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Citizens Science Perspectives on Drivers of Sedimentation in the Lusitu River Catchment in Chirundu District, Zambia

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Authors' contributions

This work was carried out in collaboration among all authors. Authors NS, MM, RW and IZ contributed to the study design. Data collection, analysis and drafting of the first manuscript was done by author NS. All authors read and approved the final manuscript.

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ABSTRACT

The problem of sediment generation is very pronounced in Southern Zambia and, Lusitu River Catchment in particular. Despite numerous positivistic and geophysical explanations on factors influencing sedimentation, there is still a gap regarding comprehensive understanding of citizens science-based perspectives in the study of geophysical processes, specifically around sedimentation. Previous research has primarily focused on mapping land-use changes and assessing the impact of livelihood activities on geomorphic changes using techniques such as GIS, SWAT, and others, but with minimal or no consideration given to the role of citizens scientific perspectives. The study was informed by analytic eclecticism paradigm and used mixed

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methodology that was inherently citizens science. Data was collected using observation and semi-structured interviews and was analysed using descriptive statistics namely, mean, standard deviation, coefficient of variation and, thematic analysis. The results showed that agricultural activities particularly, dry season crop field preparation prior to the onset of rainfall and intensive soil tillage farming practices were the major drivers of sedimentation of the Lusitu River. Geomorphic factors driving sedimentation of Lusitu River were gully erosion, loose soils (Leptosols), unstable riverbanks and weak sedimentary rock formations. Addressing the drivers of sedimentation in the Lusitu region requires a holistic approach that recognizes the importance of citizens' scientific perspectives. Efforts should focus on raising awareness and engaging with local communities to promote sustainable land and water management practices. This includes integrating traditional knowledge with modern scientific methods, fostering community participation in decision-making processes, and providing access to resources and education. The paper says that, understanding drivers of sedimentation in hydrological systems is a function of understanding not only the geophysical process independent of human perspectives, but also the citizens' scientific perspectives.

Keywords: Sediment; anthropogenic activities; Lusitu River; drivers of sedimentation.

1. INTRODUCTION

A study on the social perspectives on sediment [1] showed that there is a considerable increase in the quest to integrate social and physical processes in explaining phenomena in fluvial and anthropogenic geomorphology. This is a contemporary effort to bridge the gap between the social and natural sciences in the emerging field of Critical Physical Geography [2,3]. Many river channels have undergone dramatic changes in recent decades due to sedimentation [4,5]. For example, studies on the Yellow River (Mongolia Reach Region) show that the Yellow River channel reduced following an increase in siltation of the Mongolia Reach Region [6,7,8,9]. A long-term trend of reduction in rainfall intensity is considered as factors leading to the changes in runoff and sediment load of the reach [6,10,11,12,13,14]. Furthermore poor land management and sheet erosion has led to topsoil being carried into the water bodies [15]. However, human activities may primarily be responsible for sediment runoff in most areas of the world. For example, these may include poor agricultural activities like downhill ploughing and deep ploughing [16]. As a result these human activities tend to expose the soils for potential erosion. On the other hand, some of the natural factors such as highly erodible soils and steep unstable slopes, increase rates of erosion and sediment loads. Nonetheless, natural erosion is normally a very slow process compared to human-induced or accelerated erosion which can result in major increases in sediment generation [16]. Some principal factors which influenced accelerated erosion rates were area under cultivation, changes of landuse, crop rotation and agricultural practices [17]. The key anthropogenic drivers of high sediment load in rivers are agricultural practices [18]. Clearing of vegetation to promote agricultural expansion, as well as tillage techniques which loosened soil, increased rates of erosion by runoff. This resulted in highly destructive forms of erosion such as gullies which make farmland useless. The other major human-induced changes, which disturb the natural processes of erosion and sediment transport include construction of dams and other river-control structures, such as locks and weirs among others [19].

Sediment problems faced by different river basins are to a large extent river-specific due to specific combination of controlling factors, which include, but not exclusively topography, surface conditions and landuse patterns and the socio-economic conditions in a river basin [20]. Local factors which include topography, river control structures, soil and water conservation measures, tree cover, landuse or land disturbance such as agriculture and mining influence sediment loads in rivers [21]. Further, climate change is influencing sediment loads of rivers around the world due to changes in sediment yields as a result of climate change and associated changes in rainfall and runoff [22]. Effects of climate change in sediment yield may also interact with other anthropogenic causes of sedimentation in rivers, such as agricultural production [23,24,25].

A study on the most significant factors in the development of the Alva gully in Portugal based on a study of the modification of its morphological characteristics, used Principal

Component Analysis (PCA) to estimate the correlation between the quantitative characteristics and other variables such as biophysical variables [26]. The results showed that, the main factors that controlled the spatial variation of soil erosion were soil penetration resistance, slope, slope shape, and vegetation cover. The study found that, a convex bank slope has denudation rates greater than a concave bank slope in respect to gully widening. Soil erosion processes such as gully erosion are localised, thus are dependent upon prevailing factors such as type of soil and rainfall amount. Hence the study could not deduce how gully erosion was influenced by all the factor as the gully was not gauged.

A study in the Kaduna Watershed (Nigeria), Western Africa [27] used Soil and Water Assessment Tool (SWAT) to assess the roles of landuse change, land cover area, and runoff on watershed's sediment yield. The SWAT model generated NS, r^2 and *p*-factor of 0.71, 0.80, and .86, respectively. Therefore, the model performed well for stream flow and sediment yield predictions. The study suggested that, the destruction of evergreen forests and a significant change in landuse from grass cover and forest to agricultural and residential use between 1975 and 2013, increased sediment yield by 68% [27]. There are many other studies which have documented the interplay of drivers of sedimentation, such as landuse change, landuse area size, runoff, steeper slopes and stream gradients [28,29,30,31].

In East Africa, a study found that catchment environmental factors driving sedimentation were slope, climate, vegetation cover, soil and geology, and topography [32]. Other factors were landuse changes and climate changes, which were driving accelerated soil erosion in the semi-arid East Africa. This led to increases in reservoir sedimentation, and decreased energy production. Similar findings were reported in Ethiopia [33]. Many studies have documented that soil erosion is a serious problem in Zambia [34,35,36], and that it is attributed to long history of sedentary agriculture and overgrazing by cattle, especially in the Southern part of Zambia [34]. Many studies have shown that, crop farming is a key factor in sediment generation [35,37,38,39].

While we appreciate all the geophysically documented studies that have been done over the years with regard to drivers of sedimentation, majority of them widely sideline the social and citizens' science perspectives that can inform the debates especially from the people who actually propel the geophysical processes. Many of the above studies have mapped landuse changes and how livelihood contribute to geomorphic changes using GIS techniques, SWAT, among others, but with little or no field voice from the people who actually engage in such activities that expedite the changes. Hence, this study.

2. MATERIALS AND METHODS

Lusitu River Catchment covers an area of about 1,831 km^2, its geographical location is at 16^O 05' 0" S to 16^O 25' 0" S and 28^{O}10' 0" E to 28^O 50' 0" E.

Lusitu River has since the early 1980s been non-perennial. It is a major tributary of the Zambezi River between Kariba Dam and Chirundu Town. Lusitu River stretches across Chirundu, Siavonga and Chikankata Districts of Southern Province, Zambia. In terms of vegetation, this part of the catchment is mainly composed of Mopane and Munga woodland (Balkiaea). The catchment is composed of mosaic vegetation including herbaceous savannah and woodland savannah with large areas lying bare during dry season and under seasonal grass cover/crop cover during rainy season. Lusitu River supports a large population of over 20,000 Gwembe Tonga speaking People who were relocated to Lusitu Catchment in 1958, following the construction of Kariba Dam. There are 7,126 cattle and 32,800 goats mainly concentrated in the downstream section of Lusitu River [40]. In terms of climate, the study area experiences a hot, semi-arid climate with higher temperatures and lesser rainfall [41]. The area generally receives below average (845 mm) rainfall Fig. 2.

The soil types in the study area are Luvisols, Cambisols and Leptosols. The Luvisols and Cambisols dominate the lower and middle sections of the catchment and are associated with Karoo Supergroup in the Zambezi Valley and adjacent escarpment zone. They are sometimes referred to as Gwembe valley soils. Luvisols are soils that have high clay content in the subsoil than in the topsoil as a result of pedogenetic processes (especially clay migration). Cambisols are soils in an early development stage with at least an incipient subsurface soil formation. They are shallow and gravelly soils derived from acid rocks, occurring in rolling to hilly areas, including escarpment magmatic and metamorphic rocks of the escarpment zone in the Zambezi Valley [41]. The upper catchment is dominated by the Leptosol. These soils have a very shallow profile depth which is an indication of little influence of soil forming processes and are highly susceptible to erosion.

The geology of the catchment mainly belongs to the Karoo Supergroup in the Zambezi Valley and adjacent escarpment zone [41]. The study area lies entirely over the sedimentary rock formation, which belongs to the Upper Karoo. The dominant rocks covering the Lusitu area are sandstones and inter-bedded mudstones and red sandstones. Most of the sandstones are calcareous and some contain pyritic concretions. Other geological formations are low Karoo undifferentiated, dominant in the middle of the catchment. The upper catchment comprises of undifferentiated calcarious-silicate, Meta-carbonate rocks, and undifferentiated granite gneiss, Mine Series undifferentiated and basal and coal.

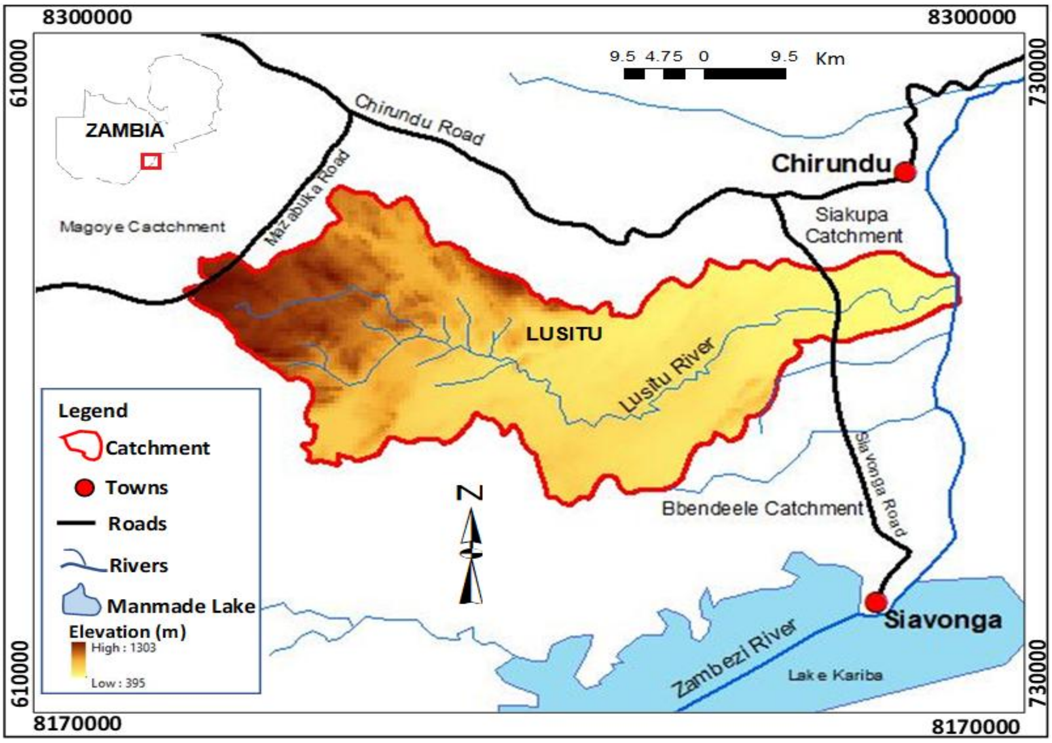


Fig. 1. Location map of Lusitu River catchment

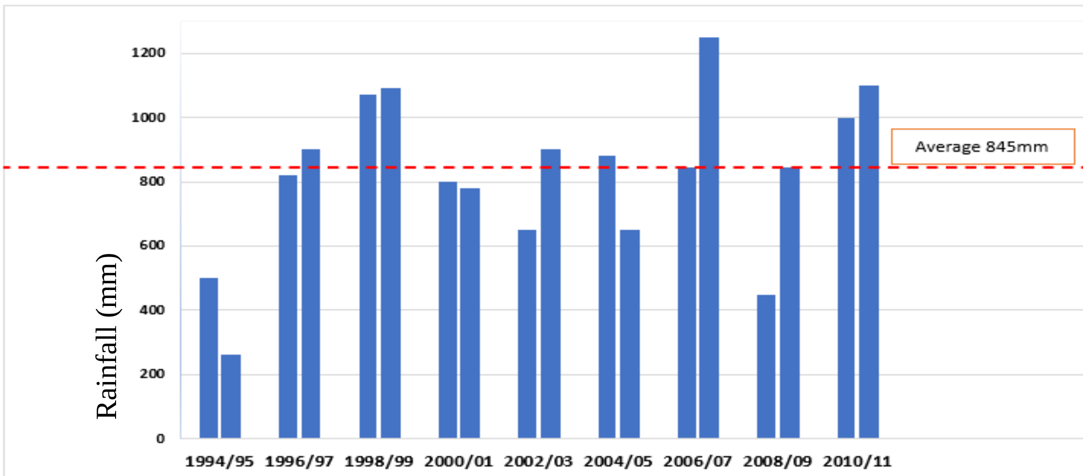


Fig. 2. Lusitu River catchment rainfall data, 1994 to 2011

In terms of social demographic characteristics, the study area is a rural community with linear settlements following the Lusitu River and feeder roads. The people are Tonga Tribe with little to no educational attainments [42]. It has several primary schools and only three secondary schools. The study worked with 45 crop agriculture farmers, 45 livestock farmers (all directly dependent on water from the Lusitu River), 10 Charcoal producers, and 4 Traditional Leaders. Landuse is dominantly rain-fed cultivation of cereals; sorghum, maize and millet. Intensive gardens on the banks of Lusitu River produce vegetables such as giant rape, pumpkin leaves, tomatoes and green maize among others. Livestock (predominantly cattle and goats) ownership accounts for 30% of net farm income [42]. The area has great potential in goat rearing as evidenced from large goat population in the area [43] and as such, Lusitu River is an important source of water for livestock watering for improvement of livelihoods in these rural communities. Flora Species of economic value include: Baobab (Adansonia digitata), Musau (Ziziphus Mauritana) and Musiika (Tamarindus indica). Fruits from these trees form part of the family diet and are sold in local markets and to traders mainly from Lusaka city.

The study was methodologically inspired by Citizens science, a framework that transcends the scientific rigidity of fixating knowledge creation to hardcore strategies involving experts only toward a transgressive one where community members are interactively engaged in the co-creation of knowledge [44]. Data was collected using direct observations with the aid of GPS and photography. Some of the observed variables include gully erosion, human activities, among others. Semi-structured interviews were used to collect qualitative data on main drivers of sedimentation which participants were aware of in the Lusitu River Catchment. They were also asked to rank severity of both human and geophysical drivers of sedimentation in the Lusitu River Catchment using a Likert scale where 1 was equal to less severity, 2; moderate severity and 3, high severity. Accidental Focused Group Discussion (AFGD) was done with four participants who were relocated to Lusitu during the construction of the Kariba Dam between 1958 and early 1960s. This was accidental because it was initially not planned for in the research protocol, but it was opportunistic to find some originally relocated participants who could give a social-geophysically lived experience on the hydrological system under study. Data was analysed using descriptive statistics namely, mean, standard deviation, coefficient of variation for closed rankable data and, thematic analysis for all qualitative data. The study was inherently informed by analytic eclecticism paradigm whose onto-epistemic stance is understanding reality independent of the people, but whose meaning interpretation is influenced by social-ecological inter-relationalities, corporeality and spatiality [45,46]. A mixed methodology approach was used to implement the study within the analytic Eclecticists' lens [47,48].

3. RESULTS AND DISCUSSION

The study conducted ranking of severity of occurrence of drivers of sedimentation in the Lusitu River Catchment by the local people, which were later validated by expert observations. It was evident that anthropogenic activities especially agricultural activities were a major contributor of sediment into Lusitu River. Riverbank gardening had mean rank of Three with no deviation followed by dry season crop field preparation prior to the onset of rainfall and intensive soil tillage farming practices. Sand mining was found to be the least contributor of sediment into the Lusitu River as collectively confirmed by both local people and the expert observations (Table 1).

Based on semi-structured interviews with 104 participants, it was further noted that most of their perspectives on drivers of sedimentation were clustered around human activities, which shows that they were more familiar with human activities than the geomorphic process. It also shows how involved the people were in these activities. Generally, the frequency of responses oscillated between 20%-29% across all emerging themes (Fig. 4).

Through thematic analysis of responses, the study established that over population, search for alternative livelihoods, climatic and geomorphic factors were influencing accelerated sediment generation in the Lusitu River Catchment and some of the qualitative descriptors are shown in Table 2. The general impression that emerged from the findings is that, sedimentation in the Lusitu River Catchment was a function of combined process of human and geophysical processes. Most strikingly was isolation of some cultural practices such as Nkolola Ceremony that potentially contribute to degradation and siltation of the river. This was unique case to this study as earlier studies have never documented this as far as our literature search was concerned.

Table 1. Participants' rankings of severity of drivers of sedimentation in the Lusitu River catchment

	Charcoal Burning	Vegetation Clearance for New Crop Fields	Dry Season Crop Field Preparation	Intensive soil tillage farming	Animal Grazing	River bank gardening	Sand Mining	Brick Moulding	Soil Erosion
Mean Rank	2.65	1.89	2.86	2.86	2.68	3.00	1.00	1.59	2.68
SDV	0.54	0.81	0.35	0.35	0.47	0.00	0.00	0.55	0.47
CV	0.20	0.43	0.12	0.12	0.18	0.00	0.00	0.35	0.18

n= 104

Table 2. Factors influencing accelerated soil erosion in Lusitu

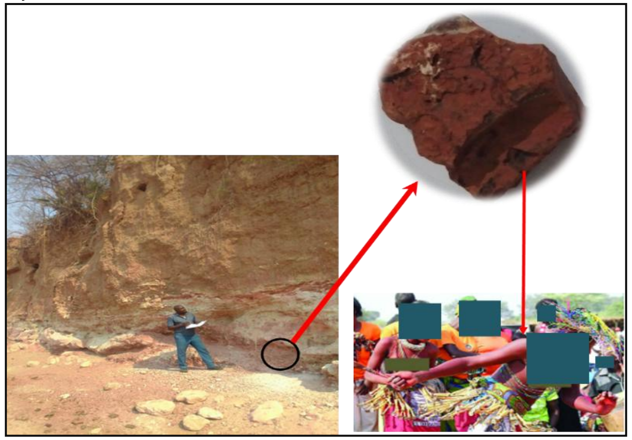
Themes	Description of themes
Indigenous cultural practices	• The local people practice an indigenous cultural ceremony locally known as *Nkolola* for girls' initiations. • The makeup powder they use is made from river red clay soils, which causes river banks degradation and instability promoting bank erosion and bed deposition  *Red sedimentary rock used for producing makeup powder during the Nkolola Initiation Ceremony. Nkolola Ceremony Picture by Michelo Himaambo, (Times of Zambia, April, 1, 2016).*
Increase in human population	• Population has increased since the resettlement in 1958. • Land was limited due to Chiefdom boundaries of the resettled population under chief Chipepo and the native population under chief Sikoongo. • As human population increase, so is livestock population exceeded carrying capacity.
Livelihoods	• No capital is required to start charcoal burning. • Charcoal business is very profitable. • Selling irrigated crops in dry season is very profitable.
Extreme weather events	• Occurrence of flush floods • High frequency of droughts.
Geomorphic factors	• Loose soils which are highly erodible. • Unstable riverbanks.

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Fig. 3. Observed gully erosion in Lusitu River catchment

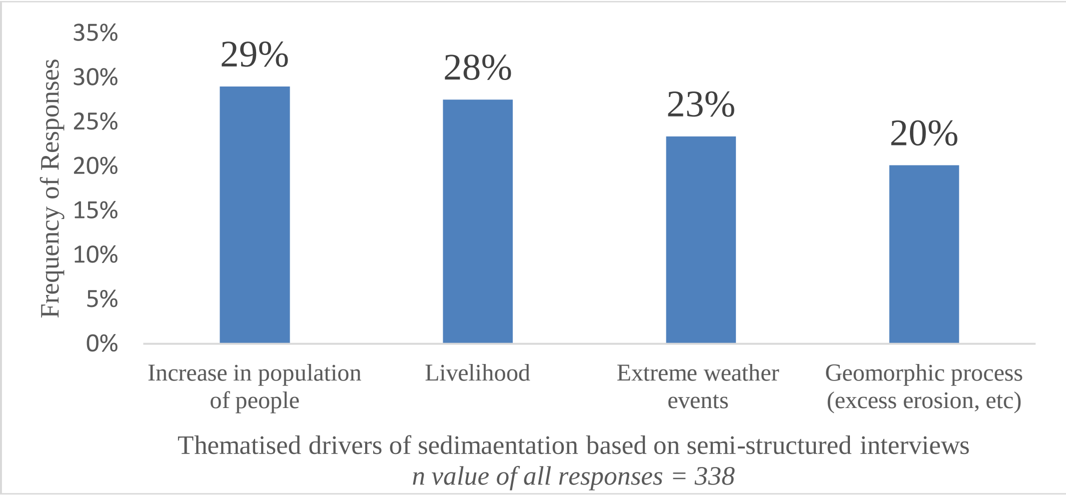

Fig. 4. Factors influencing sedimentation

Some participants were asked to explain what they observed to be the main causes of siltation based on their lived experiences. One of the participants said:

"*citupa kuumpa malasya nkuyanda mali akuligwasya, ilaleta ntimba. Kayi kuti wakkala biyo ulafwa nzala. Nyika yakulima munsi amulonga njisyoonto alimwi meenda alafwaambaana kuyuminina nkaambo museenga wakavwula mu mulonga", P1.* (We burn charcoal as an alternative source of money for our livelihood, which brings sediment. There is limited land for cultivation along the river and water dries up early because there is too much sand in the river).

Another participant said that:

"*cajeya nyika yesu a mulonga nkuvwula kwabantu azivwuubwa. Masena akulima amacelelo aceya. Alimwi basikugonka malasya balilika biya zisamu.", P2* (What has caused degradation of our land and the river is increase in population of people and livestock. Also, charcoal burners are harvesting trees by burning them from ground level).

A male participant aged 75 years at the time of study recalled that:

"*mu* 1978 *kwakawa mvula mpati cimwi ciindi. Meenda akali kwandula mulonga, museenga wakavwula wakeetwa a meenda mu mulonga."* (There was a heavy flood event in 1978 which cut several meanders and deposited a lot of sediment in the river channel).

In an AFGD, six participants who were actually relocated at the time of the construction of the Kariba Dam were purposively engaged in a discussion to narrate the changes they had observed in the flow regimes of the Lusitu River between 1958 and 2023. Based on the verbatim presented in Table 3, the study findings resonated with what experts records from Zambezi River Authority (ZRA) (1996) were showing that, Lusitu River used to be perennial up to the early 1980s.

From the narratives in Table 3, it is evident that people understood the processes around the river based on the interaction with it. It also shows that, in the past, one of the reasons why the river was preserved could be attributed to the cultural beliefs that was linked to the river, implying that hydrologists, geomorphologists and water resource managers should consider integrating such indigenous epistemologies within their planning processes. Both destructive and constructive indigenous epistemologies must be explored and evaluated for their potential usefulness in general science of water.

The ranking of severity of occurrence of drivers of sedimentation in the Lusitu River Catchment showed that anthropogenic activities were the most responsible for sediment generation. These findings are consistent with other studies [17,18,27]. The practice of gardening on the riverbanks among the Gwembe Tonga of Lusitu was historical. It was practiced when they occupied the section of the Zambezi River, now the central part of Lake Kariba. The study highlights the need for effective governance mechanisms that regulate land use, promote sustainable practices, and ensure equitable access to resources. This section of the Zambezi River was a flood plain [48]. However, as the floods receded, maize, pumpkins and sweet potatoes were cultivated up to the riverbanks. Participants who were part of the resettlement into Lusitu in 1958, narrated that, the then, Federal Government told the people to be resettled that Lusitu River was perennial with plenty of water for gardening. However, people resisted to be moved away from the fertile alluvial soils which enabled them to grow crops throughout the year. As resistance and hostilities grew, the Chisamu War (in Chisamu village, now near Ng'ombe Ilede) broke out, where at least, eight people were killed while thirty-two were wounded. This was a defence of riverbank gardens [48]. Hence, the practice of riverbank gardening along the Lusitu River started immediately they were resettled in Lusitu, in 1958. The gardens mainly produced crops for home consumption. The above scenario confirms earlier argument that sedimentation in Zambia was accelerated by long history of sedentary agriculture [34].

Table 3. Social narratives on the evolution of the Lusitu River flow

Narrative		**Participant's Year of Birth**
Original Language Expressed (Chitonga)	**English Language Translation**	
"Nitwakalonzengwa mu 1958, twakasika mu October ookuno. Twakajana meenda akali kweenda. Akali malamfwu meeda".	We were resettled here (Lusitu) in October, 1958 and found Lusitu River flowing. The river had deep water.	1938
"Basikutulonzya bakaamba kuti nkumuya kuli mulonga mupati munakulima acilimo. Lino tupengede meenda. Kumatongo twakali kulima acilimo. Tuyanda meenda ngibaka tusyomezya."	During resettlement, we were told that there is a big river with water for irrigation farming even in the dry season, as this was our lifestyle. We need the water we were promised".	1940
"Nitwakasika ookuno ku Lusitu, ooyuu nulonga tiwakali kuyuminina pe. Twakali kujeya baswi mwaka oonse. Masamu akali manji mumbali amulonga."	When we arrived in Lusitu, the river was perennial. We used to catch plenty of fish throughout the year. There were plenty of trees along the riverbanks.	*1947*
"Ooyu mulonga wakalijisi meenda manji kusika muma 1970 katucili basankwa. Nkomwe zyamulonga zyakali zilamfwu. Wakali wa Malende. Bantu tibakali kuzumizigwa kusanzyila kumuloga mitiba.	Lusitu River had plenty of water up to 1970s when we were still youth. The river channel was deep. People were not allowed to clean dishes from the river because it was believed to host rainy spirits.	1950

Based on participant's narratives, the commercialisation of gardening along Lusitu River was an adaptive measure to droughts, especially the 1994 and 1995 droughts. Since then, people realised the monetary economic value of riverbank gardens, other than merely contributing to domestic food supply. The commercialisation of gardens led to destruction of riverine vegetation such as reeds and ficus trees, to clear land for gardens and reclaiming parts of the river channel for gardening. Hence, augmenting soil erosion. The situation was hastened by cleared trees in the buffer zone for rain-fed crop cultivation where prior to the onset of the rainfall, the fields were cleared of any regenerating vegetation which was heaped and burnt, comparable to the Chitemene System of farming reported to induce high sediment generation [49]. This practice left crop fields bare, thereby encouraged high sediment generation which was transported by runoff into streams and deposited in the Lusitu River. Intensive soil tillage farming practices, which were ox-drawn ploughing and weeding by hoes loosened the soil, and increased sediment generation. The common mode of transporting ploughs to the fields was usage of sledges, which overtime, led to development of gullies. The effects of agricultural practices on sediment generation have been widely discussed by a number of scholars who similarly found that change of landuse from forest to agriculture generically increased sediment yield and deposition [17,18,25,27,39,50].

Livestock grazing which was ranked to almost very severe, with a mean rank of 2.68 out of 3, a standard deviation of 0.47 and a coefficient of variation of 18% showed that majority of people (82%) in Lusitu were aware that overgrazing contributed to land degradation. Grazing areas became bare because there was limited land for animal grazing due to strict chiefdom boundaries between Chief Sikoongo (native to the area), and Chief Chipepo (resettled to the area). As mentioned earlier, Chirundu District had a total of 7, 126 cattle and 32, 800 goats [43] mainly concentrated in the downstream section of the Lusitu River. Studies have shown that large herds of cattle kept by the local people in the Southern Province of Zambia accelerated the process of sedimentation [34,39,50].

In accordance to the findings of the study, the deforestation of Mopane woodland due to charcoal production activity in the catchment had a mean rank of 2.65 out of 3 with 20% coefficient of variation implying that it was a serious driver of sediment generation. Charcoal production had left large tracts of land cleared of vegetation. A study on deforestation due to charcoal production reported that the current contribution towards forest degradation resulting from charcoal production in terms of both spatial extent and produced charcoal is surpassing deforestation for agriculture expansion [51]. The impetus for large-scale charcoal production in Lusitu, was driven by high preference of charcoal from mopane trees in nearby towns; Chirundu, Siavonga, Kafue and Lusaka. It was reported to burn slowly, lasting longer than charcoal from other tree species. Hence, helped to save household energy costs in the face of load shedding, and increased electricity costs. Studies in Zambia have documented that, increase in charcoal demand in Lusaka (and other towns) was driven by long hours of load shedding, which has led to diminishing of tree species preferred for charcoal production [52,53]. In Lusitu, Charcoal Producers showed that, it was easier to engage in charcoal burning because it did not require any capital other than an axe, a hoe, shovel and personal labour. Even though Chief Chipepo banned charcoal production in his chiefdom, the study found that it was difficult to control, or even to end the practice of charcoal production because it was a lucrative alternative source of livelihood, in response to consistent droughts in Lusitu. The study found that Charcoal Producers were hostile to any effort made by traditional leaders to end charcoal burning, similar to another study on charcoal production in Central Zambia [52]. In Lusitu, Charcoal Producers demanded for an alternative source of livelihood which could give them financial gains, as did charcoal production business. Such a demand was impossible in the existing local economy.

The contribution of sediment generation into Lusitu River due to sand mining was found to be minimal. It had a lowest mean rank of 1, with no deviation. The study found that sand deposited on the riverbed was not utilised due to presence of construction sand in streams such as Machembele, near Chirundu town, and Bbendeele closer to Siavonga town. However, in 2019, sand was commercially mined in Lusitu River by Sino Hydro Corporation, a Chinese construction firm. Sand was ferried to Kafue for construction of Kafue Gorge Lower Power Station. This provided evidence that, sand deposited in Lusitu River is of high grade for construction of super structures. The limited contribution of sand mining activities in Lusitu to the geomorphic change of the Lusitu River differ from the findings in the Magoye Catchment also in Southern Zambia where sand mining was found to be a serious contributor to the river channel degradation due to high demand from the construction sector [54]. The discussion of findings underscores the importance of understanding and addressing sociocultural perspectives in tackling sedimentation in the Lusitu region. By recognizing the influence of cultural practices, beliefs, and social dynamics, effective strategies can be developed to promote sustainable land and water management practices.

One most notable and unique driver of sedimentation in Lusitu Catchment was associated with Indigenous practices such as the *Nkolola* Initiation Ceremony for girls. The local people were mining a red sedimentary rock, which they used to make powder locally called *Munsila* and is used for body makeup for girls undergoing initiation ceremony, called *Nkolola*. This was found to have a weakening influence on the riverbanks, hence contribute to sediment generation from collapsing riverbanks. Such a scenario goes on to show that even cultural practices should not be left out in the mainstreaming of sustainability principles around river management and protection. In support of this, UNESCO [55] shows that, if cultural practices are well integrated, they could be the main driver of sustainability messages around various environmental resources such as rivers. Contextually speaking, the river protection and restoration framework or measures must decisively include custodians of such ceremonies.

The population of the resettled Gwembe Tonga people increased from an initial population of 6,000 people in 1958 to about 28,000 by 2022 [56]. This increase of population over time potentially implies pressure on cultivated land, which could have been contributing to land degradation leading to siltation. This is similar to Ethiopia experiencing land degradation in the Blue Nile highlands hosting about 90% of the country's population where such population pressure severely triggered erosion and sedimentation of rivers and reservoirs [57,58,59,60,61,62]. In these densely settled areas, the role of Citizen science in in land and water resources management cannot be overemphasized, as it fosters environmentally friendly dispositions and engagement, which in its right is a means of social inclusion which facilitates the participation of citizens with important governance implications such as those related to water resources management [63,64]. The application of Citizen Science has dominated water quality monitoring [65], unlike other areas of study such as sediment generation in river catchments. It is therefore, important to engage in Citizen Science which promote environmental awareness and engagement, and generation of new evidence for several research problems [66,67,68] including sediment generation which affect water quality and quantity in rivers and reservoirs.

Even though Lusitu Catchment receives less rainfall (Fig. 2), occurrence of flush floods induce sediment generation and transportation. A number of studies have widely documented the influence of rainfall in sedimentation [49,69,70,71]. The occurrence of flush floods on steep slopes of the upper Lusitu River Catchment with Leptosols which are highly erodible [41] and on land with less vegetation cover, could have played a significant role in the generation of high amounts of sediment, leading to the drying up of the Lusitu River. Similarly, a number of studies have shown that natural factors such as highly erodible soils, steep slopes and high rainfall intensities increased rates of erosion and sediment loads in rivers [12,23,24,72].

4. CONCLUSIONS

Through an in-depth analysis of local communities perspectives, their practices, and their interactions with the river system, several key findings emerged. Anthropogenic activities such as traditional farming practices and excessive land clearing significantly contributed to sedimentation in the Lusitu Catchment. These practices, deeply rooted in the sociocultural fabric of the communities have led to increased soil erosion and sediment deposition into nearby water bodies. Furthermore, the study shed light on the historical cultural beliefs and attitudes that perpetuate unsustainable or sustainable resource management practices. Addressing the drivers of sedimentation in the Lusitu Catchment requires a holistic approach that recognizes the importance of sociocultural and citizens science perspectives. Efforts should focus on raising awareness and engaging with local communities to promote sustainable land and water management practices. This includes integrating traditional knowledge with modern scientific methods, fostering community participation in decision-making processes, and providing access to resources and education.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Parrinello G, Kondolf MG. The social life of sediment. Water and History. 2021;13:1-12.
2. Ashmore P. Transforming Toronto's rivers: A socio-geomorphic perspective. In: Lave R, Biermann C, Lane S, editors. The Palgrave handbook in critical physical geography. Palgrave Macmillan, Cham. 2018;485–511.
3. Lave R, Biermann C, Lane S, editors. The Palgrave handbook of critical physical geography. Palgrave, Macmillan; London; 2018.
4. Ran L, Wang S, Fan X. Channel change at Toudaoguai Station and its responses to the operation of upstream reservoirs in the upper Yellow River. Journal of Geographical Sciences. 2010;20(2):231-247.
5. Xu J. An example of the upper Yellow River, China. River Research and Applications. 2013;2995: 593-607.
6. Fan X, Shi C, Shao W, Zhou Y. The suspended sediment dynamics in the Inner-Mongolia reaches of the Upper Yellow River. CATENA. 2013;109:72-82.
7. Qin Y, Zhang X, Wang F, Yan H, Han H. Scour and silting evolution and its influencing factors in Inner Mongolia Reach of the Yellow River. Journal of Geographical Sciences. 2011;21(6):1037-1046.
8. Ta W, Jia X, Wang H. Channel deposition induced by bank erosion in response to decreased flows in the sand-banked reach of the upstream Yellow River. CATENA. 2013;105:62-68.
9. Zhang L, Zhang H, Tang H, Zhao C. Particle size distribution of bed materials in the sandy river bed of alluvial rivers. International Journal of Sediment Research. 2017; 2(3):331-339.
10. Zhang S, Yu W, Zhang H. Sediment characteristic and the variety trend analysis for upstream Yellow River. Journal of Water Resources and Water Engineering. 2005;16:57-61.
11. Xu Z, Li J, Liu C. Long-term trend analysis for major climate variables in the Yellow River basin. Hydrological Processes. 2007;21(14):1935-1948.
12. Wang Y, Wu B, Zhong D. Calculation methods for deposition volume in non-flood and flood seasons in the Inner Mongolia reach of the Yellow River. Journal of Geographical Sciences. 2016;26(6):707-721.
13. Wu B, Wang Y, Zhou L. Characteristics of sedimentation and water level at same discharge in the Inner Mongolia Reach of the Yellow River. Journal of Sediment Research. 2015;3:8-14.
14. Shi H, Hu C, Wang Y, Liu C, Li H. Analyses of trends and causes for variations in runoff and sediment load of the Yellow River. International Journal Sediment Research. 2017;32(2):171-179.
15. Dai Z, Liu JT. Impacts of large dams on downstream fluvial sedimentation: An example of the Three Gorges Dam (TGD) on the Changjiang (Yangtze River). Journal of Hydrology. 2013;480:10–18.
16. Makwara E, Gamira D. About to lose all the Soil in Zaka's Ward 5, Zimbabwe: Rewards of Unsustainable Land Use. European Journal of Sustainable Development. 2012;1:457–476.
17. Zhao G, Mu X, Wen Z, Wang F, Gao P. Soil erosion, conservation, and eco-environment changes in the Loess Plateau of China. Land Degradation Development. 2013;24(5):499-510.
18. UNESCO. Sediment issues and sediment management in lager river basins. Interim case study synthesis report. International Sediment Initiative Technical Document in Hydrology. UNESCO office in Beijing and IRTCES; 2011.
19. Zahar Y, Ghorbel A, Albergel J. Impacts of large dams on downstream flow conditions of rivers: Aggradation and reduction of the Medjerda channel capacity downstream of the Sidi Salem Dam (Tunisia). Journal of Hydrology. 2008;351(3-4):3318-330.
20. Walling DE, Fang D. Recent trends in the suspended sediment loads of the world's

rivers. Global and Planetary Change. 2003;39:111–126.
21. Poesen J. Factors controlling sediment yield at the catchment scale in NW Mediterranean geo ecosystems. J. Soil. Sediment. 2011;11:690–707.
22. Wang S, Szeles B, Krammer C, Schmaltz E, Song K, Li Y, Zhang Z, Bloschl G, Strauss P. Agricultural intensification vs. climate change: what drives long-term changes in sediment load? Hydrol. Earth Syst. Sci. 2022;26:3021–3036.
23. Ananda J, Herath G. Soil erosion in developing countries: A socio-economic appraisal. Journal of Environmental Management. 2003;68(4):343-353.
24. Midgley GF, Bond WJ. Future of African terrestrial biodiversity and ecosystems under anthropogenic climate change. Nature Climate Change. 2015;5(9):823-829.
25. Liu X, Yang S, Zhou X, Guan Y, Wang Z, Chen K. Spatial-temporal characteristics of land use changes in the ten tributaries of Yellow River in the Inner-Mongolia since 1980. South-to-North Water Transfers and Water Science Technology. 2016;14(1):30-36.
26. Martins B, Nunes A, Meira-Castro A, Lourenço L, Hermenegildo C. Local Factors Controlling Gully Development in a Mediterranean Environment. Land. 2022; 11: 204.
27. Daramola J, Adepehin EJ, Ekhwan TM, Choy LK, Mokhtar J, Tabiti TS. Impacts of Land-Use Change, Associated Land-Use Area and Runoff on Watershed Sediment Yield: Implications from the Kaduna Watershed. Water. 2022;14: 325.
28. Ichim I. The Relationship between Sediment Delivery Ratio and Stream Order: A Romanian Case Study. 1990;79–86.
29. Milliman JD, Syvitski JPM. Geomorphic tectonic control of sediment discharge to the ocean: the importance of small mountainous rivers. Journal of Geology. 1992;100:525–544.
30. Birkinshaw SJ, Bathurst JC. Model study of the relationship between sediment yield and river basin area. Earth Surf. Processes Landforms. 2006;31:750–761.
31. Umit D. Modeling Sediment yield and Deposition Using the SWAT Model: A Case Study of Cubuk I and Cubuk II Reservoirs, Turkey. Ph.D. Thesis, University Fort Collins, CO, USA, Water. 2022;14:325.
32. Amasi A, Wynants M, Blake W, Mtei K. Drivers, Impacts and Mitigation of Increased Sedimentation in the Hydropower Reservoirs of East Africa. Land. 2021;10:638.
33. Kidane D, Alemu B. The effect of upstream land use practices on soil erosion and sedimentation in the upper Blue Nile Basin, Ethiopia. Research Journal of Agriculture and Environmental Management. 2015; 4(2):055-068.
34. Sichingabula MH. Problems of sedimentation in small dams in Zambia. Human Impact on Erosion and Sedimentation (Proceedings of the Rabat Symposium, April 1997). IAHS. 1997;245: 6-8.
35. Hamatuli M, Muchanga M. Social Perspectives on the Effects of Buffer Zone Anthropogenic Activities on Mashili Reservoir of Shibuyunji District, Central Province, Zambia. International Journal of Humanities Social Sciences and Education (IJHSSE). 2022; 8(11).
36. Chisola NM, Kuraz M. Patterns and Implications of Hydrologic Regime Change in Chongwe River, Zambia. Journal of Geography and Geology. 2016;8(3).
37. Sichingabula HM. Impact of Sediment on Ecosystem and National Economy. Windhoek, SASSCAL; 2018.
38. Simweene S, Muchanga M. Socio-hydrological learning for integrated Siltation control and Water Resources Management in a Small Reservoir of Southern Zambia. American Journal of Humanities and Social Sciences. 2021; 29:24-32.
39. Muchanga M, Sichingabula MH, Wankie R, Banda K. Impact of Sedimentation and Bathymetry of Selected Small Reservoirs on the Priority Water-Linked Sectors in the Zambezi River Basin. Journal of Geography and Geology. 2023;15(1):27-49.
40. Ministry of Livestock and Fisheries. Livestock Survey Report, Lusaka; 2022.
41. Baumle R, Neukum C, Nkhoma J, Silembo O. The Groundwater Resources of Southern Province, Zambia (Phase 1), 1-Technical Report, Lusaka; 2007.
42. Lusitu Irrigation Development Support Project. Environmental and Social Impact Assessment Report Volume 3 for the

Proposed Irrigation Scheme in Lusitu in Chirundu district: Lusaka; 2015.

43. Central Statistics Office (CSO). Livestock and Aquaculture Census. Lusaka; 2017.
44. Haklay MM, Dorler D, Heigl F, Manzoni M, Hecker F, Vohland K. What Is Citizen Science? The Challenges of Definition; 2021.
Available:https://doi.org/10.1007/978-3-030-58278-4_2
45. Guba EG, editor. The Paradigm Dialog. London: SAGE Publications; 1990.
46. Chalawila I, Muchanga M. Challenges Experienced By Postgraduate Candidates in the Application of Conceptual Frameworks in Scientific Research. International Journal of Scientific Research and Management (IJSRM). 2022; 10(2).
DOI: 10.18535/ijsrm/v10i2.el02
47. Bryman A. Social Research Methods. New York: Oxford Press; 2008.
48. Zambezi River Authority (ZRA). Kariba Dam's Operation Noah Re-Launched; 1996.
49. Sichingabula HM. Analysis and results of discharge and sediment monitoring activities in the southern Lake Tanganyika Basin: Final Report. 'Lake Tanganyika Biodiversity Project funded by UNDP/GEF/RAF/G32; 1999.
50. Muchanga M. Determination of sediment, water quantity and quality for Swat Modelling of sedimentation in the Makoye reservoir, Southern province, Zambia. University of Zambia, Lusaka; 2020.
51. Mulenga BP, Tembo ST, Sitko N. Cooking Fuel Choice in Urban Zambia: Implications on Forest Cover. IAPRI working paper No. 94. Lusaka: Indaba Agricultural Research Institute; 2015.
52. Dlamini C, Kaala BM, Syampungani S, Samboko PC. Load shedding and charcoal use in Zambia: What are the Implications on Forest Resources? Indaba Agricultural Research Institute: 4, Lusaka; 2016.
53. Samboko PC, Chapoto A, Mweemba, B. (2016). The Impact of Power Rationing on Zambia's Agricultural sector. IAPRI working paper No. 105, Lusaka, Zambia, Indaba Agricultural research Institute; 2016.
54. WARMA. Lower Kafue River Basin. 2019 Report Card: Lusaka; 2019.
55. UNESCO. UNESCO's Work on Culture and Sustainable Development: Programme and Meeting Document; 2015.
56. Zambia Statistics Agency (Zamstats). 2022 Censes of Population and Housing Preliminary Report. Lusaka; 2022.
57. Hurni H, Tato K, Zeleke G. The implications of changes in population, land use, and land management for surface runoff in the Upper Nile Basin area of Ethiopia. Mountain Research and Development. 2005;25(2):147–154.
58. Bewket W, Sterk G. Dynamics in land cover and its effect on stream flow in the Chemoga watershed, Blue Nile basin Ethiopia. Hydrological Processes. 2005;19(2):445– 458.
59. Nyssen J, Haile M, Nauds J, Munro N, Poesen J, Moeyersons J, Frankl A, Deckers J, Pankhurst R. Desertification? Northern Ethiopia re-photographed after 140 years. Sci Total Environ. 2009; 407:2749–2755.
DOI: 10.1016/j.scitotenv.2008.12.016
60. Rientjes THM, Haile AT, Kebede E, Mannaerts, CMM, Habib E, Steenhuis TS. Changes in land cover, rainfall and stream flow in Upper Gilgel Abbay catchment, Blue Nile basin - Ethiopia. Hydrology and Earth System Sciences. 2011;15(6):1979–1989.
61. Asfaw A, Simane B, Hassen A, Bantider A. Variability and time series trend analysis of rainfall and temperature in northcentral Ethiopia: A case study in Woleka sub-basin. Weather and Climate Extremes. 2018;19:29–41.
62. Mersha DB, Zeleke G, Alamirew T, Dejen AZ, Gebrehiwot SG. Assessing the effect of sustainable land management on improving water security in the Blue Nile Highlands: A paired catchment approach. Environmental Monitoring Assessment. 2022;194:197
63. Van Noordwijk T. Creating Positive Environmental Impact Through Citizen Science. In: The Science of Citizen Science. Springer, Cham; 2021.
Available:https://doi. org/10.1007/978-3-030-58278-4_19
64. Mattijssen T. A synthesis on active citizenship in European nature conservation: social and environmental impacts, democratic tensions, and governance implications. Ecology and Society. 2022;27(2). ISO 690
65. San Llorente Capdevila A, Kokimova A, Sinha R, Avellán Tamara, Kim J, Kirschke S. Success factors for citizen science projects in water quality monitoring.

Science of The Total Environment. 2020; 728,137843.
ISSN 0048-9697.
Available:https://doi.org/10.1016/j.scitotenv.2020.137843

66. Hecker S, Wicke N, Haklay M, Bonn A. How Does Policy Conceptualise Citizen Science? A Qualitative Content Analysis of International Policy Documents. Citizen Science: Theory and Practice. 2019; 4(1):32.
67. Werenkraut V, Baudino F, Roy HE. Citizen science reveals the distribution of the invasive harlequin ladybird (Harmonia axyridis Pallas) in Argentina. Biological Invasions; 2020.
DOI:10.1007/s10530-020-02312-7
68. Pierini VI, Mazzeo N, Cazenave M, Semmartin M. Waste generation and pro-environmental behaviors at household level: A citizen science study in Buenos Aires (Argentina). Resour, Conserv Recycling 170:105560; 2021.
Available:https://doi.org/10.1016/j.resconrec.2021.105560
69. Leopold LB, Wolman MG, Miller JP. Fluvial Processes in Geomorphology. 4th Edition. New York: Dover Publication; 1995.
70. Das MM, Saikia MD. Hydrology. New Delhi: PHI Learning Private Limited; 2009.
71. Viessman W, Lewis G. Introduction to Hydrology. 5th Edition. Upper Saddle River: Pearson Education; 2012.
72. Lu XX, Ran L, Liu SS, Jiang T, Zhang, SR, Wang JJ. Sediment Loads Response to Climate Change: A Preliminary Study of Eight Large Chinese Rivers. International Journal of Sediment Research. 2013;28: 1-14.

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