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Morphological Characteristics and Soil Physical Attributes of Erhumunse Gully in Benin-City, Edo State: Implications for Household Crop Cultivation

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This study analysed the morphological characteristics and physical attributes of the soils of Erhumwunse gully, a sub-catchment of the larger Iwogban gully catchment in Benin City, Edo State, Nigeria. The study used physical measurements to identify the morphology of the Erhumwunse gully including, state, shape, and dimension. It used laboratory tests to analyse the soil physical properties, such as grain size, specific gravity, natural moisture content, plastic limit, and coefficient of permeability, amongst others. The results revealed that morphologically, the gully is active, medium, u-shaped, and in its second stage of development. The gully soil is predominantly silty-clay sandy, with low natural moisture ranging from 16 to 22 percent and an average liquid limit of 47, which is an indication of low plasticity. The loss of land to gully formation, coupled with the high percentage of sand, low plasticity, and low natural moisture of the soils, has resulted in limited varieties of cultivable crops and low yield. To prevent further expansion of gullies, the study recommends the use of sandbags, local drainage channelization, and the planting of vegetation as temporary control measures and land use zoning in a wider catchment management plan as a long term permanent solution.
Keywords: Atterberg limit; Crop yield; Land use; Soil erosion; Specific gravity

Introduction

Nigeria is one of the countries most affected by gully erosion, a severe form of environmental degradation resulting from the rapid removal of soil as a result of water flow. Anthropogenic activities, such as deforestation, agriculture, and urbanisation, have been recognised as significant contributors to gully erosion, leading to loss of arable land, infrastructure damage, and environmental degradation (Igwe & Fukoka, 2010; Hassen & Bantider, 2020). Unfortunately, the lost land resources are essential to the sustenance of the residents, especially peasant farmers who depend on them for sustainability and livelihood (Odunuga *et al*., 2018).

Gully erosion, as a form of soil erosion that affects soil productivity, deprives proper land use and can threaten infrastructures such as roads, buildings, drainage and, human life (Issaka & Ashraf, 2017; Jibo *et al*., 2020; Hassanuzzamen & Shit, 2025). Multiple on-site and remote effects of gully erosion threaten sustainable development, which is especially evident in tropical climate environments (Frankl *et al*., 2014). Such on-site impacts include decline in soil fertility and thickness, which could adversely affect crop yield and worsen food insecurity. Off-site impacts, which include siltation of drainage channels, could result in flooding and loss of property (Hassanuzzamen & Shit, 2025).

Due to the deleterious impacts of gully erosion on soil, agricultural activities, and food security, many studies have been carried out on it in recent times. The results of the study by Bhandari *et al.* (2021) on the impact of soil erosion on agricultural output in the Rangun watershed of Nepal showed that loss of topsoil and gully formation in cultivable land are responsible for the decline in the productivity rate of cultivated area with the average area of cultivated land reducing at an annual rate of 2.96 ha yr-1 and the volume of productivity decreasing at the rate of 2.38 Quintals per year.

Yazie *et al.* (2021) analysed the rate of gully erosion and its impacts on soil loss and crop yield in the Genbo Wonze watershed of Ethiopia for 3 decades. The results of the study revealed, amongst others, a loss of approximately 340,957 Tonnes of soil and approximately 10 hectares (ha) of agricultural land. The study also showed that 24 Tonnes of Teff grains and 14 Tonnes of forage are lost per year. In a study that assessed the effects of soil erosion on food security in the Eastern Cape Province of South Africa, Ighodaro *et al.* (2016), found that 75 percent of the sample population of farmers reported more than 21 percent loss of their cultivated crops and 55 percent reported being adversely affected by combined negative impact of soil erosion on their crops, livestock and household food security.

In a study to assess the physical and socio-economic impacts of gully erosion in Akko Local Government Area of Gombe State, Jibo *et al.* (2020), identified disruption of farming activities, destruction of farmlands, and farm produce as some of the prevailing socio-economic consequences of gully propagation in the area.

In Edo State, it is estimated that approximately 5 percent of the landmass has been lost to gully erosion. This situation has been attributed to a high rate of urbanisation and improper termination of drains and water courses (Kayode-Ojo *et al.*, 2019). The situation has also affected the livelihoods of local communities, causing environmental degradation and food insecurity. At Iwogban Quarters (the study location) in the Ikpoba Okha Local Government Area of Edo state, the formation and propagation of gullies have contributed to the high rate of soil erosion experienced in the community. The propagation of these gullies and the dangers posed to lives and property have resulted in some residents abandoning their buildings for safer locations. According to the Edo State Flood, Erosion and Watershed Management Agency [Edo-FEWMA] (2023), these gullies have resulted in the collapse of twenty-eight buildings, and there is an imminent threat to structures worth 750 million Naira. Furthermore, the continuous propagation of these gullies has contributed to the degradation of soil health and the loss of arable land for household gardening, thereby worsening food insecurity, especially during the period of economic downturn. Within the Iwogban catchment, crops cultivated in home gardens include water yam (Dioscorea alata), white yam (Dioscorea roundata), cocoyam (Colocasia esculenta), cassava (Manihot esculenta Crantz), pumpkin (Cucubia pepo), mangoes (Mangifera Indica), guavas (Psidium guajava Linnaeus), avocadoes (Persea Americana), garden eggs (Solanum aethiopicum), bitter leaf (Vernonia amygdalina), and water leaf (Talinum triangulare).

Going by the current situation within the Erhumwunse sub-catchment and by extension other gully ravaged areas in Edo state, achieving Sustainable Development Goals (SDGs-2), which aims to eradicate all forms of hunger and malnutrition by 2030 through the promotion of sustainable agriculture, the drive to end hunger and attain food security, including improved nutrition, could be very difficult. Many of the residents who have been forced to abandon their houses and home gardens are likely to incur more expenses in feeding their families due to the high rate of food inflation and lower purchasing power. According to the National Bureau of Statistics [NBS] (2025), year-on-year food inflation increased by 26.08 percent in January 2025 when compared with January 2024. This has further exacerbated household food insecurity and rendered many families prone to poverty. This situation could prevent the community from achieving SDG-1 of No Poverty. Consequently, this study aimed at the assessment of the morphological characteristics, soil physical properties and their implications for household crop cultivation.

Materials and Methods

Study area

Erhumwunse Gully is a sub-catchment of a larger gully complex known as the Iwogban Catchment (Figure 1). The gully is located on the Ikpoba slope road to the east of the Ikpoba River between longitudes 5° 39' E and 5° 38' E and latitudes 6° 23' N and 6° 21' N and in an area spanning 4.39 km^2 in the Ikpoba-Okha Local Government Area of Edo State. The sub-catchment is enclosed by four major roads: Upper Mission Road (North), Ikpoba Hill Road (South), Lucky Way Road (East), and Temboga Road (West). The sub-catchment is made up of a number of quarters including Uteh, Temboga, and Iwogban. It is also characterised by several large gullies (Figures 2a. and 2b) found at Ekhaguere Street, St. Jude Street, and Omoriege-Uteh Street.

In Edo State where the Erhumwunse sub-catchment is located, the dry season varies between November and March, while the wet season is between April and October. Annual rainfall varies between 2,000 and 2,300mm while mean daily temperature ranges between 24°C in the wet season and 28°C in the dry season (Odiana & Idahosa-Ohio, 2023). The underlying geology of the Erhumwunse sub-catchment is consistent with the geology of Edo State, which is made up of quaternary deposits, Benin formation, Ajali sandstone, and the Ogwashi-Asaba formation. The quaternary deposits are mainly alluvial deposits of the Ovia and Ikpoba Rivers and the Benin formation, which is made up of reddish to brown lateritic soil, clay, coarse to very coarse poorly sorted sands, ferruginous sandstones, gravels, and mudcracks (Ikhile, 2016). The Ogwashi-Asaba formation is characterised by a combination of gritty sands, clay, and lignite seam with clay intercalations of continental deposits, while the Ajali sandstone is made up of medium to coarse sub-angular to sub-rounded quartz arenites. The soil of the area is predominantly made up of reddish brown sandy clays derived from deep chemical weathering of the parent rock materials (Hoque & Ezepue, 1977; Kogbe, 1976; Awalla & Ezeh, 2004; Ikhile, 2016; Aigbadon *et al*., 2021).

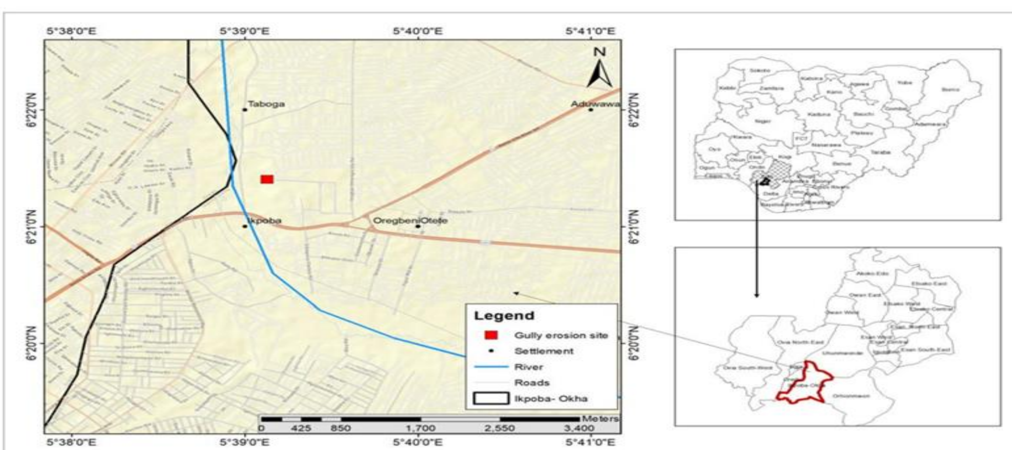

Figure 1: Location of gully site within the study area

Figure 2: (a) Gully site
Source: Authors (2024)

Figure 2: (b) Gully converted to dumpsite
Source: Authors (2024)

Datasets and methods of analysis

A topographical map of Benin City (Benin City, Sheet 298NW) and the catchment map of the study area showing the areas susceptible to erosion, were sourced from the Edo-Flood and Erosion Watershed Management Agency (Edo-State FEWMA, 2023). The topographical sheet, along with ground- truthing was used to map the Erhumwunse gully sub-catchment and the location of the soil erosion-prone areas along the flood routes. Field activities were conducted to assess the current state of the gullies. Physical measurements were used to identify the morphology of the Erhumwunse gully morphology, including state, shape and, dimension. Laboratory test analyses were conducted to analyse the soil physical properties, including grain size, specific gravity, natural moisture content, plastic limit, and coefficient of permeability, amongst others. The gully morphological characteristics follows Suresh's (2006) gully classification (Table 1).

Table 1: Classification of the Morphological Characteristics of Gullies

Characteristics	Specification	Description
Development	First Stage	Channel erosion and gully deepening. Gradual onset of erosion due to resistant topsoil, which is bound together by plant roots.
	Second Stage	Rapid development of gully due to the impact of storm runoff from the upstream section of the gully head. The width and depth of the gully are enlarged.
	Third Stage	Healing stage is characterised by the growth of vegetation in the gully. No significant erosion of materials from the gully section.
	Fourth Stage	Terminal stage of gully development and full stabilisation. Further change is impossible except the healing process is disturbed.
Shape	U-shaped	Formed in alluvial plains where surface and sub-soils are highly erodible. Runoff undercuts and gully banks collapse, resulting in a U- shaped vertical side wall.
	V-shaped	Formed where sub-soil is resistant to rapid erosion by runoff. Resistance to erosion increases with depth. These are common steep, sloped, hilly areas.
State	Active	These are gullies with enlarged dimensions resulting from soil characteristics, land use, and the volume of runoff flowing through the gully. Such gullies are formed in flat terrain.
	In-active	These are gullies with constant dimensions over time. They are found in rocky areas.

Dimension	Small Gully	These are gullies that can be traversed by farm machinery. They can be removed by ploughing and smoothing operations and by stabilisation with vegetal cover. Gully depth varies between 3 and 9 m, bed width is not less than 18 m, and sides are uniformly sloping between 8 percent and 15 percent.
	Medium Gully	These are gullies that cannot be easily traversed by farm machinery. They are controlled by ploughing or terracing. They vary between 3 and 9 m in depth, and the width is not less than 18 m.
	Large Gully	These gullies have gone beyond reclamation. Reclamation can be achieved through a cropping system or the planting of a meadow. Such gullies are 3 to 9 m deep, and the width of the bed is not less than 18 m.

Source: Adapted from Suresh (2006).

To determine the physical characteristics of the soils at the Erhumwunse gully, a total of 15 soil samples were collected. These were collected from the gully head, gully bed, and gully mouth at 5 cm, 15 cm, and 30 cm respectively with the use of a hand Auger. The colour of the collected soil samples was established using the Munsell soil colour charts, while the other physical properties were analysed at the University of Lagos Soil Mechanics Laboratory. The analyses were done in accordance with the British Standard (BS): 1377.75. The following tests were conducted: Specific Gravity Test, Particle Size Distribution Test (using sieve analysis), Atterberg or Consistency Limit Test, Moisture Content and Compaction Test, as well as the Permeability Test.

To ascertain the total area of land lost to gully erosion, land use/landcover mapping of the sub-catchment was carried out using Sentinel-2A with a 10 m spatial resolution. In carrying out the land use/land cover mapping, Image analysis for supervised classification was adopted. The sub-catchment was reclassified under three cover management types adapted from the Federal Department of Agriculture and Land Resources [FDALR] (2009) and the Final Report on the Assessment of Soil Degradation in Nigeria. Thus, the classes are Urban, Extensive smallholder and Grassland land use, and land cover.

Results and Discussion

Gully dimension and shape

The results of the analysis of the morphological characteristics of Erhumwunse gully based on Suresh's (2006) classification scheme are presented in Table 2. As shown in Table 2, the Erhumwunse gully is in its second stage of development. It is a medium, U-shaped active gully with a depth of 5 m and a width of 7 m.

Table 2: Morphological Characteristics of Erhumwunse Gully

Characteristics	**Specification**	Description
Development	Second Stage	The gully is at a rapid development stage as a result of the heavy impact of storm runoff from the upstream portion of the gully head resulting in gully enlargement both in width and depth.
Shape	U-shaped	The gully is located at a plain surface where surface and sub-surface soils are easily erodible. As runoff flow increases, the gully banks collapse, forming a vertical side wall in U- shaped gully.
State	Active	The gully is in an active state as its dimensions are enlarged with time. The size enlargement is based on the soil characteristics, land use, and volume of runoff passing through the gully.
Dimension (Depth- 5m Width- 7m)	Medium	The gully is medium-sized and cannot be easily crossed by farm implements. It can only be controlled by terracing or ploughing operations. The medium-sized gully is 3 to 9m deep with a bed width of less than 18 m.

Physical characteristics of the soil of Erhumwunse gully

Soil colour

The results of the soil colour analyses based on the Munsell soil colour charts are presented. As shown in Table 3, the soils of Erhumwunse sub-catchment are reddish brown and yellowish red in colour. These colours are consistent with the colours of the soils of Benin formation, which were described by Reyment (1965) as being reddish-brown-yellow. Similarly, the results from the study of Elenwo & Onweremadu (2024), showed that soils of the region are predominantly characterised by reddish hues. The reddish hue of the soils is an indication of the presence of iron oxides in the soils (Trakoonyingcharoen *et al.,* 2006) and the highly weathered status of the soils (Ketrot *et al.,* 2013). According to Huang *et al.,* (2016), iron oxides affect soil nitrogen cycling. The disruption of soil nitrogen cycling has the potential to affect plant growth, nutrient uptake, and the yield of crops cultivated within the catchment. Nitrogen is an important macronutrient for plants, which is essential for the synthesis of protein and the formation of chlorophyll (Liu *et al.,* 2016). Any nitrogen deficiency brought about by the disruption of soil nitrogen cycling and erosion of the soil would require the application of nitrogen fertilizer to increase crop yield and food production in the study area.

Table 3: Colour of Soils at Different Segments of the Erhumwunse Gully

S/n	Erhumwunse	Hue	Value	Chroma	Description
1	Gully Head	Reddish Brown	5	4	RB 5/4
2	Gully Bed	Yellowish Red	5	8	YR 5/8
3	Gully Mouth	Dark Reddish Brown	3	4	DRB 3/4

Particle size distribution and grain size

The summary of the particle size distribution and grain size analysis of the soils of the gully is as shown in Tables 4 and 5, respectively. As shown in Table 4, the soil of the catchment is mainly characterised by sand (59.5%), silt (19.61%), clay (20%), and occasional gravel (1%). The presence of sand (59.5%) and silt (19.61%) suggests that this soil is relatively vulnerable to erosion due to the low cohesion of these soil particles. The presence of clay (20%) shows the potential for good soil aggregation, which could provide some resistance to erosion. However, the high percentage of sand may counteract this effect. Thus, it can be deduced that the soil is loose and can be easily eroded. Furthermore, the high proportion of sand in the soil is an indication of the low nutrient status and water holding capacity of the soil. This implies that more fertilizers and water need to be applied frequently in order to improve the quality and health of the soil and also meet the water requirements of the various cultivated crops (Abdelfattah *et al.,* 2021). The high percentage of sand has negative implications for household crop production through low yield and loss of cultivated land area to erosion.

Table 4: Summary of the Particle Size Distribution of the Soils of Erhumwunse Gully

Sample Point	Percentage of Sand, Silt, and Clay		
	Sand	Silt	Clay
Gully Head	66.3	16.9	16.8
Gully Bed	70.7	13.7	15.6
Gully Mouth	41.5	30.9	27.6.
Average	59.5	20.5	20.0

Similarly, the results of the sieve analysis test (Table 5) indicate that the percentage of soil passing through sieve No. 3.35 mm has a tiny proportion of occasional gravel (1 percent). The average percentage of soil passing through sieve No. 2.0 mm is 99 percent, while the average percentage passing sieve No. 0.075 mm is 39.6 percent. This indicates that the soil is a silty-clay sandy soil with fine grains. This result is consistent with results obtained from an earlier study in Edo State by Andre-Obayanju *et al.,* (2017). The silty-clay constituent of the soil has the potential to cause waterlogging during the rainy season, resulting in root rot and tuber rot due to the deprivation of oxygen to the roots of some of the crops cultivated in the area, such as yams and cocoyam, which requires well-drained soils. All of these affect the total crop output and potential profit from crop cultivation in the area.

Table 5: Results of the Grain Size Analysis of the Soils of Erhumwunse Gully

		Percentage Passing Sieve								
Sample number	Sample point	3.35 mm	2.0 mm	1.18 mm	0.60 mm	0.63 mm	0.30 mm	0.21 mm	0.15 mm	0.08 mm
1	Gully head	99.9	99.1	95.21	74.1	75.0	58.0	50.0	46.0	39.2
2	Gully bed	99.93	99.89	93.0	79.0	72.0	55.0	49.0	45.0	39.5
3	Gully mouth	99.6	99.2	94.98	73.0	77.0	59.0	54.0	48.0	40.1
	Average	99.71	99.10	94.45	75.40	74.67	57.3	51.0	46.0	39.6

Other physical characteristics of the soil of Erhumwunse gully

The summary of the results of the Specific Gravity Test, Natural Soil Moisture Content, Atterberg Limit Test, Compaction Test, and Permeability Test is as presented in Table 6.

As shown in Table 6, the values of the Specific Gravity of the soil vary between 2.63 and 2.71. According to Holtz *et al.* as cited in Ferderico *et al.* (2018), the Specific Gravity of most soils typically vary between 2.60 and 2.80. Furthermore, the values of the Specific Gravity of soil from the gully indicate that different sections of the gully are made up of a combination of soil types ranging from sand, silty-sand, inorganic silt, and inorganic clay based on the classification of (Hossain,2018). The relatively low level of cohesiveness of the soils, as indicated by the Specific Gravity, suggests that the strength of the soil as a construction material for the foundation of buildings is also relatively low. According to Roy & Bhalla (2017), soils with higher values of Specific Gravity lend more strength to structures like roads and building foundations. The abandonment of some of the buildings and, by extension, the loss of the home gardens due to gully erosion may be traceable to the specific gravity of the soil in the area. This directly or indirectly causes reduced crop yield and land acreage cultivated.

The range of natural moisture suggests low natural moisture, which is an indication of relatively dry soil and increased vulnerability to soil erosion. The low natural soil moisture is also unfavourable for crop growth and consequently the viability of crops in the various home gardens. This is due to the important role that soil moisture plays in crop growth and production. Soil moisture serves as a medium for the dissolution and uptake of nutrients. Lack of soil moisture reduces soil nutrient availability, leading to a reduction in leaf size and stem extension. It could also lead to limited root development, disruption of plant-water relations, reduction in water use efficiency, and a decline in microbial decomposition of organic matter (Ansari & Deshmukh, 2017; Bhattacharya, 2021; Food and Agriculture Organisation [FAO] Soils Bulletin, Undated). In order to retain soil moisture, reduce evaporation, and enhance crop yield in the area, soil moisture conservation techniques such as mulching may need to be adopted.

Based on the Unified Soil Classification System (USCS) Guide, the results of the Atterberg limit tests, as shown by the sample plot (Figure 3), have an average liquid limit of 47, which is an indication of low plasticity soil. The average plasticity index of 30 based on the USCS plasticity chart (Figure 4) shows that the soil lies below the "A-line". This helps to classify the soil as belonging to the SM Group, that is, sand-silt mixtures with the letter S representing sand and M representing silt mixtures. The average plastic limit of 16.3 is also an indication of low plasticity of the soil, suggesting that the clay content is relatively low. The low plasticity level is an indication of the soil's susceptibility to erosion and, by extension, reduced crop quality and yield in the study area due to low water retention, limited nutrient availability, and restricted or shallow systems associated with low plasticity soil. These results (the Atterberg limit tests) conform to the range of values obtained for the liquid limit, plastic limit, and plasticity index of soils in the area as shown by the works of Andre-Obayanju *et al.* (2017), Ojeaga and Afolabi (2022), and Kayode-Ojo *et al.* (2023).

Table 6: Results of Other Physical Parameters of Soils in the Erhumwunse Gully

Sample Point	Specific Gravity	Natural Moisture Content	Atterberg Limit test			Compaction		Coefficient of permeability
			LL	PL	PI	OMC (%)	MDD (g/cm3)	K(cm/sec)
Gully Head	2.63	16.0%	44	16	28	10.9	1.50	$1.783x10^{-4}$
Gully Bed	2.68	18.6%	47	16	16	11.0	1.51	$1.783x10^{-3}$
Gully Mouth	2.71	22.0%	50	17	33	11.2	1.52	$1.783x10^{-5}$
Average	2.67	18.7%	47	16.3	30	11.0	1.53	$1.783x10^{-4}$

LL = Liquid limit, PL = Plastic Limit, PL = Plasticity Index, OMC = Optimum Moisture Content and MDD = Maximum Dry Density

The attainment of Optimum Moisture Content and Maximum Dry Density plays a crucial role in soil compaction (Rahmat & Ismail, 2018). The compaction of soil results in low porosity, reduced infiltration, increased resistance to root penetration, and limitation to plant growth (Shittu *et al.,* 2017). Furthermore, soil compaction increases soil strength and reduces soil fertility through the depletion of soil water storage and supply of moisture and nutrients. This necessitates additional application of fertilizers (Hamza & Anderson, 2005).

The evaluation of the Optimum Moisture Content and Maximum Dry Density through the compaction test shows values of Optimum Moisture Content within the range of 10.9 to 11.2 percent, while Maximum Dry Density, varied between 1.50 and 1.52 g/cm^3. Based on FAO (2006), the range of values for the Optimum Moisture Content is an indication of clayey sands and soils with sand-clay mix, which requires values in the range of 11 to 10 percent for maximum degree of compaction. The range of values for the Maximum Dry Density of the soils based on the United States Department of Agriculture (USDA) Natural Resources Conservation Service [NRCS] (2001), falls outside the ideal dry density of less than 1.10 g/cm^3 for the soil textural class of the catchment. Furthermore, the range of values suggests that the growth of the roots of crops cultivated in the home gardens within the catchment may be limited. According to the USDA-NRCS (2001) values of dry density less than 1.58 g/cm^3 usually restrict the root growth of plants.

The values of the coefficient of permeability of the soils of the study area, which vary between 1.783x10^{-4} and 1.783x10^{-4} cm/sec, indicate that it lies between the typical range for the mixture of sand, silt, and clay, which according to Thomas (2012) varies between 10^{-3} and 10^{-7} cm/sec. This signifies low permeability. Generally, soils with a high proportion of sand particles allow for more infiltration of water, reducing the risk of surface runoff and associated erosion. However, the ease of water infiltration into the soil, can be counteracted due to the presence of silt and clay. The restriction of free drainage in the soils, especially during the rainy season, could result in waterlogging, leading to crop losses in the various home gardens in the catchment. The waterlogging of the soils could also result in physiological and metabolic changes in the crops planted. This is because waterlogging generates hypoxic (oxygen-deficient) or anoxic (total absence of oxygen) conditions in the soil. Furthermore, waterlogging reduces photosynthesis in plants due to stomatal closure and the production of Abscisic Acid (ABA), ethylene, and active oxygen species. In addition, waterlogging leads to a decline in the nitrate concentration of soils (Kaur *et al.,* 2019).

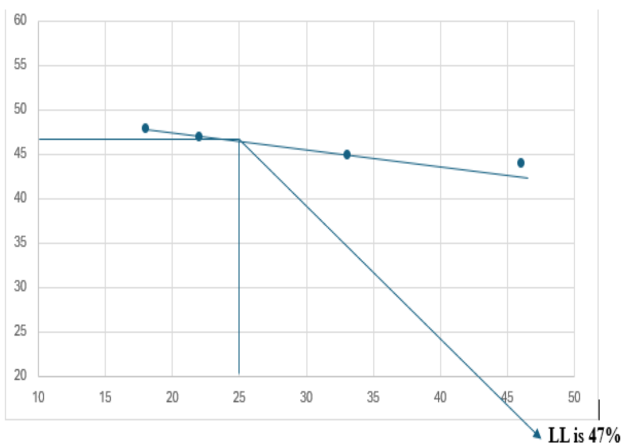

Figure 3: Sample plot of Atterberg limit test for the study area

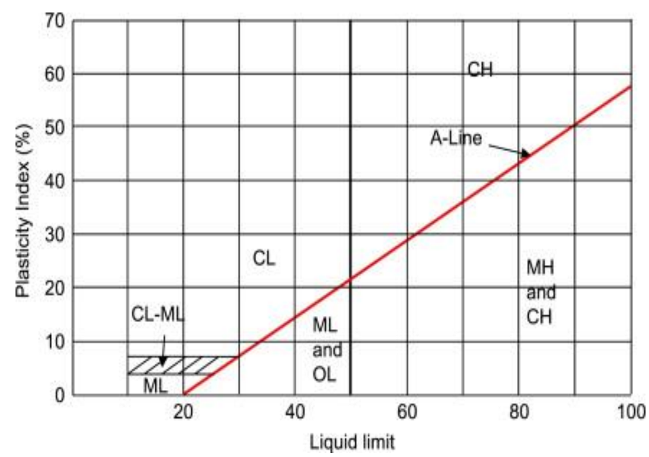

Figure 4: Unified Soil Classification System Source: Howard (1988)

Land use and land cover of the Erhumwunse sub-catchment

The land use and land cover of the Erhumwunse sub-catchment (Figure 5) was categorised into three land cover types, namely Urban, Extensive small holder, and grassland, as shown in Table 7. The largest portion of the study area is dominated by the built-up environment, which covers about 729,116.29 m^2, representing about 45.1 percent of the total areal extent. This is followed by an extensive small holder land use category of about 591,003.52 m^2, which represents 36.5 percent of the total area, and the remaining area, spanning 297,003.97 m^2 or 18 percent, is covered by grassland.

The 591,003.52 m^2 of land devoted to extensive smallholder subsistence farming is an indication of the importance attached to agriculture, food production, and household food security. This land use category is, however, continually under the threat of erosion and gully formation due to the land use and active nature of the gully. Many of the residents of this sub-catchment depend on household gardening to feed their families, while some have taken to this small household farming as their occupation and source of livelihood. Unfortunately, the loss of available land to gully formation as well as the loss of soil nutrients and the physical characteristics of the soil have resulted in poor crop yield, limited varieties of cultivated crops, increased food insecurity, and reduced income for smallholder farmers. The implications of soil erosion and gullying for Household Crop Cultivation for the peasant farmers, especially those whose livelihoods depend on the output from this venture, are damaging. There is a reduction in both crop yield and the available arable land. As a mitigation strategy for preventing the loss of home gardens, sidewalls and demarcations are constructed along the erosion route as shown in Figure 6. Although this works for the individual households that can afford to demarcate their small piece of land, it is, however, not affordable and sustainable for many households. A proactive catchment management plan that ensures sustainable urban agriculture developed in the land area would be required.

Figure 5: Landuse and Landcover of the Erhumwunse Sub-catchment

Table 7: Landuse and Landcover of the Erhumwunse Sub-catchment

Land use/ Landcover	Area (m^2)	Percentage
Built-up/Urban	729,116.29	45.1
Extensive smallholder	591,003.52	36.5
Grassland	297,003.97	18.4

Figure 6: Demarcation to Safeguard a Home Garden from the Impact of Gully Erosion.

Conclusion

Gully erosion at Erhumwunse sub-catchment poses a serious environmental threat and a challenge to household food security. In recent years, several residents have had to abandon their houses and their home gardens that hitherto served as a source of food security and incomes to some families within the catchment. This study analysed the morphological characteristics of the gully and the physical characteristics of soils from the gully.

The results of the study showed a relatively high level of vulnerability to erosion as indicated by the active state of the gully, and a low level of cohesiveness of the soil, which is characterised by a high proportion of sand. Thus, this results in high vulnerability of soil to erosion and consequent loss of nutrients. To replenish some of the nutrients of the eroded soil, households that are still engaged in home gardening may need to apply fertilisers to the soil to boost the yields from their gardens. Soilless farming can also be explored by residents with home gardens for the cultivation of some crops as a means of circumventing loss of crops to erosion and increasing yield from their crops. Erosion mitigation measures such as the use of sandbags, local drainage channelisation, and the planting of vegetation such as the vertiver grass to stabilise the soil and reduce surface runoff are recommended as temporary measures to prevent further expansion of gullies within the catchment. It is also recommended that land use zoning and practices should be incorporated into the wider catchment management plan for the area.

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