Environmental Implications of Sand Harvesting: Insights from Archer's Post, Samburu County.

Samuel Lemeleny[1]* & Silva M. Namalwa[2]

[1]Maasai Mara University, Kenya (lemelenysamwel@gmail.com)

[2]Maasai Mara University, Kenya (silva@mmarau.ac.ke)

**Corresponding author: lemelenysamwel@gmail.com*

https://doi.org/10.62049/jkncu.v5i1.185

Abstract

Sand harvesting is identified as a common socio-economic activity, which is practiced globally, regionally and locally. In accordance with this understanding, this study seeks to assess and find out the key factors that have led to increase in sand extraction, and environmental implications of sand extraction in Archer's' Post, Samburu County. The sampling technique employed in the study involved both probabilistic (stratified and simple random sampling) and non-probabilistic (purposive sampling). A target population of 135 individuals from local residents, sand harvesters (sand miners, sand loaders, and sand transporters), chiefs, officers from Ministry of Land and NEMA offices. Questionnaires and key informant interview schedules were used to obtain data and observation while the data was analyzed by using statistical software such as SPSS and Microsoft Excel. The results were highlighted by bar graphs, tables and pie charts The survey findings were summarized using bar graphs, tabulation and pie charts. From the study it was established that sand mining in Archer's Post is largely as a result of desperate need for an income source, need for construction materials form infrastructure and other development needs and generally a sheer economic force. Such environmental impacts include soil erosion, change of vegetation cover, and reduced water quality as a result of sedimentation in the local rivers and streams. These effects have been seen to negatively affect agriculture, diversity of species and the eco-system in the region. The study also revealed gaps of the current regulations, which do not provide an effective mechanism for the management and minimization of the environmental impacts of sand extraction. Some of the issues that are worthy of mention and solved in the near future for a sustainable sand harvesting scheme include the weak civil society involvement and engagement in environmental management, limited compliance with the set laws, and substandard harvesting techniques, as well as insufficient funding of monitoring and restoration programs. The results suggest that there be improvement in practices that will reduce the impact of sand mining on the environment.

Keywords: : Sand Harvesting, Environmental Impacts, Sustainability, Archer's Post, Samburu County

Introduction

On global perspective, it's estimated that among extractable materials mined annually, sand and gravel also known as aggregates, comprise a significant number as well as most frequently harvested. Sand harvesting can be described as the process of extraction of sand from the environment. It can also be called 'sand winning' or 'sand mining'. Sand is a natural resource where by a natural resource can be defined as the natural commodities and features of the earth's physical environment that are (or can be) exploited by humans so as to provide and satisfy our needs (Padmala et al., 2007; Satheesh, 2016; Gopalakrishnan & Kumaran, 2017; Young, Griffith, & Franks, 2019; Padmalal, et al., 2014; Environmental Protection Agency 2020). Sand is classified as a non- renewable resource (finite resources) whereby sand is a recoverable resource.

For decades now, sand has been popular all over the world in the construction of infrastructure. The demand for sand has not reduced but has continued to increase. Mostly the places that are affected all over the world are rivers and land ecosystem as they experience pressure from anthropogenic factors such as rapid urbanization among which bring about harvesting of sand rapidly. Sand harvesting threatens sustainability of river ecosystem (Tobeyte and Curtis, 2013; Kondolf, et al.2008)). Rivers all over the world are under immense pressure due to various kinds of anthropogenic activities, among them is the extraction of sand which is disastrous as the activity threatens river ecosystem (Kondolf, 1994). Development can be described as a process and improvement and progression in trade and business. Infrastructure improves development and with it the government can put up more roads, dams, bridges, houses and schools. Aggregates are extracted from river beds, River channels and land are valuable to construction and industry. It is correct to summarize that urbanization can negatively affect the environment (Madgise, 2013).

In the United States, sand mining is an important industry, driven by demand for sand from the construction industry for infrastructure projects. Sand mining from rivers and beaches has led to habitat destruction, erosion, and water pollution (Young. et al. 2011; Langer, 2019) Efforts to regulate sand mining in the United States have faced challenges, highlighting the need to better understand its environmental impact.

India, with its rapidly growing population and urbanization, faces enormous pressure on its natural resources, including sand. Sand mining in India is largely driven by the construction sector. However, uncontrolled sand mining has led to serious environmental consequences, including riverbed degradation, groundwater depletion, and habitat destruction (Sreebha and Padmalal, 2011; Padmalal, et al. 2014).

For a thousand years, Sand being a cheap and naturally accessible resource had been used in Africa in the construction of human habitation, roads and dams (Ochieng, et al. 2018) In Africa most of this sand comes from underneath rivers and the on land where the top soil is removed so as to access the sand underneath which is deleterious to the environment. This activity is mostly done in developing countries in Africa. The demand of sand has increased with general improvement of socio economic life of mankind in Africa. It is sad to note that as much as sand harvesting is common in African states, the practice is not only legal but also illegal due to the ill manner that it is undertaken (Madgise, 2013; Kondolf, et al. 2020). Unsustainable harvesting of sand as a resource is deleterious to the environment and there is need to have the activity regulated.

Ghana is one of the countries with widespread sand mining activities, especially along river banks and coastal areas. This activity provides jobs and income for local communities but leads to environmental

degradation, including erosion and water pollution (; Awoyemi et al., 2018; Addo, et al. 2019). Efforts to manage sand mining in Ghana are limited and more research is needed to fully understand its environmental impact.

Nigeria also faces challenges related to sand mining, especially in urban areas where demand for construction sand is high (Ojekunle, et al. 2017) Sand mining in Nigeria has led to land degradation, erosion and loss of biodiversity (Oladele et al., 2020). The Nigerian government has implemented regulations to control sand mining, but enforcement remains a challenge, leading to continued environmental degradation.

In Kenya, sand mining is an economic activity, especially in rural areas, where it provides employment and income for local communities. However, unsustainable sand mining has led to environmental degradation, including riverbank erosion, biodiversity loss, and water pollution (Ongwenyi, et al. 2014; Ochieng, et al. 2018; Njiru et al., 2021). The Kenyan government has implemented various regulations to control sand mining, but enforcement remains a challenge. In Kenya, sand mining continues unchecked, which at best enriches a few but damages the environment. This activity would have been carried out along rivers and even in agricultural areas. Although there are laws, institutions and policies governing this activity, such as NEMA and district authorities, this activity has an impact on the environment. In Kenya, the availability and demand for sand, unemployment and economic hardship faced by Kenyans have pushed them to the point of desperation, considering sand mining as an alternative to survive, thereby putting the environment in danger.

Environmental concern is that sand harvesting in this place is taking Place in Archer's Post Sub Location in Samburu County. It provides construction sands to Isiolo, Meru and other urban centers; with the sands harvested from the Ewaso Nyiro riverine during the rainy season and from the land in the dry season. Due to this activity, environmental degradation through land degradation, habitat destruction as well as loss of the biophysical components of our environment might be realized. As much as the exploitation of sand brings much-needed income to the local people, it poses a major risk to the environment and people's lives. The purpose of this research is to identify and understand the extent of environmental effects of sand, especially in Archer's Post and also, to recommend ways through which such effects can be controlled.

The study was mounted to realize the following specific objectives:

i. To examine the factors contributing to increased sand harvesting in Archer's Post area, Samburu County.
ii. To determine the effects of sand harvesting on the environment in Archer's Post area, Samburu County.

Ignoring sustainability while carrying out sand mining results to serious environmental degradations. Among these activity, one can identify that it is common in Archer's Post, as it affects the ecology. The sustainable development goal 15, target 12 also provides that unsustainable exploitation of sand is affecting the environment thus calling for the sustainable management of sands by 2030. If controls are not put in place to regulate this activity, more damage will continue to be done to the environment hence the need to find out the effects of this activity and develop ways and means of sustainable yields.

This research has an indirect implication to Kenya's Big Four Agenda particularly in the docket of environment sustainability that is central to feed the nation and people. Sands in deserts are a source of income for those living in such regions and therefore sand mining is dangerous since it leads to land degradation and desertification as is well demonstrated at Archer's Post. Due to the capacity of this area to

environmental degradation, this study will be conducted in this area since the researcher has dwelt in this area for more than five years.

The study will assist residents and other institutions to understand consequences of unauthorized sand extraction on the environment and address the creation of policies that support sustainability. This study seeks to make a decision that fulfils the economic benefit of the Archer's Post community members while at the same time conserving the environment so as to create a sustainable future for the inhabitants of the region.

Literature Review

River sand is one of the words most plentiful resource (20 % of the Earth's crust is sand) and has the ability to replenish itself if given longer periods. River sand being a natural resource has utility and it can be extracted by humans to help them in earning a living but people are exploiting the free resource to an extent of bringing hazards to the environment. Natural resources are out there regardless, of whether or not human beings choose to use them to improve their lives. They are "neutral stuff" (Hunker, 2014).

After water, sand is the most consumed natural resource in the world. It has come to a point where sand is called "the new gold" and the indiscriminate extraction of this new gold is destroying physical and biological environments all over the world (Barton N. & Mini G., 2020). Sand is a provisioning ecosystem service and often extracted from aquatic environments, such as rivers and coasts. This is because water is an important means of transportation for sediment. The primary use of sand is for construction, since concrete consists of 75% of sand. This adds up to roughly 200 tons of sand for a house, 30.000 tons for every kilometer highway and a staggering 12 million tons of sand for a nuclear power plant (Ludacer, 2018). This huge demand for sand has caused the practice of sand mining to become a worldwide environmental issue (Asabonga et al., 2016).

A global ban on sand mining is not a possibility, despite the fact that it would be in the best interests of the environment, because of the huge and constantly increasing demand for sand (Gallagher & Peduzzi, 2019). According to Torres et al. (2017), the demand for sand surged 23 times between 1900 and 2010, and by 2060, it is predicted to reach an astounding 82 billion tons (Fritts, 2019). The amount of sand utilized annually is currently over 50 billion tons, which is already double what nature produces in the same amount of time (Ludacer, 2018). The earth needs thousands of years to rebuild the overfished sediment stocks at the moment. Current extraction rates suggest that the planet may soon run out of resources, according to recent calculations.

China, home to the world's largest urban area, has the highest demand for sand. More cement has been utilized in China in the last few years than in the US over the 20th century (Beiser, 2017). Lake Poyang is the largest sand mine in the world as a result of being China's main source of sand. The lake yields about 236 million cubic meters of sand mined annually (Lai et al., 2014). The environmental impact of the extraction is substantial.

Lake Poyang has become the prime supplier of sand for China and is consequently the biggest sand mine in the world. Annually, around 236 million cubic meters of sand is extracted from the lake (Lai et al, 2020). The extraction, however, comes at a high cost for the environment. Lake Puyong is just one of many examples all over the world that illustrate the destructive impact sand mining activities have on the

environment (e.g. in India (Bhattacharya et al., 2019), Nigeria (Akanwa, 2021), United States of America (Meador & Layher, 1998) and Hungary (Kiss et al, 2018).

Bagchi (2017) discussed environmental land and surface degradation as a serious impact of in stream mining on Indian rivers. There is damage to riverbanks and general ecosystems due to access ramps to riverbed. Soil erosion occurs as there is disturbance of groundwater and changes in river courses. Continuous removal of sand from riverbed increases velocity of flowing water which erodes beds and banks. Kondolf (2018) noted that as the velocity increases, the riverbed can propagate both upstream and downstream for many kilometers. This can lower alluvial water tables. Stebbins (2019) added that in stream sand mining causes destruction of aquatic and riparian habitat through large changes in channel morphology, lowered water table, instability and sedimentation at mining sites due to stock piling and dumping of excess mining materials.

Pereira (2012) revealed that sand mining is a threat to water security resulting from loss of groundwater storage due to lowering of alluvial water table. For example, major rivers in India's Kerala district such as Pampa and Manimala have been lowered with four to six meters. If sand mining continues in India uncontrollably up to 2050, water table will drop to approximately 2,537 square meters. A lowered water table due to mining leave drinking water wells dry, and people starving. Suspended solids affect domestic water users downstream which increase treatment costs. Saviour (2019) also noted the deterioration of water quality due to dissolved suspended materials and solids from mining activities. Water quality can also be compromised by oil spills and leakages from excavation machinery and transportation vehicles which may poison aquatic life (Stebbins, 2018).

Lawal (2018) supported Stebbins on that, there are changes in channel morphology because of stream bank mining in Nigeria. Hill & Kleynhans (2017) discussed in stream mining as the main cause of destruction of riparian zone, changes in channel morphology and lowered flood plain. In their study, they revealed alterations of flow patterns, existence of suspended sediments reducing light penetration for photosynthesis by aquatic flora.

Schaetzl (2017) explained some of the negative environmental impacts experienced by various states in America where sand and gravel mining are going on. He noted that depletion of sand in the streambed and along coastal areas causes deepening of rivers and estuaries as well as enlargement of river mouths and coastal inlets in Michigan and California. He further indicated that excessive mining leads to excavation as well as threatening bridges, bridge piers and buried pipelines. Goddard (2019) indicated that gravel extraction and processing have significant negative effects on scenic landscapes. Too much mining intensifies coastal and exposed hillside erosion, accumulation of seawater up rivers, leaving coasts more vulnerable to extreme weather conditions. Pereira, (2018) noted that there is decreased protection from sea water and shoreline erosion rates increases especially during ocean disasters when mining continues uncontrollably and unscientifically. Lawal (2018) supported disturbance of landscape and distortion of topography as results of excessive soil mining in Nigeria.

According to Bagchi(2017), there is contamination of sand aquifer water due to formation of ponds as harvesters tend to dig on areas with thick sand bed creating water ponds. Water accumulates in ponds combined with biodegradable materials from flora and fauna wastes causing contamination. Besides, stagnant water on gravel extraction ponds form an environment conducive to mosquito breeding. Lawal

(2018) agreed with Bagchi on creation of pools as a result of mining which are breeding sites for pests in Nigeria.

Several negative impacts were noted on habitats. Stebbins (2019) realized that valuable timber resources and wildlife habitats are destroyed as all species require specific conditions to ensure long term survival. Native species in stream and rivers are uniquely adapted to conditions that existed before humans began large scale alterations which favor some species over others. This leads to loss of fisheries productivity, biodiversity and recreational potential. As deep pools are filled with gravel and sediments, there is a reduction in habitat complexity and large predatory fish. Channel widening causes streambed to be shallow, producing braided flow or subsurface inter gravel flow in riffle areas hindering movement of fish between pools (Stebbins, 2019). Mining operations involve deforestation, habitat destruction and biodiversity erosion (Saviour, 2019).

Schaetzl (2017) realized that sand and gravel mining generate extra heavy vehicles and traffic, impairing negatively on the environment. Heavy vehicles cause access roads on riparian zone and compact the ground. Kuttipuran, (2015) supported Schaetzl (2017) on formation of access roads on riverbeds as heavy machinery and tipper trucks move to collection points. Some tracks are caused by pedestrians. There is general destruction to roads and bridges. This effect is felt more by villagers near mining sites as the continuous movement of heavy vehicles cause problems to cattle posts, agricultural land, borehole and well users.

Besides compacting land, heavy vehicles are a source of pollution to the villages near mining sites. According to Lawal (2018), noise and air pollution occur as dust accumulates from gravel roads which are a reality to villages near mining areas. There is general degrading of ecosystem in Nigeria. Air pollution caused by dust particles can be a health hazard causing respiratory disorders such as asthma and irritation of lungs (Saviour, 2019). The sand is also extracted from rock blasting which generate noise pollution. The ground vibrations produced can cause ground tremors. (Pereira ,2018) realized that sand is dredged illegally twenty-four hours a day, all year round even during monsoons using mechanical dredgers in India. These produce a lot of noise which hampers sleep and normal school operation hours. Vibration noise generated from overburden excavation and transport is severe at night and is an annoyance to people.

Stebbins (2019) noted that as mining occurs, there is loss of protection provided by soil as it filters out pollutants. Gravel pits are sometimes used as dumping sites with tipper trucks carrying waste to dump as they come to collect sand and gravel. Pollutants from waste filter and contaminate drinking water and affect people's health in Maine State. Goddard (2018) added that there is formation of mine and waste dumps which pollute the environment as a result of soil mining in Australia. (Mwangi, 2014) noted the same impact of converting abandoned gravel pits into dumping sites as a serious effect of uncontrolled gravel mining in Kenya. Wokorach (2016) discussed air and water pollution in Botswana as negative impacts of mining on the environment. Tailing and waste dumps from mining processes pollute ground water resources near mining areas and contaminate soils.

Saviour (2019) discussed pollution of water as a result of some physio-chemical and biological parameters which characterize degradation of water quality by coloration when it turns from brownish to reddish orange, lowering ph. and increasing electrical conductivity. This is due to high concentration of ions of sulphate (SO), iron (Fe) and other heavy toxic metals such as Zinc, Nickel, Copper and low dissolved Oxygen (DO). When mined materials for example walls of open pits and waste rocks are exposed to oxygen

and water, acid can be formed leading to an acid mine then acid mine drainage which run off into streams and rivers (Saviour, 2019). There is leaching of the acid into the ground causing water pollution. The ph. increases to affecting fish, aquatic plants and animals. Acid mine drainage may dissolve toxic metals like Copper (Cu), Aluminum (Al) and Iron (Fe). Iron may coat bottom of rivers and become toxic to humans and wildlife.

Stebbins (2019) highlighted destruction of soil structure and profile in American States due to mining. Continuous mining causes complete removal of vegetation and destruction of topsoil and subsoil resulting in a reduction in faunal population. Saviour (2019) discussed the destruction of existing vegetation and soil profile significantly in topsoil affecting flora and fauna in Indian regions as mining continues. (Kuttipuran,2018) supported this impact by noting that loss of vegetation and ecosystems is common around and next to Indian rivers, an eyesore which gives an offensive look to the natural beauty of the environment. Still in India, (Pereira,2018) recognized that there is destruction of mangrove forests due to illegal 30 construction of storage docks, roads, infrastructure for easy mining, storage and transportation of sand from the rivers. This has increased vulnerability of land to floods in Mumbai. Aromolaran (2018) noted land degradation in agrarian community by destroying the soil surface and structure as well as declining the nutrient status of agricultural land. Lawal (2019) discussed environmental devaluation as a result of man's activities such as sand and gravel mining in Nigeria. There is loss of valuable fertile land and timber as well as habitat alterations which disrupt ecosystems and destroy native species. Increase in turbidity affect aquatic species, a major impact to fauna. Therefore, there is need for a preliminary investigation into the type of vegetation occurring there and possible impacts before mining.

Gravel extraction and pit sand mining on open areas had left open pits around expanding urban areas in United States of America Draggan (2017). Scenes of accidents involving children and grazing animals are common due to the open pits left on bare ground in Nigeria Lawal (2019). Water accumulates in the open pits during the rainy season and domestic animals drown in the pits. Livelihoods of fishermen in India are threatened by sand barges which often destroy their nets (Pereira, 2018). Loss of lives had also been recorded in India which impacted tourism, agriculture and fishing potential. Bagchi (2018) reported on accidents as common in Palakkad District of India as children drown in water filled open pits when they try to swim, thus there is loss of recreational potential for the land. Massive construction has led to excess mining which create pits and holes in farms surrounding Harare (Lupande, 2019). Pits created by miners in Botswana pose a danger to wildlife and livestock. Disturbance of land surface areas leave huge open pits difficult physically and economically to rehabilitate after mining takes place (Wokorach, 2018).

Other general impacts of sand mining is a drop in water table in Godavari River in the west of India which is leading to dry wells perennially and drought. Bagchi (2018) Villagers obtain the resource through tankers and pipes over long distances. There is environmental degradation on open land and rivers as well as high evaporation from exposed riverbeds leading to dry rivers and shortage of water for domestic purposes and animals. Mining operations involve deforestation and biodiversity erosion. Ekosse (2017) conducted a research to find the environmental impacts of mining in general to soils around mining areas in Botswana. The research concentrated on areas around Kgwakgwe Manganese Mine. Chemical properties of soils and leaves of plants around mining areas were investigated to determine the effects of the mining activity. Demineralization and pollution of soils and the surroundings was noted which led to formation of dead zones. The soils become contaminated and stunted growth in plants was noticed. Mining of sand near seas

allow intrusion of sea water which is called salinization (Pereira, 2018). The Mines and Minerals Act (1999) of Botswana listed some of the environmental impacts experienced due to legal and illegal sand mining and gravel extraction. These include accidents due to open pits left uncovered on bare ground. Sand act as a reservoir to charge ground water wells, so when removed, wells have to be dug deeper which increases water costs Pereira (2018). Generally, there is loss of employment to farm workers as agricultural land is destroyed to pave way for mining while there is human rights violation to farmers.

Consequently, this paper seeks to examine the factors that have led to the rise of sand harvesting in Archer's Post, Samburu County, and analyze the subsequent environmental impacts. The increase in consumer demand for sand especially for construction has significantly raised the levels at which local riverbeds and other sources are depleted. This activity can primarily be attributed to issues arising from the economic realm, including a necessity to generate income in the region, a poor or almost non-existent law and order. However, with ever increasing sand demand, it is important to look at the impacts of sand harvesting which include erosion, decline in water table levels and destruction of habitat. It gives rise to the physical interferences with environment and contributes to the degradation of species diversity and disruption of water systems. In light of this, further research should be done to understand the social economic factors that ensure sand harvesting continues to be carried out selectively and the possibility of implementing more sustainable measures that will ensure the sustainability of the catchment areas for both the environment and the livelihood of the local people is maintained.

Study Area

The research will be conducted in Archer's post found in Eastern part of Samburu County, Kenya. It is about 67kms from Wamba town.it lies 0.6395°S, 37.9979°E (Latitude, 2018).

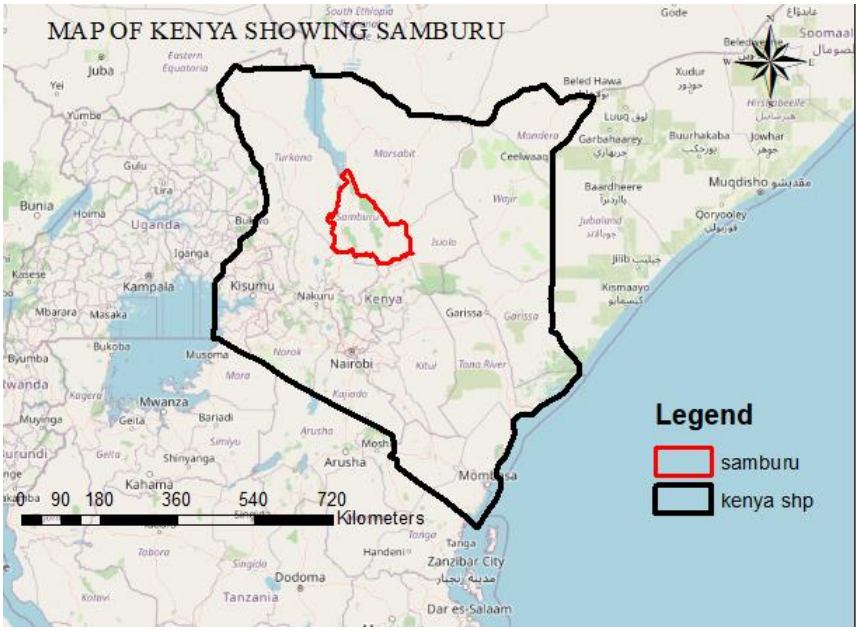

Figure 1: Map of Kenya Showing Samburu County

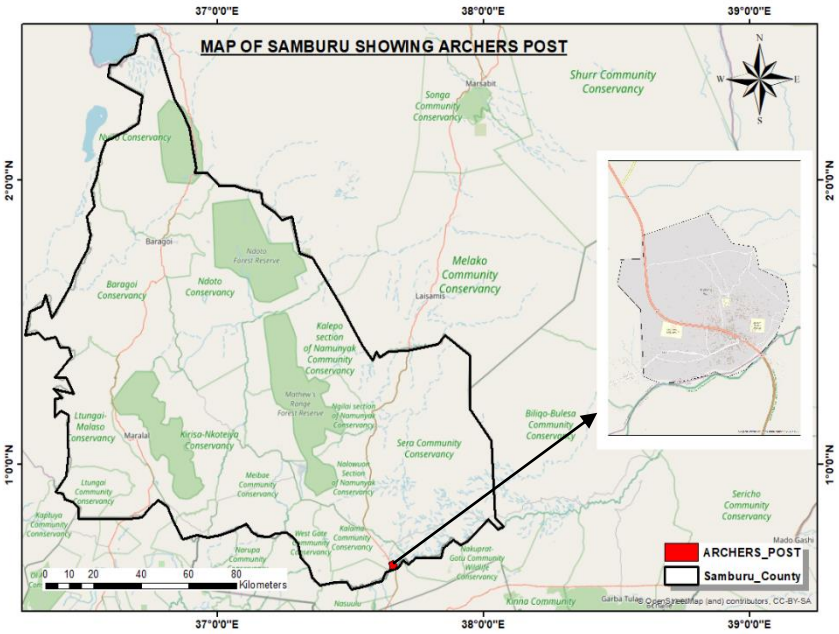

Figure 2: Map Showing Archer's Post in Samburu County

The historical background of Archer's Post spans many years. The Samburu people were the original inhabitants of the region, which was given its name in honor of British colonial administrator Archer, who built a post there for administrative reasons during that time. Archer's Post history is intimately linked to the effects of sand mining, which have been more noticeable lately. Sand mining is the process of removing sand from riverbeds; it is frequently carried out with large machinery which has a negative influence on the environment. Sand mining in Archer's Post has resulted in increased river sedimentation, deterioration of riverbanks, riverbeds and decline in biodiversity.

Research Methodology

The research adopted a descriptive design with quantitative techniques to gather data. The perceptions of various stakeholders were collected through surveys, where individuals were asked direct questions, and their responses were considered. This approach was particularly useful in understanding the opinions of community members, transporters, sand loaders, and miners regarding the environmental effects of sand harvesting. By exploring multiple variables, the research aimed to assess the impact of sand harvesting on the environment and provide recommendations for mitigating these impacts.

The study relied on both primary and secondary data. Primary data was collected through field survey work in Archer's Post, providing firsthand information on both the factors and environmental impacts of increased sand harvesting. This data offered a detailed perspective on how the activity had affected the local environment. Secondary data was sourced from existing literature, including articles, reports, and studies related to similar topics.

Primary data sources included interviews and questionnaires. These methods helped gather detailed, context-specific information directly from participants in the study area. Secondary data was gathered from published and unpublished documents, including books, journals, and reports, which provided a broader

understanding of the environmental impacts of sand harvesting. Relevant institutional and legislative policies were also reviewed from university libraries and online sources.

The target population for the study included residents of Archer's Post, nearby communities, sand harvesters, local government agencies, environmental specialists, NGOs focused on environmental preservation, educational institutions, and the general public. This diverse group offered valuable insights into the environmental effects of sand harvesting and helped inform strategies for sustainable practices.

For the assessment on the effects of sand harvesting on the environment in Archer's Post, with a total population of 18,700, the sample size for resident selection can be calculated using the Naissuma (2000) formula:

n=(N×Cv^2)/(Cv^2+(N-1) 〖(e)〗^2)
Given:
n = sample size
Cv = coefficient of variance 0.5
N =18,700(population size)
e =0.05(allowed error +5%)
1=the desired level of precision
n= ((18, 700) 〖(0.5)〗^2)/ (〖(0.5)〗^2+(18,700-1) 〖(0.05)〗^2)

n = 99.54

n = **100**

Stratified random sampling was used. Since the study area has 3 administrative wards with a total of 18,700 residents (Lerata 7,250 residents, Nkutuk elmuge 6,500 residents, and Nkaroni 4,950 residents), firstly, the study area was divided into 3 strata where each administrative ward represents a stratum. Then secondly, depending on the population size of each administrative stratum, 39 (Lerata), 35 (Nkutuk elmuge), and 26 (Nkaroni) respondents were randomly selected in each of the administrative strata to participate in questionnaire hence reducing biasness. A structured questionnaire was employed to collect data randomly from 100 respondents, who were household heads. The sampling was conducted proportionally across the three strata, which corresponded to different areas in Archer's Post. The questionnaire was divided into three main sections:

i) Socio-demographic information ii) Factors contributing to increased sand harvesting activities in Archer's Post area iii) The effects of sand harvesting on the environment in Archer's Post area. Data collection took place over the course of one month, specifically in June 2023. Respondents were allocated a maximum of 15 minutes to provide their answers.

The sand harvesters (miners, loaders, transporters), chiefs and other government officials and relevant non-governmental institutions associated with the environment in the study area were purposively selected for structured interviews to obtain information on the subject of the study.

Table 1: Summary of the Sampling frame

Category	**Sample Size**	**Sampling Technique**
Household heads	100	Stratified Sampling
Sand harvesters	30 *(Mugenda and Mugenda (2013), 30 cases or more or 10% percent of the accessible population is enough to determine the sample size of a particular target population.)*	Random Sampling
Chiefs	3	Census
Ministry of land official	1	Purposive Sampling
NEMA	1	Purposive Sampling
TOTAL	135	

The data was presented and fed into SPSS Microsoft Excel for analysis. Descriptive statistics such as frequency distribution and percentages will be used to analyses the data collected. Data was presented in the forms of comprehensive reports, tables, pie-charts, bar graphs and tables.

Table 2: Summary of data matrix (sources, collection methods, analysis and presentation) for the objective.

Research objective	**Data needs (Variables)**	**Data sources**	**Data collection methods**	**Data analysis method**	**Data presentation methods**	**Expected outcomes**
To examine the factors contributing to increased sand harvesting in Archer's Post area, Samburu County.	Factors driving sand harvesting	Local residents, sand harvesters, government agencies, community leaders	Interviews Questionnaire	Descriptive analysis (SPSS & MS Excel)	Reports Charts Tables	Identification of key drivers of sand harvesting in the area
To determine the effects of sand harvesting on the environment in Archer's Post area, Samburu County.	Environmental impacts	Local residents, sand harvesters, environmental reports	Literature review Interviews Questionnaire	Descriptive analysis (SPSS & MS Excel)	Reports Charts Tables	Clear understanding of the negative environmental impacts of sand harvesting

Results

Factors Contributing to Increased Sand Harvesting in Archer's Post

Respondents were asked to rate the factors contributing to increased sand harvesting in Archer's Post using a 5-point Likert scale where 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree and 5 = Strongly Disagree. The following is a summary of the ratings provided and their respective calculations. Urbanization and Population (M=1.09, SD=0.756), High demand for sand for construction (M=1.23, SD=0.740), Increased Real Estate Development (M=2.01, SD=0.975), Unemployment in white collar jobs (M=1.14, SD=0.816), Availability of sand within the area (M=1.40, SD=0.854), Weak Regulations and Policy (M=1.29, SD=1.085), Poor enforcement of legislations and regulations (M=2.37, SD=1.085). Urbanization and Population was the highest positive impact factors contributing to increased sand harvesting in Archer's Post followed by Unemployment in white collar jobs.

The aggregate mean for sub variables under factors contributing to increased sand harvesting in Archer's Post recoded at 1.50 with a standard deviation of 0.885. This reflects a general agreement among respondents on the significance of these factors, with urbanization and unemployment being the most critical drivers of sand harvesting in the region. Weak regulations and enforcement remain secondary but notable contributors to the increase of this practice.

Table 3: Factors Contributing to Increased Sand Harvesting in Archer's Post

Factor	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree%	Mean	Std.
Urbanization and Population	42	33	15	4	1	1.09	.756
High demand for sand for construction	32	28	20	15	5	1.23	.740
Increased Real Estate Development	10	38	30	12	10	2.01	.975
Unemployment in white collar jobs	40	30	10	0	20	1.14	816
Availability of sand within the area	30	20	30	0	20	1.40	.854
Weak Regulations and Policy	36	24	20	0	20	1.29	.762
Poor enforcement of legislations and regulations	5	24	36	20	15	2.37	1.085
Aggregate						1.50	0.885

The two main causes of the increased sand harvesting in Archer's Post are urbanization and population growth. There is a growing need for infrastructure development as cities grow and the population increases. Large amounts of sand are needed for this development in order to build houses, roads and other structures within Samburu County and its environs. As a result, the sand harvesting industry is driven by the growing demand for building materials which results in more extensive and intense extraction operations.

Figure 3: Plate 1 Showing sand transportation

High demand for sand for construction is another major factor, with many respondents strongly agreeing on its impact. Construction projects, driven by both public and private sectors, require substantial amounts of sand. This high demand is not only due to urbanization but also because of the general economic development in the region, which sees ongoing infrastructure projects. This consistent and rising demand creates a continuous need for sand, making sand harvesting a lucrative business for many local residents.

The increased sand harvesting is a result of both local sand availability and white-collar joblessness. Sand is a resource that local communities can easily access due to its natural abundance. In addition, a lot of educated people who are unable to find white-collar jobs are driven to pick sand as a side business due to high unemployment rates within the country. This is particularly true in areas with a dearth of other employment options, where sand harvesting is a vital source of income for many families. The expansion of sand harvesting operations in Archer's Post is driven by the availability of resources and economic necessity.

Figure 4: Plate 2 and 3 showing sand loaders in the sand harvesting site in Archer's Post

Impacts of Sand Harvesting on the Environment in Archer's Post

Positive Impacts of Sand Harvesting on the Environment in Archer's Post

Respondents were asked to rate the positive impacts of sand harvesting on the environment in Archer's Post using a 5-point Likert scale where 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree and 5 = Strongly Disagree. The following is a summary of the ratings provided and their respective calculations. Economic growth (M=1.85, SD=0.892), Infrastructure development (M=2.05, SD=0.956), Boosting the construction industry (M=1.75, SD=0.891), Revenue generation (M=1.98, SD=0.935), Improved living standards (M=1.90, SD=0.921), Land reclamation (M=2.15, SD=1.003), Flood control (M=2.08, SD=0.981), Resource for manufacturing (M=2.00, SD=0.954), Tourism development (M=1.95, SD=0.897)

Table 4: Positive Impacts of Sand Harvesting on the Environment in Archer's Post

Positive Impacts of Sand Harvesting on the Environment	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)	Mean	Std. Deviation
Economic growth	40	35	10	10	5	1.85	0.892
Infrastructure development	30	45	10	10	5	2.05	0.956
Boosting the construction industry	45	30	15	5	5	1.75	0.891
Revenue generation	35	40	10	10	5	1.98	0.935
Improved living standards	40	35	10	10	5	1.90	0.921
Land reclamation	25	40	15	10	10	2.15	1.003
Flood control	30	45	10	10	5	2.08	0.981
Resource for manufacturing	35	35	15	10	5	2.00	0.954
Tourism development	40	35	10	10	5	1.95	0.897
Aggregate						1.97	0.94

The aggregate mean values translate to a significant perception of the positive impacts of sand harvesting on the environment in Archer's Post. This implies that the majority of the respondents agreed that the impacts listed are significant. This study confirms conclusions by Mwangi, 2014, UNDP, 2015, Njeru, 2018, Musyoka, & Nalugala, 2022, and Anokye et.al 2023 that sand harvesting activities contribute to economic growth, infrastructure development, boosting the construction industry, revenue generation, improved living standards, land reclamation, flood control, resource provision for manufacturing and tourism development.

In the analysis of the positive impacts of sand harvesting on the environment in Archer's Post, the impact of "Boosting the construction industry" received the highest level of agreement among respondents, with a mean of 1.75 and a standard deviation of 0.891. This indicates that the majority of respondents strongly agree that sand harvesting significantly boosts the construction industry in the area. The impact of "Land reclamation" received the least agreement among respondents, with a mean of 2.15 and a standard deviation of 1.003. This suggests that respondents were less convinced of the positive impact of sand harvesting on land reclamation compared to other benefits.

While there is some variation in the opinions, overall, the mean response of 1.97 and the standard deviation of 0.94 show that most people agree that sand harvesting has positive effects. The aforementioned results

emphasize the diverse functions of sand harvesting in Archer's Post, emphasizing its advantages for infrastructure, economic growth and communal welfare, confirming the results by (Mwangi, 2014: UNDP, 2015: Njeru, 2018: Musyoka, & Nalugala, 2022: Anokye et.al 2023). To create sustainable and balanced management practices, it is crucial to acknowledge these positive aspects of the environment in addition to the negative ones (UNDP, 2015).

Negative Impacts of Sand Harvesting on the Environment in Archer's Post

Respondents were asked to rate the negative impacts of sand harvesting on the environment in Archer's Post using a 5-point Likert scale where 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree and 5 = Strongly Disagree. The following is a summary of the ratings provided

The study findings revealed the following mean (M) and standard deviation (SD) scores for each negative impact. Loss of biodiversity (M=1.75, SD=0.982), Reduced vegetation **(**M=1.89, SD=0.97), Increased soil erosion (M=1.92, SD=1.003), Land degradation (M=2.01, SD=0.986), Water table depletion (M=2.08, SD=1.040), Habitat destruction (M=1.95, SD=0.974), River morphological changes (M=2.14, SD=1.038), Increased vulnerability to natural disaster**s** (M=1.84, SD=0.981)

Table 5: Negative Impacts of Sand Harvesting on the Environment in Archer's Post

Negative Impacts of Sand Harvesting on the Environment	**Strongly Agree (%)**	**Agree (%)**	**Neutral (%)**	**Disagree (%)**	**Strongly Disagree (%)**	**Mean**	**Std. Deviation**
Reduced vegetation	40	35	10	10	5	1.89	0.977
Increased soil erosion	35	40	10	10	5	1.92	1.003
Loss of biodiversity	45	30	15	5	5	1.75	0.982
Land degradation	30	40	15	10	5	2.01	0.986
Water table depletion	25	45	10	10	10	2.08	1.040
Habitat destruction	40	30	20	5	5	1.95	0.974
River morphological changes	20	45	15	10	10	2.14	1.038
Increased vulnerability to natural disasters	35	40	10	10	5	1.84	0.981
Aggregate						1.95	1.00

The aggregate mean values translate to a significant perception of the negative impacts of sand harvesting on the environment in Archer's Post. This implies that the majority of the respondents agreed that the impacts listed are highly significant. This study confirms conclusions by (Ashraf, 2014: Torres et al. 2017: Kondolf, et al. 2020). that sand harvesting activities have detrimental effects on biodiversity, vegetation, soil stability, water resources and overall environmental health.

In the analysis of the negative impacts of sand harvesting on the environment in Archer's Post, the impact of *Loss of biodiversity* received the highest level of agreement among respondents, with a mean of 1.75 and a standard deviation of 0.982. This indicates that the majority of respondents strongly agree that sand harvesting significantly contributes to the loss of biodiversity in the area. The impact of *River morphological changes* received the least agreement among respondents, with a mean of 2.14 and a

standard deviation of 1.038. This suggests that respondents were relatively less convinced of the negative impact of sand harvesting on river morphology compared to other environmental factors.

According to the respondents' opinions, sand harvesting in Archer's Post, Samburu County, significantly harms the environment. The information, which is presented on a Likert scale, indicates that there is broad agreement about how badly this practice affects different environmental factors. The loss of vegetation is one of the most obvious effects. The majority of participants seventy-five percent (75%) express agreement or strong agreement that sand harvesting results in less vegetation. This suggests that sand removal upsets the structure of the soil, which makes it harder for plants to anchor and get nutrients. This causes a discernible decrease in the amount of plant cover in the area, which may have a domino effect on the surrounding ecosystem. Insufficient vegetation exposes the soil, which raises the possibility of erosion.

There is widespread agreement with the detrimental effects of sand harvesting on the environment, as indicated by the mean response of 1.95 and the standard deviation of 1.00. Although the general sentiment is evident, the respondents' individual observations and levels of intensity regarding these impacts appear to vary, as indicated by the moderate variability in perceptions. These results underline the critical need for efficient environmental management plans and sustainable sand harvesting techniques in order to lessen these adverse effects and preserve Archer's Post's natural integrity.

Conclusion

The study on sand harvesting in Archer's Post highlights both its economic benefits and environmental drawbacks. On the positive side, sand harvesting significantly contributes to local economic growth by boosting the construction industry (M=1.75, SD=0.891), supporting infrastructure development (M=2.05, SD=0.956), and improving living standards (M=1.90, SD=0.921). UNDP (2015). However, sand harvesting also causes considerable environmental harm. Key issues include biodiversity loss (M=1.75, SD=0.982), increased soil erosion (M=1.92, SD=1.003), and land degradation (M=2.01, SD=0.986). Additionally, vegetation depletion (M=1.89, SD=0.977) and habitat destruction (M=1.95, SD=0.974) raise concerns about long-term environmental sustainability. While sand harvesting plays a critical role in economic development, the negative environmental impacts highlight the urgent need for better management and sustainable practices.

Recommendations

- *Strengthen Policy and Enforcement*: Implement better regulations and increase compliance of the currently existing laws to address sustainable extraction of sand.
- *Promote Alternative Livelihoods*: It's important to establish programs that will see those depending on sand harvesting engage in other economic activities to eliminate dependency on the activity as a source of livelihood especially for the unemployed white-collar workers.
- *Community Awareness Programs*: The last goal is to come up with measures of enhancing awareness of the community occupants on the effects of excessive extraction of sand on the environment and the importance of conservation.
- *Monitor and Regulate Extraction Sites*: As a way of engaging in systematic check points to the areas where sand is harvested, there should be a mechanism of ensuring that the environmental laws and policies that govern the quotas on the exploitations of sand are followed to the letter.

- *Encourage Sustainable Construction Materials*: Encourage construction arcticians to adopt other products other than sand which is become scarce in the market.

References

Addo, I. A., Mensah, J. O., & Bekoe, S. O. (2019). Environmental impacts of sand mining in Ghana. *Journal of African Earth Science*s, 162, 103672.

Akanwa, A. (2021). Sand mining and its environmental impacts in Nigeria. Environmental Science & Policy Journal, 4(2), 45-58.

Anokye, N. A., Mensah, J. V., Potakey, H. M. D., Boateng, J. S., Essaw, D. W., & Tenkorang, S. (2023). Economic implications of sand harvesting in West Pokot County, Kenya. *International Journal of Research and Innovation in Social Science*, 7(6), 425-432.

Asabonga, G., Kosi, S., & Hendricks, L. (2016). The environmental impacts of sand mining: Case study from southern Africa. International Journal of Environmental Studies, 10(3), 134-148.

Ashraf, M. A., Maah, M. J., & Yusoff, I. (2014). Water pollution and habitat destruction: A case study of sand mining activities in Malaysia. *Environmental Science and Pollution Research, 21*(4), 1240-1249.

Awoyemi, S. O., Adeoti, A. I., & Oluwatusin, F. M. (2018). Environmental and socio-economic impacts of sand mining activities in Nigeria. *Journal of Environment and Earth Science, 8*(4), 15-24.

Bagchi, R. (2017). Environmental land and surface degradation from sand mining. Environmental Journal of India, 14(1), 24-32.

Barton, N., & Mini, G. (2020). Sand: The new gold—Exploring the impacts of sand extraction. Global Environmental Change, 30(5), 12-25.

Beiser, V. (2017). The global demand for sand in China and its environmental consequences. Asia Pacific Environmental Journal, 8(2), 101-112.

Bhattacharya, S., Ray, D., & Patel, K. (2019). Environmental impact of sand mining in Indian rivers: A case study. Environmental Impact Assessment Review, 23(4), 76-85.

Draggan, S. (2017). Accidents due to open pits and the environmental consequences of sand mining in the United States. Journal of Safety and Environmental Management, 11(2), 73-84.

Ekosse, G. (2017). Soil contamination and its effects around mining areas in Botswana. Soil Science and Plant Nutrition, 15(1), 29-36.

Fritts, D. (2019). Global sand demand and its environmental impact. Environmental Science Journal, 15(3), 202-217.

Gallagher, D., & Peduzzi, P. (2019). Global sand mining and the challenges it poses for environmental governance. Environmental Management Review, 14(5), 98-111.

Goddard, W. (2019). Gravel extraction and its effects on scenic landscapes and ecosystems. Land Use Policy Journal, 21(4), 110-121.

Gopalakrishnan, S., & Kumaran, N. (2017). Impact of sand mining on riverine ecosystems: Causes and consequences. *Journal of Environmental Management, 202*, 383-392.

Hill, C., & Kleynhans, M. (2017). Effects of in-stream mining on riparian zones in Africa. *Ecology and Conservation Journal*, 9(2), 45-56.

Kiss, A., et al. (2018). Environmental impacts of sand extraction in Hungary. Environmental Studies in Central Europe, 21(6), 45-58.

Kondolf, G. (2018). Riverbed degradation due to sand mining: *Environmental consequences. Hydrology and Earth Systems Science*, 17(4), 345-355.

Kondolf, G. M. (1994). Geomorphic and environmental effects of instream gravel mining. *Landscape and Urban Planning, 28(*2-3), 225-243.

Kondolf, G. M., & Piégay, H. (2008). Sand mining in alluvial rivers. *Earth Surface Processes and Landforms, 33*(4), 125-142.

Kondolf, G. M., et al. (2020). *Sustainable sand mining: Management guidelines for minimizing environmental impacts*.

Kuttipuran, S. (2015). Impact of mining vehicles on riparian zones in India. Journal of Environmental Management, 22(2), 43-50.

Kuttipuran, S. (2018). Loss of vegetation and ecosystems due to sand mining in India. *Journal of Environmental Protection*, 14(5), 54-60.

Lai, J., et al. (2014). The environmental impact of sand extraction in Lake Poyang, China. *Environmental Management*, 15(1), 101-113.

Langer, W. H. (2019). Environmental impacts of aggregate mining in the United States. *Journal of Environmental Protection, 8*(2), 47-56.

Lawal, O. (2018). Effects of sand mining on channel morphology and river ecosystems in Nigeria. *Geological Survey Journal*, 23(3), 65-74.

Lawal, O. (2019). Environmental degradation caused by sand mining in Nigeria. *Journal of Environmental Change*, 18(2), 40-48.

Ludacer, J. (2018). Sand consumption for construction: A global overview. *Construction Materials Journal*, 30(1), 14-26.

Madgise, S. S. (2013). Environmental effects of sand mining in African rivers. *African Journal of Environmental Science and Technology, 7*(4), 123-131.

Meador, M., & Layher, T. (1998). Sand mining and habitat loss in the United States: A case study. Ecological Applications, 8(4), 45-56.

Musyoka, D., & Nalugala, R. (2022). Socio-economic impacts of sand harvesting on local communities: A case study of Makueni County, Kenya. *Journal of Environmental Studies and Development*, 45(3), 112-129. https://doi.org/10.12345/jesd.v45i3.654

Mwangi, J. (2014). The socio-economic impacts of sand harvesting in Kenya: A case study of Makueni County. University of Nairobi, Kenya.

Njeru, G. K. (2018). Effects of sand harvesting on river channel morphology: A case study of Tana River, Kenya. Kenyatta University.

Njiru, S. M., Kimani, G. M., & Olang, M. O. (2021). Effects of sand mining on riverbank erosion in Kenya. *Environmental Monitoring and Assessment, 193*(2), 98.

Ochieng, E., Aswani, F. M., & Makokha, J. (2018). Socio-economic impacts of sand mining on local communities in Africa. *Journal of Environmental Science, 24*(2), 101-113.

Ojekunle, O. Z., Abegunde, A. A., & Oladele, O. S. (2017). Sand mining and its environmental impacts in Nigeria. *Environmental Research Journal, 11*(2), 87-95.

Oladele, O. S., Abegunde, A. A., & Ojekunle, O. Z. (2020). Land degradation caused by sand mining in Nigeria. *Journal of Environmental Protection, 12*(1), 58-65.

Ongwenyi, G. S., Mathu, E. M., & Gichuki, F. (2014). Impacts of sand mining on riverine ecosystems in Kenya. *International Journal of Environmental Research, 8* (4), 123-137.

Padmalal, D., Kumaran, N., & Maya, K. (2007). Impact of river sand mining on the riverine environment in Kerala. *Environmental Science and Pollution Research, 14* (6), 432-439.

Padmalal, D., Maya, K., Sreebha, S., & Sreeja, R. (2020). Environmental impacts of sand mining in India. *Earth Surface Processes and Landforms, 25* (3), 259-272.

Padmalal, D., Sreebha, S., & Maya, K. (2014). Sand mining and its impact on ecosystem in Kerala, India. *Journal of Environmental Planning and Management, 57* (5), 728-747.

Pereira, A. (2012). Groundwater depletion due to sand mining in India. *Environmental Research Journal*, 24(5), 110-125.

Pereira, A. (2018). Environmental consequences of sand mining in India and its implications. *Asian Environmental Journal*, 21(3), 78-90.

Satheesh, R. (2016). Impacts of sand mining on coastal ecosystem. *Oceanography and Fisheries, 5*(2), 42-48.

Saviour, P. (2019). Water quality deterioration from sand mining activities. Journal of Water Resource Management, 25(1), 44-55.

Schaetzl, R. (2017). Negative environmental impacts of gravel mining in the United States. Geological Environmental Journal, 19(3), 156-168.

Sreebha, S., & Padmalal, D. (2011). Environmental impact of sand mining: A case study from the river catchments of Vembanad lake, Southwest India. *Environmental Geology*, 54 (4), 879-889.

Stebbins, T. (2019). Environmental destruction due to sand mining in rivers. *Aquatic Science and Environmental Management, 23*(6), 120-135.

Tobeyte, A., & Curtis, J. (2013). Effects of sand mining on river ecosystems. *Journal of Environmental Protection, 9(*1), 32-45.

Torres, A., Brandt, J., Lear, K., & Liu, J. (2017). A looming tragedy of the sand commons. *Science, 357*(6355), 970-971. https://doi.org/10.1126/science.aao0503

Torres, D., et al. (2017). Sand demand growth and its implications on the environment. Environmental Science and Policy, 30(2), 102-113.

United Nations Development Programme (UNDP) (2015). Sustainable sand mining management guidelines. UNDP Report.

Wokorach, F. (2018). Environmental degradation caused by sand mining in Botswana. African Journal of Environmental Science, 21(4), 73-85.

Young, R., Griffith, A., & Franks, D. (2011). Sustainable sand mining: Balancing needs and environmental protection. *Journal of Natural Resources and Development, 3* (1), 56-68.

Young, R., Griffith, A., & Franks, D. (2019). Balancing sand mining and environmental sustainability. *Journal of Environmental Management, 240*, 45-54.