IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 22, Issue 11, Ver. 10 (November. 2017) PP 31-37
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Social-Environmental Effects of River Sand Mining: Case Study of Ephemeral River Kivou in Kitui County, Kenya

Muiruri Philip Gathogo.[1]Meshack O. Amimo.[1]
(Dep. of Geography, Kenyatta University, Kenya)
Corresponding Author:Meshack O. Amimo.

Abstract: Sand mining has been undertaken across the world over centuries, with increasing frequency and intensity noted with time. Currently, indiscriminate sand mining is taking place in River Kivou which forms the center of focus of this study. The activity is profoundly driven by high demand for construction sand, high levels of unemployment as well as adverse climatic conditions in the area. Random sampling on the seven active mining sites helped to arrive at three sites. Systematic sampling technique got applied to the selected sites at intervals of 10 meters, with data on width and depth taken. Stratified sampling helped to arrive at a suitablesample size comprising of sand miners, landownersand households. The study involved collection of data on the river channel depth and width at the active sites of mining and on the control sites. Data on some environmental and social variables such as availability of water, insecurity, prostitution, school dropout rates, conflicts, employment, drug and substance abuse was collected using oral interviews to administer the structured questionnaires and Community-Based Participatory Research (CBPR). One way ANOVA test results indicate thepresence of significant alteration of river channels width and depth by sand mining activity. On the other hand, percentages were used to analyze the social impacts of sand mining. Results indicate apositiveeffect on employment and adverseimpact on all other variables apart from school dropout rates and insecurity both of which were insignificantly affected.

Keywords: Social-Environmental effects, Ephemeral stream, River Kivou, Sand mining, and Sustainability.

Date of Submission: 02-11-2017 Date of acceptance: 18-11-2017

I. INTRODUCTION

Sand mining is an activity that has been carried out for centuries, mainly for construction purposes (Orr & Krumenacher, 2015).Often, the construction industry prefers sand from the river beds, flood plains and from shores of the lakes. According to Kondolf (1997), sand from the sources above is angular in shape, a factor that promotes thestrength of the concrete, unlike desert sands which have circular and smooth grains. Today, the rate of sand mining from river channels is approximated to be twice as much the sand transported by rivers of the world per year (Peduzzi, 2014).Such a high rate of sand mining is not sustainable, and mitigation measures need to be adopted to protect rivers from imminent degradation. According to Lu *et al.* (2007); Kondolf (1997); Nabegu (2013) and Rinaldi *et al*. (2005), high rates of sand mining from the river channels brings about adverse effects to the environment. Regarding this, Mwaura *et al.* (2013) and Wambua (2015) point out that sand mining is taking place at a high rate unregulated in Kenya, more so in river channels near the rapidly urbanizingCentre's.Additionally, concern hasbeen raisedover remote focus directed to the study of ephemeral rivers across the world (Nabegu, 2014).

The primary objective of this study is to find out the social-environmental impacts of sand mining in seasonal river Kivou. Need to address these aspects in this study has been heightened by the indiscriminate nature of sand mining that has been taking place over the last two decades in riverKivou in Kitui county, with frequency and intensity of sand mining increasing dramatically with time. Unfortunately, being an ephemeral stream, most scholars have neglected studying the phenomena and its associated impacts on the society and the environment.An attempt has been made in this paper to address some of the social and environmental effects of sand mining in the ephemeral rivers in Kitui County, with a case study of river Kivou. Presence of such information will help draw theattention of environmental policymakers towards coining sound river rehabilitation strategies as well as prudent sand mining strategies as the case is in the developed countries.

II. STUDY AREA

The study area is located in Kitui County, Mwingi Sub-County, Kenya. River Kivou is a tributary of river Enziu.Its sub-catchment lies between longitudes 38^0 05'E and 38^0 15'E and latitudes0^0 50' S Sand 0^0 58' S. See Fig. 1.0.The areais characterized by hot and dry climatic conditions, with temperature and rainfall ranging between 24^0c-26^0c and 400-800mmper annum respectively (Nissen, 1982).The area is marked by an average evaporation rate of between 1800-2000 mm per annum, a factor that makes theexistence of surface water difficult. Remarkably, most of therivers traversing the area are ephemeral in nature. Pastoralism, drought crop farming, and sand mining comprise the significant economic activities. Regarding geology, the area isdominated by metamorphic rocks namely biotite gneisses, leucocratic gneisses and granulite's, all of which are of sedimentary origin (Pulfrey, 1954).Over the years, these rocks have suffered a lot of chemical and mechanical weathering which have resulted in theformation of a thin crust of regolith. The resultant soils are highly drained and of poor fertility index, only supporting thegrowth of scattered trees, shrubs and little grass, a factor that promotes high erosional rates across the terrain.

Map of the Study Area

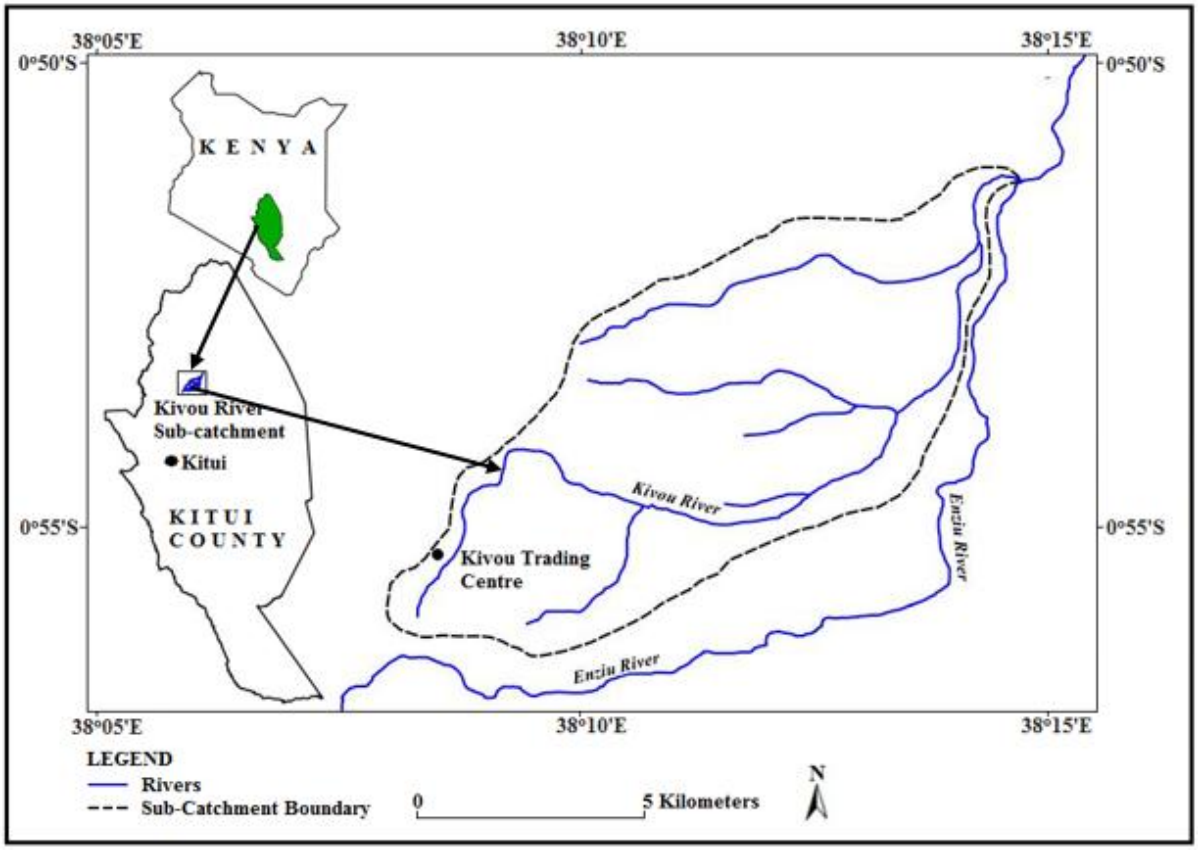

Figure 1.0: Location of Kivou River sub-catchment in Kitui County
Source: Author, 2017

III. SAND MINING IN RIVER KIVOU

River kivouis an ephemeral stream in nature and stretches for a length ofapproximately 24 km.It is in its youthfulstage, and it forms a tributary to riverEnziu.Over the last two decades, sand mining activities have been carried out in this river, with theintensity of the exercise increasing progressively with time.According to Wambua (2015), rapid state of urbanization in the nearby towns such as Mwingi, Thika, and Nairobi, all of which derives sand for construction from rivers in Kitui county have exacerbated the rate of sand mining. Currently, sand mining is taking place unregulated in seven sites along river Kivounamely Mwania, Kwa Nduuthi, Kivou, Ndalani, Mangoloma, Kesu and Kanginga. From the local interview with the sand miners, it is approximated that about 8-15 Lories are loaded every day from respective sites.Thistranslatesto about 50-60 tons per day. Such high levels of sand mining are conceived tobe driven by factors such as high demand for sand in the construction industry, high levels of unemployment, and the adverse climatic condition of the study area which limits the inhabitant's economic options. In a bid to salvage the environment from the eventualadverse environmental impacts, there is aneed for the intervention measures to be devised and implemented in the form

of informed policies. See Fig. 2.0 illustrating the conceived causes, proposed interventions and environmental impacts of sand mining in river Kivou. Sand mining in this river is going on at a high rate which is uncontrolled, a factor that raises need to study the phenomena in a bid to enrich the existing technical literature and inform the policy-making process.

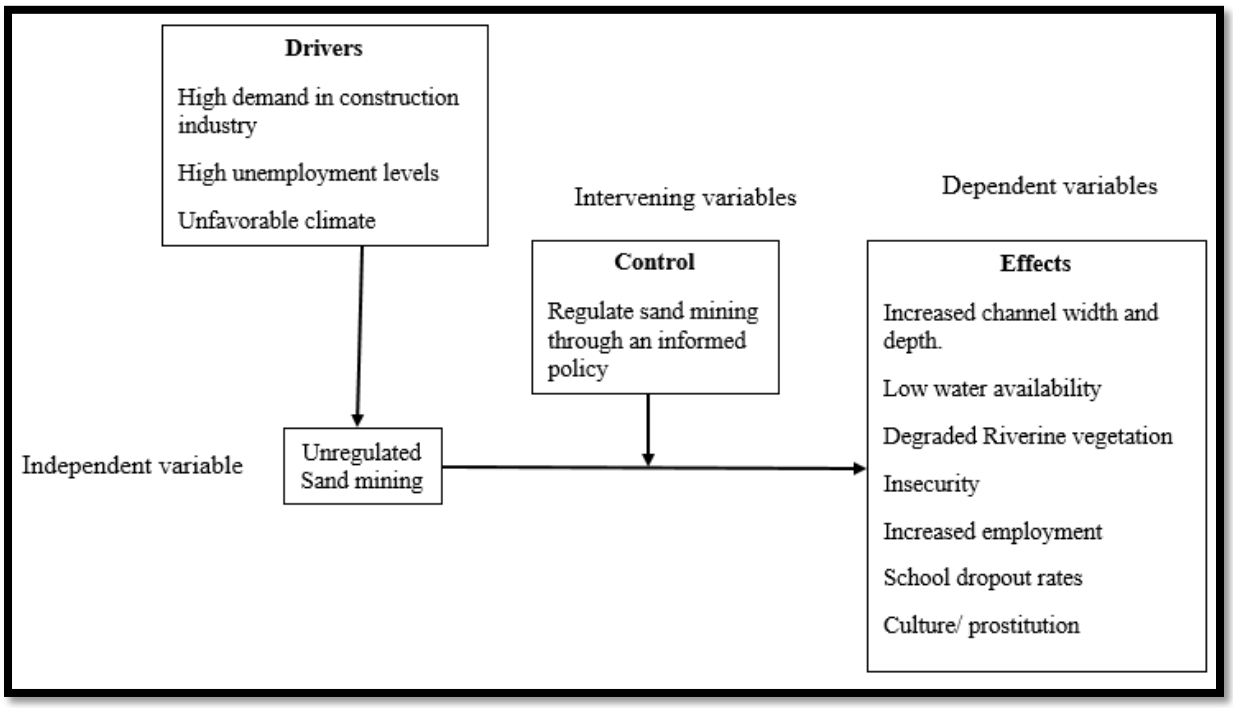

Figure 2.0: Causes, Control and Impacts of Sand Mining
Source: Author, 2017

IV. METHODOLOGY

1.1. Sampling Techniques

Random sampling on the seven active sand mining sites identified along river kivou namely Mwania, Kwa Nduuthi, Kivou, Ndalani, Mangoloma, Kesu and Kangingawas done, and three sites namely Kesu, Kivou and Mwania, were selected.From the sites chosen, systematic sampling technique was applied to collect data on the channel width and depth. On the other hand, stratified sampling technique was employed on population (1500 people) as obtained from sampling framesgotten from Mwingi Sand Mining Cooperative, where a sample size of 150 respondents was arrived at (100 sand miners, 45 households, 5landowners). Additionally, random sampling was done to come up with a list of respondents (five groups of 5 respondent) who were considered to participate in Community-Based Participatory Research (CBPR) thus bringing about a total sample size of 175 respondents. The population sampling got informed by Mugenda and Mugenda's (2009) principle on sampling in research which recommendsthe minimum sample size to be a 10% of the study population for it to be an adequate representative.

1.2. Data Collection

Different types of data were collected using variousmethods. For instance, data on river width and depth wascollected at the active mining sites and on the unaffected stretches up and downstream of the selected activemining sites using physical measurements in the field. A tape measure and a rope were used to establish width and depth of the dry river channel, with 30 points at intervals of 10 meters considered ineach of the active sites, upstream and downstream of each of the active mining sites.Data on variables such as security status, water availability, prostitution, education, and employment was obtained through use of oral interview to administer structuredquestionnaires and validated using CBPR.

1.3. Data Analysis

Analysis of sand mining on the physical parameters of the river channel namely width and depth was carried out using ANOVA. The technique enabled comparison of the said variables from the active sites of mining and the unaffected portions of the river channel, whereby the unaffected sites acted as control sites. This technique has gained broad application in analyzing geographical phenomena and was used by Nabegu (2014) to examine the effects of sand mining on river morphology in Nigeria, thus rationalizing its suitability and reliability. On the other hand, data obtained from the structured questionnaires and CBPRwas analyzed by use of percentages and presented using a table.

V. RESULTS AND DISCUSSIONS

1.1. Results of Environmental Impacts of Sand Miningto the River Channel

Abreakdown of descriptive statistics on the river channel widthsgot prepared as shown in Table 1.0 below. From the figures in the column of the mean as well as an illustration by box plots in Fig. 3.0, it is clear that sand mining has significantly altered thewidth of the channel at the mining sites. To evaluate the statistical significance of this variation, a one way ANOVA was carried out between the groups of the three sites. The ANOVA test results in Table 2.0 indicate a significant difference in at least one of the three sections (P= 0.0000) at 95% level of significance. A further analysis through Tukey's post HOC test pointed out that the widths at mining sites significantly differs from the control stretches of the river channel. See Table 3.0 below.

Table 1: Descriptive Statistics of Widths of the Three Sites

	N	Range	Min	Max	Mean	S.D	Variance
Upstream	90	2	24	27	25.4222	1.1216	1.2579
Downstream	90	2	24	26	24.9889	0.8002	0.6403
Mining site	90	2	29	31	30.0556	0.7983	0.6373

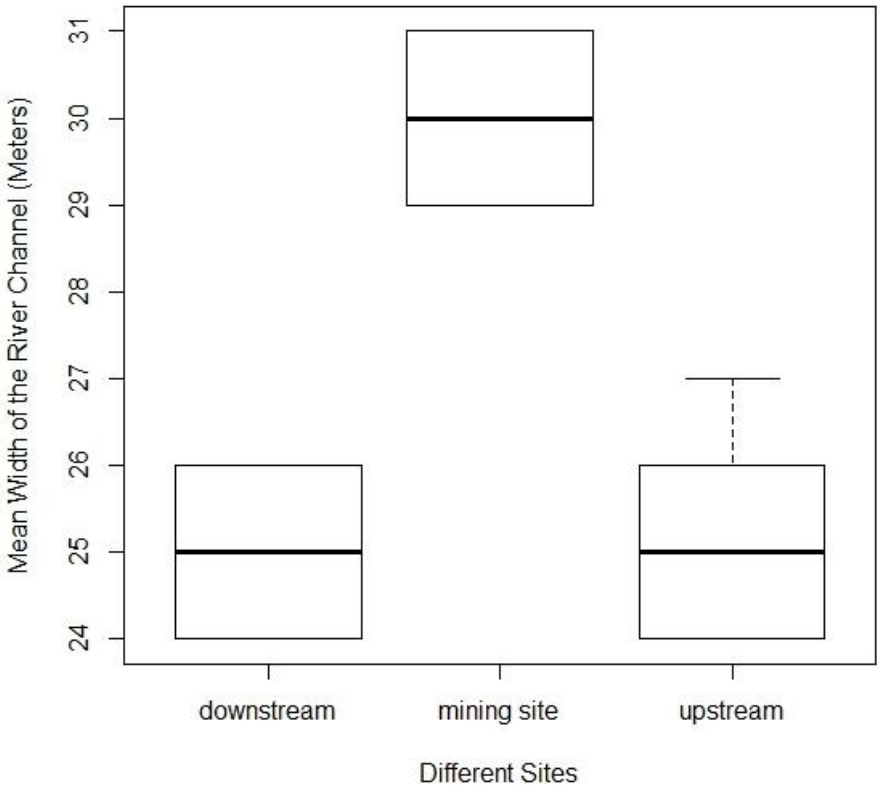

Figure 3.0: Boxplots showing the mean width of the river a channel at active and control sites.

Table 2.0: A One Way ANOVA Test Results for the River Channel Width

Source	**Df**	**Sum Sq.**	**Mean Sq.**	**F Value**	**P Value**
Between-Group	2	1425.7	712.9	839.2	0.0000
Within-Groups	267	227.7	0.8		

Table 3.0: Tukey's ANOVA Post Hoc Test Results on River Channel Width

Sites	**Difference**	**Lower**	**Upper**	**Adj. P Value**
Mining Site-Downstream	5.0667	4.7428	5.3905	0.0000
Upstream-Downstream	0.4177	0.0948	0.7406	0.0071
Upstream-Mining Site	-4.6490	-4.9719	-4.3260	0.0000

On the other hand, Table 4.0 shows descriptive statistics of the channel depth at the three sites. Again, figures indicated in the column of means, as well as the illustration by box plots in Fig. 4.0,indicate the presence of somesubstantial variation of the average channel depths at differentsections. As a way of determining the

statistical significance of these meandepths, a one way ANOVA test was conducted. As indicated in table 5.0, the test results show thepresence of a statistically significant variation in depths in at least one of the three sites(P = 0.0000) at 95% level of significance. Post HOC test results indicate that the mining sites varies significantly with the control sites as shown in Table 6.0.

Table 4.0: Descriptive Statistics of the Depths of the Three Sites

	N	Range	Min	Max	Mean	S.D	Variance
Upstream	90	2	2	4	3.6667	0.8300	0.6889
Downstream	90	2	3	5	3.3111	0.7695	0.5921
Mining site	90	3	3	7	5.7111	1.0137	1.0277

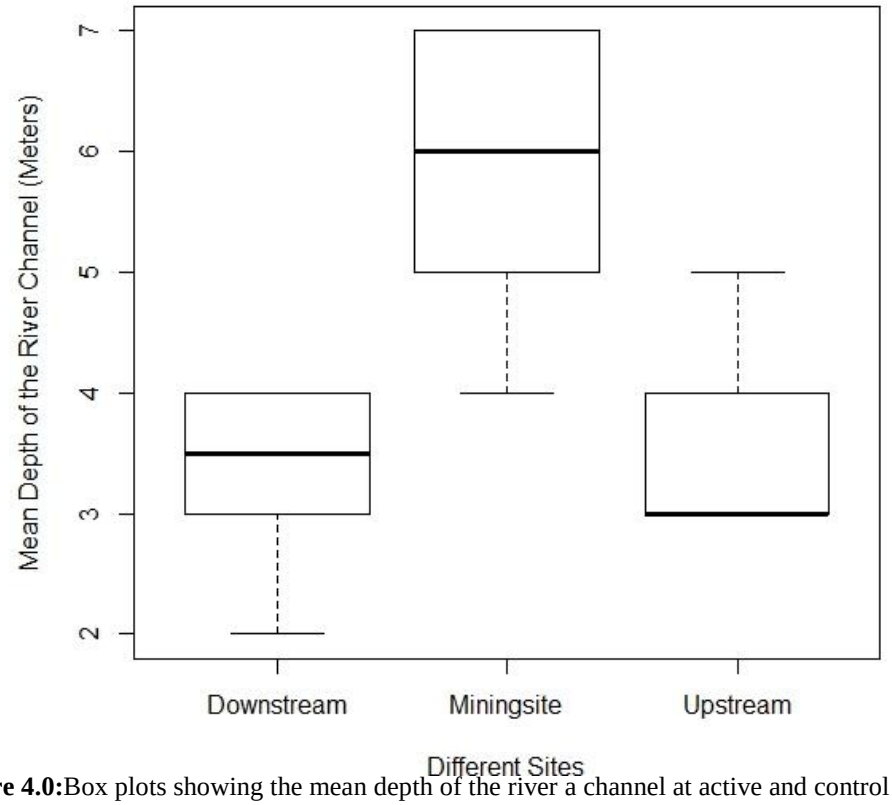

Figure 4.0: Box plots showing the mean depth of the river a channel at active and control sites.

Table 5.0: A One Way ANOVA testResults of the Channel Depth

Source	**Df**	**Sum Sq.**	**Mean Sq.**	**F Value**	**P Value**
Between-Group	2	302.0	150.99	194	0.0000
Within-Groups	267	207.8	0.78		

Table 6.0: Tukey's ANOVA Post Hoc Test Results on River Channel Depth

Sites	**Difference**	**Lower**	**Upper**	**Adj. P Value**
Mining Site-Downstream	2.4000	2.0900	2.7099	0.0000
Upstream-Downstream	0.3556	0.0456	0.6655	0.0199
Upstream-Mining Site	-2.0444	-2.3544	-1.7345	0.0000

1.1.1. Discussions

Data analysis results point out that sand mining in River Kivou has significantly modified the channels width and depth, an indication of high and unsustainable levels of sand mining. According to Kondolf (1994) and Kondolf *et al*., (2002),sand mining which exceeds the natural replacement rates leads to alteration of the river morphology, a factor that is associated with adverse environmental impacts such as lowering of the water table impounded in sand reserves, stream bank instability and loss of riverine vegetation, channel erosion, river incision among others. Some of these impacts have been noted on the ground in river Kivou. These include thedestruction of the riparian vegetation, depletion of sand reserves, armoring of the river bed, lowering of the water table in sand reserves as well as bank instability. Further, relatively increased depth on the river channel is noted on the control sites at the portions just adjacent to the active mining sites. On the upstream sections, this

may be attributed to sliding of sand particles to fill the pits left at the active site. On the other hand, the relatively increased depth noted on the downstream portions adjacent to the active part may be attributed to the hungry water effectof the river water especially during the wet season. Following this, there is animminent need for formulation of suitable sand mining control measures to help protect the river environment form eventual degradation.

1.2. Social Impacts of Sand Mining

The social aspects were analyzed using descriptive statistics. See Table 7.0 showing a summary of the social effects of sand mining. In this, sand mining is seen to significantly influence water availability, prostitution, employment, community conflicts and drug and substance abuse.

Table 7.0: Social Effects of Sand Mining

Variables	**Respondents % (Yes)**	**Rank**
Water availability	95	1
Insecurity	35	7
Culture/prostitution	75	2
School drop-out rates	38	6
Community conflicts	67	3
Drug and substance abuse	52	5
Employment	65	4

As depicted from the results in Table 7.0, sand mining has greatly impacted on the water resource.This agrees with sentiments of Nabegu (2013) indicating that sand mining in the perennial rivers leads to lowering of the water table, especially as observed in the wells near the river. In this case, lowering of thewater table in the sand reserves along the ephemeral stream channel was reported. Since this area suffers theabsence of surface water, the water impounded in the sand reserves and protected from evaporation by the sand aquifer acts as the only other alternative source of water, and drying up of such has a dire consequence to the residents of riverKivou catchment.

On the cultural aspect, many respondents, as well as the remarks got from the CBRP, indicate a high negative influence. Prostitution index has been signalized to be high in the area, and more so as a result of sand mining activities. The activity has significantly deviated from the norm and morals of the predominant community in this area, and as a matter of fact and concern, it is revolutionizing the culture of the area to the negative. The high unemployment rate and high poverty index in the area (61.56%) as indicated by GOK. (2010)can closely be associatedwith the shaping up of this activity.

Increased employment opportunities to the localshavegot highlighted as a significant positive impact of sand mining. Young men and women in the area have secured jobs in thesand mining industry, either directly or indirectly. For instance, energetic young men are hired as sand miners and loaders while women supply such workers with foodstuffswhile at the working sites thus generating some income to upkeep their families.

On the other hand, the study established that sand mining activity has greatlyinfluenced theoccurrence of conflicts in the community. Regarding this, sand mining has interfered with the natural sources of water impounded in sand aquifers, and thus the residents of this area engage in occasional confrontations with the sand miners. Additionally, conflicts over land ownership for the sake of gaining legitimacy to start up sand mining were reported between sand miners and the landowners. Further disputes arising from sand mining incline on the economic aspect of the activity. Sand miners from different parts of Kitui Countyand those from the local/ Kivou area compete for jobs, a factor that ends up in conflicts.

Lastly, sand mining activity indicated asignificant influence on drug and substance abuse in Kivou area. Data from questionnaires andCBPRstrongly showed that most of the sand miners are people who engage in drug and substance abuse compared to the general population of people not involved in the activity.Such include Alcoholism, Bhang, and Miraa consumption, all of which are costlybehaviors. Going by this, it is evident that such people earn extra income compared to the rest of the population in the area, a factor that makes them able to sustain the habit.

VI. CONCLUSION

Sand mining in river Kivou is an activity that isassociated with adverse environmental and social impacts. The study has established that sand mining has brought about alterations in the river channel morphometric parameters such as depth and width. Further, it has led to lowering of the water table in the sand reserves along the river channel, a factor that leads to drying up of shallow water holes sunk thereof thus subjecting the locals into suffering.Additionally, the activity has led to thedestruction of the riparian vegetation as well as destabilizing the banks of the channel.On the other hand, sand mining has brought about adverse

social effects such as increased conflicts, drug and substance abuse and prostitution.In order to safeguard the environment as well as the social well-being of the community, there is aneedfor the National Environmental Management Authority (NEMA) in corroboration with the county governmentto come up with suitable regulatory measures to inform and control sand mining activity in River Kivou.

REFERENCES

[1]. Orr, I., & Krumenacher, M. (2015). Environmental Impacts of Industrial Silica Sand (Frac Sand) Mining. United States.

[2]. Kondolf, G. M. (1997). Hungry water: effects of dams and gravel mining on river channels. Environmental Management, 21(4), 533–551.

[3]. Peduzzi, P. (2014). Sand, rarer than one thinks. Environmental Development, 11, 208– 218.

[4]. Lu, X. X., Zhang, S. R., Xie, S. P., & Ma, P. K. (2007). Rapid channel incision of the lower Pearl River (China) since the 1990s as a consequence of sediment depletion. Hydrology and Earth System Sciences Discussions, 11(6), 1897–1906.

[5]. Nabegu, A. B. (2013). The effect of sand mining on ground water in Kano river catchment. Journal of Environment and Earth Science ISSN, Vol. 3, No.2, 2013, 2224–3216.

[6]. Rinaldi, M., Wyżga, B., & Surian, N. (2005). Sediment mining in alluvial channels: physical effects and management perspectives. River Research and Applications,21(7), 805–828.

[7]. https://doi.org/10.1002/rra.884

[8]. Mwaura, S. K. (2013). The Effects of Sand Harvesting on Economic Growth in Kenya with case study of Machakos County. International Journal of Social Sciences and Entrepreneurship, (5), 342–350.

[9]. Wambua M. P. (2015). Environmental and socio-economic impacts of sand Harvesting on the community in river Kivou catchment, Mwingi Sub-County, Kitui County, Kenya. Unpublished M.A. Thesis. Kenyatta University.

[10]. Nabegu, A. B. (2014). Morphologic Response of a Stream Channel to Extensive Sand Mining. Research Journal of Environmental and Earth Sciences, 6(2), 96-101.

[11]. Nissen, P. (1982). Rain catchment and water supply in rural Africa. London: Hodder and stoughton.

[12]. Pulfrey W. (1954) Geologial survey report of kenya, Nairobi.

[13]. Mugenda, M. O., & Mugenda, A. G. (2009). Research Methods in Education: quantitative and Qualitative Approach, Nairobi.

[14]. Kondolf, G. M. (1994) Geomorphic and environmental effects of instream gravel mining. Landscape and Urban Planning 28: 225-243.

[15]. Kondolf, G. M., Smeltzer, M. and Kimball, L. (2002) Freshwater gravel mining and dredging issues. Center for Environmental Design Research. University of California, Berkeley for the Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation.

[16]. GOK, (2010). Government of Kenya. The 2009 Kenya National Census Results. Ministry of Home Affairs, Nairobi, Kenya.

Muiruri Philip Gathogo Social-Environmental Effects of River Sand Mining: Case Study of Ephemeral River Kivou in Kitui County, Kenya." IOSR Journal Of Humanities And Social Science (IOSR-JHSS), vol. 22, no. 11, 2017, pp. 31-37.