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Master of Geo-Information for Environmental and Sustainable Development

ENVIRONMENTAL IMPACTS OF SAND HARVESTING IN RWANDA. CASE STUDY OF KAJEGEMBA WETLAND, KAMONYI DISTRICT, SOUTHERN PROVINCE

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RESEARCH PROJECT

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A research Project submitted in partial fulfillment of the requirements for the Award of the Degree of Master of Science in Geo-Information for Environmental and Sustainable Development in the School of Architecture and Built Environment

Kigali, August 2018

DECLARATION

I hereby declare that the study on "ENVIRONMENTAL IMPACTS OF SAND HARVESTING IN KAJEGEMBA WETLAND is my original work and has never been submitted for a degree award in any other University.

Signature …… …Date…….

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Abstract

Nowadays, the demand for sand in Rwanda has increased tremendously as a result of rapid economic development and subsequent growth of construction sector. This, in many ways, has resulted in uncontrolled mining of sand resources wherever they occur in the country leading to severe damages to environment. The case is rather alarming in Kajegemba wetland, Kamonyi District, Southern province, Rwanda. This study was therefore carried out to investigate the environmental impacts resulting from sand harvesting in Kajegemba wetland. Data used in the present study were collected through desk review, field observations, survey, interview and laboratory analysis of water sample. The study revealed that irrespective of the large quantity of sand being mined from the wetland with its economic importance, sand mining activities in the wetland are causing much harm. Results of the field observations show that land degradation, water pollution showed by high turbidity of water, erosion, loss of vegetation and collapsing of stream banks (90 m over), are the major environmental effects that result due to sand mining in the area. 0.2 % of the wetland has been found to be degraded. Water of the streams in the wetland were highly turbid (18-21 Turb NTU) because of high sediment deposit as a result of sand mining activities. Restoration of the created pits to prevent from the spread of disease transmission vectors, water retention, erosion, land collapsing, etc. would be a remedy to the environmental problems related to sand harvesting in the area. Also, sand mining activities should be carried out in selected places not in every corner of the wetland. Sand mining activities should be carried out in controlled and organized way to ensure that the environment is protected.

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I also address my full gratitude to the University of Rwanda for his financial support during my studies. Special thanks to my colleagues and any other person who gave me any support especially local authorities of Kamonyi district and all interviewees who responded to my survey and interview questionnaires, I kindly give my sincere gratitude.

Edouard MICOMYIZA

Dedication

This research is dedicated to:

My beloved wife Joy KWIZERA,

My daughter MICOMYIZA IZERE Anaïs,

My Sons MIZERO MICO Anaël and NDIZEYE MICO Ariel, and

MVUYEKURE and NAHIMANA families for their unwavering support throughout the study**.**

Table of contents

List of Tables

List of Figures

List of Appendixes

List of abbreviations and acronyms

µS/cm:	Microsiemens per Centimeter
CST:	College of Science and Technology
DO:	Dissolved oxygen
DS:	Down Stream
EC:	Electrical conductivity
F:	Female
GoR:	Government of Rwanda
GPS:	Global Positioning System: GPS
HOD	Head od Department
M:	Male
NTU:	Nephelometric Turbidity Unit
pH:	Potential hydrogen
RCC:	Reinforced Concrete Cement
REMA:	Rwanda Environmental Management Authority
RSBS:	Rwanda Standard Bureau
SABE	School of Architrcture and Built Environment
SPSS:	Statistical Package for Social Science
UNEP:	United Nations Environment Programme
UR:	University of Rwanda
US:	Up Stream
USA:	United States of America
WHO:	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

All over the world, wetland ecosystems are being over exploited in order to meet the growing demand for various natural materials including sand. In many places of the world sand is extracted either from rivers, river beds, floodplains, land, and wetlands. The use of sand and gravel as the most important aggregate materials in the construction of buildings, roads, dams and civil engineering works, and the production of bricks, glass, and sandpapers, and reclamation as date from ancient times Padmalal and Maya (2014). Kondolf (2000) reported that the ever-increasing population and economic developments impose an exponential rise in their demand throughout the world. The increasing demand for sand and gravel to make the concrete for the buildings has resulted in an increasing production of those raw materials leading to the destruction and degradation of coastal, riverine and lacustrine ecosystems, and the changes in hydrological and coastal flow regimes that alter their ecological character and affect the species dependent on them. Unfortunately, according to Hemalatha, Chandrakanth et al. (2005), sand has no substitute for use as building material in reinforced concrete cement (RCC).

Today, sand is still used intensively in construction industry but currently there are also many other industries that use this natural resource like metals processing and plastic industries. Hence, sand is used as a principal constituent in many construction materials such as cement, mortar, tile, brick, glass, adhesives, ceramics, etc.; and it has an important role in water filtration. These multiple utilizations led to an exponential consumption growth and this trend is expected to continue due to population growth and increasing standards of living Gavriletea (2017). Nowadays, after fresh water, sand is considered as the second most consumed natural resource worldwide. The United Nations Environment Programme UNEP, (2014) stipulates that “sand and gravel represent the highest volume of raw material used on earth after water “but also sounded the alarm over the fact that “their use greatly exceeds their natural renewal rates”

In Rwanda, sand harvesting is also an important economic activity and a large number of people in rural areas rely on that activity. Sand is mostly harvested from rivers, and associated valleys and wetlands. Wetlands are known to be the world’s most productive ecosystems. Wetlands are sources of wildlife, fish, wood and several non-timber products that are widely used by

neighboring populations. Most importantly, wetland soils can have great agricultural potential when properly used Chemonics International Inc., (2008).

According to REMA (2008) wetlands in Rwanda are used in different ways and have a great role to play in the national economy. The main functions of wetlands include agriculture production, hydrological functions, biodiversity reservoirs, flood mitigation, peat reserve, mitigation of climate change, groundwater recharge, sediment and pollution retention, leisure and tourism and cultural value. Goods and services provided by the wetlands constitute an important contribution to the social wellbeing of many rural households facing food insecurity, poverty and vulnerability. Over the recent years, population growth coupled with the growing demand for agricultural production and economic development have led to the conversion of wetlands into agricultural land. According to REMA (2008), reclamation of wetlands is acute since 1990 and, to a large extent, was supported by the government with the aim to boost agricultural production, revitalize the rural economy and reduce poverty REMA (2008). That process resulted in wetland degradation especially for wetlands located outside protected areas.

The degradation of wetland is caused by various human activities carried in those ecosystems. Human activities that threat wetlands in Rwanda include settlements and road construction, drainage, unplanned conversion of wetlands into agricultural places, municipal and industrial pollution and excessive harvest of various products REMA, (2006). Land use practices such as trampling of stocks, human disturbances, burning of vegetation, soil excavation processes have devastated vegetation cover to such an extent that the soil surface of areas has become susceptible to erosion REMA (2008).

Unregulated or poorly regulated exploitation of products like clay, peat and sand also constitute an important threat to many wetlands in various part of the country and people living in the immediate surroundings. The dangers to human life and health associated with sand harvesting include the displacement of people, land use changes, dust and noise pollution among others. For instance, Kajegemba wetland, located in Kamonyi district, Southern province is a place where acute environmental impacts associated with extraction of huge quantity of are observed Kondolf (2000).

Today, sand is still used intensively in construction industry but currently there are also many other industries that use this natural resource like metals processing and plastic industries. Hence, sand is used as a principal constituent in many construction materials such as cement, mortar, tile, brick, glass, adhesives, ceramics, etc.; and it has an important role in water filtration. These multiple utilizations led to an exponential consumption growth and this trend is expected to continue due to population growth and increasing standards of living Gavriletea (2017). Nowadays, after fresh water, sand is considered as the second most consumed natural resource worldwide. The United Nations Environment Programme UNEP, (2014) stipulates that "Sand and gravel represent the highest volume of raw material used on earth after water "but also sounded the alarm over the fact that "their use greatly exceeds their natural renewal rates"

Since sand and gravel can be extracted easily from river sources and such deposits do not require much processing other than size grading, most of the tropical and subtropical countries still depend on river sources such as in stream, floodplain, and terrace deposits, to meet their aggregate requirements, especially sand- the fine aggregate -in construction works. But it is now well understood that continued and indiscriminate sand mining can cause irreparable and irreversible damages to the ecological and socio-economic environments of the region, in the long run Walker (1994); Kitetu and Rowan (1997); Kondolf (2000); Padmalal and Maya (2014)

.

1.2 Problem Statement

According to UNEP (2014), sand is the second most consumed natural resource after water. Sand may be extracted wherever it appears but mostly it is harvested in wetlands hence affecting wetland main functions and uses. Many studies carried out by different researchers Mensah (1997); Kondolf (2000); Hemalatha, Chandrakanth et al. 2005; John (2009); Padmalal and Maya (2014); Gavriletea (2017), assessed the environmental impacts associated with sand mining or exploitation in various parts of the world.

In Rwanda, there are many rivers and associated wetlands where sand is harvested for various purposes. Sand mining is an important economic activity for many rural people who live in the vicinity of place where sand, gravel and stones are found. In some places, working in quarries is likely the most important off-farm job. There are many rivers and associated rivers and wetlands well renowned for sand extraction, among them is Kajegemba wetland.

Kajegemba is the midstream of Kajegemba wetland located in Kayumbu sector, Kamonyi district southern Province. Kajegemba is one stream of Kayumbu river but because the stream is not well known, people use Kayumbu to refer to that valley. This valley has become popular because the quality of its sand that is used in construction. Since some years back, this wetland has become the main provider of sand for Kigali. Indeed, Kigali is rapidly growing and huge buildings are mushrooming. Another part of sand extracted there is used in the city of Muhanga. Consequently, thousands of tons of sand are extracted every year in that valley. The bulk of sand extracted can be roughly estimated by the number of sand piles and sand pit found in the valley. Currently, it is not well documented how Kajegemba wetland has been affected by sand mining activities. Therefore, this study will clarify to which extent the environment in Kajegemba area is affected by sand exploitation in the wetland, especially in the national context where the government is interested in the good management of wetland with the aim of using them to boost agricultural production REMA, (2008).

1.3 Justification of the study

Kajegemba wetland is a narrow wetland characterized by a sandy soil. A great number of people who live in the immediate vicinity are employed in sand collection that is one of the major sources of income generation. However, the environmental consequences associated with that extraction are not well documented and this constitutes a problem of concern. Thus, the research findings from this study will be translated into recommendations that will help the Government of Rwanda (GoR) and the local community around Kajegemba wetland to mitigate environmental problems related to sand harvesting in the area.

1.4 Objectives

1.4.1 General Objective

The overall objective of this study is to evaluate environmental impacts associated with sand harvesting in Kajegemba wetland and suggest possible mitigation measures to cope with these problems.

1.4.2 Specific Objectives

Specific objectives of this study will

1. Investigate the impacts of sand harvesting on land degradation,
2. Investigate impacts of sand mining on water quality,
3. Investigate impacts of sand mining on land cover, and finally, and
4. Suggest efficient and effective alternative and mitigation measures to cope with the negative environmental impacts of sand harvesting.

1.4.3 Research questions

The current study will address the following research questions:

1. What are the impacts of sand harvesting on the environment in Kajegemba wetland?
2. What are the impacts of sand mining on water quality in Kajegemba wetland?
3. What are the impacts of sand harvesting on land cover in Kajegemba wetland?
4. What are efficient and effective alternative and mitigation measures to cope with the negative environmental impacts of sand harvesting?

1.5 Delimitation

The study will only focus on environmental impacts of sand harvesting activities on land degradation, hydrological aspects and biodiversity changes and it will be limited on sand contractors and population that are in vicinity of the Kajegemba wetland in Kamonyi district; Rwanda.

CHAPTER TWO: LITERATURE REVIEW

1.1 Introduction

Soil constitutes an important source of raw materials like clay, sand, gravel and minerals. It is a non-renewable natural resource with potentially rapid degradation and depletion rates and extremely slow formation and regeneration processes John (2009); Saviour (2012).

Sand as a soil resource is made up of very small pieces of rocks and minerals, a result of weathering that forms beaches and deserts. The durability of sand makes it suitable raw material for building constructions but its extraction impacts negatively on the environment. Many researchers Hill and Kleynrans (1999); Mahasenan, Smith et al. (2003); Krause, Diesing et al. (2010) have analyzed negative environmental impacts of sand exploitation activities around the world, and the conclusion was that sand harvesting is becoming an environmental issue as the demand for sand is increasing tremendously in the construction industry.

1.2 Sand exploitation in the world

Sand is exploited in all the continents, in developed countries and developing countries as well Asabonga, Cecilia et al. (2017). Worldwide, sand is produced, processed and used in construction industry and other manufacturing industries. The use of sand is more pronounced in the developed and fast-growing nations in Asia and Latin America. Rapid industrialization, urbanization and associated developments, are the main causes of the over-exploitation of the river bed materials such as sand and gravel. Sreebha and Padmalal (2011) have noticed that, during the past few decades, the need for sand and gravel has risen exponentially in order to meet its ever-increasing demand particularly in the construction sector. Sand is exploited from different environment sources such as rivers, streams, land, etc. All over the world, the exploitation of sand is associated with considerable impacts on the environment. Sand and gravel extraction have been one of the serious environmental problems around the globe in recent years. Some of these impacts were identified to be deforestation, loss of biodiversity, soil erosion, water pollution and acid drainage.

The leading countries in mining and processing sand and gravel are United States of America, Australia, Austria, Belgium, Brazil, India, Spain, Nigeria, Kenya and South Africa. Since sand is a cheap and readily accessible resource many companies are involved in its mining both legally and illegally without considering the damage it is causing to the people and environment Draggan (2008).

Various studies Bagchi (2010); Tillin, Houghton et al. (2011); Aromolaran (2012) have revealed that sand is strategic to global economy as it is cheap and readily accessible for use as construction material for building strong structures, landscaping, road bases and many other civil works. In India, Pereira (2012) realized that following the global soaring demand for sand was soaring in three villages in Maharashtra, riverbeds, beaches, creeks were being mined faster than nature could replenish in those resources. The country did not have a regulatory and monitoring framework for exploitation of sand sustainably hence sand excavation was done both legally and illegally. Since people thought that the resources are low value minor minerals and inexhaustible, there had never been much control.

Various researches on the negative environmental impacts of mining in Africa for instance Musah and Barkarson (2009) have assessed the sociological and ecological impacts of sand and gravel mining in the Northern Region of Ghana particularly the East Gonja District and the Gunnarsholt. Their study revealed that the following negative impacts: loss of farm or grazing lands, formation of pits with water stored in them, enhancement of erosion and loss of vegetation, destruction of landscape, generation of conflicts, loss of biodiversity and dust pollution. On their side, Hill and Kleynrans (1999) showed the potential damaging effects of sand mining and processing could have on South African economy. Aromolaran (2012) studied the effects of sand mining activities of rural people on agricultural land in agrarian communities of Ogun state in Nigeria. He found that sand mining was widespread, highly unregulated, uncontrolled and is being carried out at an alarming rate. The study revealed that mining of sand and gravel was one of the alternative livelihood activities for the rural people in Nigeria, but on the other hand that activity was becoming an environmental issue. The study also showed that there was an increase in demand for sand for construction and other purpose as communities grow because the construction requires less wood and more concrete, which increases a demand for low-cost sand.

The author noticed also mining sand and gravel resulted in the change of the soil structure, vegetation and local wildlife in the rural areas. In short, though sand mining provides raw materials which contribute to the construction of buildings and development, it has the negative effects include the permanent loss of sand in areas, as well as major habitat destruction.

1.3 Use of sand and its impacts on socio-economic development

Villioth (2014) stipulates that the importance of sand comes from the fact that, today, after water, sand is the second most consumed natural resource on Earth. For long time, sand has been an important natural resource all over the world and is fundamental to human existence. It has been used as an aggregate material for different civil constructions many centuries ago. For instance, the mortar that Egyptians used to bind their pyramids blocks was made up of clay or mud, lime and sand. Nowadays there is a growing demand for sand resource. Sand is still used intensively in the construction industry and in present days there are also other many industries which use this resource in huge amount Gavriletea (2017). Sand is used as the main component in various construction materials such as cement, mortar, tile, brick, glass, adhesives, ceramics, etc. It also used in water filtration, in chemicals and metals processing and in plastic industry. Sand is also used in bulk quantity in development infrastructures like roads, important government buildings, industries, schools, hospitals, commercial buildings, dams, etc Devi and Rongmei (2015). Therefore, mining operators in conjunction with resource agencies need to work hard and make sure that sand exploitation is done responsibly.

Apart the use of sand in construction and other industries, sand exploitation is also a source of income for people living nearby sand mines since the extraction many people get employed in that activity and other associated activities, and involved families have their income increased Lawal (2011). Sand is a natural resource that plays an important role in economic development. Panduyos and Cuenca ; Pegg (2006) studied the direct relationship that exists between sand exploitation and poverty reduction. In their study on the direct relationship between sand exploitation and poverty reduction, Pegg, (2006); Mobtaker and Osanloo (2014), etc concluded that mining can positively contribute toward poverty alleviation and economic growth, but only if a variety of demanding preconditions are met. Kowalska and Sobczyk (2014) new habitats for plants and animals, and new water reservoirs are created.

1.4 Negative environmental impacts of sand exploitation

All over the world the exploitation of natural resources is associated with significant negative impacts on environment. Sand exploitation is a worldwide activity in both developed and developing nations and it is associated with a variety of severe negative impacts on the environment. Negative environmental impacts of sand exploitation seem to outweigh positive effects. Sand mining activities are mostly considered to be unsustainable not only because they exploit resources, but also because they destroy the environment and society and leave impacts that are irreversible Carrere, (2004). A study conducted by Kempton and Atkins (2000) identified some of negative impacts related to sand mining and exploitation activities such as changes in the local flora and fauna, groundwater and air contamination, disruption of the landscape, etc. unfortunately, many of them are not quantifiable. Gavriletea (2017) emphasized that special attention should be taken to all environmental aspects related to sand mining activity since the activity is complex and involves five stages prospecting, exploration, developing, exploitation, and closure and reclamation and each is associated with impacts that contribute to the degradation of the environment.

Different authors Borges, Andrade et al. (2002); Jaramillo (2007); Madyise (2013) identified the problem of the destruction of the vegetation as a result of sand mining activity. These scientists reported that continual removal of vegetation exposes the land. They found that the destruction of vegetation causes the formation of gullies de Leeuw, Shankman et al. (2010). Asabonga, Cecilia et al. (2017) reported that sand mining activity can be considered as the main contributing factor to landslides. This is almost true because sand mining process goes hand-in-hand with vegetation clearance, which is one of the factors causing landslides. Another negative environmental impact of sand mining observed by Schaetzl (1990) is increase number of heavy vehicles and traffic, impairing negatively on the environment.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Introduction

The research was qualitative and it was done in two sets: data collection and the review of the existing literature in relation to the research. To say that the research was qualitative means that it adopted a descriptive approach. The research involved direct field observations aiming at capturing the existing physical impacts of sand mining on environment and interviews with the people to collect the information on sand extraction in Kajegemba wetland. In order to understand the socioeconomic condition of the mining people, interview and informal discussion was conducted with the people at the extraction sites in the wetland. On the field, global positioning system (GPS) was used to record coordinates for the location of sand extraction pits The study findings were presented in form of maps, photos, graphs.

3.2 Description of Study Area

Kajegemba wetland cuts across three sectors which are Cyeza in Muhanga District, Nyarubaka and Musambira in Kamonyi District, Southern province. The study area cuts across both Kamonyi and Muhanga districts but a very large portion is located in Kamonyi district. The total surface area is 81.83 ha. The altitude is around 1788 m. (See figure 3.1)The wetland is characterized by a sandy soil. The main streams in the wetland are Kajegemba, Kanyombya, and Mpombori. The main activities that are carried out in the wetland are agriculture and sand harvesting. The company that has the permission for extracting sand is SAND SON. The company employs non-permanent workers who extract the sand not on regular basis. These sand miners sell the extracted sand and share the benefit with the company.

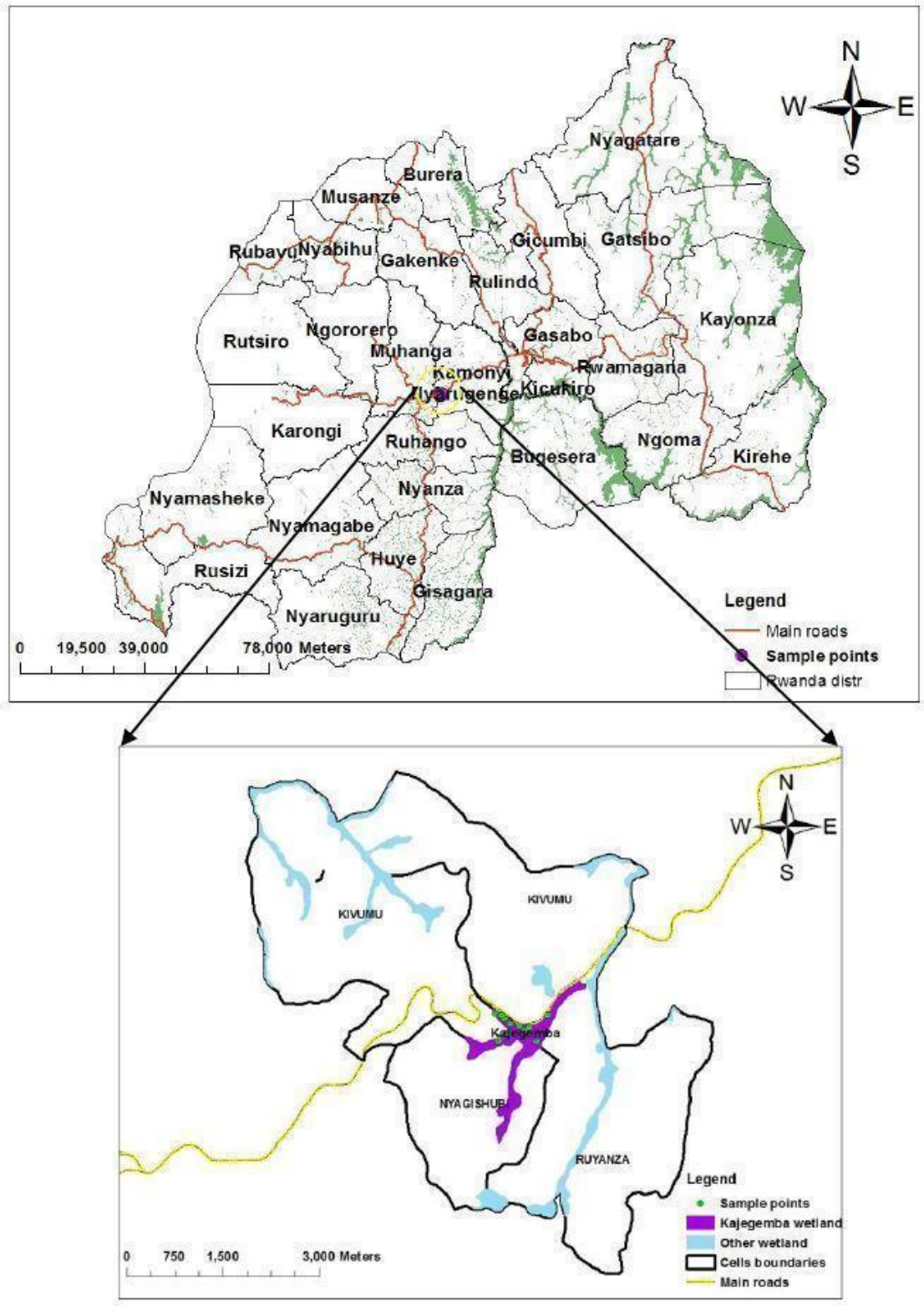


Figure 3. 1: Study area map

Source: Primary Data

3.3 Research methods

Data used in this research have been collected through various techniques. They include the desk review, field observation and measurement, survey, interview, and laboratory analysis. Each method has provided specific data that were processed and analyzed in order to attain the research objectives.

3.3.1. Desk review

For a good understanding and analysis of the topic, different documents were consulted and analyzed. Those include policies and laws that govern quarries and sand extraction in Rwanda, districts reports, environmental management policies, and water resources management master plan as well. The environmental management plan of the area set by the company which harvests sand in Kajegemba, and other documents related to sand extraction were consulted**.**

3.3.2. Field observation and mapping

Thanks to field observation, physical features of Kajegemba wetland were collected and described. GPS was used to record coordinates for the location of sand extraction pits of different depth and other related damages in the area. Recorded coordinates were processed with GIS tool to produce the map (See figure 3.2). Those include sand mining pits, water ponds, stream banks damages, changes of water bed, constructions in the wetlands used by miners and sand transporters, main places of trucks parking, places with traces of water and soil pollution, places of samples taken, etc... A folding rule was used to measure the depth and diameter of sand pit.

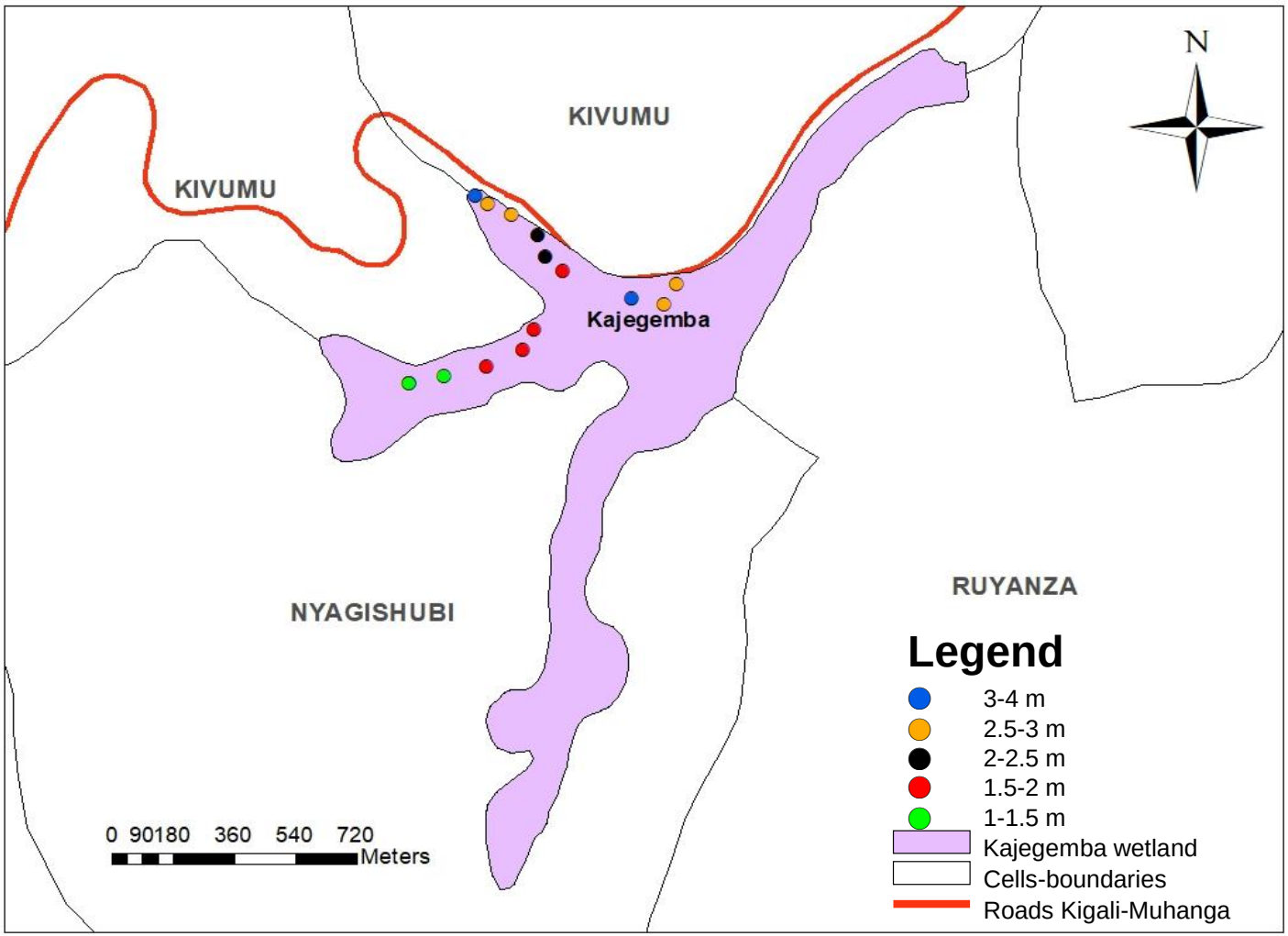


Figure 3. 2: Selected sand Pit's Locations

Source: Primary Data

3.3.3. Survey

3.3.3.1. Sampling technique

In this study, the random sampling technique was used. Farmers living in the villages located in the immediate vicinity of the sand mining and sand (truck) sellers were identified and interviewed in Kamonyi district. In this study, nonprobability sampling in particular convenience (or purposive) sampling designs were used. The 112 respondents were nearly equally selected in three cells: Kivumu (38), Nyagishubi (37), and Nyarubaka (37).

3.3.3.2. Sample size

The target population was defined as heads of the households that live in the immediate vicinity of the wetlands. This decision was made because we assume that such households' heads are the ones that are mostly affected by environmental impacts and are more responsible than any adult people. The number of heads of households was based on the report/ information from the administrative heads of nearby villages and it was 112. The person to be surveyed was the head of the households because we think that s/he is the most knowledgeable person to provide information on mining harvesting.

3.3.3.3. Survey questionnaire design and administration mode

An ad hoc survey questionnaire was developed. It contains both closed and open-ended questions. The survey questionnaire focused on impacts of sand harvesting on land degradation, hydrological aspects, biodiversity changes, and so-far applied and also possible mitigations as well. For more details, the survey questionnaire is presented in appendix 4. Heads of households or their representatives where to ones to be surveyed because we assume, they are the ones to know better negative environmental impacts associated with sand extraction.

In order to use effectively the time dedicated for that exercise, face-to-face questionnaire administration was applied. By doing so, all questionnaires answered and filled in were immediately collected. The survey was held from 8th August to 10th August 2018 because of the late authorization of data collection by the district. The survey was conducted with the help of two research assistants.

3.3.4. Interview

Interview was held with key informant in order to get more insight on the environmental impacts of sand mining. 20 heads of households found in the close proximity of the marshland, the manager of sand mining company and the staffs in charge of environment at cell, sector and district levels were interviewed. The interview was held from 8th August to 10th August 2018.

3.3.5. Laboratory analysis

In order to evaluate the impact of sand mining on water, water samples were taken in the wetland. Two sampling sites were selected randomly one at upstream and the second on downstream and their location is showed on the map of study area (see figure 3.3). Physico-chemical parameters of water which were analyzed in UR Chemistry laboratory are water temperature, pH, turbidity, conductivity, and dissolved oxygen.

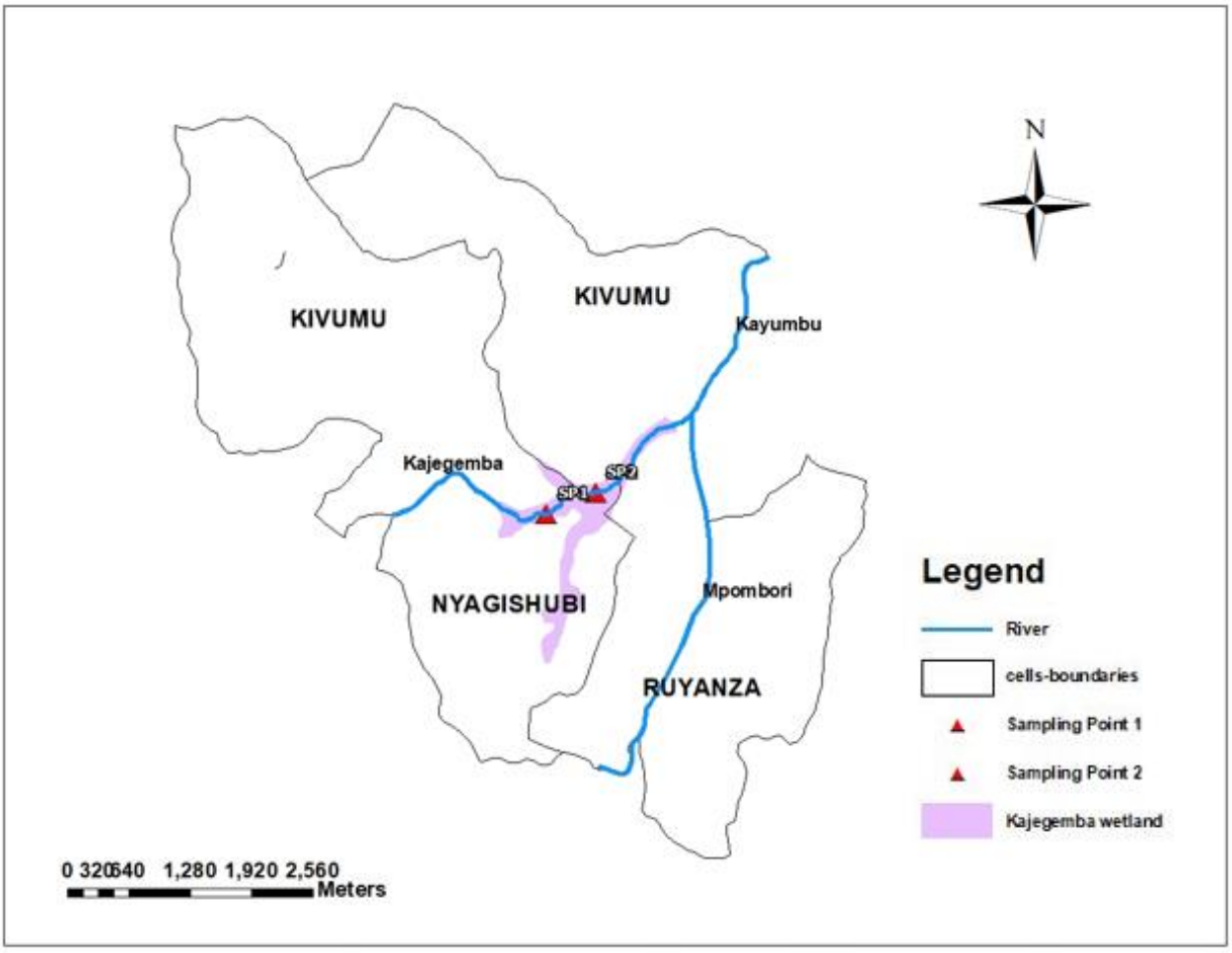


Figure 3. 3 Water sampling point map

3.3.6. GIS Software

ArcGis 10.3 was used to map the study area and to integrated and display physical elements that were taken on the ground using GPS device.

3.4 Data presentation, processing and analysis

Throughout the research, primary data was collected through observations of affected sites, taking photographs, interviews, and recording GPS coordinates. Secondary data were obtained from published related researches and books. Statistical analysis of data was done using Statistical Package for Social Science (SPSS) software. The demographic data of mean age, distance of home from exploitation site and the mean of involvement by villagers in exploitation activities were calculated.

CHAPTER IV: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the results and findings on environmental impacts of sand mining in Kajegemba wetland as observed on the fields or provided by the respondents or revealed by laboratory analysis.

During field survey, the researcher considered and sampled some places where sand was mined in Kajegemba wetland to investigate the extent of the environmental related effects caused by miners. One hundred and twelve (112) respondents were picked as a sample to participate in the questionnaire survey. Thirty-eight (38) were from Kivumu, thirty-seven (37) from Nyagishubi and Nyarubaka villages each. Interviews were conducted on people who were directly and indirectly involved in sand mining activities.

The findings are presented relative to the research questions and objectives of the study. However, sub categories of very important issues are also presented under different research questions. Some of these categories were present and were included in the interview guide while some of them were developed as a result of the interview process and the different responses that respondents gave upon trigger investigation. Study findings are discussed accordingly as the survey was designed and conducted.

4.2 Socio-demographic characteristics of the respondents

Participants in this study were both males and females. The inclusion criterion for the questionnaire survey was 21 years and above for either male or female who were available in sampled households and voluntarily takes part in the study.

Table 4. 1: Distribution of study participant by gender

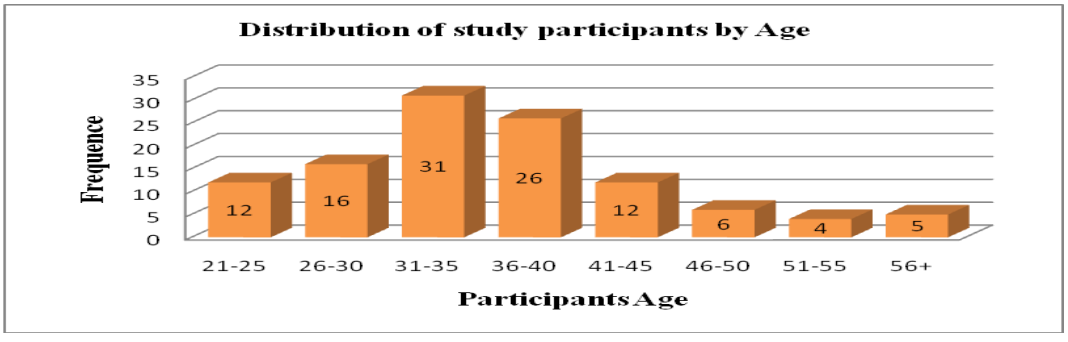
Cells			GENDER		Total
			F	M	
Cell	Kivumu	Count	13	25	38
		% of Total	11.6%	22.3%	33.9%
	Nyagishubi	Count	20	17	37
		% of Total	17.9%	15.2%	33.0%
	Nyarubaka	Count	17	20	37
		% of Total	15.2%	17.9%	33.0%
Total		Count	50	62	112
		% of Total	44.6%	55.4%	100.0%

Source: Primary data

According to Table 4.1, over a total of 112 respondents surveyed, 62 persons (55.4 %) were males and 50 (44.6 %) were females. More males showed interest to participate in the research than females. This is because sand mining is normally a male dominated activity.

4.2.1 Distribution of study participants by age

Data from Figure 4.1 shows that the big portion of the respondents is comprised the following age groups 31-35, 36-40, and 26-30 years, that is 73% of the respondents. Results from table 2 also indicate that the total number of the respondents decreases considerably above 45 years. This is because youth and young adults are physically strong hence capable to participate in sand mining activities. These findings corroborate with the findings by (Tariro 2013) which concluded that young literate than adults can understand the questions related to sand and gravel extraction and are aware of environmental issues.



Source: Survey

Figure 4. 1: Distribution of study participants by age

4.2.2 Distribution of study participants by education

Study participants were distributed according to education level as follows: 30.4 % (34) were non-educated, 35.7 % (40) had primary education, 28.6 (32) had secondary education, and 5.4 % (6) had university education. The data of education level indicate that study participants with secondary level education and below were the most to involve in sand mining activities. Only 6 study participants had tertiary education (See Table 4.1).

Table 4. 2: Study participant by education level

Characteristics			GENDER		Total
			F	M	
Education Level	No education	Count	11	23	34
		% of Total	9.8%	20.5%	30.4%
	Primary	Count	20	20	40
		% of Total	17.9%	17.9%	35.7%
	Secondary	Count	17	15	32
		% of Total	15.2%	13.4%	28.6%
	University	Count	2	4	6
		% of Total	1.8%	3.6%	5.4%
Total		Count	50	62	112
		% of Total	44.6%	55.4%	100.0%

Source: Survey

4.2.3 Activities of study participants at and around sand mining places

The results from the field survey indicate that the most of the respondents are employed in agriculture, farming and sand mining. Farming is the most occurring activity followed by sand mining and agricultural (See Table 4.3). These results indicate that farming and sand mining activities benefit a big number of people residing in the communities around Kajegemba wetland.

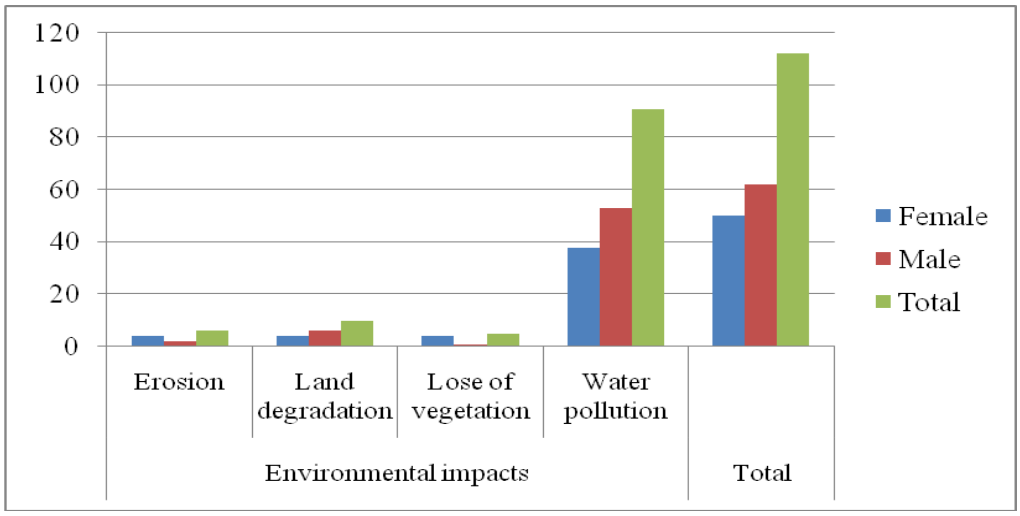
Table 4. 3: Activities at and around sand mining places

Sex		Activities			Total
		Agriculture	Farming	Sand mining	
Gender	**F**	7	39	4	50
	M	2	35	25	62
Total		9	74	29	112

Source: Survey

4.3 Major environmental related impacts associated with sand mining activities reported by the respondents

Both sand and non-sand miners know that uncontrolled sand harvesting activities is associated with adverse impacts on the environment. Study interviewees openly declared their perceptions and the problems about environmental impacts related to sand mining activities and its transportation they are exposed to. Erosion, land degradation, loss of vegetation, and water pollution were the most severe effects among the observed environmental impacts of sand mining practices (See Figure 4.3). Study respondents also reported a death of one sand miner due to sand mine which collapsed while mining. Cases of injuries have also been reported by interviewees. These findings are consistent with the findings made by (Mensah 1997) who identified almost the same environmental impacts of coastal sand mining in Ghana. During our survey, it was remarked that no field monitoring either before or after sand mining was carried out by local administrative authorities to ensure environmental protection. It was also observed that sand harvesting is done in an uncontrolled manner and this was probably the reason of high level of environmental impacts observed in the area as it is shown by all the field photos referred to in this thesis. In addition, a high number of study respondents said that there should be a mechanism of controlling sand harvesting activities in the area as this leads to the loss of agricultural production resulting from the degradation of land which is a result of sand harvesting activities.



Source: Primary data

Figure 4. 2: Major environmental impacts of sand mining activities in Kajegemba wetland

4.4 Impacts of sand harvesting on land degradation

Environmental and land degradation had been observed in the field observation during the study as impacts associated with sand mining activities in Kajegemba wetland. The observed impacts on land degradation were of two types. These are agricultural soil depletion and vegetation degradation (see figure 4.4).

Source: Photo taken on April 23rd 2018

Figure 4.3: Soil depletion and vegetation degradation

Figure 4.5 shows that crop fields were turning into eroded soil as more sand was mined. Implicitly, there is general shortage of productive land as erosion especially in the rainy season causes floods in the wetland. The respondents (75 %) also acknowledged the reduction in agricultural production as a result of land degradation impact of sand mining activities. These results are similar to (Madyise 2013) who observed that land degradation was one of the most adverse environmental impacts of sand and gravel mining in Gaborone, Botswana.

Source: Photo taken on April 23rd 2018

Figure 4.4: Loss of productive land by erosion

In the study area, landform instability was identified as an environmental impact of sand mining and was due to the removal of riparian vegetation. The physical and environmental impacts of sand mining are the results of excavation that is taking place in the study area. Actually, in field data collection 19 excavated pits were identified and noted during the survey. During the raining season these pits collect and store stagnant water and hence serve as breeding ground for pests such as mosquitoes and other water borne insects which in turn can affect the health of the people living in and around the wetland (see figure 4.6).

Source: Photo taken on April 23rd 2018

Figure 4.5: Pits created in Kajegemba wetland which can serve as disease breeding sites

Results from field observation showed that one of the physical effects of sand mining in Kajegemba wetland is the reduction of farmlands where cultivable land has been converted into pits as a result of sand mining activities. Farming is one of the activities taking place in the area but sand harvesting has taken up a big part of the productive land meant for this activity. Sand pits are very close each other, some are close to the streams (contrary to the law governing environment), and others close to crops. Over 19 sand pits found in the wetlands and measured, 10 have a depth between 1 and 4.5 m, thus they are shallow. Theoretically they cannot cause damage to human life or animals. Over 19 sand pits found in the wetlands and measured, 10 have a radius between 10 and 20 m, others are small. The total area for all the created pits was 1645.6 square meters which represent 0.2 % of the total wetland area. With reference to figure 4.7, it is observable that agricultural soil is removed during sand mining activities which results into loss of agricultural productivity.

Source: Photo taken on April 23rd 2018

Figure 4. 6: Reduction in farmland

4.5 Hydrological impacts of sand harvesting

Sediments from sand mining places running off into streams and wetland constituted significant source of water pollution in study area. Surface water quality is being affected through contamination with suspended and dissolved materials. In-stream mining of sand in the area has led to the re-suspension of sediments in the water causing the brownish coloration of the water and this water is being consumed by the miners in the area due to lack of alternative source for drinking water (see figure 4.8).

Source: Photo taken on April 23rd 2018

Figure 4. 7: Downstream water quality deterioration as a result of sediments' deposits

Continuous removal of vegetation exposes the land to erosion. Study respondent identified erosion as a serious effect of mining to streams and crop fields. Continuous mining was also found to reduce infiltration rates. There was significant collapse of stream banks as a result of sand mining activities in the wetland. Sand mining transforms the riverbeds into large and deep pits. Widening and deepening of streams had been noted as a negative impact. Continuous in-stream sand mining alters river courses and increases the general width of the streams: 3 m at some places, 5 metres at some other places while normally the stream used to be narrow and shallow (see figure 4.9).

Source: Photo taken on April 23rd 2018

Figure 4. 8: Erosion and collapse of stream banks

Sand mining around and within the streams which pass through Kajegemba wetland has made the banks of those streams to become weaker and gradually collapses. This did not only lead to filling of the stream channels with sediments but gave room for the water in the streams to flow out resulting in erosion which washes away the fertile soil and hence resulted in loss of agricultural productivity (see figure 4.10).

Source: Photo taken on April 23rd 2018

Figure 4. 9: Loss of fertile soil due to erosion

In-stream sand mining activities were found to have impacts upon the streams' water quality. Impacts include increased short-term turbidity at the mining site due to re-suspension of sediments, sedimentation due to sand stocks on the stream beds and dumping of excess mining materials and organic particulate matter, and oil spills or leakage from transportation vehicles. Suspended solids would adversely affect water users and aquatic ecosystems resulting in high chance of poisoning of aquatic life. The impact on human life would be particularly significant to water users downstream of the sand mining sites who abstract water for domestic use.

Due to excessive in-stream sand mining in Kajegemba wetland there was observable degradation of streams. In-stream mining was found to lower the streams' bottom, which led to bank erosion.

The results of physico-chemical analyses of water samples randomly collected at two sites are presented in the table 4.

4.6 Water quality analysis

Physico-chemical parameters that were measured are only pH, electrical conductivity, turbidity, dissolved oxygen, and water temperature. The lack of reagents and chemicals was the main reason of analyzing only the above parameters. These parameters were analyzed in UR/ CST Chemistry laboratory.

Table 4. 4: Physico-chemical characteristics of water from Kajegemba

Characteristics	**Kajegemba Stream**		Rwanda Norms of Potable Water (RSB)	WHO standards for fresh water
	US	DS		
pH	5.9	6.3	6.5 – 8.5	6.5-9
T (°C)	20.3	21.2		
EC (µS/cm)	330	480	1500	1400
Turb NTU	18	21	5 max	5.0
DO mg/l	3.3	4.1		-

DS: Downstream, US: Upstream

Source: Laboratory analysis

4.6.1 pH

The pH values were acidic (5.9 - 6.3). The maximum pH value (6.3) was recorded in the downstream and minimum (5.9) in the upstream of Kajegemba stream. The recorded values of pH did not comply with the WHO standard for fresh water. Factors like air temperature would probably be the reason for the recorded pH values since they may bring about changes in the pH values of water. The pH plays an important role in all chemical reactions associated with formation, alteration and de-solution of minerals in water. The mining activities at Kajegemba stream thus produced significant negative impact on Kajegemba Stream.

4.6.2 Electrical conductivity (EC) in µS/cm

EC values recorded were in the range from 330 µS/cm to 480 µS/cm. These slightly high EC values are an indication that the quantity of dissolved ions in the upstream and downstream of Kajegemba stream is seemingly high. Conductivity affects water quality and aquatic life. Conductivity and salinity are strongly correlated. High conductivity implies high salinity and vice-versa. Aquatic animals and plants are known to adapt to a specific range of salinity. Beyond this range, they are negatively affected and may die. Some animals can tolerate high salinity, but not low salinity, while others can handle low salinity, but not high salinity (https://www.fondriest.com/news/what-is-conductivity.htm).

4.6.3 Turbidity in NTU

Turbidity indicates how far light can travel through water and is caused by fine dispersed and colloidal particles in water. The turbidity values varied between 18 and 21 NTU and were found to be above the limits prescribed by WHO. High turbid water is associated with low dissolved oxygen and hence constitutes a threat to aquatic life.

In general, all rivers in Rwanda are characterized by high turbidity because of high loading rates of sediments coming from the hill sides due to frequent agricultural activities happening on slopes and in valleys. Particles of soil washed by erosion are dissolved in water stream because vegetation that initially was filtering water from runoff has been cleared. Sand mining activities coupled with erosion in the area also would contribute to the recorded high values of turbidity of the streams in the area.

4.6.4 Dissolved oxygen (DO) in mg/l

Dissolved oxygen is an important water quality parameter that constitutes the oxygen reservoir for aquatic organisms that utilize it for respiration. Most aquatic organisms depend on dissolved oxygen for their survival. Values of dissolved oxygen recorded in this study varied between 3.3 mg/l and 4.1 mg/l. This relatively high level of oxygen recorded in the water can probably be attributed in part to the turbulence created in water by the sand mining activities. Turbulence positively affects dissolved oxygen in water, due to the trapping of atmospheric oxygen by exposed water molecules during turbulence.

4.7 Biodiversity changes related to sand harvesting

During field survey, interviewees reported loss of some indigenous vegetation as some previously existing medicinal and non-medicinal plants such as *Solenostemon latifolius, Waterpapper, Cyperus papyrus, Guizotia scabra, Rumex abyssinicus, Ocimum gratissimum*, etc. were not found at the time of the study. Sand miners usually cleared the vegetation to make rooms for the collected sand. Also transportation heavy trucks were found to destroy some plants. Loss of vegetation was noted during the study as a serious negative impact of sand harvesting. Vegetation and ecosystems were destroyed along stream banks to make access roads into mining areas. Sand extraction requires clearing of open lands before mining. There is remarkable destruction of stream bank hinterland and flora when extraction is done approaching stream beds.

Extraction of sand in Kajegemba wetland has also resulted in destruction of vegetation thereby destroying the natural habitats of some animals. Some very important wetland plant species were also destroyed and the soil is exposed to erosion. In-stream sand mining has resulted in the destruction of aquatic and riparian habitat through large changes in the channel morphology (refer to figure 11 & 12). Animals like some bird species such as black-headed heron, hadada ibis, grey crowned crane, etc were not found in the wetland during the survey period.

Source: Photo taken on April 23rd 2018

Figure 4. 10: Loss of vegetation along stream banks due to sand deposits

Source: Photo taken on April 23rd 2018

Figure 4. 11: Destruction of vegetation to make access road for heavy trucks

4.7 Mitigation measures

4.7.1 Measures in place

During our field interview, 92 % of interviewees reported that there is no any appropriate measure that is put in place to control the environmental impacts resulting from sand mining activities in the area. During the field survey, it was impossible for us to access the contract between Kamonyi district and SAND SON (the company that is operating sand harvesting in the wetland) because of confidentiality issues according to the staff in charge of mining and quarry at the district. The representative of the company also refused to give us a copy of the contract. Hence it was not possible to know exactly what were the responsibilities of the company in terms of mitigating the possible environmental impacts which might result from their sand harvesting works. Consequently, it was difficult to identify what is being done as solutions to the observed problems as it should be mention in environmental management plan. Only few sand miners interviewed reported that they try to restore the created pits through refilling them by fertile soil that was removed before extraction of sand but from our observation we noticed that this measure was not effective since the fertile soil which is removed before sand harvesting activities is not enough to refill the created pits.

4.7.2 Measures to apply

Since sand mining in Kajegemba wetland is associated with several environmental impacts, the following mitigation measures are recommended to be put in place to remedy the problems. Sand mining activities would not be carried out everywhere but in selected specific sites within the wetland and this will cause the least environmental damage. The detention basins should be created between 50 and 100 meters from the stream which will serve to collect the sand eroded from upland, to avoid the sand to be deposited in the stream. According to organic law, in-stream sand harvesting in Kajegemba wetland would be stopped. Moreover, no sand harvesting activity would be carried out in a distance less than 10 meters away from the stream banks. Field monitoring of sensitive habitats before and during the sand mining works can be done by means of sampling, visual observations and surveys.

The advantage of regular field monitoring is that the predicted effects can be verified. In order to restore the pits created, sand mining activities should be suspended at least three years and the sediments from other areas will come and fill those pits.

Restored pits will also prevent from accidents such as death and injuries, land degradation, retention of water which may spread disease causing and transmission vectors, etc. Carrying out sand mining activities in a controlled and organized way would also protect the environment.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Since the country is developing fast, the demand for sand for construction and other purposes is growing every day in Rwanda, and the process of mining this aggregate has resulted to serious environmental impacts. In Kajegemba wetland, Southern province, Rwanda, sand mining is going on at a large scale especially in rainy season. Results of field work shows that land degradation, water pollution, erosion, loss of vegetation and the collapse of stream banks are the physical environmental impacts associated with mining of sand in the area.

Generally, sand mining in Kajegemba wetland has resulted in disturbance of land surface areas, leaving many open pits which are difficult to rehabilitate at the time mining terminate and these usually constitute breeding sites for disease transmission vectors. There is a need for enforcement of the law or policy governing sand mining in order to cope with environmental problems related to sand mining in Kajegemba wetland and implement all the stated recommendations.

5.2 Recommendations

To minimize the negative impact of sand mining on the Kajegemba wetland environment, the following recommendations are made:

1. Indiscriminate opening up of plots for sand mining should be discouraged by appropriate local authorities.
2. The district should develop a policy forcing sand miners to reinvest and repair the old (disused) mine sites. This reinstatement activity can go a long way at reducing the chance for occurrence of landslide in the locality.
3. Stakeholders at all levels in the district would discuss the problem of sand mining in Kajegemba wetland and come up with immediate solutions which curb environmental damage.
4. It is important to have an Environmental Assessment Management and Monitoring Plan. Close monitoring ensures that there is proper mining.
5. There is a need for enforcement of the law governing mining of sand in Rwanda in order to protect the environment.

6. Since water quality of Kajegemba stream does not comply with RSB standards for potable water, it is therefore recommended that people in the vicinity of the wetland would use it for other purposes like irrigation rather than drinking purpose.

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APPENDICES

Appendix 1: Distribution table of study participants by age

			GENDER		Total
			F	M	
Age	21 - 25	Count	3	9	12
		% of Total	2.7%	8.0%	10.7%
	26 - 30	Count	9	7	16
		% of Total	8.0%	6.2%	14.3%
	31 - 35	Count	17	14	31
		% of Total	15.2%	12.5%	27.7%
	36 - 40	Count	12	14	26
		% of Total	10.7%	12.5%	23.2%
	41 - 45	Count	4	8	12
		% of Total	3.6%	7.1%	10.7%
	46 - 50	Count	4	2	6
		% of Total	3.6%	1.8%	5.4%
	51 - 55	Count	0	4	4
		% of Total	0.0%	3.6%	3.6%
	56+	Count	1	4	5
		% of Total	0.9%	3.6%	4.5%
Total		Count	50	62	112
		% of Total	44.6%	55.4%	100.0%

Source: Primary data

Appendix 2: Major environmental impacts of sand mining activities in Kajegemba wetland

		Types				Total
		Erosion	Land degradation	Loss of vegetation	Water pollution	
Gender	**F**	4	4	4	38	50
	M	2	6	1	53	62
Total		6	10	5	91	112

Source: Primary data

Appendix 3: Characteristics of the sand pit

Pit No	Longitude	Latitude	Radius (m)	Dept (m)	Description of immediate surroundings	Presence of sterile (soil that is not sand)	Bottom with water
1	2°03’40.375”	29°48’44.923”	2.5	1	River, small forest	Yes	No
2	2°03’39.375”	29°48’45.133”	3	1.5	River	No	No
3	2°03’38.914”	29°48’45.700”	4	1.5	River, small banana plantation	Yes	No
4	2°03’37.818”	29°48’46.586”	6	2	River, cassava plantation	Yes	No
5	2°03’37.288”	29°48’47.172”	10	2	Banana plantation	Yes	Yes
6	2°03’31.385”	29°48’49.930”	5	1.5	River, Mud road	Yes	No
7	2°03’30.014”	29°48’48.189”	7	2	Mud road, Banana plantation, Potatoes	Yes	Yes
8	2°03’27.853”	29°48’47.477”	6	2.5	River	Yes	Yes
9	2°03’25.857”	29°48’45.009”	20	3	Asphalt road(Muhanga), Eucalyptus trees, potatoes	Yes	Yes
10	2°03’24.174”	29°48’42.293”	20	2.5	Banana plantation, River	Yes	Yes
11	2°03’23.901”	29°48’41.526”	10	3	Potatoes , banana plantation	Yes	No
12	2°03’22.292”	29°48’38.810”	15	5	Potatoes , Eucalyptus	Yes	Yes
13	2°03’21.307”	29°48’36.425”	10	4	Potatoes , coffee plantation	Yes	Yes
14	2°03’19.664”	29°48’36.140”	12	3	River, Asphalt road	Yes	Yes
15	2°03’19.726”	29°48’37.375”	10	2	River, Asphalt road	Yes	Yes
16	2°03’34.445”	29°48’54.463”	10	2	Mud road	Yes	No
17	2°03’34.181”	29°48’56.420”	5	4	River	Yes	No
18	2°03’34.764”	29°48’57.406”	9	3	River	Yes	No
19	2°03’34.065”	29°48’58.090”	12	2.5	Mud road	Yes	No

Source: Primary data

Appendix 4: Survey Questionnaire

A. introductory letter

Micomyiza Edouard
University of Rwanda
College of Science and Technology
Masters in Geoformation for
Environmental and Sustainable Development
Tel: 07885516669/0722092075
Email: micoedo@gmail.com

My name is Micomyiza Edouard, Student in MSc programme at CST. I am carrying out a research on **environmental impacts of sand harvesting in Kajegemba wetland** for Master of Science Degree in Geo-Information for Environmental and Sustainable Development with University of Rwanda. Would you please respond to the following questions related to my research topic? The information you will provide will be treated with confidentiality and will not be disclosed to any other person.

I thank you for your time and collaboration

Signature:

Micomyiza Edouard

General questions for sand mining

PART A

District:…….
Sector:……..
Cell:……..
Village:…….

PERSONAL DETAILS

Tick the correct option.

1. GENDER: Male ☐ Female ☐

2. AGE GROUP 21-25 ☐ 26-30 ☐ 31-35 ☐ 36-40 ☐

41-45 ☐ 46-50 ☐ 51-55 ☐ 56+ ☐

3. POSITION IN VILLAGE: ☐ CHIEF ORDINARY VILLAGER

PART B

GENERAL QUESTIONS ON SAND MINING

For questions 4-8, choose the appropriate answer.

4. How far do you approximately live from sand mining areas? 0-500m ☐ 501-1000m ☐ 1001-1500m ☐ 1501-2000m ☐ above 2000m ☐

5. How far do you live from the main gravel road used by tipper trucks transporting sand? 0-500m ☐ 501-1000m ☐ 1001-1500m ☐ 1501-2000m ☐ above 2000m ☐

6. Do you often work in the sand mining area? YES ☐ NO ☐ SOMETIMES ☐ RARELY ☐

7. If yes, choose activities you normally do at the sand mining areas. Sand mining ☐ fishing ☐ gardening ☐ farming ☐ others, specify ☐

8. Approximately, how many trucks pass through your village in a day? 0-5 ☐ 6-10 ☐ 10-15 ☐ 16-20 ☐ 20 and above ☐

This is important for PART C AND D. All answers are considered correct, important and will be treated with confidentiality

PART C

RESIDENTS' VIEWS ON ENVIRONMENTAL IMPACTS OF SAND HARVESTING

1. The sand mining might be affecting you as a resident in a nearby village. If yes, state the effects on activity have on your life.

A. Water pollution

B. Water depletion

C. Land degradation

D. Air pollution

E. Noise pollution

F. Dust in my house etc.

- ----------

---

3 Name 3 most negative environmental impacts of sand harvesting.

1st one:
2nd:
3rd:

4. (A) Had you ever heard of accidents reported during sand mining?

a. death of people fallen in sand pit mining

b. Injury of people

e. other.----------

(b) How does the community react to such accidents? ----------
---

PART D

MITIGATION MEASURES APPLIED AND THE POSSIBLE ONES TO BE APPLIED

6. What is done to mitigate adverse effects of sand mining?

7. What can you recommend as the immediate solutions to the negative impacts of sand mining?
(a) at KAJEGEMBA community level----------

---(b) At District level----------

---(c) At national level----------

---
8. What rehabilitation programmes can be implemented in your area----------
---

Thank you for your time. You are assured that all information will be treated with confidentiality. The feedback will be used to suggest solutions and make recommendations on mitigating negative impacts to sand mining.

Structured Questionnaire for sand miners

My name is Micomyiza Edouard. I am carrying out a research on **environmental impacts of sand harvesting in Kajegemba wetland** for Master of Science Degree in Geo-Information for Environmental and Sustainable Development with University of Rwanda. The information given will be treated with confidentiality.

Information about the interviewee

Name: ……

Occupation…….

How many years have you worked as a sand miner?

Questionnaire No: ……

Date: ……

1. How much quantity of sand can be mined in a day?

2a. Do you have any state permits and regulation on sand mining?

YES ☐ NO ☐

2b. Which of the following reasons can stop you from fetching the sand on site?

A. Once the sand is exhausted

B. When we meet gravels/ color changes.

B. At about half meter to a river bed

3. Do you think sand mining has got some environmental impacts?

YES ☐ NO ☐

3a. If YES, what was some of them?

A …….

B …….

C …….

3b. How did you know them?

A. By complains ☐ B. By personal observation ☐

3d. If by personal observation, which of them would you regard as the most severe?

4a. What measures are you putting in place to lessen the environmental impacts?

Thank you for your time. You are assured that all information will be treated with confidentiality. The feedback will be used to suggest solutions and make recommendations on mitigating negative impacts to sand mining.