

Sustainable Moderation of Sand Harvesting Effects and Conservation on Land Cover, Flora and Fauna along the Riparian Land

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ABSTRACT

Sand is an important mineral for the construction industry in the Kenyan society at large. However, protecting the environment in areas where this practice of sand mining takes place has become an environmental concern, given that the demand for sand increases with the growth of industry and construction. Sand mining though sustains the economy of the locals, can lead to considerable environmental damage which varies from pit formation to soil erosion. There is therefore need to put in place measures that can promote the economy of the locals and at the same time conserving the rich and diversified flora and fauna. The objectives of the study were: to identify effects of sand harvesting on land cover, flora and fauna; and to establish sustainable measures of land cover, flora and fauna along riparian land in Kisumu County. It was an experimental research design carried out using mixed method approaches. A sample size study population of 384 was involved, which comprised of NGO staffs, County Council staffs, local area authority staffs, sand harvesters and the local community. The local communities were randomly sampled while purposive sampling was used to select respondents from the sand harvesters, area chiefs, NGOs and the County Council staffs. Data were collected by means of self-administered questionnaires, guided interview schedules and observation check list by the researcher. The results indicated that there was negative impact of sand harvesting on land cover, flora and fauna on the riparian land along rivers. It also established the sustainable measures of land cover, flora and fauna in the study area. The research indicated that indeed the harvesting of sand is affecting the land cover, flora and fauna along riparian land negatively. The vegetation, the wildlife and the land cover are destroyed as the top soil is harvested as sand. Further, the land for agriculture is turned into waste land due to sand harvesting by formation of pits. This has resulted in the loss of the natural beauty of the environment. Because there are also economic gains in sand harvesting, sustainable measures of land cover, flora and fauna along riparian land are recommended. These should include; regulating the harvesting periods or controlled harvesting, re-shaping of the land where sand has been harvested, advocating for continuous awareness and positive education programmes on conservation measures of land cover, flora and fauna and enacting necessary legislative laws aimed at conserving land cover, flora and fauna.

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Introduction

Sand is important for the economic growth of the country. This is because of its use in the construction industries and sustaining the economy of the local community. The United Nations environments (2019) observed that increased demand from construction industries was resulting in unsustainable mining rates and decrease in the stock of sand as a resource leading to reduced deposits in river deltas and accelerated beach erosion. For several years, the construction industry has used sand and gravel for building of roads and dams (The Ojos Negros Research Group, 2008). As development in both developing and developed countries increases, the demand for sand increases too. Riparian zone is necessary to the integrity of the ecosystem providing habitat for invertebrates, birds and other wildlife. The riparian zones minimize or avoid damage to stream/river banks and riparian habitat (Ashraf *et al*, 2010).

The research sought to find out the value of the riparian land and to identify the biological importance of the riparian ecosystem if conserved.

Sand harvesting creates a depression on the ground which lies on the riparian zone. Sand being a banker for different organisms is therefore interfered with. Manual sand harvesting by use of hand shovel disturb the natural ground by loosening the top soil thereby making it prone to soil erosion. Soil erosion in turn makes the soil infertile since rich soil is washed down the valley, leaving behind bare land unsuitable for agriculture. The sand extracted from the ground is also a home to some organisms. Open pit mining operations leave wounds in the landscape easily seen via satellite image (Thompson, 2017). Sand mining activities scar the landscape with excavated pits and trenches, leaving behind unsightly views which as well render the land unsuitable for any productive purpose (Adedeji, 2014).

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In Kisumu County, Instream sand mining is very common and this results in the destruction of aquatic and riparian habitat through large changes in the channel morphology. The method used to get the sand from the source determines the impact caused on the riparian ecosystem. The purpose of the study was therefore to assess the impact of sand harvesting on the riparian land in Kisumu County in order to identify ways of developing sustainable methods of ecosystem diversity.

Research Objectives

1. To identify effects of sand harvesting on land cover, flora and fauna along the riparian land in the study area.
2. To establish sustainable measures of land cover, flora and fauna along the riparian land in the study area.

Research Hypotheses

- i. Methods of sand harvesting along riparian land significantly affect the environment.
- ii. There are no conservation measures for land cover, flora and fauna along the riparian land.

Significance of the Study

The study will make an important contribution to the understanding of the impacts of sand harvesting to the people, environment, and biological ecosystem. Findings from this study is important as it will provide an input in the future planning and environmental management of the natural resources like sand and water, particularly in environmental protection.

It will help fill the knowledge gaps that exist for both the County Council and other environmental organizations on the impacts of sand harvesting to the riparian land. This will further make them enact the laws and regulation on sand harvesting to reduce the negative impacts. This in turn, will lead to sustainable use of these resources for future availability and use.

People living along other riparian land who practice sand harvesting in Kenya will be enlightened on the impacts of sand harvesting along the riparian land and how they can sustainably counteract the negative effects.

Research Methodology

It was an experimental research design done through mixed method approaches. The study target population was 31,739 (Kenya National population census, 2009). Random and purposive sampling methods were used to get respondent sampling population size of 384 using Fisher *et al* (1998) formula. The data was collected by use of self-administered questionnaires, observation check lists, and interview schedules. The sand mine stretch for about 1km along the riparian land. The questionnaires were given to the sand harvesters and the community members. Observation Check list method was used to identify the impact of sand harvesting on the riparian land. The researcher observed the activity of sand harvesting for a period of six months.

Table 1. Population involved in the study

Identity	Actual Population size	Sample population size
NGO and municipal council	5	5
LAA(Chief, CDR)	3	3
Sand harvesters	753	125
Local community	30978	251
Total	31739	384

The observations were recorded, in a note book on the number of times the sand was harvested per day. During the field trip observation photographs were taken on the sand harvesting sites on the riparian land. The observation field

trips were carried out in the company of key informants who resided in the area.

Data Presentation and Interpretation

The data collected was summarized in compact form using statistical tables and statistical package for social sciences (SPSS) which was also used to analyze the data. Data presentation was done using pie charts, bar charts tables and percentages. Chi-square test was used to analyze the association between sand harvesting and replenishment rate in the riparian zone.

The study further sought to know how much sand was harvested in a day. To assess this, the respondents were asked to select the number of tonnes of sand harvested in a day and the findings were summarized in table 2

Table 2. Distribution of the amount of sand mined within a day

Quantity of sand mined	Frequency	Percentage
1 tonne	142	36.8
2 tonnes	32	8.3
3 tonnes	18	4.7
> 3 tonnes	194	50.2
Total	386	100.0

The Findings in table 2 shows that half of the respondents 194(50.2%) noted that more than three (3) tonnes of sand was harvested in a day. However 142(36.8%), 32(8.3%) and 18(4.7%) respondents reported that 1 tonne, 2 tonnes and 3 tonnes were harvested in a day respectively.

The study sought to know whether the rate of harvesting was equal to the rate of replenishment. This would be important in order to assess impact of sand harvesting on the environment; therefore the respondents were asked whether the rate of harvesting was the same as the rate of replenishment. The findings were summarized in table 3

Table 3. Sand harvesting and replenishment rate.

Rate equal	Frequency	Percentage
Yes	77	20.0
No	309	80.0
Total	386	100.0

The Findings in table 3 clearly show that majority of respondents 309 (80%) confirmed that the rate of harvesting and replenishment were not equal with only 77 (20%) noting that the rates were equal. The findings from majority of the respondents were in line with the study carried out in Masinga Kenya (Mungai *et al*, 2000) found out that removal of sand by heavy trucks causes environmental degradation by accelerating soil erosion and affecting soil stability. An attempt should be made to equalize the rate of harvesting with the rate of replenishment in order to stabilize the land cover, fauna and flora.

The effects of sand harvesting are further summarized in figure 1

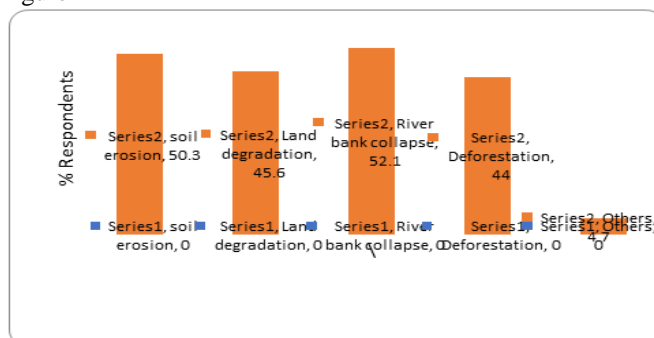


Figure 1. Effects of sand harvesting.

This was a multi-response question and the findings were as summarized and presented in figure 1. Soil erosion and river bank collapsing were noted as the leading effects of sand mining 194(50.3%) and 201(52.1%) respectively. These were followed by land degradation and deforestation while others stated other effects, 176(45.6%), 170(44%) and 18(4.7%) respectively. According to the department of natural resources and environment on irrigation and drainages, (2009), found out that the riparian buffer at the edge of water and against river bank need be retained. This will prevent vegetation loss and encourage sustainability. A study carried out in Nigeria, (Agbor 2014), found out that when sand and gravel was extracted, vegetation is destroyed and this vegetation serves as food for cattle. This then denies both animals and inhabitants in the area their livelihood. This was also in line with research carried out in Rwanda (R.E.MA, 2009), who found out that mining activities often impact on the environment, including resource depletion, energy consumption, waste generation and emission of air pollutants. A similar rate and amount of replenishing activities should be adopted to stabilize the land cover, flora and fauna.

Sand harvesting destroyed habitats for living things (flora and fauna). The details of these findings are summarized in table 4

Table 4. Sand harvesting and organisms' habitat.

Sand harvesting destroys	Frequency	Percentage
Yes	278	72.0
No	108	28.0
Total	386	100.0

The Findings in table 4 show that majority of respondents 278 (72%) noted that sand harvesting destroyed habitats while 108(28%) noted otherwise. Most of the respondents who agreed that the habitat was destroyed for living things thought that the replenishment rate was not equal to the harvesting rate 217/278, 56.2% of all respondents. This is in line with Bhattacharya *et al* (2019), who conducted a study in Korea and found out that sand harvesting is one of the leading human interventions on river system where several mining responses have direct and indirect effects on riverine biota in specific physical, chemical and biological environments under a river system.

Whether sand harvesting destroyed the habitat for living things was however found to be not significantly associated to whether they thought the rate of sand harvesting equaled the rate of replenishment ($\chi^2=2.47, p=0.12$). The cross tabulation was summarized in table 5.

Table 6. Affected organisms

Affected organisms	Frequency	Percentage
Fish	238	85.6
Tree	100	36.0
Farm animals	33	11.9
Other	15	5.4
Total	386	100.0

The study further established that fish were the most affected living organisms by sand harvesting with majority of the respondents who noted that sand harvesting affected habitats for living things mentioning trees, 238(85.6%) followed by farm animals, fish and other living organisms 100(36%), 33(11.9%) and 15(5.4%) respectively.

Table 5. Association between sand harvesting in habitat and harvesting rate equals replenishment rate.

Sand harvesting destroys/ replenishment rate=harvesting rate	Yes n (%)	No n (%)	Total n (%)
Yes	61(15.8)	217(56.2)	273 (72.0)
No	16(4.2)	92(23.8)	108(28.0)
Total	77(20.0)	309(80.0)	386(100)

The study sought to know if land degradation was a major impact of sand harvesting along the riparian land which was also to enable the researcher establish the impact of sand harvesting on biological parameters. The respondents were therefore asked to state whether sand harvesting led to land degradation and the results summarized in figure 2

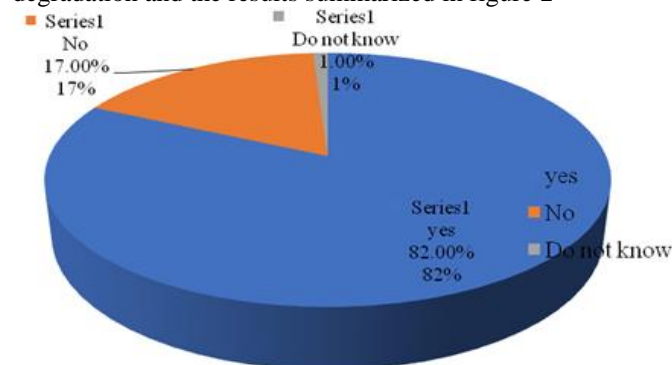


Figure 2. Land degradation

The findings in figure 2 show that majority of respondents 318(82%) agreed that sand harvesting led to land degradation while 66(17.1%) and 2(1.0 %) didn't and not knowing if it does lead to degradation respectively. More than half of all respondents 255 (66.1%) noted that sand harvesting led to land degradation and that the replenishment rate was not equal to the harvesting rate. The study also established that sand harvesting led to land degradation was not significantly associated to whether the respondents agreed the rate of sand harvesting equaled the rate of replenishment ($\chi^2=1.13, p=0.51$). This confirms Madyise (2013) finding that mining led to loss of vegetation from the bank and deepening of the river banks.

Table 7. Association of sand harvesting leading to land degradation and the harvesting rate equals replenishment rate.

	Yes n (%)	No n (%)	Total n (%)
Yes	63(16.3)	255(66.1)	318(82.4)
No	13(3.4)	53(13.7)	66(17.1)
Don't know	1(0.3)	1(0.3)	2(0.5)
Total	77(20.0)	309(80.0)	386(100)

The study also sought to know whether sand harvesting had negative impact on agriculture as a means towards establishing the impact of sand harvesting in this community. The respondents were therefore asked to state whether sand harvesting had negative impact on agriculture and the findings summarized in figure 3

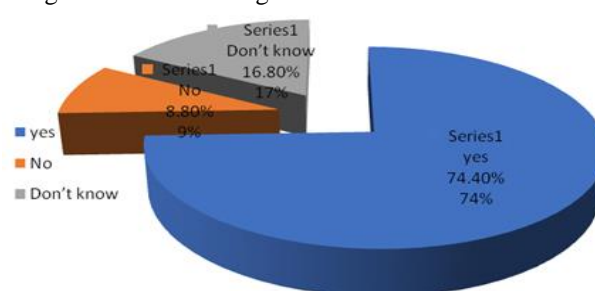


Figure 3. Destruction on agriculture

The study found that most respondents agreed that sand harvesting had negative impact on agriculture 287(74.4%) with 34(8.8%) and 65 (16.8%) stated it does not impact agriculture negatively or did not know, respectively. Top soil suitable for agriculture is carried away during sand harvesting leaving the land bare and unsuitable for agriculture.

Table 8. Impacts on agriculture.

Impact on agriculture	Frequency	Percentage
Loss of vegetation cover	88	30.7
Loss of fertile farm land	267	93.0
Loss of grazing land	21	7.3
Other	10	3.5
Total	386	100.0

These findings were corroborated by key informants who established that the land had lost its fertility thus leading to decrease in crop production. It also reported loss of vegetation cover and grazing lands. The participants also reported experiencing floods as a result of sand harvesting and deforestation. The effects of sand harvesting along riparian land were similar to those in Nzehele Valley, Limpopo Province, South Africa as established in a research by Kori and Mathada (2012). In the study, Kori and Mathada (2012) found that the extraction of gravel from riparian areas in Nzehele valley involved the clearing of vegetation to expose sand and gravel. This degraded the habitat of many organisms and the aesthetic beauty of the natural environment in the valley. The findings are also similar to those of Marioana (2018) who asserted that intensive harvesting of gravel and sand in flood plain areas leads to doubling of pits ponds surfaces, changes on floodplain morphology and landscape degradation. This means if land was for agricultural purposes then, sand harvesting can turn it into land unsuitable for agriculture. Because of this, replenishment activities must equalize the sand harvesting rate in order to stabilize agricultural productivity of the riparian land.

Other sustainable conservation measures of land cover, flora and fauna along riparian land include regulation of the sand harvesting rate. The respondents generally agreed that sand harvesting season should be regulated and education programmes should be carried out on conservation. Table 9 illustrates summary of their responses.

Table 9. Are there times sand harvesting is stopped?

Sand harvesting stopped	Frequency	Percentage
Yes	163	42.2
No	223	57.8
Total	386	100.0

The findings in table 9 show that less than half of the respondents agreed that sand harvesting should be stopped at times 163(42.2%) with 223 (57.8%) not agreeing that sand harvesting should never be stopped. This can be used as a regulatory measure and replenishment of flora and fauna.

Awareness and education programmes on conservation of flora and fauna along the riparian land should be continuously done so as to equip the local communities and sand harvesters with relevant skills. The responses are summarized in table 10.

Table 10. Education programmes carried out on conservation of sand.

Are there Education programmes	Frequency	Percentage
Yes	37	9.6
No	328	85.0
Don't know	21	5.4
Total	386	100.0

The study established that majority of the respondents stated that there were no education programmes carried out on conservation of sand 328 (85%) with only 37 (9.60%) and 21 (5.4%) stating that there were education programmes or

did not know respectively as presented in table 10. Land re-shaping programmes or activities should closely follow the sand harvesting sites. Each County should enact laws to ensure that this is adhered to.

Conclusion

The research indicates that indeed the harvesting of sand is affecting the land cover, flora and fauna along riparian land. The vegetation, the wildlife and the land cover are destroyed as the top soil is harvested as sand. Further, the land for agriculture is turned into waste land due to sand harvesting by formation of pits. The findings also indicated that the harvesting of sand had an effect on the biological life in the riparian region and affected agriculture in the area. Due to the sand harvesting, the flora and fauna along the riparian land are negatively affected. This resulted in the loss of the natural beauty of the environment.

Sustainable measures of land cover, flora and fauna along riparian land should include; regulating the harvesting periods, re-shaping the degraded land after sand harvesting, putting in place positive education programmes on conservation measures of flora and fauna and enacting necessary legislative laws aimed at conserving of land cover, flora and fauna by every County.

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