IMPACTS OF INSTREAM SAND HARVESTING ON WATER SUPPLY, A CASE STUDY OF RIVER THWAKE, MAKUENI COUNTY

BY

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DECLARATION

This project is my original work and has not been presented for any

Degree in any other university

SIGNED……..

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DATE……

This project has been submitted with my approval as the University supervisor

SIGNED……...

MOHAMMED DEKOW

DATE……

ACKNOWLEDGEMENT

I am also thankful to my supervisor **Mr Mohammed dekow** for the guidance and time that he provided during the period of my research.

I owe debts of gratitude to my sister **Christine Mwende** for the moral and financial support which made this report successful.

I would also like to thank all the people that I interviewed for the very importance information and assistance they accorded me.

DEDICATION

This work is dedicated to my late mother Mrs. Martha Kivuva.

ABSTRACT

This paper examines the impact of sand harvesting from rivers on the environment, water quality and quantity along Thwake River, Makueni County. Sand acts as a safe aquifer for water flowing below and through it. Removal of sand results in destruction of underground aquifers and loss of safe water.

Sand scooping adversely affects surface water quality and quantity and damages the aquatic ecosystem. Haulage of sand by heavy trucks causes environmental degradation by accelerating soil erosion and affecting soil stability. Storage of sand causes destruction of surface areas through clearing of vegetation and uses land that could be used for agriculture.

Related social and health problems include prostitution and high school drop-out rate leading to serious social and health problems. The beneficial effects of sand harvesting include local employment; however, the share of monetary benefits to locals is minimal.

The results show that the local community gains the least from sand harvesting, but stands to suffer the most if the degradation of the river system continues. Suggestions are made for safe and sustainable methods of managing sand harvesting, in which greater local involvement and stricter enforcement of regulations to protect the environment are vital. Therefore, the protection of water resource from destruction through activities such as sand mining is paramount for the survival of both present and future generations.

This research is a survey type of a research and employs quantitative methods of data analysis. Data was presented in form of graphs, tables and charts.

The objectives of this research are therefore to identify the impacts of sand mining along River Thwake on both water quality and quantity. It also seeks to identify the social impacts of sand harvesting on the nearby society.

This report describes in detail the major impacts both positive and negative of sand mining, and attempts to provide direction on how to resolve the negative impacts of sand mining. This it does through proposals and recommendations advanced later in this report.

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CHAPTER 1

1.1 Background information

For thousands of years, sand and gravel have been used globally in the construction of roads and buildings. Today, demand for sand and gravel continues to increase. Sand accumulation as layers of sand deposits in river courses is a dynamic phenomenon. Rivers all over the world are under immense pressure due to various kinds of anthropogenic activities due to rapid urbanization, among which indiscriminate extraction of sand and gravel is most disastrous, as the activity threatens the very existence of river ecosystems (Kondolf 1994; Rovira et al. 2005;).

Approximately 175,484 tonnes of sand are harvested yearly in the greater Makueni district with very little income earned being ploughed back to the local area for development. In recent years there have been increased concerns for maintaining high quality groundwater supplies as a result of the recognition of the potential negative impact of sand mining since the mining operations are often located in areas favorable for developing potable ground water.

Sand mining results in the destruction of aquatic and riparian habitat through large changes in the channel morphology. Impacts include bed degradation, bed coarsening, lowered water tables near the streambed, and channel instability. These physical impacts cause degradation of riparian and aquatic biota and may lead to the undermining of bridges and other structures.

In addition, continued extraction may also cause the entire streambed to degrade to the depth of excavation. Sand mining generates extra vehicle traffic, which negatively impairs the environment. Where access roads cross riparian areas, the local environment may be impacted.

Mining and dredging activities, poorly planned stockpiling and uncontrolled dumping of overburden, and fuel spills can cause reduced water quality for downstream users, increased cost for downstream water treatment plants and poisoning of aquatic life.

The aim of this study is therefore to assess the impact of sand mining on ground and surface water supply in adjourning areas of Thwake River in order to garner the necessary data that will provide information for proper regulation of the activity.

1. 2problem statement

Despite the values and functions of sand, its extract from rivers like Thwake river is leading to a number of consequences. Indiscriminate sand mining from the river Thwake is a threat to environment. On the other hand sand mining creates a large opportunity for direct and indirect employment.

Therefore there is inadequate information on sand harvesting in river thwake. The purpose of this study is to provide detailed and relevant information related to sand mining. This will enable laying strategies for the conservation and management of Catchment Rivers in a sustainable manner.

1.3 Research questions

The following questions were used to guide this study in attaining the desired objectives.

a) What is the impact of sand mining on water quality along river Thwake?
b) What are the impacts of sand mining on water quantity along river Thwake?
c) What are the impacts of sand mining on the bio physical environment
d) What are the social impacts of sand mining on the neighboring community?

1.4 Research objectives

a) To assess the Impacts of sand mining on water quality based on the findings from the research project.
b) To identify the impacts of sand mining on water quantity

c) To identify the bio physical impacts of sand mining on the environment

d) To identify the social effects of sand mining on the nearby communities

1.5 Research premises

The study was guided by the following premise

(i) That sand harvesting has no impact on the water quality

(ii) That sand harvesting has no impact on water quantity

(iii) That sand mining has no impact on the social lifestyle of the nearby society

1.6 Research justification

This research will provide an insight of complications associated with excessive sand harvesting on the environment. It will instigate the need to employ proper methods of sand mining management so as to ensure safe and sustainable methods of managing sand harvesting, in which greater local involvement and stricter enforcement of regulations to protect the environment are vital. The findings obtained from the performed research will be utilized to propose various remarks on the subject matter. Eventually, the final conclusion is based on the findings of the study and the actual research.

Upstream erosion as a result of an increase in channel slope and changes in flow velocity is also experienced. Furthermore, downstream erosion due to increased carrying capacity of the stream and downstream changes in patterns of deposition is also caused by this practice. Chemical and fuel spills of moving trucks cause reduced water quality for downstream users and also increased cost for downstream water treatment plants and poisoning of aquatic life. Suspension of streambed sediment, clearance of vegetation, and stockpiling on the streambed during sand harvesting lead to ecological impacts

1.7 Significance of the study

Findings and recommendations of the study will help stakeholders in formulating policies to protect and conserve the river and river valleys from destruction as a result of sand mining in the river valleys. This study will also help and guide stakeholders in the conservation or rivers; it will help create public awareness on the ecological and social economic values of rivers.

This study can also be replicated elsewhere here other rivers are threatened.

1.8 scope of the study

This study is confined to Thwake River in Makueni County. The study also focuses on the impact of sand mining on water quality, water quantity, bio physical and social environment

1.9 operational terms

Environment-All aspects of the surrounding of all human beings whether affecting human beings as an individual or in social groupings

Sand Means sedimentary material finer than gravel and coarser than silt with grains between 0.06mm and 2mm in diameter and includes stones, coral, earth and turf but does not include silica sand

Sand harvesting Sand harvesting", means the removal, extraction, harvesting or scooping of sand from designated sites.

EMCA, 1999 Environmental Management and Co-ordination Act, 1999

E.I.A Environmental Impact Assessment

CHAPTER 2

2.1 Literature review

Rapid increase in population of 3% per annum, unprecedented urbanization estimated at 40% and rising economic growth has led to increased and continued demand for river sand as material for housing and general infrastructure construction in Makueni region and the main source is from river channels because they provide high quality material at low cost.

River sand is particularly desirable because weak materials are eliminated by abrasion and attrition leaving durable, rounded and well-sorted materials that require less processing than many other sources (Barksdale, 1991) and are commonly located near the market or transportation routes.

However, sand mining has been shown to cause severe negative environmental impacts that are not reversible (Kondolf, 1997; Rovira, *et.al.*,2005; Rinaldi, *et.al.*,2005; Nabegu, 2012). One of the most serious and subtle but ignored negative consequence of sand mining is on ground water recharge and quality as a result of the extraction process (Herlling, 1982), because for centuries, humans have been enjoying the natural benefits provided by rivers without understanding much on the river ecosystem (Naiman 1992; Naiman and Bilby 1998), particularly alluvial channels such as Kano River (Lu *et.al.*, 2007). For instance, some of the characteristics that make sand a valuable resource also make it a very good aquifer and recharge materials.

Also, sand mining within an aquifer recharge area will increase the vulnerability of the aquifer to be contaminated because it decreases the distance between the ground water table and land surface. In some cases, the excavation actually penetrates the shallow aquifers, leading a direct access to ground water (Depreeze, 2000).

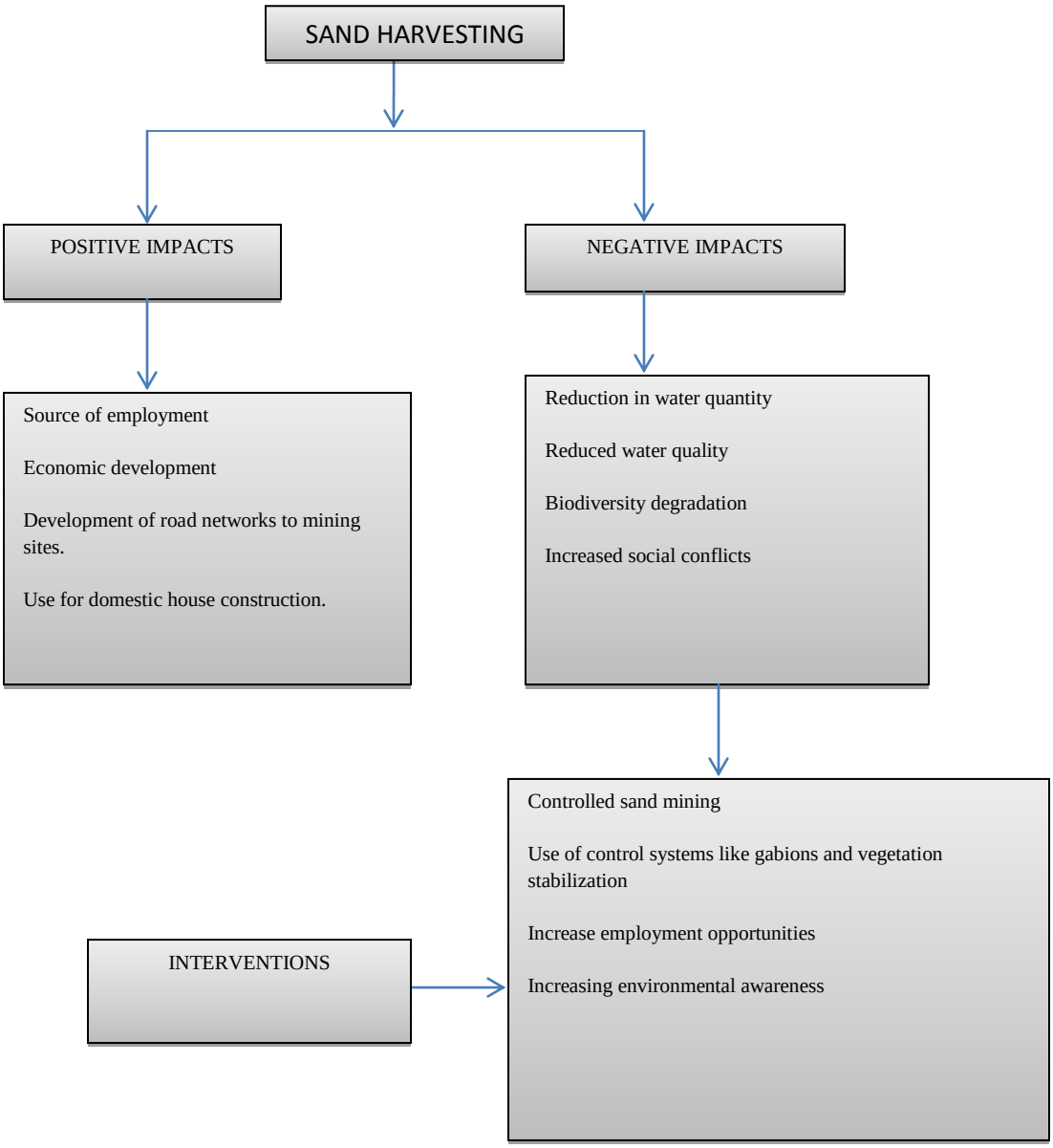
In recent years there have been increased concerns for maintaining high quality groundwater supplies as a result of the recognition of the potential negative impact of sand mining since the mining operations are often located in areas favorable for developing Potable groundwater.

Despite this, there have been no studies on the extent of sand mining operations or of the impacts in Makueni region. In addition, minimization of the negative effects of sand mining requires a detailed understanding of the nature and sources of the impacts on ground water resources (Kondolf, 1997,Rinaldi*et.al.*,2005, Rovira, *et.al.,* 2005) . Sand mining has also caused social conflicts among mining groups in the entire county (makueni county first intergrated plan 2013-2017).

The aim of this study is therefore to assess the impact of sand mining on water availability in adjourning areas of Thwake River in order to gather the necessary data that will provide information for proper regulation of the activity.

2.2 Conceptual framework

The conceptual frame work is based on the fact that sand mining has several impacts to the environment both negative and positive. The advantages of sand harvesting include giving a source of employment, economic development, development of infrastructure to mining sites and use as a raw material for domestic construction.



Consequently, the negative effects of sand mining include reduction in water quantity and quality, biodiversity degradation and increased social conflicts such as conflicts within the mining cartels.

The interventions will include controlled sand mining by policy makers like the county government, use of control systems like gabions and vegetation stabilization. Increased employment opportunities and environmental awareness would also help to reduce negative impacts of sand mining.

Other interventions would include encouraging participation in community based organizations hence reducing the effect of possible social conflicts.

2.3 physical effects of sand mining to the environment

Several studies have documented the river bed degradation is caused by the two general forms of in stream mining which include pit excavation and bar skimming

Bed degradation, also known as channel incision, occurs through two primary processes kno and "hungry" water.

In head cutting, excavation of a mining pit in the active channel lowers the stream bed, creatin locally steepens channel slope and increases flow energy.

During high flows, a nick point becomes a location of bed erosion that gradually moves upstrea

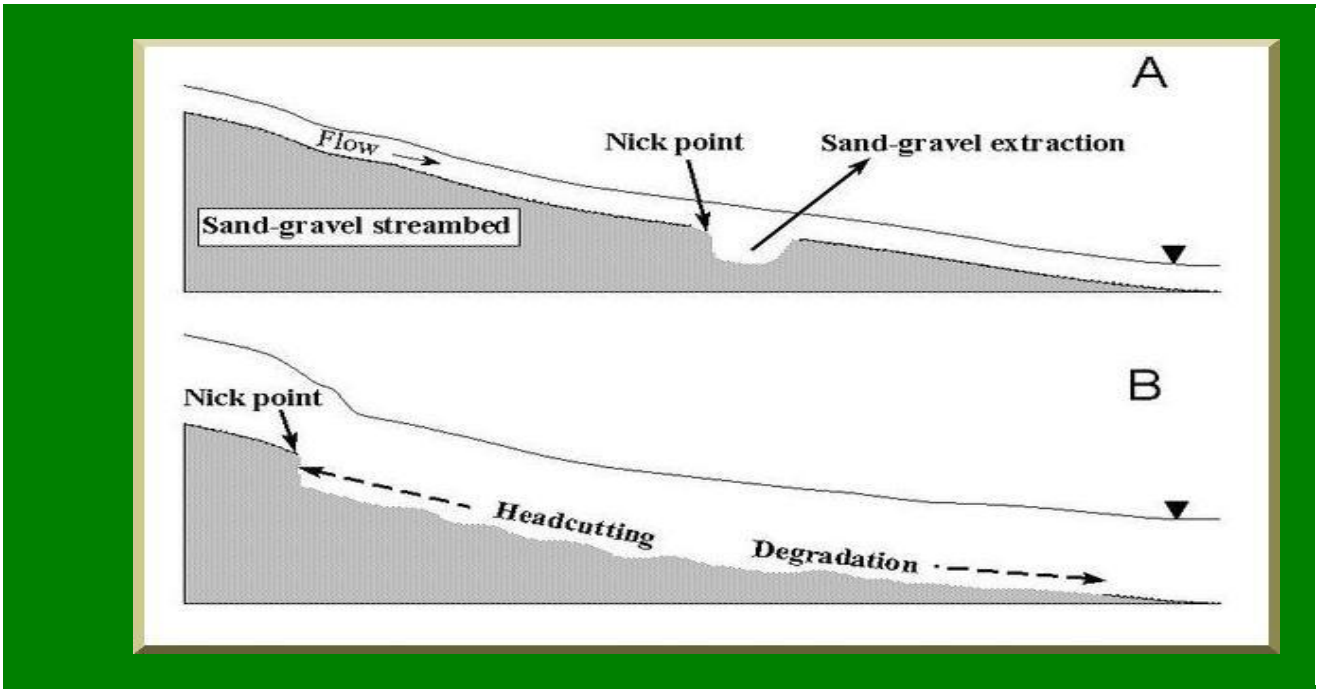


Fig. 1 Diagram of sand-and-gravel stream bed showing (A) the nick point that develops with a pit excavation, and (B) the upstream head cutting and downstream bed degradation that develop during high flows.

Head cutting mobilizes substantial quantities of streambed sediments which are then transported downstream to deposit in the excavated area and locations further downstream. In gravel-rich streams, effects downstream of mining sites may be short-lived when mining ends, because the balance between sediment input and

transport at a site can reestablish itself relatively quickly. Effects in gravel-poor streams may develop rapidly and persist for many years after mining has finished.

Regardless of downstream effects, head cutting in both gravel-rich and gravel-poor streams remains a major concern. Head cuts often move long distances upstream and into tributaries, in some watersheds moving as far as the headwaters or until halted by geologic controls or man-made structures.

A second form of bed degradation occurs when mineral extraction increases the flow capacity of the channel. A pit excavation locally increases flow depth (Fig. 1) and a bar skimming operation increases flow width (Fig. 2). Both conditions produce slower stream flow velocities and lower flow energies, causing sediments arriving from upstream to deposit at the mining site.

As stream flow moves beyond the site and flow energies increase in response to the "normal" channel form downstream, the amount of transported sediment leaving the site is now less than the sediment carrying capacity of the flow. This sediment-deficient flow or "hungry" water picks up more sediment from the stream reach below the mining site, furthering the bed degradation process (Fig. 1). This condition continues until the equilibrium between input and output of sediments at the site is reestablished.

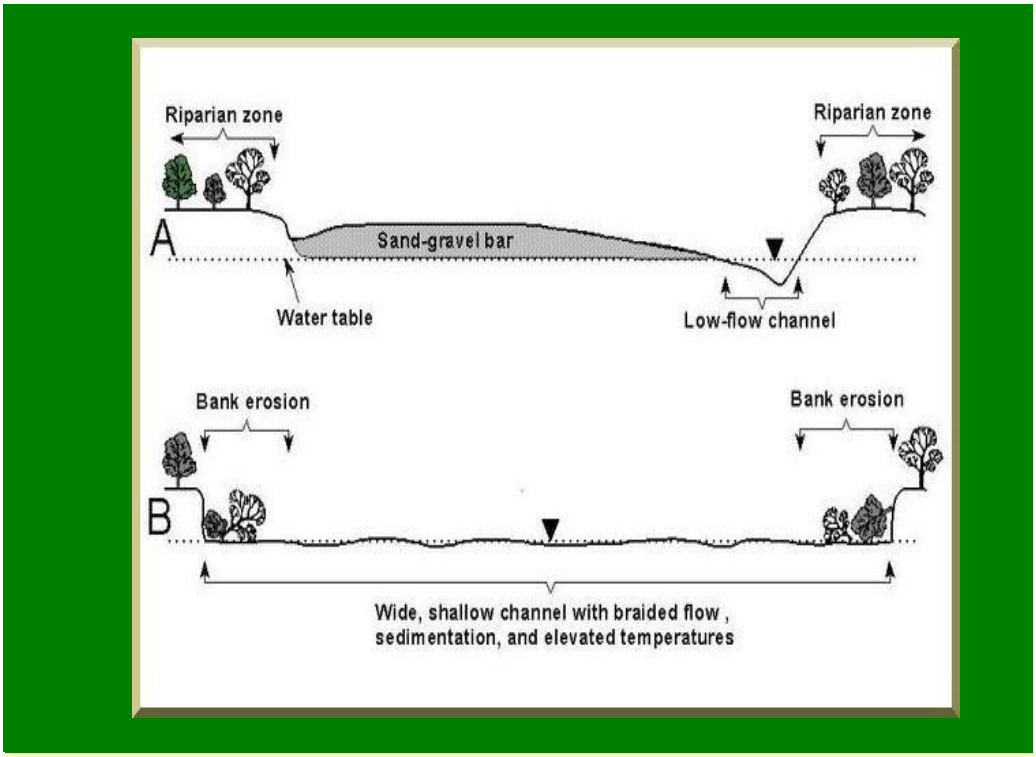


Fig. 2 Diagram of channel cross sections showing (A) a typical sand-gravel bar in relation to the low-flow channel, riparian zone and water table, and (B) the wide shallow channel that results from unrestricted mining and that is characterized by bank erosion, braided flow, sedimentation, and increased water temperatures.

A similar effect occurs below dams, which trap sediment and release "hungry" water downstream, where channel incision usually ensues. Instream mineral excavation

downstream of dams compounds this problem.

Although other factors such as levees, bank protection, and altered flow regimes also promote channel incision, mineral extraction rates in many streams are often orders-of-magnitude in excess of sediment supply from the watershed, suggesting that extraction is largely responsible for observed channel changes. Susceptibility to hungry-water effects would depend on the rate of extraction relative to the rate of replenishment. Gravel-poor streams would be most susceptible to disturbance.

Channel incision not only causes vertical instability in the channel bed, but also causes lateral instability in the form of accelerated stream bank erosion and channel widening. Incision increases stream bank heights, resulting in bank failure when the mechanical properties of the bank material cannot sustain the material weight.

Channel widening causes swallowing of the streambed (Fig. 2) as deep pools fill with gravel and other sediments. Swallowing and widening of the channel also increases stream temperature extremes, and channel instability increases transport of sediments downstream.

Mining-induced bed degradation and other channel changes may not develop for several years until major channel-adjustment flows occur, and adjustments may continue long after extraction has ended.

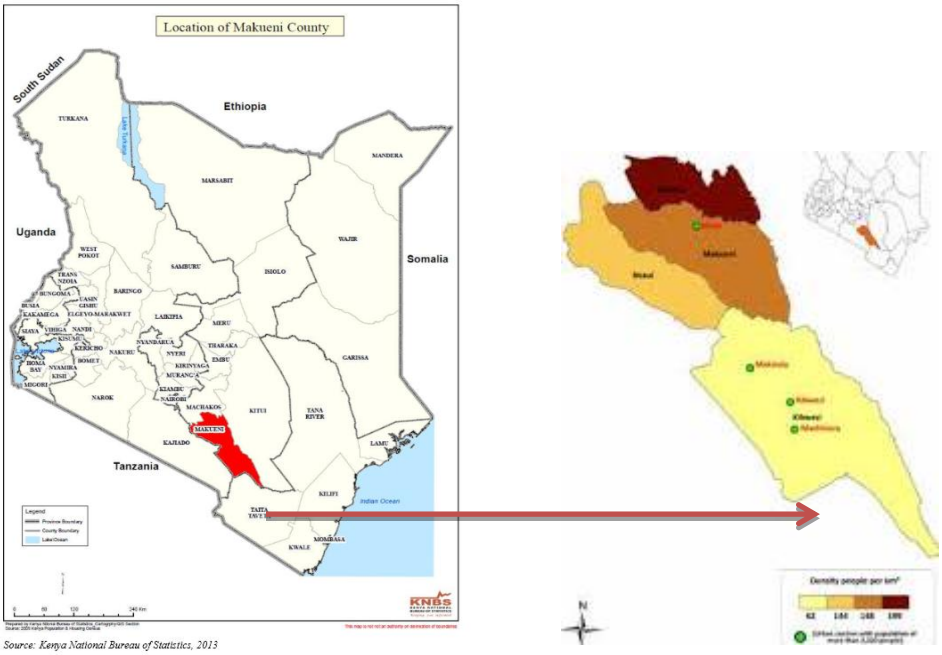
CHAPTER 3

AREA OF STUDY

3.1 Location and size

Makueni County which covers an area of 8,034.7 Km2 is one of the forty seven counties in the country. The County borders several counties which include Kajiado to the West, TaitaTaveta to the South, Kitui to the East and Machakos to the North. It lies between Latitude 1º 35´ and 30 00 South and Longitude 37º10´ and 38º 30´East.

Map 1: Location of the County in Kenya



Source: Kenya National Bureau of Statistics, 2013

The county lies in the arid and semi-arid zones of the eastern region of the country. The major physical features in Makueni County include the volcanic Chyulu hills which lie along the southwest border of the county in Kibwezi West Constituency, Mbooni Hills in Mbooni constituency and Kilungu Hills in Kaiti constituency which rise to 1,900m above

Sea level. The county terrain is generally low-lying from 600m above sea level in Tsavo at the southern end of the county.

In the year 2012 the projected population in the county was 922,183 consisting of 449,036 males and 473,147 females.

3. 2 Physical and Topographic Features

The county lies in the arid and semi arid zones of the eastern region of the country. The major physical features in Makueni County include the volcanic Chyulu hills which lie along the southwest border of the county in Kibwezi West Constituency, Mbooni Hills in Mbooni constituency and Kilungu Hills in Kaiti constituency which rise to 1,900m above sea level. The county terrain is generally low-lying from 600m above sea level in Tsavo at the southern end of the county. .

The main river in the county is Athi River, which is perennial and fed by tributaries such as Kambu, Kiboko, Kaiti, Thwake and MtitoAndei, which drain from various parts of the county. A few other streams flow from the Mbooni and Kilungu Hills but their flow becomes irregular as they move to the low-lying areas. These rivers provide a high potential for both large and small-scale irrigation.

3.3 Ecological Conditions

The county is largely arid and semi-arid and usually prone to frequent droughts. The lower side which is very dry receives little rainfall ranging from 300mm to 400mm. The depressed rains in the lower part of the county hardly sustain the major staple food of maize and beans. Unfortunately, the traditional crops which are drought tolerant have largely been abandoned.

This means livestock rearing remains the common viable economic activity being undertaken by the local people in the lower region. The condition has negatively affected agriculture which is the main economic activity in the county hence people have opted to do sand mining as an economic activity.

3.4 Climatic Conditions

The county experiences two rainy seasons, the long rains occurring in March /April while the short rains occur in November/December. The hilly parts of Mbooni and Kilungu receive 800-1200mm of rainfall per year. High temperatures of 35.8 C are experienced in the low-lying areas causing high evaporation which worsens the dry conditions.

Climate variations and extreme differences in temperatures can be explained by change in altitude. The areas to the North such as Kilungu and Mbooni hills are usually cool with temperatures ranging from 20.2 C to 24.6 C, while the low-lying areas of the South such as Kitise are usually hot. Generally, the county experiences high temperatures during the day and low temperatures at night. During the dry periods between May and October the lower parts of the county experience severe heat.

The Northern part of the county is hilly with medium rainfall ranging from 800mm to 1200mm and has high potential for food crop production. This part of the County, covering mainly in Kilungu and Kaiti has few natural and planted forests the area is therefore suitable for horticulture.

3.5 Administrative Units

The County is currently divided into six constituencies Mbooni ;Kilome Constituency ; Kaiti ; Makueni; Kibwezi West and East ; nine sub-counties and twenty five divisions as shown in Table Six. The sub counties are Makueni, Kilungu, Mukaa, Kibwezi, Kathonzweni, Makindu, Mbooni East, Mbooni West and Nzaui. Among the Divisions, MtitoAndei, Makindu and Kibwezi are the largest and are situated in the low potential areas of the County while, Kee, Mbitini, Kalamba, Kilome and Kasikeu are the smallest in that order.

Sub county	**Division**	**Area (Km².)**	**No of Location**	**No. of Sub location**
Kilungu	Kilungu	97. 2	3	7
	Ilima	62	4	9
Makueni	Kaiti	184	4	10
	Kee	81.9	2	6
	Wote	400.6	5	10
Kathonzweni	Kathonzweni	183.4	2	4
	Kithuki	148.7	2	3
	Kitise	291.5	2	4
	Mavindini	257.1	3	7
Mbooni west	Mbooni	141.6	4	11
	Tulimani	126	4	6
Mbooni East	Kisau	310.2	3	12
	Kalawa	330	4	14
	Kako Location	52.6	1	1
Kibwezi	MtitoAndei	931.2	6	6
	Kibwezi	817.7	2	11
	Machinery	127.1	2	3
Makindu	Makindu	880. 2	4	15
	Tsavo West	474.1	0	0

	National Park			
	ChyulluGame Reserve	724.3	0	0
Mukaa	Kilome	101.6	2	4
	Malili	257.5	3	6
	Kasikeu	108.6	2	4
	Kiou	16. 2	2	5
Nzaui	Mbitini	84.5	3	10
	Mulala	145. 2	3	13
	Matiliku	109. 2	2	6
	Kalamba	93.7	3	4
	Nguu	350.3	5	15
Total		8034	82	2 06

Source: County commissioner's office Makueni

CHAPTER 4

Design and methodology

4.1 Research design

This study was conducted between October 2013 and April 2014. A part of Thwake River at Makueni County was surveyed to ascertain the number and location of active sand mining. To assess the impact of sand mining, the channel was divided into three sites based on the technique used by Brown et.al.(1998) consisting of upstream of the active mining, active mining area and downstream of the mining area.

The upstream of the mining site was assumed to be undisturbed and was thus considered as reference site. The mining site was an area of active sand mining. The downstream area was the area with no active mining but, within the impact of the mining activity.

4. 2 Nature and sources of data

In order to determine the impact of sand mining, inventory of boreholes, wash bore and open wells around the three sites was conducted within a one kilometer radius. Fifty water samples in each of the three sites at various flow levels were collected for nephelometric turbidity analysis.

To determine historic changes such as age of wells and rate of well failure, interview was conducted with 25 respondents who use wells for irrigation, domestic and other purposes in each of the three sites**.**

4.2.1 Secondary data

Secondary data was obtained from several sources such as journals, reports, books, magazines, publications, National and district development plans, manuals and documents relevant to the study. These documents were obtained from different ministries, libraries, local authorities and the internet.

4.2.2 Primary data

Primary data was obtained from households where the information about the impacts of sand mining on human settlement, social-economic and physical environment was sorted. Sand traders were also interviewed and the output tonnage over years was be analyzed.

4.2.3 Target population

In order to achieve the objectives of this study, the target population consisted of 22,183 households (GOK 1999), A sample of public health officers, sand mining companies and groups. In addition to that defined target population, the other means of ensuring an adequately chosen and representative sample, 500m distance from the sand mining sites that locates within the target population was demarcated from the map of the study area from which to take the sample.

Stratified random sampling of human settlements was undertaken. Due to time and financial constraints, 15 households were interviewed.

4.3 Data analysis and presentation

To achieve the purpose and objectives of the study, various methods and techniques were applied in data analysis and presentation. The data collected was summarized in tables, graphs and charts.

The data was analyzed quantitatively by describing it. The collected responses were tabulated and appropriate analytical methods selected and used for analyzing the data. This took into account the variable to be measured.

The findings were presented in the form of short discussions, graphs, percentages and tables. The recommendations and conclusions of this study were based on the findings.

4.4 Research instruments

The research instruments which were used in data collection included Questionnaires, Oral interviews, photography and random sampling.

CHAPTER FIVE

5.0 Data analysis and discussion

This chapter entails attempts to analyze the recorded data from interviews, questionnaires, photography literature review and the observed data in relation to the set objectives of the study. This chapter also analyses the impact of sand mining on wells situated within 1km radius.

The channel was divided into three sites consisting of Upstream of the active mining, the active mining area and the downstream of the mining area.

The upstream of the mining site was assumed to be unaffected by sand mining and was thus considered as reference site. The mining site was an area of active sand mining. The downstream area is the area with no active mining but, within the impact of the mining activity.

Plate 1 and 2 showing mining activities that take place at the mining site

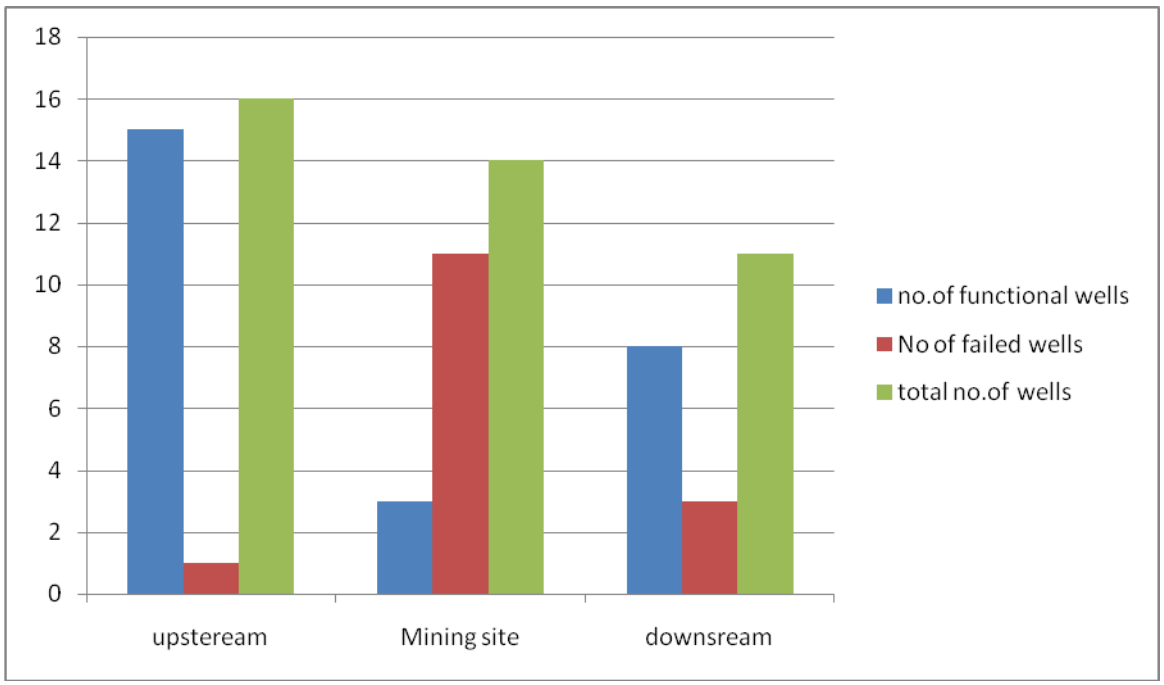
In order to determine the impact of sand mining, an inventory of bore holes and open wells within one kilometer radius in the three sites was taken and fifty water samples at each of the three sites at various flow levels was taken for water availability and turbidity analysis.

To determine historic changes on the wells such as age of wells and well failure rate, interview was conducted with 25 respondents who use wells for irrigation, domestic and other purposes in each of the three sites.

The officer responsible for the Mbooni sub-county regional water scheme that operates 90% of all boreholes in the area was also interviewed.

The graph below shows that the majority of the wells 39% are located in the upstream site and the least 26%, in the mining site and 34% downstream.

Figure 1.1 Distance between mining activity and well failure

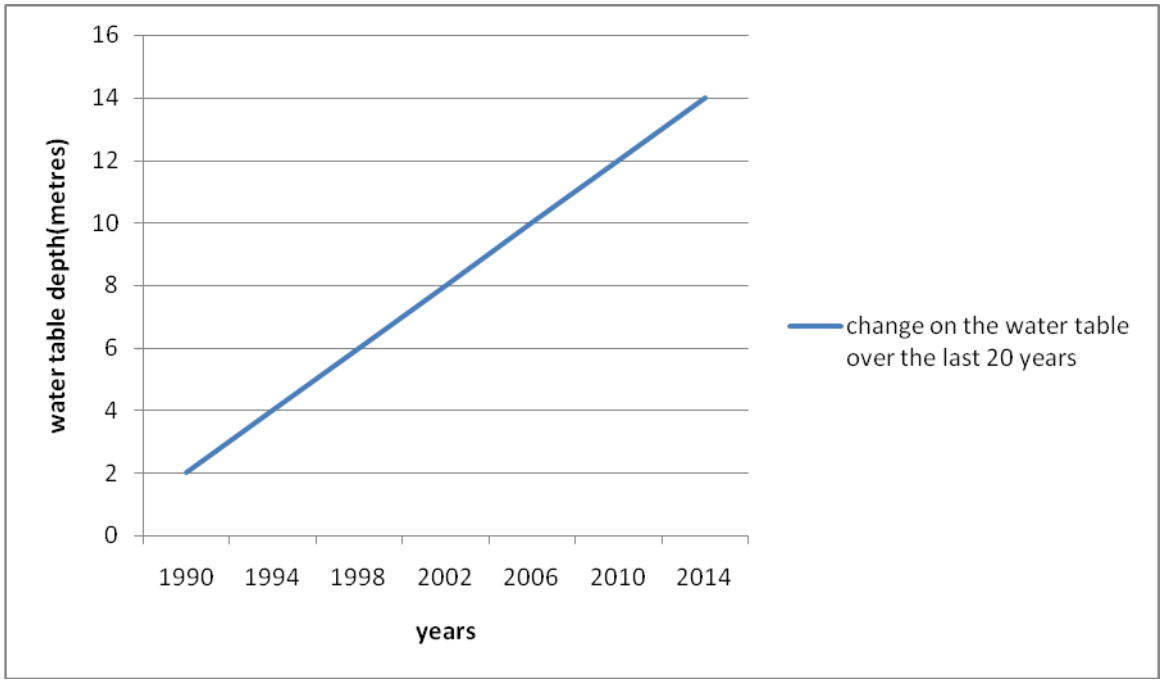


The boreholes are used for the municipal water supply to major towns like Wote in the region. They are also the major source of domestic water for the residents.

The absence of boreholes and wells in the mining site is due to the fact that they are the most susceptible to sand mining impact because sand mining results in the river channel turning into large and deep pit as a result of continuous excavation, consequently, the groundwater table drops. According to (Depreeze, 2000), when sand mining becomes intense, the vertical and lateral movement of water is checked and affects the recharge of groundwater and due to the drop in ground water levels, quantity and quality of water is affected negatively especially during the dry season when there is no rainfall.

Interview conducted with the users of the wells indicate that in the mining site, groundwater table has been lowered up to 13 meters from 3 meters in the last twenty years. It was also observed that the ground water levels in this area stabilized at 4 meters in the rainy season (July – September) but drops to 7-9 meters in the dry season (November –June) .

Fig 1.2 change of the water table over the last 20 years



5.1.1 Impact of mining on Age of Wells

The Age of well refers to number of years a well has functioned (Thrivikumaji, 1993). According to the interviews and questionnaires conducted, Bore wells in mining site have an average life span of 5 years, downstream 11 years and upstream 24 years.

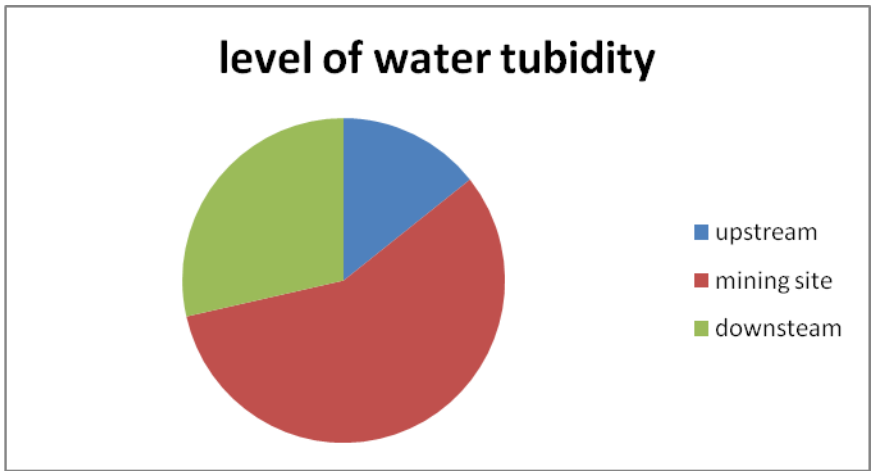
The age of well illustrate the impact of sand mining on ground water and this is reflected in the rate of well failure, which is 80 % in the mining site compared with downstream 24% and upstream 15 % . Figure 1.1illustrates the variation in failure between well types in the different sites. Secondly, as sand is extracted rapidly, groundwater evaporates fast, reducing groundwater recharge, increasing initial and premature failure of wells (Landsberg, 1982).

5.1.2 Impact of mining on Ground Water Quality

Table 1.2 shows the mean turbidity of water collected in the three sites. Turbidity is the cloudiness or murkiness of water, which is an expression of the optical properties of water, which cause the light to be scattered and absorbed rather than transmitted in straight lines.

It is therefore commonly regarded as the opposite of clarity (Was et al., 1997). Turbidity impairs the suitability of the water for many purposes. The pie chart indicates that turbidity is significantly higher in the mining site with the mean turbidity levels three times the levels than upstream.

Fig 1.2 showing level of water turbidity in the three sites



High levels of mean turbidity in the mining and downstream sites is due to increased riverbed and bank erosion associated with sand mining which increases suspended solids in the water at the mining and downstream sites. Mining operation also release fine sand and small silt particles that are present in the stream.

Although water turbidity does not pose a serious problem to ground water since it is unable to migrate beyond the immediate infiltration site, the continual infiltration of the turbid water does raise the potential for other sources of contaminant to migrate to the aquifer because it decreases the distance between the ground water table and land surface. In some cases, the excavation actually penetrates the shallow aquifers.

Plate 1.3 showing high water turbidity in the mining site

This is particularly the case with a shallow river, like the Thwake River with a mean depth of 3- 4 meters. Any chemical contaminants that are allowed to enter wash water or spills in the area would have quicker access to the aquifer.

Once in the ground water, a chemical substance would be free to move with the water in the aquifer.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSION AND RECCOMENDATION

Introduction

This section compares the findings from the data analysis in chapter five with the objectives of the study in chapter 1 to assess whether they have been realized.

6.1 SUMMARY OF FINDINGS

The sand mining industry is a very important industry. The industry provides employment for the youth and also plays a very important role in building the county's economy. Consequently, the river basins have been scooped off the sand to the extent of leaving either bare rock or the muddy soils.

Local people hardly benefit from this activity. They are paid very little which is not enough to sustain the natural resource. The County environmental committee has however made some efforts to bring some sanity in the utilization of the resource.

The Makueni Governor formed a sand harvesting taskforce to come up with recommendations on the best way to continue with sand harvesting business in a way that is environmentally sustainable, commercially beneficial to the local community. Their task is to make recommendations that would help move the county towards sustainable management and protection of natural resources hence improving water supply in the county.

6.2 RECCOMENDATIONS

The recommendations made as a result of this study are based on several principles. First, policy makers and the local people have the enormous task of protecting the environment. This requires inter-sectoral co-operation and community participation in the management of the river ecosystem.

Second, a controlled sand harvesting system can only come about if there are serious planning effort and clear political thinking.

Third, the provision of basic needs, poverty alleviation, the raising of economic well-being of the people, and improved technology will reduce the reliance on sand mining. Fourth, dealing with sand mining crises requires new scientific knowledge, new engineering and technology as well as new practices and methods. Based on these principles the following recommendations are made:

Increasing employment opportunities

Agriculture and fishing should be made lucrative. This involves the introduction and extension of improved modern production techniques that are affordable to farmers. This can include introduction fish ponds. Furthermore, the promotion of small scale businesses such as poultry and carpentry can reduce the problem of over dependence on sand harvesting.

To achieve this, enabling environment should be created through the provision of basic facilities like better access roads, electricity and water supply.

Regulating sand mining

The county government should regulate the activities carried out by sand miners. Local citizens in the neighboring areas should be allowed to utilize sand to build their own houses.

When sand mining is carried for commercial basis, licenses or permits should be given by the county government. These licenses should be awarded to contactors who are able to prepare Environmental Impact Assessment to demonstrate their competence, technological know-how to deal with environmental degradation. The activities of these contractors should be closely monitored and evaluated to ensure effective implementation of the regulatory strategy.

Increasing environmental awareness

A change in altitude is required for successful implementation of an environmental management plan. Therefore, application of environmental education is very important. This would change people's values, altitude, skills and behavior needed for sustainable development. The environmental education should be based on the integration between sand harvesting and social environmental factors.

Public education programs about sand harvesting in relation to water supply should be done from the national to county level.

Encouraging participation in community based activities

The communities near the river should adopt a participatory planning and decision making approach. When people are directly involved in planning and decision making process, they will be willing to contribute to community projects.

The County government should conduct workshops; seminars and field work for their employees so that they can interact with communities better. Another aspect of encouraging community participation highlighted by Cruz (1996) is use of participatory management and negotiations to resolve conflicts.

6.3 CONCLUSION

Constructions and extraction has been widely recognized for its significant importance to the building industry and the State's economy. However, without appropriate sitting and management, sand extraction can have impacts on the surrounding environment and water resources.

It has also come out clear that the premises in chapter one that the river has several social economic benefits is true. It is also evident that there are inadequate measures to control the situation of sand mining.

Therefore, the recommendations outlined in this report should be implemented for better management of sand harvesting.

APPENDIXES

7.1 APPENDIX 1: RESEARCH QUESTIONNARE

KENYATTA UNIVERSIRTY

Preamble

Dear sir / Madam. My name Kivuva mutiso, Undergraduate student at Kenyatta University (Registration Number: N36/2477/2010).This questionnaire has been designed as part of an academic study for **Assessment of the Impacts of Sand harvesting on water supply along Thwake river**. Kindly answer each of the questions to the best of your ability and your contribution is important. You are hereby assured that the information provided will be treated with confidentiality and be applied for academic purposes only. Be assured as well that any images or photographs captured and obtained during this field work are only to serve none other than academic purposes.

Part A: General household information

ID	Name	Age	Sex	Education level	Occupation
1					
2					
3					
4					
5					
6					

Use the codes below for education level and occupation

CODE A:(Education Level) CODE B: (Primary occupation)

1. Primary
2. Secondary
3. Craft/ Vocational/ Certificate
4. Diploma

5. Higher National Diploma
6. University
2. Self employed
3. Civil servant
4. Retired
5. Unemployed
6. Student /Pupil

1. Did you migrate or born Makueni county | Yes | NO |

2. If migrated, for how long have you lived here?.....

3. And why did you decide to settle here?(Tick where appropriate)

a)Employment b) Business c) Political factors

d) Specify others……

Part B: Sand harvesting information

4. Are you aware of sand harvesting in Thwake River?

a)Yes b) No

5. If yes, is sand mining in the area regulated by any institution?

a)Yes b) No

6. If yes, state the institution(s)

……

……

…….....

7. Are you aware of any relevant policies and regulations used to regulate sand harvesting?

(Yes or No)……If yes, can you name them?

……

……

……

8. Which methods are used in sand harvesting in Thwake River?

a) In-stream mining b) Off-stream mining

c) Specify any other(s) ……

9. Are the sand harvesting procedures carried sustainably for the method(s) identified above? (Yes or No) ……. If no, state how wrong they are carried.

……

……

……

10. From question above (9), what are the physical environmental impacts the sand harvesting procedure(s) and activity caused?

……

……

……

……

……

11. Has the relevant authority(s) been able to regulate the stated impacts? (Yes or No)……

a) If Yes, state the measures which have been enforced.

……

……

……
……

b) If No, can you state the gaps which have not been fully regulated.

……
……
……

12. Have all the relevant stakeholders be fully engaged in regulating sand harvesting? (Yes or No)……. If Yes, how effective have they been engaged ?

……
……
…….....

13. Can you propose some measures to be taken to regulate sand harvesting along Thwake River in kathiani sub-County?

……
……
……

7.2 APPENDIX 2:

INSTITUTIONAL INTERVIEW GUIDE

KENYATTA UNIVERSITY

Institutional Interview Guide

Name of Institution: …….....

Person Interviewed:

……..……..

Date & time of Interview: ……..

Preamble

Dear sir / Madam. My name is kivuva mutiso, Undergraduate student at Kenyatta University (Registration Number: N36/2477/2010). I would appreciate your contribution to this study on Assessment of effects of Sand Harvesting on water availability along Thwake River, Makueni County. Please, any information provided will be kept strictly confidential, according to research regulations of Kenyatta University. Thank you for your willingness.

Interview Questions

1. For how long have your institution been operating?……

2. Are aware of sand harvesting taking place along Thwake River? (Yes or No) ……

3. If Yes from question (2), are there policies and regulations enacted to regulate the activity?

(Yes or No)……. If yes, can you state them?

……

……

……

……

4. Are the policies and regulations adequately enforced?

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……

……

……

5. Are there gaps which are hindering full enforcement of the policies and regulations?

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……

……
……..

6. How can these gaps be streamlined to ensure sustainable sand harvesting?

……
……
……
……..

7. Are the procedures carried out in sand harvesting along Thwake River sustainable? (Yes or No)…….. If No, What effects do they have on water supply?

……
……
……
……..

8. What impacts do these effects have to the community welfare in the entire sub-county?

……
……
……
……

9. How can these effects be mitigated and regulated?

……
……
……
……

10. Has the relevant stakeholders been engaged in regulating the activity by institution? (Yes or No) ……. If Yes, what achievements has been attained?

……
……
……
……..

11. If No, what steps are there been taken to involve relevant stakeholders?

……
……
……
…….

12. Does the institution have any proposed strategies to enable sand harvesting in the area?

……
……
……
……..

13. Can you propose any measures to be taken to mitigate sand harvesting?

……
……

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