

Impact of Sand Harvesting on the Olkeriai Riverine Environment in Mashuuru, Kajiado County in Kenya

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Abstract: *Sand harvesting is widespread, highly unregulated, uncontrolled and is being carried out at an alarming rate. The gravity of the situation beyond the affected communities and the region at large is enormous and poses a threat not only to the environment but also to food security. The main purpose of the study was to evaluate impact of sand harvesting on the Olkeriai Riverine environment in, Mashuuru Sub-County, Kajiado County in Kenya. The study was guided by; Model of Environmental Concern. This study used descriptive survey research design. The target population of the study was 64,214 residents of Mashuuru Sub-County, Kajiado-County. The sample size was decided using Krejcie & Morgan (1970) formula and the sample size of the study was 187 respondents which comprised of 3 environmental officers, 4 administrators and 178 residents. The main type of data in this study was primary. This study used questionnaires to collect data from residents and interview schedules from environmental officers and administrators. Data analysis was done using SPSS. The quantitative data collected from questionnaires was analysed using descriptive statistics. The descriptive statistics that were used included, mean, standard deviations and percentages. Qualitative data from interviews was analysed using themes. Presentation of analysed data was done in tables of frequencies and percentages. Inferential statistics were presented to show correlation of variables and relationship between study variables. The study found that the impact of sand harvesting has a positive and statistically significant effect on the environmental in Olkeriai Riverine, Mashuuru Sub-County ($r=0.613$; $p<0.05$). This implies that sand harvesting influence environmental conservation. In conclusion sand harvesting has contributed to biodiversity loss, landslides, soil erosion and pollution to air, water and soil. Sand harvesting has degraded and caused encroaching effect to ecosystem biodiversity of Olkeriai Riverine in Mashuuru Sub-County. The study recommends to the national government to deploy enough environmental officers who will help in enforcing the law and policies that are tailored to protect destruction of endangered zones. The existence of government formulated policies to regulate land use and impacts on the environment will amount to nothing if they are effectively implemented.*

Keywords: *Sand Harvesting, Impact assessment, Riverine Environment, Sand Harvesting Impact.*

INTRODUCTION

The worldwide depletion of vegetation and degradation of soil profiles have significant detrimental effects on the ecosystem. The act of removing vegetation and causing soil profile damage leads to the eradication of habitats both above and below the earth, resulting in a decline in the population of wildlife (Cele, 2021). As a result of this occurrence, natural ecosystems and

their associated networks of food will no longer be constructed in the same manner. It increases the rate at which the river is flowing, which in turn alters the river's natural flow pattern and wears away at its banks. The presence of sand is crucial for the maintenance and nourishment of river ecosystems. Sand harvesting has several effects on the river ecosystem. The desiccation of riverbeds occurs as a consequence of prolonged solar radiation exposure, resulting in a reduction of both surface and groundwater levels. The depletion of sand inside streambeds leads to the process of river and estuary deepening, as well as the expansion of river mouths. Saline-water intrusion is seen as a consequence (Ayyam et al., 2019).

Since 2010, the amount of sand and grit produced in the U.S. has been going up steadily. According to Trudinger's (2019) research, the United States is identified as the primary producer of sand, with Italy, France, and Germany following suit. Italy and Spain are now facing a predicament that may be attributed to a prolonged period of economic stagnation after the most recent financial crisis. In the year 2012, there was a notable decline of 20.9% in Italian cement output. This decline may be attributed to the recession of the economy, which therefore led to a decline in the building sector. The United States of America is recognized as the top exporter globally, with Germany ranking as the fourth-largest producer worldwide. During the period from 2010 to 2014, the exports of the United States exhibited a gradual and steady increase. However, it is important to note that not all nations had a similar pattern in their export levels during this time frame. There are several factors that contribute to this circumstance. The output of sand has seen a decline, along with a drop in its internal use. According to Gavriletea (2017), the absence of technical standards has had a detrimental impact on the lifespan of mines and has contributed to an escalation in environmental damage connected with sand digging in the Amazon countryside near Santarem.

Within the sub-Saharan African region, there has been a significant degradation of the natural environment, characterized by the depletion of land cover, occurrences of landslides, and erosion. These issues are particularly prevalent in places where there is intensive sand harvesting. Currently, a significant proportion of African nations are experiencing a phase of economic expansion, which is facilitated by the use of natural resources. Notably, the exploitation of resources such as sand and gravel plays a crucial role in generating economic benefits for these countries. Environmental impact of sand and gravel collection, despite its significance as a natural resource, is profoundly detrimental. Sand mining has emerged as the primary menace to the diverse range of flora and fauna found along perennial rivers and ephemeral water courses in Ghana. According to Niekerk and Nema-konde (2017), the impact of this phenomenon includes the degradation of riverine vegetation, erosion, contamination of water supplies, and a decline in animal biodiversity.

The practice of sand collecting at the local level has resulted in the enhancement of infrastructure. Despite recommended infrastructural expansion, Kenya's sand harvesting rate is so worrying that the government had to write the National Sand Harvesting Guidelines 2007. The policy directive stipulated that each District Environment Committee (DEC) is required to designate a Technical Sand Harvesting Committee (TSHC) comprised of its members. The primary role of the TSHC is to provide guidance and offer recommendations to the DEC regarding sand harvesting operations

within the district, as well as oversees the implementation of regulations pertaining to all sand harvesting activities. The implementation of this strategy aims to establish effective and enduring practices for the extraction of sand within a certain geographical area where sand extraction is taking place (Katisya-Njoroge, 2021).

Sand harvesting is widespread, highly unregulated, uncontrolled and is being carried out at an alarming rate. The gravity of the situation beyond the affected communities and the region at large is enormous and poses a threat not only to the environment but also to food security. Although sand harvesting contributes to the construction of buildings and development, its negative effects include the permanent loss of sand in areas, as well as major habitat destruction. The Olkeriai Riverine environment, Mashuuru Sub-County, Kajiado County Kenya has been degraded over decades since the beginning of sand harvesting intensified. The ecosystem is not safe if the situation is not corrected at the moment since natural and indigenous plants and animals are lost daily due to continuous sand harvesting. Despite increasing dependence on the colossal quantities of sand and gravel being used, sand harvesting leaves a significant negative impact on the environment. Extreme sand harvesting has been mostly ignored by policy makers and remains largely unknown by the general public.

The absence of global data on aggregates sand harvesting makes environmental assessment very difficult and has contributed to the lack of awareness about this issue. Also, heavy vehicle traffic has also been witnessed in the Mashuuru Sub-County, with heavy commercial vehicle transporting the sand to the market. Accidents by such heavy vehicles, oil spills in sand harvesting areas and degradation of riparian land have been witnessed (Rentier, & Cammeraat, 2022). This trend has shown that there is a problem of degradation of the ecosystem and lowering of water table. In addition, there are no studies that have been done to evaluate the impact of sand harvesting in Mashuuru Sub-county. It is for this reason therefore that this study sought to address the gaps by investigating the impact of sand harvesting and its impact on Olkeriai Riverine Environment, Mashuuru Sub-County, Kajiado County Kenya. The general objective of the study was to investigate impact of sand harvesting on the Olkeriai Riverine environment in, Mashuuru Sub-County, Kajiado County in Kenya. And the research question; what was the impact of sand harvesting on the Olkeriai riverine environment in Mashuuru Sub-County, Kajiado County in Kenya?

METHODOLOGY

The study adopted a descriptive survey research design approach which is qualitative and quantitative in nature, where sand harvesting and its impact on environment is described as phenomenon in the real-life context. This design is suitable because the study is trying to investigate impact of sand harvesting, effectiveness of environmental conservation policies and measures put in place to curb environmental concerns caused by sand harvesting in Olkeriai Riverine, Mashuuru Sub-County. Descriptive survey helps answer the what, when, where, and how questions regarding the research problem, rather than the why.

Target Population is the complete set of cases from which a sample is selected whether it describes human beings or items that the researcher intends to draw data from. The target population consists of the specific group or geographical area that researcher aim to draw

conclusions about (Mweshi, & Sakyi, 2020). It includes all the entities or individuals that are subject to the environmental effects of sand harvesting in the area under investigation. The study target population included residents of Mashuuru sub-county, Kajiado-County. The population of this study was 64,214 adult residents of Mashuuru Sub-County, Kajiado-County (KPHC, 2023)

The study employed geographical cluster sampling. Cluster sampling is a sampling technique used when "natural" but relatively heterogeneous groupings are evident in a statistical population. Sampling is a process or technique of choosing a sub-group from a population to participate in the study; it is the process of selecting a number of individuals for a study in such a way that the individuals selected represent the large group from which they were selected (Reichel & Morales, 2017). The population of the study was highly heterogeneous. As such the study adopted random sampling method to give chances to all the members of the population a chance to be chosen to be members of the sample. Target groups include all the members of the sub county (youths, adults and elderly). The main objective of cluster sampling is to reduce costs by increasing sampling efficiency. The sample size was decided using Krejcie & Morgan (1970) formula as shown in Equation 3.1

$$n = \frac{\chi^2 NP (1-P)}{d^2 (N-1) + \chi^2 P(1-P)} \dots \dots \dots (\text{Eq. 3.1})$$

Where:

n = required sample size.

χ^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (2.706025).

N = the population size (64,214).

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (.06).

$$n = \frac{1.645^2 \times 64214 \times 0.5(1 - 0.5)}{0.06^2 (64214 - 1) + 1.645^2 \times 0.5(1 - 0.5)}$$

$$n = 187.370067024$$

$$n = 187$$

Table 1: Sample Size

Target	Sample size	Sampling Technique
Environmental officers	3	Purposive sampling
Administrators;	4	Purposive sampling
Chiefs,	2	Purposive sampling
Word Administrators		
Residents	178	Random sampling
Total	187	

The study used a closed ended questionnaire because it is easier to use when collecting data, it is possible to generalize the study findings and generate empirical claims that support decision-making. A structured questionnaire is user-friendly and simple to quantify (Tsang, 2017). The questionnaires consisted of two parts: first part was demographic information and the second part of the questionnaire contains a Likert type of scale questions based on the study objectives.

Data analysis was done using SPSS, a computerized statistical package by encoding responses from questionnaires and providing understandable descriptive results. The quantitative data collected from questionnaires was analysed using descriptive statistics. Descriptive statistics is the discipline of quantitatively describing the main features of a collected data which provides simple summaries about the sample and about the observations that have been made (Loeb et al., 2017). The descriptive statistics that were used included, mean, standard deviations and percentages. Qualitative data from interviews was analysed using themes. Presentation of analysed data was done in tables of frequencies and percentages. Inferential statistics were presented to show correlation of variables and relationship between study variables.

RESULTS

Impacts of Sand Harvesting on Environment

The study sought to examine the impacts of sand harvesting on Olkeriai Riverine environment, Mashuuru Sub-County, Kajiado County Kenya. The findings are indicated in Table 2.

Table 2: Impacts of sand harvesting on environment

Statement		SD	D	UN	A	SA	Total	Mean	Std. Dev
Sand harvesting has caused internal displacement of households and ecosystem.	F	4	35	22	94	10	165	3.43	.970
	P	2.4	21.2	13.3	57.0	6.1	100	68.6	
Sand excavation has caused upstream erosion and landslides as a result of an increase in channel slope and changes in flow velocity.	F	2	4	9	104	46	165	4.14	.723
	P	1.2	2.4	5.5	63.0	27.9	100	82.8	
Clearing of vegetation during sand harvesting has enabled increased alien vegetation cover.	F	1	20	32	79	33	165	3.75	.935
	P	.6	12.1	19.4	47.9	20.0	100	74.9	
Sand harvesting has caused increased soil erosion and air pollution in the region.	F	0	5	7	90	63	165	4.28	.686
	P	0.0	3.0	4.2	54.5	38.2	100	85.6	
Sand mining causes direct loss of stream reserve habitat and disturbances of species attached to streambed deposits.	F	3	12	3	111	36	165	4.00	.834
	P	1.8	7.3	1.8	67.3	21.8	100	80.0	
Groundwater table drops leaving the drinking water wells on the embankments of these rivers dry.	F	3	0	9	102	51	165	4.20	.700
	P	1.8	0.0	5.5	61.8	30.9	100	84.0	
Uncontrolled dumping of overburden and chemical/fuel spills will cause reduced water quality for downstream users.	F	0	5	15	103	42	165	4.10	.677
	P	0.0	3.0	9.1	62.4	25.5	100	82.1	

Correlation Analysis Results

Table 3: Overall Correlation Analysis Results

		Impacts of sand harvesting practices	Environment.
Impacts of sand harvesting.	Pearson Correlation	1	
	Sig. (2-tailed)		
Environment.	Pearson Correlation	.613**	1
	Sig. (2-tailed)	.000	
**. Correlation is significant at the 0.01 level (2-tailed).			

The findings as shown in table 3 indicate that impact of sand harvesting has a positive and statistically significant effect on the environmental in Olkeriai Riverine, Mashuuru Sub-County ($r=0.613$; $p<0.05$). This implies that sand harvesting influence environmental conservation in Olkeriai Riverine, Mashuuru Sub-County.

Multiple Regression Analysis

The study used multiple linear regression analysis to determine the combined linear relationship between the dependent variable and the independent variables. Table 4 show results of model summary.

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.781	.610	.602	.33327

The results in table 4 on model summary indicated that $R=0.781$, $R^2=0.610$ and adjusted $R=0.602$. R-value gives an indication that there is a linear relationship between impacts of sand harvesting and environmental conservation in Olkeriai Riverine Mashuuru Sub-County. The R^2 indicates that explanatory power of the independent variables is 0.610. This means that the regression model explains 61.0% of the variation in environmental conservation in Olkeriai Riverine Mashuuru Sub-County which is accounted by impacts of sand harvesting whereas 39.0% of the environmental conservation in Olkeriai Riverine Mashuuru Sub-County is accounted by other factors that the study did not studied.

Fitness of Regression Model

The analysis of variance (ANOVA) was used to determine if the multiple regression model was fit for the data. The results were as shown in table 5.

Table 5: ANOVA for Testing Multiple Regression Model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27.914	3	9.305	83.776	.000 ^b
	Residual	17.882	161	.111		
	Total	45.796	164			

a. *Dependent Variable: environmental conservation*; b. *Predictors: (Constant), sand harvesting*.

The results from table 5 indicates that the influence of independent variables on the dependent variable was statistically significant ($F=83.776$; $p<0.05$). This implies that the multiple regression model was fit for the data on sand harvesting and environmental conservation.

Regression Coefficients

T-test of statistical significance of each regression coefficient was conducted in order to determine the beta (β) which shows how strongly each independent variable influences the dependent variable. Table 6 shows the regression analysis results.

Table 6: Regression Analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.216	1.216		6.195	0.00
	Sand harvesting	.269	.034	.435	7.912	.000

The study findings in table 6 shows the regression coefficients results whereby sand harvesting had a positive and statistically significant effect on environmental conservation at Olkeriai Riverine Mashuuru Sub-County ($\beta=0.269$, $p=0.000$). The multiple regression equation for sand harvesting was as shown below:

$$Y_i = 1.216 + 0.269X_1$$

This implied that at constant sand harvesting and environmental conservation is at 1.216 units. The coefficient of 0.269 indicates that reducing an impact of sand harvesting by one unit increases environmental conservation in Olkeriai Riverine Mashuuru Sub-County by 0.269 units. Therefore, the county government and national government ought to focus on effectiveness of environmental conservation policies so as to protect environment from negative impact of sand harvesting. It is evident that environmental policy and conservation policies have become important subjects owing to the increased pressure on the environment mainly through environmental pollution and the cost resulting from negligence.

DISCUSSION

Table 2 shows statistical results on the physical impacts of sand harvesting on environment. The study showed that 104(63.1%) agreed, 22(13.3%) were undecided, 39(23.6%) disagreed with the statement that sand harvesting have caused internal displacement of households and ecosystem. At 68.6%(Mean=3.43, and Std Dev=0.970) agreed that sand harvesting have caused internal displacement of households and ecosystem destruction. Large scale mining of sand has led to displacement of households forcing them to move into other regions.

Findings also showed that 150(90.9%) agreed, 9(5.5%) were undecided, 6(3.6%) disagreed with the statement that sand excavation has caused upstream erosion and landslides as a result of an increase in channel slope and changes in flow velocity. At 82.8% (Mean=4.14, and Std Dev=0.723) respondents accepted that sand excavation has caused upstream erosion and landslides as a result of an increase in channel slope and changes in flow velocity. Deep excavations had resulted to landslides, pollution and escalated erosions in the region. Air, water and soil have been polluted round the year. The findings concur with Watson et al., (2018) that sand mining operations resulted in deforestation, habitat destruction and biodiversity erosion in some ecosystems. Large-scale sand mining operations have also seen damage to valuable timber resources and wildlife habitats. Such impacts are said to be insurmountable if sand extraction activities are located on small river or stream than on a large stream (Dar et al., 2023).

Results on clearing of vegetation showed that 112(67.9%) agreed, 32(19.4%) were undecided, 21(12.7%) disagreed with the statement that clearing of vegetation during sand harvesting has enabled increased alien vegetation cover. At 74.9% (Mean=3.75, and Std Dev=0.935) respondents stated that clearing of vegetation during sand harvesting has enabled increased alien vegetation cover. The findings are in line with Cuda et al., (2014) that sand harvesting operations involve deforestation, habitat destruction and biodiversity erosion. Native species in stream and rivers are uniquely adapted to conditions that existed before human began large scale alterations which favour some species over others. This leads to loss of biodiversity and recreational potential.

Response on increased soil erosion showed that 153(92.7%) of the respondents agreed, 7(4.2%) were undecided, and 5(3.0%) disagreed with the statement that sand harvesting has caused increased soil erosion and air pollution in the region. At 85.6% (Mean=4.28, Std Dev=0.686) respondents accepted that sand harvesting has caused increased soil erosion and poor air quality in the area vis-à-vis other areas in the region. Noise and air pollution is common in the region with large scale mining activities. Noise comes from heavy machinery, dust from soil pollutes are, oil spills and erosion of soil is common. The study results are supported by Madyise (2015) findings that besides compacting land, heavy vehicles are a source of pollution to the villages near sand harvesting sites. Noise and air pollution occur as dust accumulates from gravel roads which are a reality to villages near sand harvesting areas. There is general degrading of ecosystem. Air pollution caused by dust particles can be a health hazard causing respiratory disorders such as asthma and irritation of lungs. The sand is also extracted from rock blasting which generate noise pollution.

The response on loss of stream reserve habitat showed that 147(89.1%) of the respondents agreed, 3(1.8%) were undecided, 15(9.1%) disagreed with the statement that sand mining cause

effect on the direct loss of stream reserve habitat and disturbances of species attached to streambed deposits. At 80.0% (Mean=4.0, Std Dev=0.834) respondents accepted that sand mining causes direct loss of stream reserve habitat and disturbances of species attached to streambed deposits. Sand harvesting along the riverbanks have led to the loss of aquatic habitat through displacement. Chacha (2017) found that extraction of bed material in excess causes bed degradation which can undermine aspects of the aquatic habitat and deplete the entire depth of gravels, exposing other substrates that may underlie the gravel, which could in turn, affect the quality of natural habitat.

The study also found that 153(92.7%) of the respondents agreed, 9(5.5%) were undecided and 3(1.8%) disagreed that groundwater table drops, leaving the drinking water wells on the embankments of these rivers dry. At 84.0% (Mean=4.20, Std Dev=0.700) respondents agreed that groundwater table drops leaving the drinking water wells on the embankments of these rivers dry. Extreme sand harvesting has contributed to the lowering of water table which reduce survival rate of the natural ecosystem which depends on water. The findings are in agreement with Gondo et al., (2019) who stated that rapid removal of sand reduces groundwater recharge and may result in premature failure of irrigation wells and associated problems in farming. Certain magnitudes of the extraction may result also in the lowering of the water table and subsequently water security issues.

In addition, 145(87.9%) of the respondents agreed, 9.1%(15) were undecided, and 5(3.0%) disagreed with the statement that uncontrolled dumping of overburden and chemical/fuel spills will cause reduced water quality for downstream users. At 82.1% (Mean=4.10, Std Dev=0.677) respondents accepted that uncontrolled dumping of overburden and chemical/fuel spills will cause reduced water quality for downstream users. The findings concur with Mundetia et al., (2018) that activities such as illegal sand harvesting, deforestation, excessive ground water extraction, and untreated sewage discharge deteriorates water resource capacity and quality of the rivers. Water quality can be compromised by oil spills and leakages from excavation machinery and transportation vehicles. One of the environmental officers in an interview reported that:

Sand harvesting has contributed to the physical and ecological effects on the ecosystem. It has contributed to biodiversity loss, landslides, soil erosion and pollution to air, water and soil. Sand harvesting has degraded and caused encroaching effect to ecosystem biodiversity of Olkeriai Riverine in Mashuuru Sub-County (Officer 1, 2024).

CONCLUSION

In the Olkeriai Riverine of Mashuuru Sub-County, the consequences of sand harvesting are profound, resulting in biodiversity loss, landslides, soil erosion, and contamination of air, water, and soil. The study emphasizes the urgent need for robust environmental conservation measures to address the escalating degradation caused by sand harvesting activities. Statistical analyses, particularly correlation and regression, highlight the significant role of sand harvesting in shaping the environmental landscape, stressing the importance of coordinated efforts from local and national governments to implement effective environmental policies. Additionally, the regression coefficients demonstrate a direct and statistically significant relationship between sand

harvesting and environmental conservation, emphasizing the potential for reducing its impact to enhance preservation efforts. This underscores the necessity for policymakers to prioritize sustainable sand harvesting practices and regulations that balance economic interests with environmental protection, ensuring the long-term sustainability and resilience of ecosystems affected by sand harvesting.

Based on the study findings, recommendations emerge for both county and national governments. The Ministry of Environment and Natural Resources at the county level should regulate mining zones, ensuring measures are in place for the evacuation of households and protection of natural habitats. It is imperative to thoroughly assess the consequences of sand harvesting before permitting mining activities. The study urges the national government to deploy sufficient environmental officers to enforce laws and policies aimed at safeguarding endangered areas. Moreover, effective implementation of government-formulated policies is essential, emphasizing the need for robust regulatory frameworks at both county and national levels. These frameworks should include stringent guidelines for sand harvesting operations, robust monitoring mechanisms, and enforcement strategies to ensure compliance with environmental conservation standards. Additionally, future research is recommended to explore challenges in implementing environmental conservation policies in Kenya, with potential for similar studies abroad or within African countries.

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