protect fragile areas from development.

***Source*:** Fieldwork

5. Ngaski: Foreseeing the Future

The result obtained from table 16 shows that Ngask**i** deals with systemic issues requiring robust planning and adaptation to environmental shifts. As indicated in Table 16

Table 16: Tackling Soil Erosion in Ngaski (Low topographic elevation)

Cause	Detailed Mitigation Measure
Poor Land Use Planning	Land Capability Classification: Conduct a comprehensive study to identify which areas are best suited for farming, forestry, grazing, or development, and enforce this plan. Buffer Zones: Legally establish vegetated buffer zones around fragile ecosystems (like wetlands, rivers, and steep slopes) where no development is permitted.
Soil Disturbance	Minimum Tillage/No Tillage Adoption: Promote farming techniques that keep the soil covered and reduce the use of plowing and harrowing. Maintain Permanent Vegetation: Ensure soil is always protected, especially during the non-growing season, using cover crops or crop residue.
Urbanization	Drought/Flood Resistant Crops: Introduce and promote crop varieties that can better withstand extreme weather events. Water Harvesting & Storage: Build check dams, ponds, and reservoirs to capture and store rainwater for use during dry spells, which also slows down erosive runoff during intense rains. Early Warning Systems for extreme weather events

***Source*:** Fieldwork

6. Yauri: Dealing with Illicit Activity and Damage

The results derived from Table 17 shows that Yauri's problems require addressing illegal activities and the subsequent land degradation. As indicated in Table 17

Table 17: Tackling Soil Erosion in Yauri (Medium topographic elevation)

Cause	Detailed Mitigation Measure
Illegal Logging	Increased Forest Patrols & Penalties: Strengthen law enforcement efforts and impose severe penalties for unauthorized tree cutting. Community Forest Management: Involve local communities in the sustainable management and protection of the forests, giving them a vested interest in its health.

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Cause	Detailed Mitigation Measure
Soil Pollution	Remediation Techniques (Bioremediation): Use plants or microorganisms to clean up contaminated soil. Regulation and Monitoring: Strictly regulate the use and disposal of harmful chemicals (e.g., certain pesticides and industrial waste) to prevent contaminants from entering the soil.
Land Degradation	Gully Reclamation: Construct temporary or permanent structures (like check dams built from stones or logs) in active gullies to slow water velocity, trap sediment, and allow vegetation to re-establish. Soil Amendments: Add organic matter (compost, manure) and beneficial minerals to restore soil fertility and structure.

Source: Fieldwork

7. Zuru: Protecting Our Waterways

The results drives from Table 18 shows that Zuru's focus must be on managing the interface between land and water to prevent loss of valuable riverbank soil.As indicated in Table 18.

Table 18: Tackling Soil Erosion in Zuru (High topographic elevation)

Cause	Detailed Mitigation Measure
Riverbank Erosion	**Bioengineering (Vetiver Grass/Willows):** Plant deep-rooted, dense vegetation like Vetiver grass or willows directly on the riverbanks to physically bind the soil together. Gabions and Riprap: Install cages filled with rocks (gabions) or loose rock material (riprap) at the base of the bank to absorb the energy of the water current.
Deforestation	**Riparian Buffer Strips:** Replant and maintain wide strips of native trees and shrubs along all riverbanks and tributaries to shade the water, stabilize the banks, and reduce overland flow velocity entering the river.
Poor Agricultural Practices	**Sediment Control Basins:** Construct small basins at the edge of fields to temporarily hold runoff water and allow sediment to settle before the water leaves the farm. Vegetative Barriers: Plant dense strips of stiff-stemmed grasses or shrubs along contours within fields to slow water and filter sediment.

Source: Fieldwork

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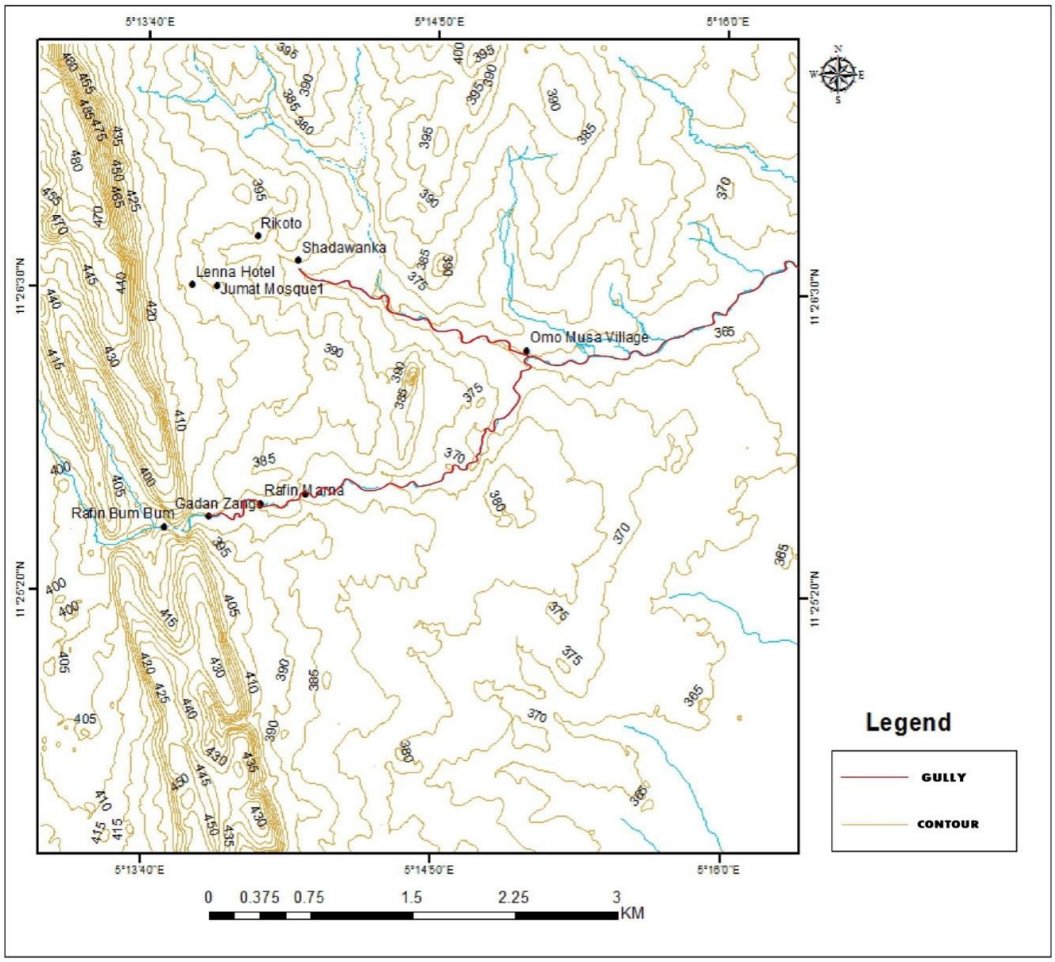

Figure 9: Topographical map of the Study Area showing the gully affected area in Rikoto and Rafin Zuru districts. (2024)
(Source: NASRDA)

Addressing Gully Erosion in Zuru Metropolis

The results derived from Figure 9 shows that the gully erosion in the Zuru metropolis, particularly in the **Rikoto** and **Rafin Zuru** districts, presents a significant environmental and community challenge. Due to the analysis of the described trajectory, we will be able to understand the immediate human intervention and the suggested community-based solution. The gully starts its devastating route at one of the identified and closely populated points which underlines the direct danger to the infrastructure and the life of the community. The erosion begins at the area of Lenna Hotel, which is located close to Izala Mosque (Masallachin Jummaa), in the Rokito district. This location of origin close to landmarks marks the direct threat of residential and religious buildings. That is followed by the gully passing through the most important community locations, such as

Shadawanka and Omo Musa Village (also called Rafin Mose). All the water and sediment are finally released to the Zuru Metropolis Dam and this is a long term danger to the quality of the water resource and the dam functionality due to siltation of the dam. The study Proposed Mitigation using Community Garden Concept is based on the research finding. The essential mitigation plan will be established on the principle of turning a hazardous area into a community resource and combining innovative methods with traditional ones: The principal suggestion is to create a Community Garden on the gully sides, which will be used to serve two purposes:

Physical Protection (Buffer Zone): A 35 meter buffer zone is to be created on both sides of the gully. This area is converted into a green area, physically stabilizing the slopes and preventing further widening or deepening of the gully.

i. **Social and Economic Benefit:** The green area functions as a Community Garden. This integrates horticultural science, artful composition, and spatial organization to create functional "outdoor rooms" for different uses, aligning with modern landscape design principles by adopting a holistic approach:
    a) **Indigenous Management Practices:** Leveraging local knowledge and time tested methods for land and water management ensures sustainability and community buy in.
    b) **Modern Soil Erosion Control:** Incorporating techniques like Biotech (Like, vetiver grass planting, bioengineering) and Landscape Designs provides robust, scientifically proven erosion resistance. The detailed view of proposed activities are presented in (Figure 10 and 11) a focus on maximizing utility from the reclaimed land, perhaps involving composting, rainwater harvesting, or using locally sourced materials for construction, ensuring the site remains productive and self-sustaining.

While the Community Garden is foundational, complementary measures are crucial for comprehensive gully control and optimal results. Gully Head Stabilization implement immediate, structural measures at the gully head (near Lenna Hotel) to stop the backward erosion. This could involve check dams (gabions or stone masonry) or diversion trenches to reroute surface water away from the erosive point.While Bioengineering and Revetments along the entire gully course, utilize live fascines, brush layers, and contour wattling (bioengineering) in conjunction with hard structures like stone pitching or reinforced concrete revetments where flow velocities are highest, the use of Stormwater Management Upstream are to address the source of the excess runoff by improving the upstream drainage network. This includes constructing or repairing lined drainage channels (culverts/gutters) in the Rikoto area to prevent sheet flow from concentrating and feeding the gully.

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Terracing and Contour Farming on adjacent land or within the wider 35 meter buffer, introduce terracing and contour planting to slow runoff, increase infiltration, and stabilize the soil profile, especially for areas used for the community garden.

Silt Trap/Sediment Basin: Construct a sediment basin or silt trap just before the gully empties into the Zuru Metropolis Dam. This is vital to capture sediment, reducing the dam's siltation rate, protecting its lifespan, and minimizing the environmental impact of the reclamation efforts. These measures, combined with the Community Garden, create a resilient system that manages water flow, stabilizes soil, and provides social and economic benefits to the Zuru community.

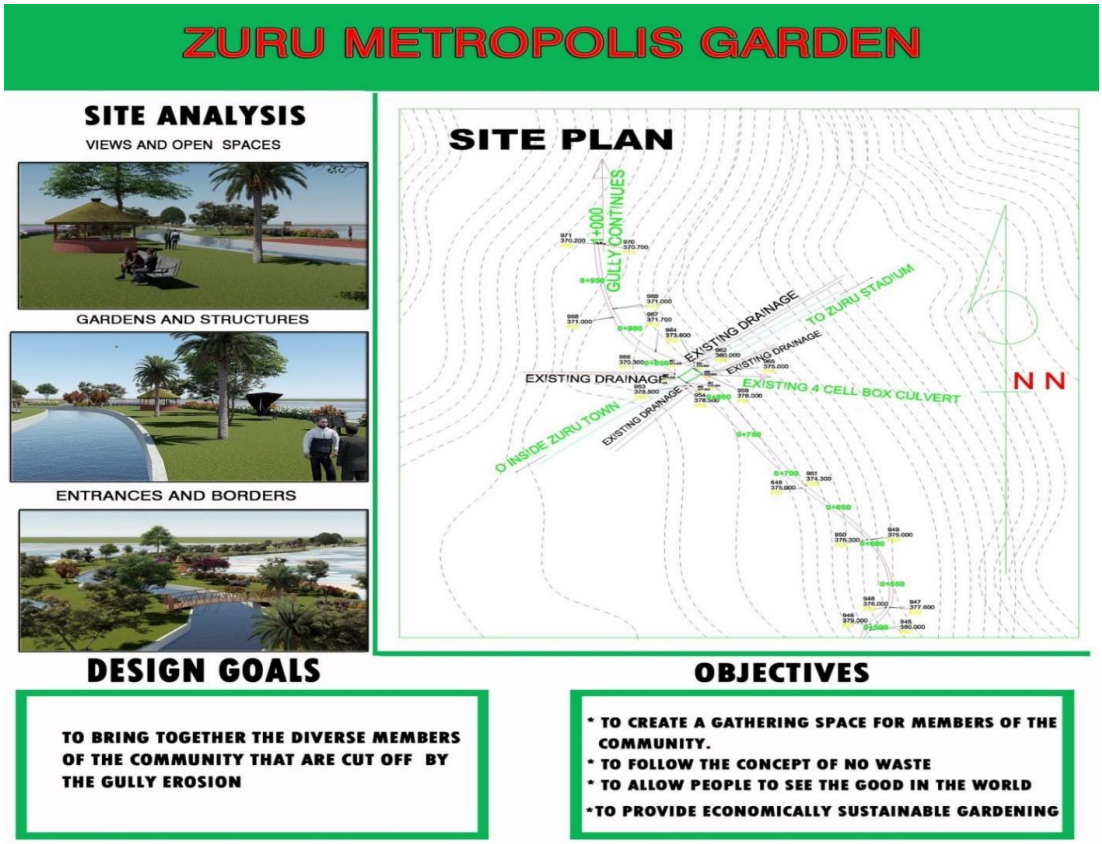

Figure 10: Detailed view of Zuru metropolis community garden at the study area (***Source***: Field work (19Th July 2024)

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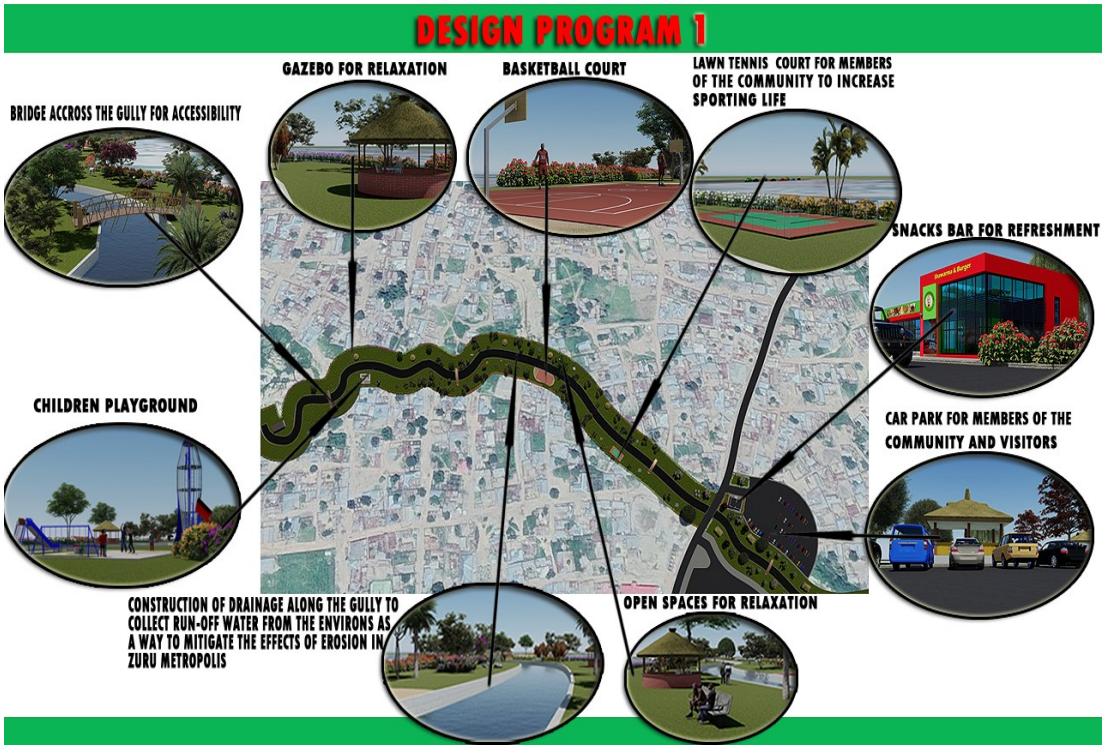

Figure 11: Detailed view of Activities forms at the study area
(***Source:*** Field work) (19Th July 2024)

Integrating Livelihood and Land Reclamation: The Zuru Orchard Proposal

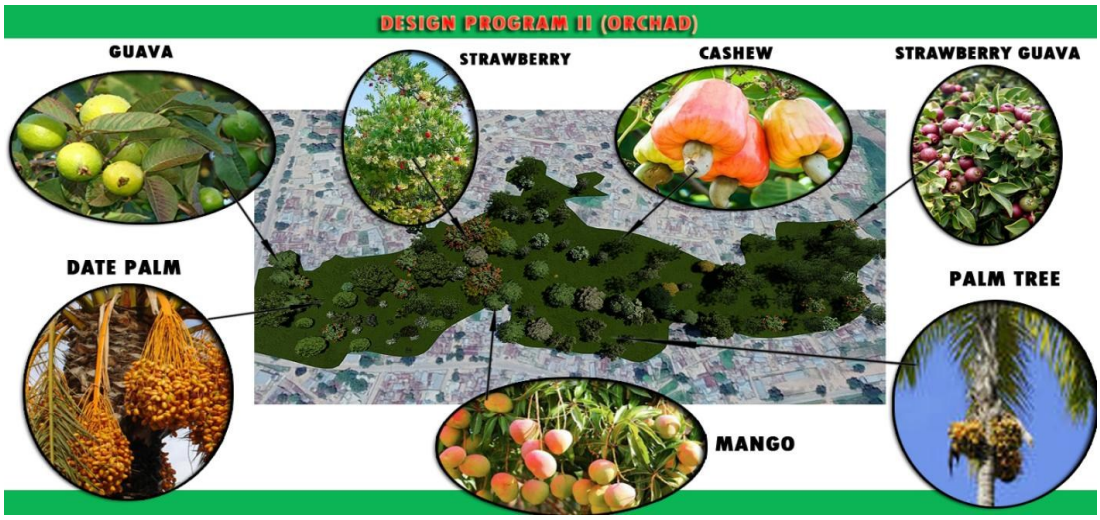

Figure 12: Detailed view of Tree forms (orchards) at the study area
(***Source:*** Field work) (19Th July 2024)

Orchard as a Mitigation Strategy

The proposed orchard is an excellent example of bioengineering that aligns environmental protection with socioeconomic empowerment. The integration of an orchard serves multiple critical functions beyond mere aesthetics. Planting economic trees provides deep, extensive root systems that bind the soil, preventing gully head wall retreat and side slope collapse. This is a sustainable, living solution for long term soil stabilization. By acting as a source of cash crops, the orchard provides job opportunities and a sustainable livelihood for the community in the affected area. Also, improved Ecological and Environmental Buffers as follow:

i. **Buffers:** The orchard creates a buffer zone against the gully's edges, protecting the land behind it.
ii. **Air Quality:** Trees are natural attenuators (reducers) of air pollution, dust, and auto emissions.
iii. **Wildlife Habitat:** The trees provide valuable wildlife habitat, enhancing local biodiversity.
iv. **Sound Barriers:** Dense tree planting can also serve as effective sound barriers for nearby residential areas.

2023	Description
	The most effective, sustainable, and community friendly gully control strategies always rely on blend of local knowledge **(Indigenous)** and scientific principles. This approach ensures high effectiveness while fostering community ownership.
2025	

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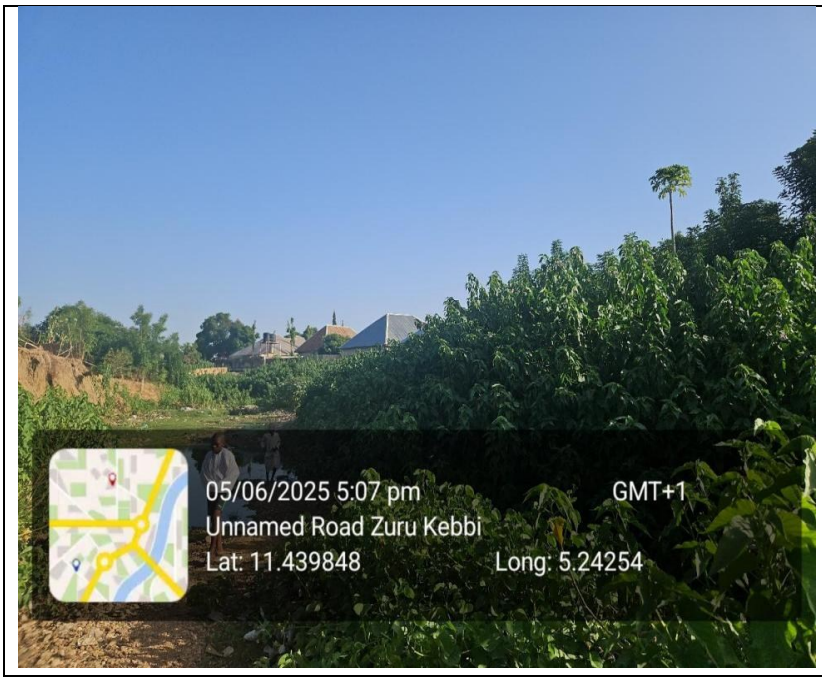	**Use of Local Species:** Planting deep rooted native grasses and trees known to the community for their medicinal or economic value (like the proposed cash crops) can effectively motivate the community to be actively engage on the local knowledge of Indigenous Management Practices in Mitigating Soil Erosion in the Study Area.

Plate 1 **The Synergy of Indigenous Erosion Control by the Community of the Study Area** (***Source:*** Field work) (20Th July 2025)

2023	**Description**
	After carefully studying the impact of the gully, on the process of data collection. We call the attention of the community leader **GAFAKKAN ZURU** by introducing indigenous knowledge often focuses on using locally available, inexpensive materials and natural flow principles, promoting sustainability and ownership**.**

2023	
	**GAFAKKAN ZURU** consider the active threat and the community's daily struggle the loss of ancestral land, the danger to homes, and the constant fear of the next rainy season. It demands immediate action. Like a joke we commence in to action Tuesday 27th June 2023. The results after two years shows very effective and less cost.As shown on Plate4.1

Plate 1: **The Study Area before the Commencement of Indigenous Erosion Control by the Community.**

(***Source:*** Field work) (6Th July 2023)

Conclusion

This study shows that soil erosion in Southern Kebbi is a serious and growing problem caused by the combined effects of heavy rainfall and human activities such as deforestation, poor farming practices, overgrazing, and uncontrolled land use. The dominance of gully erosion indicates that soil degradation has reached an advanced stage in many communities, threatening farmlands, settlements, and water resources. The sandy nature of the soils, their generally acidic condition, and high drainage rates further increase vulnerability to erosion. Despite these challenges, the study clearly demonstrates that indigenous management practices, when properly applied, play an important role in reducing soil loss and improving land stability.

Recommendations

The study recommends strengthening and expanding the use of indigenous soil conservation practices such as agroforestry, contour farming, terracing, crop rotation, mulching, and controlled grazing. Tree planting and vegetation restoration using local species should be encouraged to protect the soil and reduce runoff. Government and

local authorities should enforce land-use regulations, especially against indiscriminate deforestation and unregulated mining and construction. Continuous community education, supported by extension services and simple monitoring tools such as GIS, is essential to ensure sustainable land management. Integrating local knowledge with modern conservation methods will provide a practical and long-term solution to soil erosion in Southern Kebbi.

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