EFFECTS OF WATER HYACINTH ON ECONOMIC ACTIVITIES OF THE COMMUNITY AROUND LAKE VICTORIA: A CASE OF DUNGA BEACH IN KISUMU-KENYA

BY

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A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ARTS IN PROJECT PLANNING AND MANAGEMENT OF THE UNIVERSITY OF NAIROBI

2013

DECLARATION

This research project report is my original work and has not been presented for an award in any other university.

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This research project report is dedicated to my late brother Engineer Mc Ageng'o who taught me that the roots of education are bitter but the fruits are sweet.

ACKNOWLEDGEMENT

First and foremost, I want to thank, Dr. John Ouru, Dr. Maria Onyango and Dr.Raphael Nyonje from the University of Nairobi, Kisumu campus for their support and guidance during my project development. It is through their constant guidance and correction that enabled me to complete the project in time. I would also like to acknowledge all my lecturers in the Department of Extra Mural studies in Kisumu campus that taught me different units in Project Planning and Management and the library staff for their assistance when looking for research materials. In particular I wish to thank Dr.Rambo our resident lecturer for his guidance and support. I also thank my able class mates like Zipporah Anaswa, Joy Otieno, Kennedy Otieno Otieno and Nivian Ogogo for their support and sharing of information resources used in the proposal development and the final writing of this project.

Many thanks to the CEO and the entire staff of Lake Victoria South Water Services Board for the support they gave me during the period of the study. I would also not forget to thank my research assistants, data entry clerk, the respondents of Dunga beach and the staff of Kisumu water and Sewerage Company for their cooperation and support during data collection. Finally in a very special way I thank my wife Pamela Amondi, Children Britney and Briana for their love, constant encouragement and support throughout my study period and the almighty God for making all this possible.

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ABBREVIATIONS AND ACRONYMS

FAO	-	Food and Agriculture Organization
IBM	-	International Business Machines
KIWASCO	-	Kisumu Water and Sewerage Company
LVEMP I	-	Lake Victoria Environmental Management Project Phase I
NAS	-	National Academy of Science
NCST	-	Council of Science and Technology
PASW	-	Predictive Analytics SoftWare
PPMC	-	Pearson's Product Moment Correlation
SPSS	-	Statistical Package for Social Scientists
UNWDR	-	Uganda National Water Development Report

ABSTRACT

Fresh water bodies constitute a vital component of a wide variety of living environments as integral water resource base in many human societies in the world. Water hyacinth has invaded freshwater systems in over 50 countries on five continents and changes to its density have the potential to affect other ecological and human communities in areas where it is established either positively or negatively. The hyacinth, since its introduction in Kenya has been a menace to the riparian communities, causing several problems. However, the range of problems with water hyacinth infestation is in general terms widely known, the real extent of the influence on the socioeconomic status and welfare of the people who depend on the affected water has not been well quantified and documented. The purpose of this study was to determine the influence of water hyacinth on the economic activities of the community around Lake Victoria and focused on Dunga beach in Kisumu. The study sought to establish the extent to which the water hyacinth affects the water business, fishing industry, weaving industry and tourism activities of the target community. Utilizing the descriptive survey research design, the study targeted the 8,561 households in Nyallenda B Sub location which covers the entire Dunga beach. The study used a sample size of 331 households. The study area was zoned into 4 village clusters and simple random sampling used to proportionately select the study's sample size based on the number of households in each village cluster. Data collection instruments included the household questionnaire for the community members and the key informant interview guide. The questionnaire was validated through review by the supervisor and research experts from the University of Nairobi then pilot-tested on sample of 10 respondents drawn from Usoma beach with similar characteristics as Dunga beach. The reliability of the questionnaire was determined using the Cronbanch alpha coefficient, producing a reliability coefficient of $\alpha = 0.82$. The data collected using the household questionnaire was cleaned, coded and entered into the computer and analyzed with the aid of the Statistical Package for Social Scientists. Descriptive data was analyzed using percentages, frequencies and means and the results presented in frequency distribution tables. Correlation analysis using the Pearson's Product Moment Correlation Coefficient was also done to determine the relationships between the dependent and independent variables. The study established that 70% of the respondents agreed that the volume of water extracted from the lake available for sale was higher when the lake was clear of hyacinth compared to the seasons when the lake was fully covered by the hyacinth. More water was therefore extracted in the months of March to August when the lake was clear of hyacinth. The study also established that the means in the number of the fish quantities varied from one type of fish to the other at different times of the year due to different water hyacinth infestation level. The mean for tilapia fish was highest in the months of May-June at 1.55, followed closely by a mean of 1.44 in the months of March-April, while the lowest was in the months of July-August. The means for cat fish and mud fish were highest in the months of March-April and November to December and the lowest means observed in the months of May – June. The study also established that that the water hyacinth was harvested and used as raw material to make items that included baskets, cupboards, tablemats, seats, handbags, earrings, bangles, necklaces, trays, chairs and coffins. It was established that the highest number of tourist visitations were in the months of May-June when the level of water hyacinth infestation was low. The study concluded that the water hyacinth had varied and mixed affects on the economic activities of the riparian communities at Dunga beach and thus recommended that the multiple effects of the water hyacinth must be considered whenever efforts to control the water hyacinth are instituted. However, similar studies should be conducted on other beaches especially around Homabay to validate the findings of this study and allow generalization of the study's findings on a wider scope.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Fresh water bodies constitute a vital component of a wide variety of living environments as integral water resource base in many human societies in the world. They have been regarded as key strategic resources essential for sustaining human livelihood, promoting economic development and maintaining the environment (Uganda National Water Development Report (UNWDR), 2005). Utilization of freshwater resources include use as source of drinking water, fishing activities, sites for domestic and industrial effluents discharge, recreation and transportation activities.

Water hyacinth, a floating vascular plant, is known to cause major ecological and socio-economic changes (Center, 1994). Originally from South America, water hyacinth is one of the world's most prevalent invasive aquatic plants. It has become naturalized in many warm areas of the world. Water hyacinth has invaded freshwater systems in over 50 countries on five continents; it is especially pervasive throughout Southeast Asia, the southeastern United States, central and western Africa, and Central America (Bartodziej & Weymouth, 1995; Brendonck *et al.*, 2003; Lu *et al.*, 2007; Martinez Jimenez and Gomez Balandra, 2007).

Water hyacinth is prevalent in tropical and subtropical water bodies where nutrient levels are often high due to agricultural runoff, deforestation, and insufficient wastewater treatment. There is not a clear record of how, why, and when water hyacinth was introduced to water bodies outside of its native range, but many populations are well

established and persistent despite control efforts. Its success as an invader is attributed to its ability to outcompete native vegetation and phytoplankton for light and its release from consumers (*Neochetina eichhorniae and N. bruchi*) found within its native range (Wilson *et al.* 2007). Invasions vary in extent and duration but generally cause similar problems. Changes to water hyacinth density have the potential to affect other ecological and human communities in areas where it is established; these changes may be perceived as positive or negative depending on the designated or beneficial uses of the water body (Gibbons *et al.*, 1994).

The first reference to water hyacinth in the United States was at the beginning of the 20th century on the occasion of the Louisiana Purchase (Sculthorpe 1967). The spread continued to Florida where there are many references to control the spread and infestations that occurred (Schardt 1984). It was also introduced into North and South Carolina. In the countries of South America, there are reports of its presence in 1902 in Brazil, 1942 in Argentina, 1959 in Paraguay, Uruguay, Bolivia, Ecuador, and Colombia, 1976 in Venezuela, and 1979 in Chile. In Central America, it is cited in Mexico, Nicaragua, Costa Rica, and El Salvador in 1965, Panama in 1966, and Puerto Rico and the Dominican Republic from 1971. Water hyacinth grows rapidly (Penfound and Earle, 1948) forming expansive colonies of tall, interwoven floating plants. It blankets large waterbodies (Fig. 2), creating impenetrable barriers and obstructing navigation (Gowanloch and Bajkov, 1948; Zeiger, 1962). It has been reported that floating mats block drainage, causing flooding or preventing subsidence of floodwaters. Large rafts accumulate where water channels narrow, sometimes causing bridges to collapse. Water hyacinth hinders irrigation

by impeding water flow, by clogging irrigation pumps, and by interfering with weirs (Penfound and Earle, 1948).

In Europe, the water hyacinth was possibly introduced as an ornamental plant in the first third of the 20th century in Portugal, because the first reference to its presence there dates from 1939. Since then, it has spread over the central-west of the country through irrigation canals and currently exists in the middle and lower Sado and Tagus Basins (Guerreiro 1976; Figueiredo et al. 1984; Amaral and Rocha 1994). Hyacinth infestations block access to recreational areas and decrease waterfront property values, oftentimes harming the economies of communities that depend upon fishing and water sports for revenue. Shifting water hyacinth mats sometimes prevent boats from reaching shore, trapping the occupants and exposing them to environmental hazards (Harley, 1990). Water hyacinth infestations intensify mosquito problems by hindering insecticide application, interfering with predators, increasing habitat for species that attach to plants, and impeding runoff and water circulation (Seabrook, 1962).

In Spain, the first documented cases date from 1989, appearing only sparsely and more or less sporadically between parallels 36° and 43°N, forming small localized populations that disappeared when the ponds or wetlands in which they had been detected dried out, or because of the salinity of the habitat (GIC 2006). The greatest damage due to its fast expansion has been in the middle reaches of the River Guadiana in the SW Iberian Peninsula. Detected in the Autumn of 2004, it underwent a marked recession during the winter but in April 2005 there occurred a strong regeneration of the fragments that had been left on the banks. By October and November it occupied an area of approximately 200 ha, covering 75 km of river, and producing in that period a biomass of 175 000 Tm.

Due to its rapid expansion, mechanical extraction was carried out by the *Confederación Hidrográfica del Guadiana* (CHG) of Spain's Ministry of the Environment since the affected zone is an important area of irrigation farming and hydraulic works and this alien plant weed provoked acute social alarm.

It was introduced into Asia at the end of the 19th century through Japan and Indonesia (Ueki, et al. 1975) and became naturalized in rice fields in the south and gradually extending northwards. In Indonesia, there are references to its appearance in Bogor where it was grown as an ornamental in the Botanical Gardens (Backer 1951). Today it extends from the plains up to an altitude of 1600 m.

Water hyacinth is the most predominant, persistent and troublesome aquatic weed in India. It was first introduced as an ornamental plant in India in 1896 from Brazil (Rao, 1988). In India, water hyacinth has stretched over 200,000 ha of water surface in the country (Murugesan *et al.*, 2005) and its exuberance has been highly noticed throughout the course of the river Thamirabarani, a perennial river in south India (Murugesan *et al.*, 2002; Murugesan, 2001). Because of its beautiful blooms and foliage, water hyacinth has been carried by tourists, plant collectors and botanists to over 80 countries around the world in the last 100 years.

According to Parsons (1963), its introduction into Australia and Oceania occurred in 1890 near Darwin (Northern Territories). Today, it exists in the coastal areas of all the federated states of Australia and has also appeared in many islands of the Pacific Ocean (Burton 2005).

In Africa, the water hyacinth was first reported in Egypt between 1879. It is considered one of the most notorious weed species in tropical West Africa (Food and Agriculture Organization (FAO), 2000). Water hyacinth infestation of freshwater ecosystems has been recently reported by several workers (Luken and Thieret, 1997; Bolorunduro, 2000; Osumo, 2001; Masami *et al.*, 2008); and its major effect appears to be disruption of normal ecological functioning of aquatic ecosystems where it is found thriving. Beneficial effects of the water hyacinth have also been reported as an aid in water purification through conversion of toxic ammonia to usable nitrates as well as capacity to absorb heavy metals and organic compounds from water body (Simeon *et al.*, 1987; Cowx and Welcomme, 1998; Ingole and Bhole, 2002). The influence of aquatic macrophytes on the limnological properties of water bodies has been recognized (Petre, 2000; Lee and McNaughton, 2004). They may, therefore, be regarded as efficient indicators of water quality.

Water hyacinth has spread over a great part of tropical and subtropical Africa. The plants are thought to have been introduced in Sudan into the River Congo, and that tributaries of the Congo may have extended the plant during floods. Since the 1940s, the plant has infested many African countries and has become a major problem for this continent in terms of the conservation of its aquatic ecosystems (Mendonca 1958; GISD 2005). The hyacinth has been linked to myriad changes in invaded ecosystems, including reduced water flow and a dramatic increase light attenuation, with consequent effects on primary and secondary production (Carpenter and Lodge 1986). In addition, mass accumulations of aquatic plants strongly interfere with recreational and commercial vessel

navigation, fisheries, and human health (Opande *et al.*, 2004; Hershner and Havens 2008; Villamagna and Murphy, 2010).

The weed was first reported in the Ugandan portion of Lake Victoria in 1990 (Thompson, 1991). It is believed that it entered the lake in 1989 via the Kagera River, which has its mouth in the Ugandan portion of the lake (Muli 1996). Estimates made in April 1999 and in August 1999 indicated that the input of water hyacinth into Lake Victoria through the River Kagera was 3.5 ha per week (Mailu, 2001).

In Ghana, water hyacinth was found for the first time in Tano lagoon, apparently entering this water body from Cote d'Ivoire. More recently fishermen reported a decline in fish catches and it was suggested that this was due to the presence of the water hyacinth. Much of the water hyacinth in Tano lagoon is mobile, being moved by wind or water currents. Holcik (1995), who investigated the situation, thought that the low catches are not due to the decline in fish stocks but rather a result of both the inefficient deployment of nets and of the difficult access to the fishing grounds due to the water hyacinth cover.

According to Mailu, the water hyacinth infestations in the portion of Lake Victoria in Tanzania in 1999 were located in Mara Bay, Bauman Gulf, Speke Gulf, Mwanza Gulf, Emin Pasha Gulf and Rubafu Bay. Currently, water hyacinth occurs also in the Kagera, Sigi and Pangani rivers, as well as in streams and water ponds around Dar-es-Salaam and close to Lake Victoria. The total cover estimate of water hyacinth in the Tanzanian waters of Lake Victoria was 2000 ha (Mailu, 2001).

Water hyacinth was first sited in the Kenyan side of the lake in 1992 (Republic of Uganda, 2005). Water hyacinth occurred in form of stationary mats in sheltered bays and

along much of the lakeshore, in addition to the mobile mats that were propelled around the lake by winds, waves and water currents (Balirwa, Wanda, and Muyodi, 2009). Despite water hyacinth's invasive nature and dominance in Lake Victoria in the 1990s, water hyacinth largely disappeared from Lake Victoria by the end of 1999. For instance, no water hyacinth was found on the Gulf from April 2002 until October 2004, only appearing again at the next measurement date of December 2005 (Gichuki et al, 2011).

Around Dunga beach, the gulf region is now fully covered by the hyacinth and growth of algal bloom and has become a menace to communities and biodiversity. Its rapid dissemination in this area is stimulated by the influx of nutrients through run-offs which cause eutrophication and the lack of natural enemies to destroy the weed. Also, the lack of knowledge about the extent of damage to the riparian communities and the cutting and releasing of bunches of water hyacinth into the lake by the beach communities has also contributed to its spread. The rich biodiversity of the Winam gulf, its social importance acting as a site for cultural manifestations and recreational activities as well as its economic importance acting as a source of income for the local community, all make it very important to the beach communities. This study, therefore, examined the economic impacts of water hyacinth on beach communities around Dunga beach, Lake Victoria in Kisumu County - Kenya.

1.2 Statement of the Problem

Water hyacinth has become a growing problem across many areas of the globe including Africa. Infestations of this weed are reaching crisis proportions in important freshwater bodies of the region. This is causing environmental, economic, and social

problems and accumulated damages that can easily be valued in the order of billions of dollars thus attracting a lot of attention in development debates globally. It directly affects not only the riparian communities but also all those people who in one way or another depend on environmental services or production from the affected water bodies (International Development Research Centre, 2000).

Since its appearance in Lake Victoria, Water hyacinth has been a menace to the riparian communities. Studies conducted in ponds and satellite lakes in lake Victoria basin in March 2000 to ascertain the presence of water hyacinth and its effect to the communities and the environment found out that in all the ponds where water hyacinth was found, the communities experienced varying problems, for example, at Bukabwa pond in Tanzania, the weed had resulted in a serious water shortage and fishing in the ponds was no longer possible (Ndunguru *et al.*, 2005). The communities had to walk approximately 10 km in search of drinking water. Water hyacinth infestation at Ngulyati pond (10.5ha) had denied easy access to water by communities and the water quality in this pond, in terms of colour, smell and taste, was completely degraded. During heavy rains water hyacinth is washed into neighboring rice fields causing poor rice germination and establishment.

Water hyacinth in Dunga area where the raw water intake for KIWASCO is situated has turned the water green due to high concentration of algae, and black as a result of the rotting hyacinth. This has made the treatment of the water very difficult and expensive for KIWASCO making the water at times unsuitable for drinking and other domestic use, forcing the company to at times shut down the plant when the raw water quality changes as a result of the dense matt of the weed at the intake (Odiwuor, 2013). However, although the range of problems with water hyacinth infestation is in general

terms widely known, the real extent of the impacts on the socioeconomic status and welfare of the people who depend on the affected water at Dunga Beach has not been well quantified and documented. This is one of the most certain explanations for why water hyacinth problem is still poorly understood. It is against this background that this study assessed the effects of water hyacinth infestations on the economic activities of the communities around Dunga beach on Lake Victoria, Kisumu-Kenya.

1.3 Purpose of the Study

The purpose of the study was to determine the effects of water hyacinth on the economic activities of the community around Lake Victoria, focusing on Dunga beach in Kisumu.

1.4 Objectives of the Study

The study was guided by the following objectives:

1. To establish the effects of water hyacinth on water business of the community around Dunga Beach of Lake Victoria, Kisumu
2. To examine the effects of water hyacinth on the fishing industry of the community around Dunga Beach of Lake Victoria, Kisumu
3. To assess the effects of water hyacinth on the weaving industry of the community around Dunga Beach of Lake Victoria, Kisumu
4. To assess the extent to which water hyacinth affects tourism activities around Dunga Beach of Lake Victoria, Kisumu

1.5 Research Questions

The study sought to answer the following research questions:

1. How does the water hyacinth affect water business of the community around Dunga Beach of Lake Victoria, Kisumu?

2. What effect does the water hyacinth have on the fishing industry of the community around Dunga Beach of Lake Victoria, Kisumu?

3. To what extent does the water hyacinth affect the weaving industry of the community around Dunga Beach of Lake Victoria, Kisumu?

4. To what extent does the water hyacinth affect tourism activities around Dunga Beach of Lake Victoria, Kisumu?

1.6 Hypothesis of the Study

The study tested two null research hypothesis stated below:

1. **Hα:** The water hyacinth has no significant effects on the fishing industry of the community around Dunga Beach

2. **Hα:** The water hyacinth has no significant effect on the tourism industry of the community around Dunga Beach.

1.7 Significance of the Study

The study has generated information that is believed will benefit decision-makers who are concerned with the protection of the aquatic environment to make appropriate decisions and invest in various projects aimed at preventing the spread of water hyacinth to other areas. This may reduce the impacts of existing infestations on the riparian communities. The findings of this study may also be used by water production companies as a basis for designing water treatment plants capable of treating the quality resulting from toxicity of the hyacinth, so as to maintain the demand in water business.

1.8 Basic Assumptions of the Study

In conducting the study, it was assumed that the respondents' responses would be genuine, independent and would reflect their true perceptions of the influence of the water hyacinth on their economic activities. The study also assumed that the economic indicators would remain the same throughout the period of study and that the effects of the water hyacinth cut-across all the economic segments of the target community.

1.9 Limitations of the Study

The major limitation of this study was that the targeted study participants carry out their entrepreneurial activities at different times of the day, which presented a formidable challenge in respect of a cumulative data collection process. This challenge was overcome by targeting their households and coinciding the data collection exercise at such times when the target respondents would be found in the house.

The study was a descriptive survey and relied on a selected sample of households around Dunga Beach of Kisumu. Although interpretation of the data collected is predicated upon the information gathered from the sample and the findings of the research study may be generalized to the target population, it is important to note that economic indicators vary from one individual to another and from one area to another. Due caution should, therefore, be exercised in generalizing the findings of the study beyond the study area.

1.10 Delimitation of the Study

This investigated the effects of water hyacinth on the economic activities of the community resident around Dunga beach on Lake Victoria. The study was restricted to Dunga Beach of the lake and covered 331 respondents sampled from the various economic sectors. Despite the fact that other beaches equally experience similar challenges for the infestation of the water hyacinth, Dunga beach presented a unique situation since it is both a business and residential area where the community lives along the riparian land. This is the only beach that hosts the water treatment and supply company that serves the largest part of Kisumu city, and also hosts all the other business activities. In addition, this part of the gulf is closed and whereas in other areas the hyacinth takes a shorter period of time to recede and open up the water surface, it takes relatively longer time at Dunga beach.

1.11 Definitions of Terms Used in the Study

The following terms took the described meanings in the context of the study:

Fishing industry - refers to all activities that are involved from the point of fish extraction from the lake to selling of the fish to the consumer. In this study, fishing industry constituted the fishermen, fish vendors and fish processors.

Tourism activities – refers to all the leisure and sporting activities along the beach such as boat riding, sailing and sun bathing.

Water hyacinth – refers to an aquatic weed that invades the lake and spreads rapidly.

Water business – refers to all the water business activities such as the water vendors using handcarts, water kiosks and the water companies producing and selling water in bulk.

Weaving industry – refers to the handicraft products made using the stem of the water hyacinth as the raw material.

1.11 Organization of the study

This research project report contains five chapters. Chapter one provides an introduction to the study and is discussed under sub-filters of: background of the study; statement of the problem; purpose of the study; the research objectives; research questions that guided the study; hypothesis of the study; significance of the study; basic assumptions of the study; limitations and delimitations of the study and finally definitions of significant terms used in the study.

Chapter two is a review of literature from previous studies in the area of water hyacinth and its effects on the socio-economic systems of the communities around the fresh water bodies. The chapter sought to identify the gaps in research on the impact of the water hyacinth on the economic activities of the communities, specifically around Dunga beach of Lake Victoria. This section also provided the theoretical and conceptual frameworks of the study.

Chapter three is a description of the Research Methodology used in conducting the study. The research design and target population is explained. There is also a description of the sample size and sampling procedures. A description of the research instruments used, piloting of the instruments, their validity and reliability are also discussed. The later part of the chapter provides a description of data collection procedures and the operationalization of the variables of the study.

Chapter four presented and discussed the findings of the study based on the analysis of data collected using the research instruments as described in chapter three. The

findings were organized as per the objectives of the study and included interpretation of the findings and discussions as they related to the literature reviewed.

Chapter five summarized the study's findings, concluded and recommended what could be done with regard to the effects of the water hyacinth on the economic activities of the riparian communities. The chapter also suggested areas for further study and summarized the contribution of the study to the body of knowledge on the effect of the water hyacinth on the economic activities of riparian communities.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature related to the study. The literature review is discussed under sub-headings, namely; water hyacinth and the water business; water hyacinth and the fishing industry; water hyacinth and the weaving industry and water hyacinth and tourism activities. The later section of the chapter presents the conceptual framework on which the study was based. The conceptual framework provides the linkage between the literature, the study objectives and the research questions.

2.2 Water Hyacinth and the Water Business

The water hyacinth causes major detrimental impacts on water use. In drainage canals it greatly reduces flow, which can result in flooding and damage to canal banks and structures. In irrigation canals it impedes flow and clogs intakes of pumps used for conveying irrigation water (Center et al., 2002). Water flow patterns have been disrupted in utility cooling reservoirs. Water hyacinth can severely interfere with navigation of both recreational and commercial craft. In addition to interfering with boating by fisherman and water-skiers in recreational waters, water hyacinth interferes with swimming, displaces native vegetation communities, and can adversely impact sports-fish populations. Limitations on water use can reduce real estate values and tourism. As water hyacinth mats decompose, sedimentation increases and dissolved oxygen levels are reduced. Water hyacinth affects fresh water Supplies. Water intake points become blocked; the screens and filters of water processing plants become blocked with decaying plant residues. Decaying

plant matter reduces the water quality. People in rural areas who use the lake as their source of drinking water are affected directly, and the costs of pumping and purification for urban dwellers are increased.

In regard to its ability to remove different pollutants from water it can positively influence on fish populations in natural waters or on fish growing in artificial accumulations. It can easily replace straw as substrate for mushroom growing or it can be use as fodder (Lindsey and Hirt, 1999). Water hyacinths block drainage systems causing flooding or preventing withdrawal of floodwaters. This aquatic macrophyte obstructs irrigation by preventing predicted water flow in channels, clogging irrigation pumps and destroying dams (Penfound and Earle, 1948, cit. Center et al., 2002).

2.3 Water Hyacinth and the Fishing Industry

The fisheries sub-sector plays an important role in Kenyan economy. The sector provides employment to over 500,000 Kenyans engaged in fish production and fish related enterprises. The fisheries sub-sector is however unable to realize its full potential due to among other factors over-reliance to capture fisheries and environmental degradation (Wafula et al, 2005).

Water hyacinth affects access to fishing grounds and fish catch-ability (Kateregga & Sterner, 2009). Reports from around the world indicate some villages where people have died from heavy water hyacinth infestations; notably through starvation because they could not reach food sources and protein deficiency resulting from unavailability of fish (Navarro & Phiri, 2000). Water hyacinth causes severe problems to fishermen in the riparian communities. When weed infestation is present, access to fishing sites become difficult for

riparian communities which rely solely on fishing as their main economic activity (Munjigni, 2001). This leads to increase in their expenditure on fuel for engine boats and further increase in the cost of the meagre quantities of fish they catch, for the society as a whole. There is often loss of fishing gears when nets or lines become tangled in the root systems of the weed. All these lead to reduction in fish catch and subsequent loss of livelihood. Center et al. (2002) reported that water hyacinth invasions reduce available light for submerged plants hence depleting oxygen, alters the composition of invertebrate communities, impacts fisheries, displaces native plants and wildlife, and increases sediment loading.

Information from the Fisheries Department, Kenya according to Mailu (2001) indicated that there was a 28% increase in total annual fish catches between 1986–1991 and 1991–1997, from 133,097 tonnes to 169,890 tonnes. There was an increase in all species of fish caught except *Oreochromis, Clarias* and *Mormyrus,* which showed declines of 14, 37 and 59%, respectively, over the same period. These declines may have been associated with the inability of fishermen to access the fishing grounds for those species because of water hyacinth infestation. Generally therefore, as a result of water hyacinth infestation, accessibility to land and water has been hindered, resulting in reduced fish catches, especially of tilapia and mudfish which are found mainly along the shores. Fisherfolk, however, reported increased fish catches from suitable breeding grounds provided by water hyacinth e.g. tilapia, synodontis, protopterus and labeo. A reduced fish catch would have an adverse effect on the quality of life of the communities around the lake and consequently affect sustainable development in the region.

Water hyacinth can greatly affect a fishery if it induces changes in fish community composition, or if catch-ability of harvested species is changed. Diversity in fish stocks is often affected with some benefiting and others suffering from the proliferation of water hyacinth (Calvert, 2002). In Lake Victoria, fish catch rates decreased because water hyacinth mats blocked access to fishing grounds, delayed access to markets, and increased fishing costs (effort and materials) (Kateregga & Sterner, 2009). Mats also blocked breeding, nursery, and feeding grounds for economically important species, such as tilapia and Nile perch in Lake Victoria (Twongo & Howard, 1998). It is interesting to note that decreased catch-ability of certain overfished species can lead to increased fishery stocks (Kateregga & Sterner, 2009) that in the long-run could benefit a fishery and human society.

The water hyacinth is an important fish feed. The Chinese grass carp is a fast growing fish which eats aquatic plants. It grows at a tremendous rate and reaches sizes of up to 32 kg (National Academy of Science (NAS), 1979). It can eat both submerged and floating plants. The fish can be used for weed control and will eat up to 18 – 40% of its own body weight in a single day (Gopal, 1987). Also, dehydrated water hyacinth has been added to the diet of channel catfish fingerlings to increase their growth, hence used indirectly to feed fish (Gopal, 1987). According to Gopal, 1987 decay of water hyacinth after chemical control also releases nutrients which promote the growth of phytoplankton with subsequent increases in fish yield.

2.4 Water Hyacinth and Weaving Industry

In settlements where water hyacinth has destroyed economy (fishing, river transport, e.t.c) population can reorient to manufacturing of art paper, crafts, ropes,

furniture and other things from water hyacinth which will lead to reduction of unemployment and increase of income (Lindsey and Hirt, 1999). The House and Building Research Institute in Dhaka has carried out experimental work on the production of fibre boards from water hyacinth fibre and other indigenous materials (Haider, 1989). According to Haider, 1989, chopped water hyacinth stalks are reduced by boiling and then washed and beaten. The pulp is bleached and mixed with waste paper pulp and a filter agent such as china clay and the pH is balanced. The boards are floated in a vat on water and then finished in a hand press and hung to dry. The physical properties of the board are sufficiently good for use on indoor partition walls and ceilings.

The fibre from the stems of the water hyacinth plant can be used to make ropes. The stalk from the plant is shredded lengthways to expose the fibres and then left to dry for several days. The rope making process is similar to that of jute rope. The finished rope is used by a local furniture manufacturer who winds the rope around a cane frame to produce an elegant finished product (Haider, 1989). In the Philippines water hyacinth is dried and used to make baskets and matting for domestic use (NAS, 1976 cited in Ndimele *et al,* 2011). The key to a good product is to ensure that the stalks are properly dried before being used. If the stalks still contain moisture, then this can cause the product to rot quite quickly. In India, water hyacinth is also used to produce similar goods for the tourist industry. Traditional basket making and weaving skills are used (Calvert, 2002).

In settlements where water hyacinth has destroyed economy (fishing, river transport) population can reorient to manufacturing of art paper, crafts, ropes, furniture and other things from water hyacinth which will positively influence to reduction of unemployment and increase of income (Lindsey and Hirt, 1999). In Luzira Maximum

Security Prison in Kampala the prison water hyacinth is collected carefully from the lake by boat, and laid to dry in the sun for a few days, before being treated with a preservative. They make bags, tables, sleeping mats, and hospital screens. Easy chairs are made with wooden frames, and dining chairs using metal frames.

2.5 Water Hyacinth and Tourism Activities

Estuaries are very good tourist sites where thousands of tourists from all over the world derive pleasure. Water hyacinth infestation affects tourism, as their access to the beautiful view of the estuaries becomes limited. In addition, they have difficulties in accessing the inland waterways by boats due to blockage by water hyacinth. Dense mats of water hyacinth create impenetrable barriers and prevent navigation (Center et al., 2002). In this regards, the riparian communities are affected because their commercial activities are usually boosted by tourists.

It is blocking access to recreational areas and reduces values of waterfront properties. Beside that water hyacinth often creates suitable environment for mosquitoes because it disrupts application of insecticides, drainage and water circulation. All of this has negative impact on economics of communities whose main earnings come from fishing and tourism (Center et al., 2002). Lake Victoria is now clearly unattractive for sun-bathing, swimming and water sports such as wind-surfing and sailing. Many had hoped that the lake would develop into a popular area for holiday makers. The 62 islands of the Sese archipelago in the north west of the lake, in particular, are of striking beauty.

2.6 Theoretical Framework of the Study

The study was based on the Opportunity-Based Entrepreneurship theory by Drucker (1985). The theory asserts that entrepreneurs do not cause change but exploit the opportunities that change creates (change in technology, consumer preferences etc.) (Drucker, 1985). The entrepreneur always searches for change, responds to it, and exploits it as an opportunity. What is apparent in Drucker's opportunity construct is that entrepreneurs have an eye more for possibilities created by change than the problems.

Stevenson (1990) extends Drucker's opportunity-based construct to include resourcefulness. He concludes that the hub of entrepreneurial management is the pursuit of opportunity without regard to resources currently controlled. Entrepreneurs identify business opportunities to create and deliver value for stakeholders in prospective ventures. While elements of opportunities may be recognized, opportunities are made, not found. Careful investigation of and sensitivity to market needs and as well as an ability to spot suboptimal deployment of resources may help an entrepreneur begin to develop an opportunity (which may or may not result in the formation of a business). But opportunity development also involves entrepreneurs' creative work. Therefore, ''opportunity development'' rather than ''opportunity recognition,'' was the focus of this study. In this study, the residents of Dunga beach, in spite of the problems created by the presence of the water hyacinth on the surface of Lake Victoria, some take advantage of the entrepreneurial opportunities created by its infestation while others premise their entrepreneurial activities on the absence of the water hyacinth.

2.7 Conceptual Framework of the Study

The conceptual framework (Figure 2.1) shows the relationship between the independent variable (water hyacinth) and the dependent variables (economic activities). It was conceptualized that when water hyacinth covers the water surface, extraction of water from the lake is hampered leading to harvesting of lower volumes of water than the operational capacity of the water treatment plant. The hyacinth also affects the chemical composition of the water. The low water volumes reduce the water business activities that affecting the livelihoods of the people who depend on the business for their livelihoods.

With regard to the fishing industry, it was conceptualized that the coverage of the water by the water hyacinth impedes fishing thus reducing the number of fish caught. The water hyacinth entangles the fishing equipment, making fishing difficult. However, on a positive front, the water hyacinth may be eaten by the fish as feed and therefore increase the fish population.

When the hyacinth is harvested, it may be used as raw material in the weaving industry for making some forms of furniture, baskets, ropes and other craft that are sold to earn income. Some of the items made from the hyacinth may attract tourists thus promoting tourist activities. On the other hand, the water hyacinth may block the water ways thus affecting navigation of boats, which greatly affects tourism and other recreational activities.

The interaction between the water hyacinth and the economic activities may be moderated by seasonal movements of the water hyacinth which either opens up the water or covers the water surface thus impeding any activities on the surface. The level of

infestation of the hyacinth also determines the level of exposure of the water surface to allow for both biological activities and other human activities in the water. When the water hyacinth is harvested as raw material for various basketry and craft products, water surface is opened up to allow for the mentioned processes to take place. On the other hand, the toxicity of the water may influence all the biological processes, production and use of the water. The conceptual framework of the study was as shown in Figure 2.1

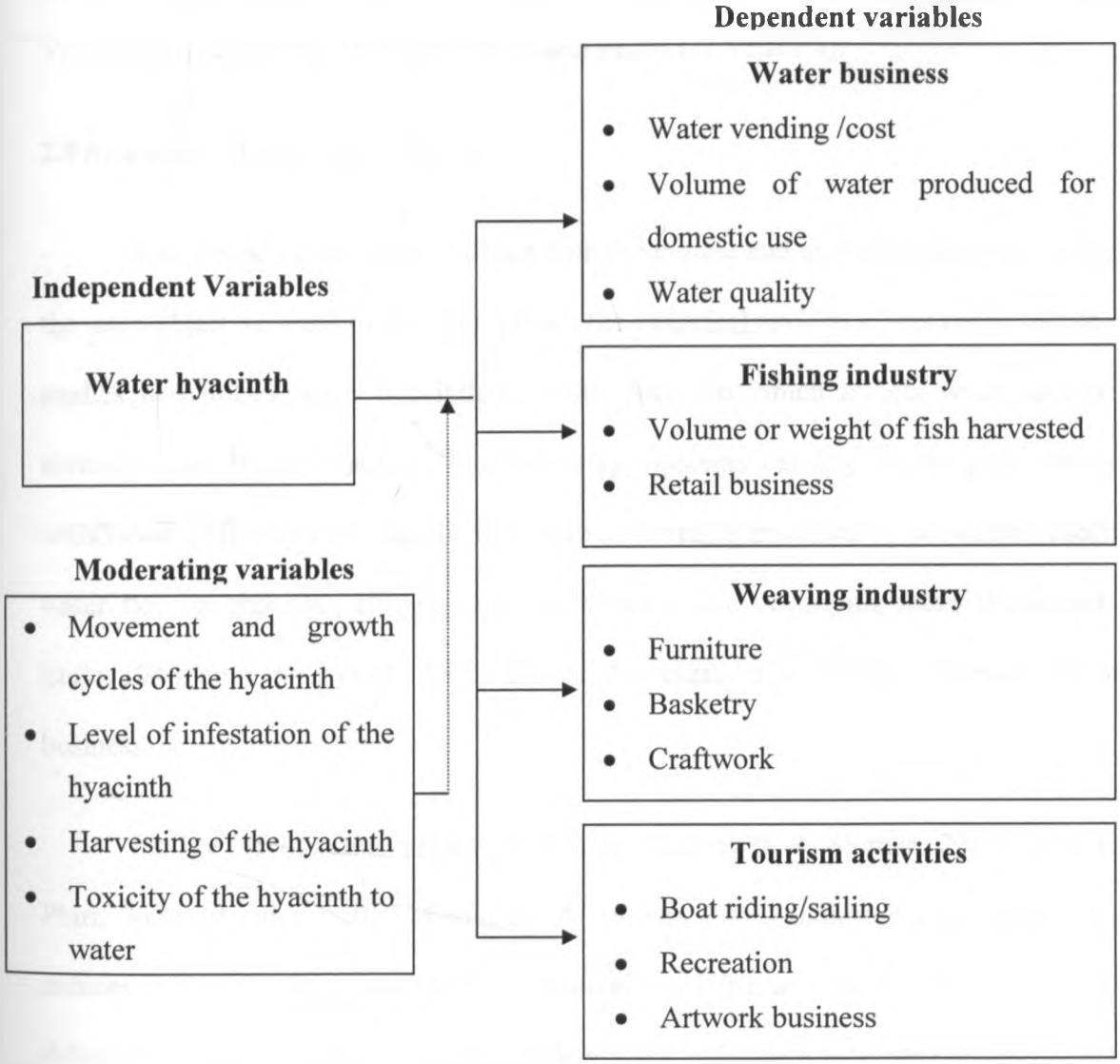

Figure 2.1: Conceptual Framework of the Study

2.8 Gaps in Literature Reviewed

In the review of related literature, it was found that a lot of studies had been done on the environmental impacts of the water hyacinth mainly concentrating on the water quality component, but no studies had been done to establish the effects of this aquatic weed on the economic activities of the community around the lake who derive their livelihood from the fresh water lake. Water quality studies were mainly conducted by Lake Victoria Environmental Management Project Phase I (LVEMP I).

2.9 Summary of Literature Review

The preceding sections reviewed both theoretical and empirical literature related to the main objective areas of the study. From the empirical review, it was noted that several studies had linked water hyacinth to water pollution which affects water quality for domestic use. Water hyacinths block drainage systems causing flooding or preventing withdrawal of floodwaters, aquatic macrophyte obstructs irrigation by preventing predicted water flow in channels, clogging irrigation pumps and destroying dams (Penfound and Earle, 1948, cit. Center et al., 2002). This study examined how these influenced the water business.

Review of literature related to fishing (Kateregga & Sterner, 2009; Navarro & Phiri, 2000; Munjigni, 2010; Kateregga & Sterner, 2009) indicated that water hyacinth reduces fish populations and hinders catch-ability of fish and causes severe problems to fishermen in the riparian communities. When weed infestation is present, access to fishing sites become difficult increasing expenditure on fuel for engine boats and further increase in the cost of the meager quantities of fish they catch, for the society as a whole. Other

studies showed (Center et al., 2002; Calvert, 2002) reported that water hyacinth invasions reduce available light for submerged plants hence depleting oxygen and impacts on fisheries while others argued that the water hyacinth is an important fish feed (NAS, 1979; Gopal, 1987).

With respect to weaving industry, review of prior studies indicated that water hyacinth has been used in art/craftwork such as manufacturing of art paper, crafts, ropes, furniture and other things creates unemployment and increase of income (Lindsey and Hirt, 1999; Haider, 1989 and Ndimele *et al,* 2011). These studies depicted the economic potential of the hyacinth utilization, which this study investigated further by studying the influence of the hyacinth on the weaving industry in the community around Dunga beach.

Finally, the review indicated that water hyacinth infestation affects tourism, as access of tourists to the beautiful view of the estuaries becomes limited. It creates difficulties in accessing the inland waterways by boats due to blockage thus preventing navigation (Center et al., 2002). In this regards, the riparian communities are affected because their commercial activities are usually boosted by tourists. This study assessed the effect of the water hyacinth on Lake Victoria on the tourism industry of the community around Dunga beach.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the proposed research design; the study's location; target population; sample size and sampling techniques; instrumentation; data collection procedures and a summary of data analysis.

3.2 Research Design

The study utilized the descriptive survey research design with both quantitative and qualitative approaches. A survey is an attempt to collect data from members of a population in order to determine the current status of that population (Mugenda and Mugenda, 1999). This design was appropriate to the study since it facilitated the description of the characteristics and the relationship between the water hyacinth infestation and the various economic activities taking place in the study area. Descriptive survey describes "what is" and is concerned with conditions or relationships that exist, opinions that are held, processes that are going on, effects that are evident or trends that are developing (Best and Khan, 1993). According to Lokesh (1984) descriptive studies are designed to obtain pertinent and precise information concerning the status of phenomena and whenever possible to draw valid general conclusions from the facts discovered. The design guided the study examining the effect of the water hyacinth on the economic activities of the community around the study area.

3.3 Target Population

Mugenda and Mugenda (1999) define target population as that population to which a researcher wants to generalize the results of the study. The ideal setting for research study is one that directly satisfies the researcher's interest and should be accessible to the researcher (Singleton, 1993). The target population for the study comprised all the households in Nyalenda B Sub location which is found in Kolwa West location, Winam Division in Kisumu East District who derives their livelihoods from Lake Victoria. The National Population and Housing Census provided a listing of 8,561 households in Nyallenda B Sub-location (Kenya National Bureau of Statistics (KNBS), (2010). This was used as a sampling frame from which a representative sample was selected for study.

3.4 Sample Size and Sampling Procedures

This section describes the sample size and the procedures used in picking the sampled subjects for the study.

3.4.1 Sample Size

Krejcie and Morgan (1970) have provided a table of determining sample size for different populations (Appendix I). The table is based on a formula which gives a sample size that when drawn randomly from a finite population size, is such that the sample will be within ±.05 of the population proportion with a 95% level of confidence. The formula is given by:

$$S = \frac{X^2 NP(1 - P)}{d^2(N - 1) + X^2P(1-P)}$$

Where:

S = the required sample size

X^2 = the table value of chi-square for one degree of freedom at the desired confidence level (0.05) which is equal to 3.841 (or 1.96^2)

N = the population size

P = the proportion of the population, assumed to be 0.50 since this would provide the maximum sample size.

d = the degree of accuracy expressed as a proportion (.05).

Applying the formula, a population N of 8,561 gave a sample size of:

$$S = \frac{3.841 \times 8561 \times 0.5\,(1-0.5)}{0.05^2 \times 8560 + 3.841 \times 0.5(1-0.5)} = \frac{8220.70025}{22.36025} = 367.65$$

Therefore, the original sample size for the study was 368 respondents.

3.4.2 Sampling Procedures

Sampling refers to the selection of some part of an aggregate or totality on the basis of which a judgment or inference about aggregate or totality is made. In other words, it is the process of obtaining information about an entire population by examining only a part of it (Kothari, 2004). A sample size is a definite plan determined before data is actually collected for obtaining a sample from a given population (Orodho, 2005).

From the onset, cluster sampling was adopted where the study area was clustered into 4 neighborhood villages namely Dunga, Oboch, Katuoro and Kapuothe. Cluster

sampling is most appropriate where there is an attempt to study characteristics in their natural settings or to ensure geographic representation of intact groups whose distinct characteristics are of interest in a research (Osuji, 2006). The next step involved determining the number of households in each of the four villages. The village elders provided information on the number of households in their respective jurisdictions.

After determining the number of households in each village, the next stage involved proportionate allocation of the sample size to the villages based on their respective total number of households. This was done using the formula:

$$SSS = \frac{X}{8562} \times 368:$$

Where: SSS = sub-sample size of each village, X = the population of each village. The final step involved selection of the study's subjects based on the sub-sample sizes, which was done through simple random sampling. In simple random sampling, each household had an equal and independent chance of being selected. Random lists of numbers that corresponded to the number of households in each village were generated then the participating households picked at random from each list.

The key informants were purposively selected, two from each sector (male and female) and one from the Kisumu Water and Sewerage Company (KIWASCO). A total of 9 key informants were, therefore, targeted to be interviewed.

3.5 Data Collection Instruments

The researcher designed two instruments, a questionnaires and a key informant guide. The questionnaire bore both closed and open-ended items and was used to collect primary data from household respondents. Generally, the questionnaire had two main parts. The first part solicited demographic information of the respondents and included type of business, sex and working experience at the beach. The second part addressed issues related to the study objectives and research questions and the responses received were analyzed to address the study's objectives and answer the research questions. The key informant guide bore unstructured questions that were directly related to the themes of the study. This was used to guide interviews with key informants who included the village elders, community leaders and official from the water company and fish processors. Interviews with the key informants were organized so as to gather data and information that was useful in filling in gaps in quantitative data from the household respondents and making clarifications. Non-participant observation was done in observing the prevailing coverage of the water surface by the water hyacinth and the various activities that were taking place around the beach.

3.5.1 Pilot testing

The questionnaire was pilot-tested on a sample of 10 respondents drawn from Usoma beach which has similar characteristics as the study location. The respondents were encouraged to make comments and suggestions concerning the instructions, clarity of questions asked and their relevance (Mugenda and Mugenda, 1999). The results from the piloting were used in validating the instruments by revising the items that were not clear.

3.5.2 Validity of the instruments

According to Saunders *et al.* (2007) validity is the extent to which data collection method accurately measure what they are intended to measure. It indicates the degree to which an instrument measures the construct under investigation (Gall. et al., 2003). When applying this to data collected through a questionnaire it means that the data collected is the data that actually should be collected. Saunders *et al.* (2007) stresses that the questions have to be understood in the way that was the purpose from the researcher, it has to be answered in the way that was thought from the researcher and the answer must be interpreted by the researcher in the way intended by the respondent. Therefore, in construction of the instrument items, the researcher used simple English language that was easily comprehensible to the respondents. Effort was made to ensure that the items were clear and precise without any ambiguity, ensuring that the items addressed the objectives of the study adequately. The instruments were given to the supervisor and other research experts at the University of Nairobi for expert judgment and review of content and face validity.

3.5.3 Reliability of the Instruments

The reliability of the questionnaire items was determined using the Cronbach alpha coefficient. Cronbach alpha provides a good measure of reliability because holding other factors constant the more similar the test content and conditions of administration are, the greater the internal consistency reliability (Chong, 2012). Bryman and Cramer (1997) recommend a reliability coefficient of 0.70 and above. Data from the pilot study was analyzed for reliability with the aid of the Statistical Package for Social Scientists (SPSS).

From the analysis, the questionnaire items gave a reliability coefficient of $\alpha = 0.82$, thus the instrument was considered reliable enough and subsequently adopted for data collection.

3.6 Data Collection Procedures

Permission to conduct research was obtained from the University of Nairobi and then a research permit from the National Council of Science and Technology (NCST). The researcher then made an exploratory visit to the area of study to meet with local leaders specifically community leaders to map out the area to identify the locations of the sampled household. The next stage was the actual field work and entailed collecting primary data from the sampled households' respondents. The questionnaire was administered to the individual respondents, assuring the respondents that information gathered would be treated confidentially and purely for the purposes of research. The researcher delivered the questionnaires in person together with two trained research assistants and waited as respondents filled in their responses, then collecting them immediately. This was followed by key informant interviews with identified community leaders and officials from stakeholder institutions to gain a deeper understanding of the issues under investigation.

3.7 Data Analysis Techniques

Both quantitative and qualitative data analysis methods were used since the data collected based on the questionnaire generated both quantitative and qualitative information. The collected data was coded after validation and editing, then entered into the computer. Data analysis was done with the aid of the SPSS. The objectives of the study were analyzed using percentages and frequency distributions to determine the influence of the water hyacinth on the different economic sectors of the community around the study

area. Qualitative data obtained from the open-ended questions in the questionnaires and key informant interviews were extracted, common themes identified, organized and then discussed under the main objective areas of the study.

3.8 Ethical considerations

Ethical measures are principles which the researcher should bind himself with in conducting his/her research. In this study, the researcher will seek the requisite approvals for conducting the research before data collection (McMillan & Schumacher 1993). Initial approval was sought from the University of Nairobi. A research permit was then obtained from the NCST followed by an introductory visit to the area to brief the local leaders on the study as a key entry point to the community.

McMillan and Schumacher (1993) recommend that information on participants should be regarded as confidential unless otherwise agreed on through informed consent. In this study, participants' confidentialities were adhered to, as they were not asked to provide their names during data collection.

3.9 Operationalization of the Variables

Table 3.1 shows how the variables of the study were operationalized

Table 3.1: Operationalization of the Study's Variables

Objectives	Independent Variable	Dependent Variables	Data Analysis Tools
To establish the effects of water hyacinth on water business of the community around Dunga Beach of Lake Victoria, Kisumu	Water hyacinth • Chemical composition of water	**Water business** • Water vending • Volume of water produced of domestic use • Water quality	Frequency and Percentages
To determine the effects of water hyacinth on the fishing industry of the community around Dunga Beach of Lake Victoria, Kisumu	Water hyacinth • Navigability of water • Feed	**Fishing industry** • Volume of fish harvested/sold • Retail business	Frequency and Percentages
To assess the effects of water hyacinth on the weaving industry of the community around Dunga Beach of Lake Victoria, Kisumu	Water hyacinth • Peak periods • Harvesting periods	**Weaving industry** • Furniture • Basketry • Craftwork	Frequency and Percentages
To assess the extent to which water hyacinth affects tourism activities around Dunga Beach of Lake Victoria, Kisumu	Water hyacinth • Navigability	**Tourism activities** • Boat riding/sailing • Recreation • Artwork business	Frequency and Percentages

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION

4.1 Introduction

The project investigated the effects of water hyacinth on the economic activities of the community around Dunga beach of Lake Victoria. Primary data was collected using the household questionnaire sampled from households in the community around Dunga beach in Kisumu and the key informants' interview guide from identified key informants in the study location. Data was analyzed as per the objectives of the study. Thus, this chapter presents the findings of the study with their interpretations and further discusses the findings in relation to reviewed scholarly works. The chapter is organized under sub-headings of: response rate; background of the respondents, water hyacinth and water business, water hyacinth and fishing industry, water hyacinth and weaving industry and water hyacinth and tourism activities.

4.2 Response Rate

Three hundred and thirty one (331) household questionnaires were returned out of 368 that were administered to the sampled households. This represented a 90% response rate. In addition, seven (7) in depth interviews were successfully conducted with the key informants, representing a response rate of 78%. Overall, there was a 90% response rate, which was achieved through personal commitment by the researcher and the use of trained research assistants who, after administering the household questionnaires, waited for the respondents to fill in their responses and collected them immediately.

Table 4.1: Response Rates

Respondent Category	Original Sample size	Number Achieved	Response Rate
Household	368	331	89.9%
Key Informants	9	7	77.7%
Total	**377**	**338**	**89.7%**

Dillman (2000) and Roth & BeVier (1998) suggest return rate of 50% as the minimal level, while Fowler (1984) suggests 60%; and De Vaus (1986), argues for 80%. Thus, the 90% return rate was considered credible enough to allow generalization of the findings to the target population The high return rate largely ensured that the sample sizes remained as close as possible to the original sample sizes thus representative of the target population.

4.3 Background of the Respondents

This section discussed the household respondents' sex, level of education, economic activities and experience in the economic activities undertaken.

4.3.1 Distribution of the Respondents by Sex

The household respondents were required to indicate their sex. It was important to establish the gender characteristics of the residents who participated in the study in order to understand the implication of gender on the economic activities in the study area. Table 4.2 shows the distribution of the respondents by sex.

Table 4.2: Distribution of the Respondents by Sex

Respondents' Sex	Frequency	Percentage
Male	273	82.5
Female	58	17.5
Total	**331**	**100.0**

Two hundred and seventy three (273) male and 58 female household respondents were interviewed, which represented 82.5% male and 17.5% female respondents respectively. The high percentage of male respondents is an indication of the dominant role that men play over women in the community, given that in the traditional African society, the man is the household head and assumes the role of family spokesperson. This probably affected the participation of the women in the economic activities. In addition, most of the economic activities are controlled by men, just like they also control most of the economic resources in the community.

4.3.2 Distribution of the Respondents by their Level of Education

The respondents were asked to indicate their level of education. It was important to establish the level of education of the respondents so as to understand whether or not they are qualified enough to understand the impact of the hyacinth on the economic activities of the study. Table 4.3 shows the distribution of the respondents by their level of education.

Table 4.3: Distribution of the Respondents by their Level of Education

Level of Education	Frequency	Percentage
Primary Education	87	26.3
Secondary Education	110	33.2
Tertiary Education	101	30.5
University Graduate	33	10.0
Total	**331**	**100.0**

The findings indicate that 33% of the household respondents had up to secondary education, 31% tertiary college education, 26% had primary school education and 10% were university graduates. The number of respondents attaining higher education was significant. Cumulatively, 41% of the respondents were educated up to the post secondary education level. On the other hand, a considerable number of respondents were just functionally literates, thus it can be concluded that by and large the respondents were progressive in education, which is so important today to create a knowledge based society. Education is one of the most important characteristics that might affect the person's attitudes and the way of looking and understanding any particular social phenomena. Given that majority of the respondents had at least secondary education, they were able to understand the questions asked and provide appropriate responses that gainfully contributed to answering the research objectives.

4.3.3 Respondents' Economic Activities

The respondents were asked to indicate the economic activities in which they were involved. Their responses were as presented in Table 4.4.

Table 4.4: Respondents' Economic Activities

Economic Activity	Frequency	Percentage
Fishing industry	125	37.8
Water business	42	12.7
Weaving/basketry	39	11.8
Tourism	125	37.8
Total	**331**	**100.0**

The findings indicate that 37.8% of the household respondents in each case were either involved in the fishing industry or tourism, while 12.7% and 11.8% of the households reported that they were involved in water business and weaving industry respectively. There were more households involved in fishing and tourism activities than in water business and weaving industry, probably due to the fact that fishing is the main economic activity around the lake while tourism business picks up favourably due to both domestic and foreign tourists visiting the area for recreation activities. Only 12.7% of the residents were involved in water business, this was mainly because the area is fairly served with water through the water company and these were mainly the water vendors and those running the water kiosks leased to them by the water company. Since a person's occupation has a bearing on his or her personality and so does the way of looking at the problem before him, the fact that almost all the respondents engaged in the economic activities that fell squarely within the interest of the study is a reflection of their level of understanding of the phenomenon under investigation. Thus, their response to the questions raised validly contributed to the conclusions of the study.

4.3.4 Respondents' Experience in Economic Activities

The respondents were asked to indicate the period of time they had been involved in their respective business activities in order to assess their experience in understanding the effects of the hyacinth on the economic activities. The findings were as shown in Table 4.5.

Table 4.5: Experience in Economic Activities

Experience	Frequency	Percentage
Less than 2 years	76	23.0
2-4 years	94	28.4
5-7 years	72	21.8
8-10 years	43	13.0
More than 10 years	46	13.9
Total	**331**	**100.0**

The findings indicate that 28% of the household respondents had 2-4 years' experience in their respective economic activities, 23% had less than 2 years' experience, 22% had 5-7 years, 14% more than 10 years and 13% had 8-10 years' experience. Generally, about 73% of the respondents had more than 2 years' experience in their respective economic activities, which was considered enough experience to provide reliable information related to the objectives of the study.

4.4 Water Hyacinth and Water Business

The first objective of the study was to establish the effects of water hyacinth on water business of the community around Dunga Beach. However, to determine the effects of the water hyacinth on the economic activities, generally, the study first sought to establish the months within the year when, from the community's perspective, the Dunga part of Lake

Victoria was either fully covered or clear of the water hyacinth. This section, therefore, presents findings on the water hyacinth infestation and analyzes its effects on the water business.

4.4.1 Water Hyacinth Infestation.

The respondents were asked to indicate the periods of the year when the lake was completely covered by the water hyacinth as well as the period when the water hyacinth would move away from the Dunga part of the Lake Victoria. Table 4.6 shows the respondents' responses.

Table 4.6: Water Hyacinth Infestation

Period in Months	Lake Covered		Lake Not Covered	
	Frequency	Percentage	Frequency	Percentage
Jan-Feb	134	40.5	12	3.6
Mar –Apr	151	45.6	122	36.9
May-Jun	37	11.2	210	63.4
Jul-Aug	41	12.4	74	22.4
Sep-Oct	114	34.4	34	10.3
Nov-Dec	151	45.6	24	7.3

The percentages in Table 4.6 indicate that highest percentage of the household respondents, 46%, observed that the lake was covered by the Water hyacinth between the months of March and April and November to December. A significant percentage of the respondents (41%) also observed that the Lake was covered between the months of

January and February, which are basically transitional months between December and March. 34% of the respondents also indicated that the lake was covered with the weed in the months of Sept- Oct .On the other hand, majority of the respondents observed that the lake was free of the water hyacinth in the months of May and June. A significant 37% of the respondents also reported that the lake was clear of the water hyacinth in the months of March and April, seemingly contradicting their very observation that the lake was covered by the water hyacinth within the same period. 10.3% of the respondents indicated that the lake was not covered in the month of September and October. A small percentage of 3.6 and 7.3 responded that the lake is not covered in the months of Jan-Feb and Nov-Dec respectively because from the residents' perspective, initial infestations in earlier years indicated that during these months the Dunga part of the lake was very clear though according to the respondents this trend changed from late last year when the lake was covered up to march before receding.

4.4.2 Volume of Water at Different Hyacinth Infestation Levels

The respondents were asked to indicate the times of the year when more water was extracted from the lake for domestic use. Their responses were as shown in Table 4.7.

Table 4.7: Period of water availability

Period in Months	Frequency	Percentage
Jan-Feb	85	25.7
Mar –Apr	100	30.2
May-Jun	187	56.5
Jul-Aug	103	31.1
Sep-Oct	48	14.5
Nov-Dec	86	26.0

More than half of the respondents, 57%, indicated that more water was extracted from the lake between the months of May and June, which is consistent with the earlier observation that the water surface was clear of the water hyacinth within this period. Significant percentages of the respondents also observed that more water was extracted in the months of July to August (31%) and March to April (30%). 26% of the respondents observed that water was available in the month of November and December. 25% of the respondents said that more water was available in the months of January and February. Only 14.5% said that more water is extracted in the months of September and October. The lower percentages were mainly observed in the months when the lake was covered with the hyacinth.

When asked to compare the volume of water available for sale during the different water hyacinth infestation levels, the household respondents' responses were as shown in Table 4.8.

Table 4.8: Volume of Water Available at Different Levels of Hyacinth Infestation

	No hyacinth		Partially covered		Completely covered	
Water Volume	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
High	231	69.8	64	19.3	54	16.3
Average	65	19.6	228	68.9	72	21.8
Low	35	10.6	39	11.8	205	61.9
Total	**331**	**100.0**	**331**	**100.0**	**331**	**100.0**

Majority of the respondents, 70%, indicated that when there was no water hyacinth on the water surface, the volume of water extracted was high compared to 19% and 16% who indicated that the volume was high when the surface was partially covered and completely covered respectively. On the other hand, 69% indicated that water volume was average in times of partial coverage while 62% indicated that water volume was low when the surface was completely covered. The water hyacinth affects availability of good drinking water as mats of water hyacinth cover the water surface, preventing reception of large inflows of water which are deoxygenated. On the other hand, death and decay of water hyacinth vegetation in large masses deteriorates water quality and the quantity of potable water, and increases treatment costs for drinking water (Patel 2012, Mironga *et al.* 2011, Ndimele *et al.* 2011). The ultimate consequence of this is that people depending on the lake as their source of drinking water are affected directly, and the costs of pumping and purification for urban dwellers are increased.

4.4.3 Water Prices at Different Levels of Hyacinth Infestation

The respondents were asked to indicate the average price of a 20 litre container of water during the different water hyacinth infestation levels. Their responses were analyzed and the findings were as shown in Table 4.9.

Table 4.9: Water Prices at Different Levels of Hyacinth Infestation

Water Price Per 20ltrs (Ksh)	No hyacinth		Partially covered		Completely covered	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
3	261	78.9	212	64.40	192	58.0
5	49	14.8	98	29.6	61	18.4
10	21	6.3	21	6.3	78	23.6
Total	**331**	**100.0**	**331**	**100.0**	**331**	**100.0**

The findings indicate that across all the levels of hyacinth infestation, majority of the respondents report that price of 20 litres of water is Ksh. 3, as observed under no hyacinth infestation (79%), water surface partially covered by water hyacinth (64%) and water surface completely covered by the hyacinth (58%). However, it was noted that the percentage of people reporting the Ksh. 3 price reduced as hyacinth infestation increased. On the other hand, as the water surface becomes partially covered, the percentage of the respondents reporting a price of Ksh. 5 for every 20 litres of water doubled from 15% to 30%, while the percentage of those who reported a price of Ksh. 10 for the same volume of water remained constant but increased to 24% as the water became completely covered by the water hyacinth.

Ordinarily, the water company, KIWASCO sells treated water from the lake at a controlled price of Ksh. 3 for every 20 litres. This explains the high percentage of respondents who reported the Ksh. 3 as the price of water across all the levels of hyacinth infestation. However, as the level of infestation increases, the volume of water extracted from the Lake and treated by the KIWASCO decreases, as both extraction and treatment becomes very difficult and expensive as a result of the dense matt of the weed at the intake (Odiwuor, 2013). This causes a scramble for the little of treated water available, forcing a good number of community members to retreat and wait for the supply of the commodity by the water vendors at a price that is inclusive of their margins, that is, Ksh 5 and 10 at times. All these challenges are attributable to the water hyacinth impeding water flow and clogging of water intakes points of the pumps used for conveying water (Center *et al.*, 2002). According to Center *et al.* (2002), the water intake points become blocked; the screens and filters of water processing plants become blocked with decaying plant residues. Decaying plant matter reduces the water quality and the people using the lake as their source of drinking water are affected directly as the costs of pumping and purification for are increased.

4.5 Water Hyacinth and Fishing Industry

The second objective of the study was to examine the effects of water hyacinth on the fishing industry of the community around Dunga Beach of Lake Victoria. This section presents the findings under sub-sections of fish quantities and fish prices.

4.5.1 Fish Quantities at Different Water Hyacinth Infestation Levels

The respondents were asked to indicate the quantities of three types of fish - tilapia, cat fish and mud fish obtained from the lake at different times of the year. A scoring strategy for the responses was adopted, where a score of 1 was adopted for "Low" and 2 for "High". Their responses were analyzed to determine the means and standard deviations. The means and standard deviations were as shown in Table 4.10.

Table 4.10: Fish Quantities at Different Times of the Year

		Tilapia		Cat fish		Mud fish	
Month	**n**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
Jan-Feb	331	1.25	.436	1.55	.499	1.57	.495
Mar-Apr	331	1.44	.497	1.74	.439	1.75	.434
May-Jun	331	1.55	.498	1.51	.501	1.53	.500
Jul-Aug	331	1.21	.405	1.48	.500	1.53	.500
Sep-Oct	331	1.31	.465	1.56	.498	1.57	.496
Nov-Dec	331	1.22	.413	1.71	.454	1.86	.346

The findings indicated that means of the fish quantities as rated by the respondents varied from one type of fish to the other at different times of the year. For instance, the mean rating for quantity of tilapia fish was highest in the months of May-June at 1.55 followed closely by a mean of 1.44 in the months of March-April, September and October had a mean of 1.31, January and February had a mean of 1.25. the month of November

and December had a mean of 1.22 for tilapia, while the lowest was in the months of July-August at 1.21. On the other hand, the mean ratings for cat fish and mud fish followed a similar trend, where the highest mean ratings were observed in the months of March-April (1.74 for cat fish and 1.75 for mud fish) and November to December (cat fish=1.71, mud fish=1.86) and the lowest means observed in the months of May – June (cat fish=1.51, mud fish=1.53). Generally, the means of cat fish and mud fish remained above those of tilapia across the year. It was also noted that the highest means for tilapia occur during the month of May-June.

4.6 Water Hyacinth and Weaving Industry

The third objective of the study sought to assess the effects of water hyacinth on the weaving industry of the community around Dunga Beach. This section therefore presents findings on the use of the hyacinth as raw material and its economic benefits to the community.

4.6.1 Harvesting of Water Hyacinth as Raw Material in Basketry

The respondents were asked to indicate whether there were instances when the water hyacinth was harvested for use as raw material, and what was made out of the material. Table 4.14 shows the responses obtained.

Table 4.14: Harvesting of the Water Hyacinth as Raw Material

Harvesting of Hyacinth	Frequency	Percentage
Yes	298	90.0
No	33	10.0
Total	**331**	**100.0**

Ninety percent (90%) of the respondents reported that the water hyacinth was harvested and used as raw material to make items that the artisan's sold as an economic engagement. When asked to list the items that were made from the water hyacinth, the respondents listed baskets, cupboards, tablemats, seats, handbags, earrings, bangles, necklaces, trays, chairs and coffins, . Majority of the respondents indicated that they use the hyacinth to make seats. The respondents reported that these items fetched good income, making the water hyacinth to be looked at as a cash crop and a source of raw materials for their products. Asked to indicate if there were other items that they thought would possibly be made from the hyacinth, the respondents' responses were as shown in Table 4.15.

Table 4.15: Possibility of Making Other Items from the Water Hyacinth

Possible to make Other Items from Hyacinth	Frequency	Percentage
Yes	270	81.6
No	61	18.4
Total	**331**	**100.0**

Eighty two percent (82%) of the respondents indicated that indeed, it was possible to make other items of economic value from the water hyacinth other than the items that were already being made. Other items that they said may be made from this water weed included caps, paper, key holders, special occasions' cards and fertilizer. Only 18.4% indicated that no item could be made from the hyacinth a part from the ones mentioned earlier.

The findings on water hyacinth and weaving industry confirm Lindsey and Hirt (1999) assertion that in areas where water hyacinth has destroyed the fishing and transport economy, the human population can reorient to manufacturing of art paper, crafts, ropes, furniture and other things from water hyacinth which positively influence to reduction of unemployment and increase of income as observed among the riparian communities of Dunga beach. To a large extent, the findings concur with NAS, (1976) as cited in Ndimele *et al,* (2011), who reported that as a readily available resource in the Philippines, the water hyacinth is dried and used in small cottage industries to make baskets and matting for domestic use and also Calvert (2002) and Patel (2012), who reported the water hyacinth as being used in India to produce paper, rope, basket, mats, shoes, sandals, bags, wallets, vases, etc for the tourist industry where traditional basket making and weaving skills are used.

4.7 Water Hyacinth and Tourism Activities

The last objective of the study was to assess the extent to which water hyacinth affects tourism activities around Dunga Beach of Lake Victoria. This section presents findings on the respondents' views on visitation of the tourists and presents an analysis of

the relationship between the water hyacinth infestation and tourist visitation. The section also presents findings on the effect of the hyacinth on various tourist activities.

4.7.1 Tourist Visitation

The respondents were asked to indicate whether there were times of the year when tourists visited the Dunga beach. Their responses were as shown in Table 4.16.

Table 4.16: Tourist Visitation

Tourists visit	Frequency	Percentage
Yes	313	94.6
No	18	5.4
Total	**331**	**100.0**

Majority of the respondents (95%) confirmed that tourists visited Dunga beach at different times of the year. This is an indication of the tourism potential of the Dunga beach as are the other areas of the beach. From the key informant interviews, it was confirmed that the area had potential to attract many tourists given that tourist activities such as swimming, wind surfing and canoeing were all possible despite the seasonal changes in the water hyacinth levels. The beach tour guides interviewed indicated that tourists visit the area and are taken to the surrounding islands like Ndere island to go and see the wild animals in the Island.

4.7.2 Number of Tourists at Different Times of the Year

The respondents were required to indicate the periods of the year between January and December when the number of tourists visiting the beach was either high or low. Scores were adopted for the respondents' responses to the number of tourists, where a score of 1 was adopted for a "low" response and a score of 2 for a "high" response. The responses were analyzed descriptively using means and standard deviations. The findings were as presented in Table 4.17.

Table 4.17: Means of the Number of Tourists at Different Times of the Year

Tourist months	N	Mean	Std. Deviation
Jan-Feb	331	1.55	.498
Mar-Apr	331	1.58	.494
May-Jun	331	1.76	.429
Jul-Aug	331	1.60	.492
Sep-Oct	331	1.51	.501
Nov-Dec	331	1.45	.498

The means in the table indicate that the highest mean for tourist visitation was in the months of May-June (1.76), followed by July-August (1.60) and March-April (1.58). the months of January and February was 1.55 while the months of September and October was 1.51. The lowest mean was obtained in the months of November-December at 1.45. The figures also indicate that the standard deviations of the means was small, an indication that the respondents ratings were almost similar and that the values were close to the means. The highest mean that relates to the months of May-June is due to the fact that

during this period, the water hyacinth levels are reported to be low, thus encouraging tourist activities on the Lake.

Lake Victoria is now clearly unattractive for sun-bathing, swimming and water sports such as wind-surfing and sailing. Many had hoped that the lake would develop into a popular area for holiday makers. The 62 islands of the Sese archipelago in the north west of the lake, in particular, are of striking beauty

4.8 Results and discussions on the Hypothesis

The hypotheses of the study were tested and the results below obtained:

1. **Hα:** The water hyacinth has no significant effects on the fishing industry of the community around Dunga Beach. To test this hypothesis the Pearson's correlation was conducted as reported in table 4.81,4.82 and 4.83 to check the relationship between water hyacinth infestation and quantities of tilapia, cat fish and mud fish respectively.

4.8.1 Relationship Between Water Hyacinth Infestation and Fish Quantities

The study sought to determine whether there was a relationship between water hyacinth infestation and fish quantities. Based on the reviewed literature, mixed effects of the water hyacinth on different fish populations have been reported. Therefore, to analyze this relationship, scores were adopted for different levels of hyacinth infestation where a score of 1 was adopted for complete coverage of water surface by the hyacinth and a score of 2 when the water surface was clear of the water hyacinth as reported by the respondents. Each respondent's scores for the periods of complete coverage of the water surface by the

hyacinth and clear water surface across the 6 bi-monthly periods were added and the average scores obtained. The average scores were used together with the means for fish quantities to conduct a Pearson's Product Moment Correlation (PPMC) to determine the relationship between water hyacinth infestation and fish quantities. The findings were as shown in Tables 4.18 (Tilapia fish), 4.19 (Cat fish) and 4.20 (Mud fish).

Table 4.18: Relationship Between Water Hyacinth Infestation and Tilapia Quantity

			Level of Hyacinth Infestation
Quantity of tilapia	Jan-Feb	Pearson Correlation (r)	-.049
		P –Value	.378
	Mar-Apr	Pearson Correlation (r)	.179**
		P –Value	.001
	May-Jun	Pearson Correlation (r)	.235**
		P –Value	.000
	Jul-Aug	Pearson Correlation (r)	-.067
		P –Value	.227
	Sep-Oct	Pearson Correlation (r)	-.159**
		P –Value	.004
	Nov-Dec	Pearson Correlation (r)	-.006
		P –Value	.908

**. Correlation is significant at the 0.01 level (2-tailed).*

The PPMC analysis indicated that there were significant positive relationships between water hyacinth infestation levels and the quantity of tilapia fish obtained in the months of Mar-Apr ($r=0.179$, $n=331$, $p<0.01$) and May-Jun ($r=0.235$, $n=331$, $p<0.01$), but a significant negative relationship between water hyacinth infestation level and tilapia quantities in the months Sep-Oct ($r= -0.159$, $n=331$, $p<0.01$). The correlations were significant at the 0.01 level of significance as shown by the p-values. As the level of water

hyacinth decreased, the quantities of tilapia increased in the months of Mar-Apr and May-Jun. High quantity of tilapia fish is associated with clean water.

Water hyacinth swamps the bays in which the fish spawn and start their lives. Important fishing grounds are covered with hyacinth. Mats of water hyacinth cannot be penetrated by canoe, making fishing extremely difficult and because the fish must now be caught further out in open water, fishermen need much more time to reach the fishing areas. This considerably reduces the quantity of fish caught. Nets are difficult to use where water hyacinth is present, either the plant sweeps them away or they become hopelessly entangled in the roots of the weed. The costs also become significantly high, thus discouraging fishing activities. There is also a decline in the quantity and the variety of fish. Water hyacinth seems to affect the breeding of Tilapia negatively, hence the low reported quantities of this economically lucrative fish species. These findings were consistent with the most recent study findings by Villamagna and Murphy (2010), who reported that the floating mats limit access to breeding, nursery and feeding grounds for some economically important fish species. Twongo and Howard (1998) had also reported that water hyacinth mats blocked breeding, nursery, and feeding grounds for economically important species, such as tilapia and Nile perch in Lake Victoria.

Table 4.19: Relationship Between Water Hyacinth Infestation and Cat Fish Quantity

			Level of Hyacinth Infestation
Quantity of cat fish	Jan-Feb	Pearson Correlation (r)	-.185**
		P –Value	.001
	Mar-Apr	Pearson Correlation (r)	-.116*
		P –Value	.035
	May-Jun	Pearson Correlation (r)	-.088
		P –Value	.112
	Jul-Aug	Pearson Correlation (r)	.000
		P –Value	.993
	Sep-Oct	Pearson Correlation (r)	-.203**
		P –Value	.000
	Nov-Dec	Pearson Correlation (r)	-.545**
		P –Value	.000

*. *Correlation is significant at the 0.01 level (2-tailed).*

The analysis revealed that there were significant negative relationships between water hyacinth infestation levels and the quantity of cat fish in the months of Jan-Feb ($r = -0.185$, $n=331$, $p<0.01$), Mar-Apr ($r= -0.116$, $n=331$, $p<0.01$), Sep-Oct ($r = -0.203$, $n=331$, $p<0.01$) and Nov-Dec ($r= -0.545$, $n=331$, $p<0.01$). The correlations were significant at the 0.01 level of significance.

The quantity of catfish increased with an increase in the coverage of water hyacinth, since coverage of the water with the hyacinth was reported to be relatively high in the months during which quantity of cat fish was reportedly high. The water hyacinth creates good breeding grounds for this variety of fish, which translates to higher quantities. However, from the key informant interviews, it was noted that though, the quantity of this type of fish may be high, problems are still experienced in fishing due to the reasons discussed under the Tilapia fish.

Table 4.20: Relationship Between Water Hyacinth Infestation and Mudfish Quantity

			Level of Hyacinth Infestation
Quantity of Mudfish	Jan-Feb	Pearson Correlation (r)	-.197**
		P –Value	.000
	Mar-Apr	Pearson Correlation (r)	-.126*
		P –Value	.000
	May-Jun	Pearson Correlation (r)	-.090
		P –Value	.103
	Jul-Aug	Pearson Correlation (r)	.003
		P –Value	.951
	Sep-Oct	Pearson Correlation (r)	-.187**
		P –Value	.001
	Nov-Dec	Pearson Correlation (r)	-.598*
		P –Value	.022

*. *Correlation is significant at the 0.01 level (2-tailed).*

Significant negative relationships also existed between water hyacinth infestation levels and the quantity of mudfish in the months of Jan-Feb ($r = -0.197$, $r=331$, $p<0.01$,), Mar-Apr ($r = -0.126$, $n=331$, $p<0.01$), Sep-Oct ($r = -0.187$, $n=331$, $p<0.01$) and Nov-Dec ($r= -0.598$, $n=331$, $p<0.01$). The correlations were significant at $p<0.01$. These correlations indicate that just like in the case of catfish, the quantity of mudfish caught increased with an increase in the coverage of water hyacinth, indicating that water hyacinth was a good breeding ground for this type of fish.

It is noted from the findings that water hyacinth induces varied changes in fish community composition and reduces catch-ability of harvested species. Calvert (2002) reported the diversity in fish stocks is often affected with some benefiting and others suffering from the proliferation of water hyacinth. On the other hand, Center *et al.* (2002) reported that water hyacinth invasions reduce available light for submerged plants hence depleting oxygen, alters the composition of invertebrate communities, impacts fisheries,

displaces native plants and wildlife, and increases sediment loading. The sediments seem to provide good breeding sites for the catfish and mudfish which are reported to increase in numbers during extensive hyacinth infestation. On the other hand, Munjigni (2001) posits that when weed infestation is present, access to fishing sites become difficult for riparian communities which rely solely on fishing as their main economic activity. Water hyacinth affects access to fishing grounds and fish catch-ability (Kateregga & Sterner, 2009).

2. **Hα:** The water hyacinth has no significant effects on the tourism industry of the community around Dunga Beach. To test this hypothesis the Pearson's correlation was conducted as reported in table 4.21 to check the relationship between water hyacinth infestation and tourist visitation in the area.

4.8.2 Relationship Between Water Hyacinth Infestation and Tourist Visitation

The respondents' scores in the tourist visits at different times of the year were used to conduct the PPMC to determine whether there was a relationship between water hyacinth infestation and the number of tourist visiting the beach. The findings were as shown in Table 4.21.

Table 4.21: Relationship Between Water Hyacinth Infestation and Tourist Visitation

Tourists visits		Level of Hyacinth Infestation
Jan-Feb	Pearson Correlation (r)	-.042
	P-value	.442
Mar-Apr	Pearson Correlation (r)	.175**
	P-value	.001
May-Jun	Pearson Correlation (r)	.535**
	P-value	.000
Jul-Aug	Pearson Correlation (r)	.124*
	P-value	.024
Sep-Oct	Pearson Correlation (r)	.181**
	P-value	.001
Nov-Dec	Pearson Correlation (r)	-.262**
	P-value	.000

*. *Correlation is significant at the 0.01 level (2-tailed).*

The PPMC analysis revealed that there were significant, positive relationships between the water hyacinth infestation levels and tourist visitations in the months of March-April ($r=0.35$, $n=331$, $p<0.01$), March-April ($r=0.175$, $n=331$, $p<0.01$), July-August ($r=0.124$, $n=131$, $p<0.01$) and September-October ($r=0.181$, $n=131$,$p<0.01$). However, there was a significant negative relationship between water hyacinth infestation levels and tourist visitations in the months of November and December ($r=-.262$, $n=331$ $p<0.01$).

The correlations indicate that high tourist visitations were associated with low infestation of the water hyacinth. Center *et al.* (2002) reported that dense mats of water hyacinth create impenetrable barriers and prevent navigation. The water hyacinth severely interferes with navigation of both recreational and commercial craft, interferes with swimming and adversely impact sports-fish populations Center *et al.* (2002)

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The purpose of the study was to investigate the effects of water hyacinth on the economic activities of the community around Dunga beach of Lake Victoria. This chapter therefore presents a summary of findings, conclusions and recommendations. The chapter further summarizes the contribution of the study to the existing body of knowledge and finally gives suggestions for further research.

5.2 Summary of the findings

The study collected data from a total of 331 households from the 368 household sample size and successfully conducted in-depth interviews with 7 key informants, representing an overall response rate of 90%. Of the household respondents reached, 82.5% were male and 17.5% were female. Up to 33% of the household respondents had secondary education, 31% tertiary college education, 26% had primary school education and 10% were university graduates. About 38% of the household respondents in each case were either involved in the fishing industry or tourism, while about 13% and 12% of the respondents were involved in water business and weaving/basketry respectively. With respect to entrepreneurial experience, about 73% of the respondents had more than 2 years' experience in their respective economic activities which was long enough to provide reliable information related to the objectives of the study.

The study established that the lake was covered by the water hyacinth between the months of March and April and November to December as reported by 46% of the

household respondents. A significant 41% of the respondents also observed that the Lake was covered between the months of January and February. On the other hand, majority of the respondents observed that the lake was free of the water hyacinth in the months of May and June, with a significant 37% of the respondents equally reporting that the lake was clear of the water hyacinth in the months of March and April.

As a result of the varying hyacinth infestation periods, more water was extracted from the lake between the months of May and June as confirmed by 57% of the respondents. A good percentage of the respondents also observed that more water was extracted in the months of July to August (31%) and March to April (30%). There was a strong, significant and negative relationship between water hyacinth infestation and water availability ($r= -0.764$, $n=331$, $p<0.01$). The ordinary price of water per 20 litres was Ksh. 3 under no hyacinth infestation (79%), water surface partially covered by water hyacinth (64%) and water surface completely covered by the hyacinth (58%). However, the percentage of people reporting the Ksh. 3 price reduced as hyacinth infestation increased. As the water surface became partially covered, the percentage of the respondents reporting a price of Ksh. 5 for every 20 litres of water doubled from 15% to 30%, while the percentage of those who reported a price of Ksh. 10 for the same volume of water remained constant but increased to 24% as the water became completely covered by the water hyacinth.

The study established that the means in the number of the fish quantities varied from one type of fish to the other at different times of the year due to different water hyacinth infestation level. The mean for tilapia fish was highest in the months of May-June at 1.55, followed closely by a mean of 1.44 in the months of March-April, while the lowest

was in the months of July-August. The means for cat fish and mud fish were highest in the months of March-April (1.74 for cat fish and 1.75 for mud fish) and November to December (cat fish=1.71, mud fish=1.86) and the lowest means observed in the months of May – June (cat fish=1.51, mud fish=1.53). There were significant positive relationships between water hyacinth infestation levels and the quantity of tilapia fish obtained in the months of Mar-Apr ($r=0.179$, $n=331$, $p<0.01$) and May-Jun ($r=0.235$, $n=331$, $p<0.01$), but a significant negative relationship between water hyacinth infestation level and tilapia quantities in the months Sep-Oct ($r= -0.159$, $n=331$, $p<0.01$), implying that as the level of water hyacinth decreased, the populations of tilapia increased in the months of Mar-Apr and May-Jun. On the other hand, significant negative relationships were observed between water hyacinth infestation levels and the quantity of cat fish in the months of Jan-Feb ($r = -0.185$, $n=331$, $p<0.01$), Mar-Apr ($r= -0.116$, $n=331$, $p<0.05$), Sep-Oct ($r = -0.203$, $n=331$, $p<0.01$) and Nov-Dec ($r= -0.545$, $n=331$, $p<0.01$). Significant negative relationships also existed between water hyacinth infestation levels and the quantity of mudfish in the months of Jan-Feb ($r = -0.197$, $r=331$, $p<0.01$), Mar-Apr ($r = -0.126$, $n=331$, $p<0.01$), Sep-Oct ($r = -0.187$, $p<0.01$) and Nov-Dec ($r= -0.598$, $n=331$, $p<0.05$).

As relates to the effect of the water hyacinth on the weaving industry, the study established that the water hyacinth was harvested and used as raw material to make items that included baskets, cupboards, tablemats, seats, handbags, earrings, bangles, necklaces, trays, chairs and coffins. These items were sold to, among others, tourists at good income, making it a lucrative business at certain periods of the year. About 82% of the respondents reported that other items of economic value that could be made from the water hyacinth were caps, paper, key holders, special occasions' cards and fertilizers.

With regard to the effect of the water hyacinth on tourism activities, the study established that Dunga beach was indeed a tourist attraction site as confirmed by 95% of the respondents that tourists visited the beach at different times of the year. It was established that the highest number of tourist visitations were in the months of May-June (mean =1.76), followed by July-August (1.60) and March-April (1.58). The lowest number of visitations was observed in the months of November-December (1.45). Significant, positive relationships existed between the water hyacinth infestation levels and tourist visitations in the months of March-April ($r=0.35$, $n=331$, $p<0.01$), March-April ($r=0.175$, $n=131$, $p<0.01$), July-August ($r=0.124$, $n=131$, $p<0.05$) and September-October ($r=0.181$, $n=131$, $p<0.01$). However, there was a significant negative relationship between water hyacinth infestation levels and tourist visitations in the months November and December, implying that high tourist visitations were associated with low infestation of the water hyacinth.

5.3 Conclusions

The existence of a strong, significant and negative relationship between water hyacinth infestation and water availability implies that the higher the infestation level of the water hyacinth, the lower the volumes of water extracted from the lake. Dense infestation of the water by the water hyacinth interferes with extraction of water from the lake. Extraction of more water from the lake is only possible when the water is clear of the hyacinth. Nevertheless, water that is extracted at such periods of dense water hyacinth infestation is extremely dirty, making it largely unsuitable for direct human use unless extensively treated using a lot of chemicals as expressed by the water company (KIWASCO) during the key informant interview. In addition, as clean becomes difficult to

obtain, the price of available treated water is increased by the water vendors who, although they buy at ordinary prices from the Kiosks of the water company, sell at higher prices to other residents living farther away from the lake and who might not be able obtain water directly from the kiosks. This, as with any other business that is subject to the market dynamics of supply and demand, affects water business both at the consumer level and the water vendors in varying proportions.

The results for the relationship between water hyacinth infestation and fish populations are varied. Whereas the water hyacinth infestation may be suicidal to the survival of the tilapia species of fish, it's very infestation seems to be a booster to the populations of catfish and mudfish. As the level of water hyacinth infestation decreases, the populations of tilapia increased but the significant negative relationship between water hyacinth infestation levels and the quantity of catfish and mudfish is a reflection of the potential of these species of fish to thrive under such conditions. These fluctuations in the fish types and their quantities has both positive effects on the fish value chains, affecting both the fish dealers such as the fishermen, fish vendors and the consumers as the laws of demand and supply take root on the fish market.

On purely positive note, the water hyacinth correlates strongly and positively with the weaving industry. The water hyacinth is harvested and used as raw material to make items of high economic value including baskets, cupboards, tablemats, seats, handbags, earrings, bangles, necklaces, trays, chairs and coffins. These items attract considerably high market prices, thus serving as economic pillars for the dealers in such merchandise.

The significant negative relationship between water hyacinth infestation levels and tourist visitations is an indication that high tourist visitations are associated with low infestation of the water hyacinth. The water hyacinth infestation negatively affects tourism, as it hampers tourist activities such as swimming, boat riding and sailing, canoeing, as well as general navigation of the waters to various recreation sites and the adjacent islands.

5.4 Recommendations

Based on the study's findings, it is recommended that the multiple effects of the water hyacinth must be considered whenever efforts to control the water hyacinth are instituted. Moreover, the opportunity costs of controlling the water hyacinth must be considered judiciously so that the most appropriate decisions are taken. For example there are species of fish such as mud fish and cat fish which thrive well in the presence of the weed unlike the tilapia that is harvested a lot when the hyacinth recedes.

Also given that efforts in the past to control the water hyacinth have had mixed results with this obnoxious water weed still remaining a challenge, perhaps the beneficial aspects of the plant with respect to the weaving/basketry industry should be mainstreamed into the control efforts with an option of industrial extraction for large scale utilization of the plant as a raw material.

Based on the findings, the water company should design a plant that is able to treat contaminated water due to hyacinth invasion such as reverse osmosis plant so as to maintain demand in water business during hyacinth infestation.

Water ways should also be created at the beach so that navigation for sailing purpose by tourists is enhanced during the time of infestation of the beach by the hyacinth. This will allow tourist to sail to the nearby islands from the beach giving income to the residents whose livelihoods depend on tourism.

5.5 Suggestions for Further Research

This was a cross-sectional study that was confined to Dunga Beach only, yet there are other beaches in Kisumu and along the shores of Lake Victoria, generally, where all the economic activities addressed in the study are carried out. In view of this, the study recommends for following areas for further research:

1. Similar studies be conducted on other beaches especially around Homabay to validate the findings of this particular study and allow generalization of the study's findings on a wider scope and also come up with time series data on water hyacinth cover on the lake to keep track on level of infestation.
2. A study should be conducted to document realistic impacts of the water hyacinth on different fish species found in the lake.
3. A longitudinal study to be designed so that the changes in the variables considered can be studied over an extended period of time to increase reliability of the findings rather than basing the results on the perceptions of the respondents involved

5.6 Contribution to Body of Knowledge

Table 5.1:
Study's Contribution to Existing Knowledge

	Objective	Contribution to knowledge
1.	To establish the effects of water hyacinth on water business of the community around Dunga Beach of Lake Victoria, Kisumu	A strong, significant and negative relationship exists between water hyacinth infestation and water availability implying that the higher the infestation level of the water hyacinth, the lower the volumes of water extracted from the lake. Dense infestation of the water by the water hyacinth interferes with extraction of water from the lake. Where possible, water that is extracted at such periods of dense water hyacinth infestation is extremely dirty.
2.	To examine the effects of water hyacinth on the fishing industry of the community around Dunga Beach of Lake Victoria, Kisumu	The results for the relationship between water hyacinth infestation and fish populations are varied. As the level of water hyacinth infestation decreases, the populations of tilapia increased but the significant negative relationship between water hyacinth infestation levels and the quantity of catfish and mudfish is a reflection of the potential of such fish species to thrive under water hyacinth infestation.
3.	To assess the effects of water hyacinth on the weaving industry of the community around Dunga Beach of Lake Victoria, Kisumu	Water hyacinth correlates strongly and positively with the weaving industry. The water hyacinth is harvested and used as raw material to make items of high economic value including baskets, cupboards, tablemats, seats, handbags, earrings, bangles, necklaces, trays, chairs and coffins.
4.	To evaluate the extent to which water hyacinth affects tourism activities around Dunga Beach of Lake Victoria, Kisumu	A significant negative relationship exists between water hyacinth infestation levels and tourist. The water hyacinth infestation negatively affects tourism as it hampers tourist activities such as swimming, boat riding, canoeing, as well as general navigation of the waters to various recreation sites.

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APPENDICES

Appendix I: Krejcie and Morgan (1970) Table for Determining Sample Size

N-n	N-n	N-n	N-n	N-n
10-10	100-80	280-162	800-260	2800-338
15-14	110-86	290-165	850-265	3000-341
20-19	120-92	300-169	900-269	3500-346
25-24	130-97	320-175	950-274	4000-351
30-28	140-103	340-181	1000-278	4500-354
35-32	150-108	360-186	1100-285	5000-357
40-36	160-113	380-191	1200-291	6000-361
45-40	170-118	400-196	1300-297	7000-364
50-44	180-123	420-201	1400-302	8000-367
55-48	190-127	440-205	1500-306	9000-368
60-52	200-132	460-210	1600-310	10000-370
65-56	210-136	480-241	1700-313	15000-375
70-59	220-140	500-217	1800-317	20000-377
75-63	230-144	550-226	1900-320	30000-379
80-66	240-148	600-234	2000-322	40000-380
85-70	250-152	650-242	2200-327	50000-381
90-73	260-155	700-248	2400-331	75000-382
95-76	270-159	750-254	2600-335	1000000-384

Appendix II: Letter of Transmittal

George Otieno Ageng'o,
P.O Box 2941,
Kisumu,

The District Officer
Kisumu East District

Re: Data Collection for Research Study.

I am a student of the University of Nairobi, pursuing a Master of Arts Degree in Project Planning and Management. Currently I am in the process of undertaking research on the effect of water hyacinth on the economic activities of the community around Dunga beach, Lake Victoria - Kisumu.

The study will involve collecting data from the community around the beach. The purpose of this letter therefore is to request your office to grant me permission to carry out the study in the area.

Yours faithfully,

George Ageng'o.

Appendix III: Study Questionnaire

INTRODUCTION:

Dear Respondent,

This questionnaire seeks information that will lead to the determination of the ***effects of water hyacinth on the economic activities of the community around Lake Victoria, focusing on Dunga beach in Kisumu.*** You have been selected by chance to assist in providing the required information, as your views are considered important to this study.

I am therefore kindly requesting you to fill this questionnaire. Please note that any information given will be treated with utmost confidentiality and will only be used for the purposes of this study. You not required to write your name on the questionnaire.

Thank you.

GEORGE O AGENG'O.

Section 1: Respondent's Profile

1. Kindly indicate your gender

   ☐ Male ☐ Female

2. What economic activities are you engaged in?

   ☐ Fishing industry ☐ Weaving/basketry

   ☐ Water business ☐ Tourism

3. What is your highest level of education?

   ☐ Primary ☐ Tertiary college

   ☐ Secondary ☐ University

4. How long have you been in this business?

   ☐ Less than 2 years ☐ More than 10 years

   ☐ 2-4 years

   ☐ 5-7 years

   ☐ 8-10 years

Section 2: Water Hyacinth Infestation

5. Are there times within the year when this part of the lake is completely covered by the water hyacinth?

   ☐ Yes

   ☐ No

6. If yes, what periods of the year is the lake completely covered by the water hyacinth? Tick (√) appropriately in the table below:

Jan-Feb	Mar –Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec

7. In the table below, indicate the period when the water hyacinth moves away from this part of the lake:

Jan-Feb	Mar –Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec

Section 3: Water Hyacinth and Water Business

8. What times of the year is more water extracted from the lake for domestic use?

Jan-Feb	Mar –Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec

9. How would you compare the volume of water available for sale during the different water hyacinth infestation levels as indicated in the table below?

Level of Water Hyacinth Infestation	Water Volume available
No Hyacinth on Water	☐ High ☐ Average ☐ Low
Water partially covered by Hyacinth	☐ High ☐ Average ☐ Low

Water completely covered by Hyacinth	□ High □ Average □ Low

10. In the table below, indicate the average price of a 20 litre container of water during the different water hyacinth infestation levels?

Level of Water Hyacinth Infestation	**Price of water (20 Litre container)**
No Hyacinth on Water	
Water partially covered by Hyacinth	
Water completely covered by Hyacinth	

Section 4: <u>Water Hyacinth and Fishing Industry</u>

11. In the following tables, indicate the quantities of the types of fish listed at different times of the year by circling the number that best describes your opinion of the quantity.

Key: 1 = Low; 2 = High

Fish type	**Jan-Feb**	**Mar –Apr**	**May-Jun**	**Jul-Aug**	**Sep-Oct**	**Nov-Dec**
Tilapia	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*
Cat fish	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*
Mud fish	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*

12. In your opinion, how does the water hyacinth affect fishing activities in the lake? -

_____

_____

13. When do fish price changes occur? Indicate in the table below:

Price increases when…..	**Price decreases when……**
When there is no hyacinth on water	When there is no hyacinth on water
When water in the lake is partially	When water in the lake is partially

covered by hyacinth	covered by hyacinth
When water in the lake completely covered by Hyacinth	When water in the lake completely covered by Hyacinth

Section 5: Water Hyacinth and Weaving Industry

14. In this area, are there instances when the water hyacinth is harvested for use as raw material

☐ Yes
☐ No

15. If yes, list some of the items that are made from the hyacinth:

_____

_____

_____

16. In the table below, indicate the times of the year when the items made from the hyacinth go for high or low prices by circling on the number that best describes your response.

Key: 1 = Low 2 = High

Jan-Feb	Mar –Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
1 2	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*

Section 6: Water Hyacinth and Tourism Activities

17. Are there any tourists who visit this area?

☐ Yes
☐ No

18. In the table below, indicate the period of the year when the number of tourists is either low or high by circling the responses that best describe your opinion:

Key: 1 = Low 2 = High

Jan-Feb	Mar –Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
1 2	*1 2*	*1 2*	*1 2*	*1 2*	*1 2*

19. To what extent would you say the following tourist activities are affected by the water hyacinth in this area?

Activity	**Not at all (1)**	**To a limited extent (2)**	**To moderate extent (3)**	**To a great extent (4)**
Navigation				
Boat riding				
Swimming				
Sun-bathing				
Windsurfing				
Sailing				

Thank you for your taking time to respond to the questions

Appendix IV: Key Informant Interview Guide for water business

INTRODUCTION:

Dear Respondent,

This study seeks information that will lead to the determination of the ***effects of water hyacinth on the economic activities of the community around Lake Victoria, focusing on Dunga beach in Kisumu.*** You have been selected by chance to assist in providing the required information, as your views are considered important to this study.

I am therefore kindly requesting you to take **20 minutes** of your time to ask you a few questions related to the study. If you would kindly allow me, I would like to ask you the following questions:

1. Kindly comment on the trend of movement of the water hyacinth on the part of Lake Victoria around Dunga beach
2. How does the water hyacinth affect the water business around the beach?

Thank you for your time and cooperation

Appendix IV: Key Informant Interview Guide for fishing industry

INTRODUCTION:

Dear Respondent,

This study seeks information that will lead to the determination of the ***effects of water hyacinth on the economic activities of the community around Lake Victoria, focusing on Dunga beach in Kisumu.*** You have been selected by chance to assist in providing the required information, as your views are considered important to this study.

I am therefore kindly requesting you to take **20 minutes** of your time to ask you a few questions related to the study. If you would kindly allow me, I would like to ask you the following questions:

1. 1 Kindly comment on the trend of movement of the water hyacinth on the part of Lake Victoria around Dunga beach.
2. Comment on the impact of the water hyacinth on the amount of fish harvested from this part of Lake Victoria.
3. In your view, has the water hyacinth affected the fish retail business? How?

Thank you for your time and cooperation

Appendix IV: Key Informant Interview Guide for tourism industry

INTRODUCTION:

Dear Respondent,

This study seeks information that will lead to the determination of the ***effects of water hyacinth on the economic activities of the community around Lake Victoria, focusing on Dunga beach in Kisumu.*** You have been selected by chance to assist in providing the required information, as your views are considered important to this study.

I am therefore kindly requesting you to take **20 minutes** of your time to ask you a few questions related to the study. If you would kindly allow me, I would like to ask you the following questions:

1 Kindly comment on the trend of movement of the water hyacinth on the part of Lake Victoria around Dunga beach

2 How has the water hyacinth affected tourism activities around Dunga beach?

Thank you for your time and cooperation

Appendix IV: Key Informant Interview Guide for the weaving industry

INTRODUCTION:

Dear Respondent,

This study seeks information that will lead to the determination of the ***effects of water hyacinth on the economic activities of the community around Lake Victoria, focusing on Dunga beach in Kisumu.*** You have been selected by chance to assist in providing the required information, as your views are considered important to this study.

I am therefore kindly requesting you to take **20 minutes** of your time to ask you a few questions related to the study. If you would kindly allow me, I would like to ask you the following questions:

1 Kindly comment on the trend of movement of the water hyacinth on the part of Lake Victoria around Dunga beach

2 How does the water hyacinth affect the weaving industry in this area?

3 What are some of the items made from the water hyacinth?

Thank you for your time and cooperation

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787 , 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/17/013/29**

Date: **2nd July 2013**

George Otieno Ageng'o
University of Nairobi
P.O Box 825-40100
Kisumu.

RE: RESEARCH AUTHORIZATION

Following your application dated **24th June, 2013** for authority to carry out research on "***Effects of water hyacinth on economic activities of the community around Lake Victoria: A case of Dunga Beach in Kisumu-Kenya.***" I am pleased to inform you that you have been authorized to undertake research in **Kisumu East District** for a period ending **31st December, 2013**

You are advised to report to **the District Commissioner, District Education Officer and District Agricultural Officer, Kisumu East District** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The District Commissioner
The District Education Officer
The District Agricultural Officer
Kisumu East District.

PAGE 2

PAGE 1

Research Permit No. NCST/RCD/17/013/2

Date of Issue 2nd Jul 2013

Fee received KSH 1000

THIS IS TO CERTIFY THAT:

Prof/Dr./Mr./Mrs./Miss/Institution George Otieno Agengo

of (Address) University of Nairobi

P. O. Box 925-40100 Kisumu

has been permitted to conduct research in

Location Kisumu East

District Nyanza

Province

on the topic: Effects of water hyacinth on economic activities of the community around Lake Victoria: A case of Dunga Beach in Kisumu-Kenya.

for a period ending: 31 December, 2013

Applicant's Signature

for Secretary
National Council fo
Science & Technolog