ASSESSMENT OF THE INFLUENCE OF FRESHWATER AQUACULTURE ON HOUSEHOLD SOCIO-ECONOMIC PERFORMANCE IN BUSIA COUNTY, KENYA

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A research thesis submitted in partial fulfilment of the requirements for the award of a Master of Science degree in Disaster Management and Sustainable Development of Masinde Muliro University of Science and Technology

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DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented at any University for a degree or any other award.

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by Masinde Muliro University of Science and Technology the thesis entitled ‘‘**Assessment of the Influence of Freshwater Aquaculture on Household Socio-economic Performance in Busia County, Kenya**.”

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DEDICATION

I dedicate this thesis to my late parents Mr. and Mrs Miima for their unwavering love and care that made me who I am today. I regard you so much.

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I take this opportunity to thank the Almighty God for His everlasting favour of good health and unending love. I acknowledge my supervisors Dr Edward M. Mugalavai and Prof. Jacob Wakhungu for their encouragement and guidance towards the accomplishment of this Thesis. I am grateful to my research assistant Mr Paul Kem for the support. I recognise Masinde Muliro University of Science and Technology and its leadership for allowing me to pursue my graduate course. To everyone involved, respondents thank you for making this study possible. My family members feel appreciated. To my friends and classmates thank you for your continuous support.

ABSTRACT

Aquaculture has enhanced food security for over 2.5 billion people generated sources of livelihood for approximately 530 million people and contributed to approximately 40 per cent of the world's fish production. There is a high demand for fish, however, fish cannot meet the demand from the capture fisheries. Busia County has been a beneficiary of the donor-funded project that funded aquaculture. From the foregoing, this study sought to assess the influence of freshwater aquaculture on household socioeconomic performance in Busia County, Kenya. specific objectives were to: determine freshwater aquaculture performance in Busia County; establish the effect of freshwater aquaculture on household socio-economic performance in Busia County; and determine aquaculture technology strategy on the freshwater aquaculture performance in Busia County. The study adopted a descriptive survey research design with both quantitative and qualitative methods. The target population was 55,608 households in Bunyala and Teso South sub-counties and a sample size of 384 households. A simple random sampling strategy was used to select the household heads and a purposive sampling strategy was used to select key informants. Questionnaires, interview schedules, focus group discussion guides and photography were used to collect data. Quantitative data were analysed using (SPSS) version 25.0 while qualitative data was analysed through verbatim reporting. Results revealed that private hatcheries dominated fingerling production hence the high cost of fingerlings. Fish feed was being sold at the local agrovets and was not quite affordable to farmers. Extension services were mainly pond management (96.1%; OR = 2.67), record keeping (92.7%) and fish marketing (77.7%). House hold size had a partial determination of the household socioeconomic performance. The cost of input was main a concern to 45% of the households as well as the market prices of the fish. Access to finance was not limited to 65% of the households. Earthen pond technology comprised 96% of the households. Aquaculture had a positive impact on the production of fish (73.8%). Conclusion: Private sector hatcheries were the main distributors of fingerlings to farmers. Pond management, recording keeping, and marketing were the main extension services accorded to households. The cost of inputs and market prices of fish and fish product was the average determinant of household socioeconomic performance. Households had access to financial support such as loans designed for aquaculture ventures. Earthen pond technology was the main technology strategy practised by the households in Busia County. Recommendations: Owing to the low investment in hatcheries by the national and county governments of Busia, there is a need to rethink the installation of government hatcheries in all sub-counties for ease of accessibility and affordability in order to promote the sustainability of aquaculture. The cost of inputs is quite high for local household farmers; thus, it is an area that the County Government of Busia to look to and help reduce the cost. Earthen pond technology is dominant, however, there is a need for subsidised lined pond systems to have as many farmers moving to lined ponds that are secure and safe for the fish and farmer.

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LIST OF ABBREVIATIONS AND ACRONYMS

ABPD:	Aquaculture Business Development Programme
ESP:	Economic Stimulus Programme
FAO:	Food and Agricultural Organisation
FGD:	Focus Group Discussions
GDP:	Gross Domestic Product
HH:	Household
KES	Kenya Shilling
KII:	Key Informant Interviews
mm:	millimetres
NACOSTI:	National Council of Science, Technology and Innovation
OECD:	Organisation for Economic Cooperation and Development
USA:	United State of America
WFP:	World Food Programme

DEFINITION OF OPERATIONAL TERMS

Aquaculture - This is the rearing of fish in a controlled environment for commercial purposes both on small-scale and large.

Extension services- Refer to services provided by agricultural officers on the best practices of rearing fish in freshwater.

Fish farming - Raising fish for commercial purposes mainly in enclosures for food.

Fish farming technologies -Refer to the methods of making fish feed and seed fish.

Food Security - Refers to the state where all people at all times have physical, economic and social access to sufficient and safe food that satisfies their dietary needs and preference for a health life.

Freshwater Aquaculture This refers to the rearing of fish in inland freshwater bodies (ponds, rivers and lakes).

Livelihood Refers to the rearing of fish as a means of securing the necessities of life for a household.

Socio-economic performance – Transformation of the households with regard to socio – economic dimensions.

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

World over, inland fisheries and aquaculture have enhanced food security for over 2.5 billion people generated sources of livelihood for approximately 530 million people and contributed approximately 40 per cent of the world's fish production (Cooke *et al.*, 2013; FAO, 2014; OECD, 2014). Ninety per cent of fish farming produces thirty per cent of the world's fish supply, which has been attributed to advanced fish farming technologies (Kobayashi *et al.*, 2015). The global decline of wild fish stocks has led to the introduction of freshwater aquaculture potential for sustainability and scalability (Chen and Qiu, 2014; Hossain, 2014; Ateweberhan *et al.*, 2018). However, poor public and political will, anthropogenic activities, threats and poor technologies employed in freshwater aquaculture have led to poor socio-economic performance globally (Jacob, 2013; Knapp and Rubino, 2016; Lynch *et al.*, 2016).

Developed countries such as the United States of America (USA) have strong laws that protect fish farming and fisheries, which is not the norm globally (Fry *et al.*, 2014). Developing countries are struggling to sustain freshwater aquaculture, however, there is an inherently poor societal and political interference, lack of or inadequate extension service provision and poor technology employed in pond design and management coupled with poor fish seed and feed production (Lebel, Lebel & Chuah, 2018).

Large-scale aquaculture in Africa has been on the decline despite the vast aquatic resources that flourish on the continent (Ababouch and Fipi, 2015). Capture fisheries especially oceans have dwindled inviting investment in freshwater aquaculture. Thus, there is an increasing dependency on freshwater aquaculture due to declining capture fisheries (Mathiesen, 2015). Freshwater aquaculture has played a vital role in contributing to food security, especially by providing primary sources of animal protein, essential nutrients, and income (Béné*et al.*, 2016).

The challenges in the continent are caused by poor pond management, resource use conflicts (water and land), unreliable sources of fish fingerlings, poor quality and accessibility of fish feed and aquaculture sustainability issues (Shitote *et al.*, 2012; Soliman and Yacout, 2016; Asiedu *et al.*, 2017). The aquaculture activities such as processing and value addition in Africa are still underdeveloped. Egypt has unsustainable growth in fish feed processing due to its overreliance on imported (90 per cent) ingredients for processing the fish feed.

Fish farming in Kenya began in the year the 1920s with tilapia species and later saw the introduction of the common carp and African catfish (Munguti*et al.*, 2014). Tilapia and African catfish are the most commonly farmed fish in Kenya (tilapia accounting for 75% and African catfish for 21% of production). Other species include common carp, rainbow trout, koi carp, and goldfish. According to Musyoka and Mutia (2016), the government of Kenya invested USD 215 (2019 May conversion rate) million into the promotion of aquaculture production through the Economic Stimulus Programme (ESP) for the period 2009 - 2013. However, the current trend of fish farming in western Kenya has remained underdeveloped with very low productivity in aquaculture. This venture is inherently faced with issues of expensive low-quality feeds, predation, inadequate and low-quality fingerlings, high costs of investment, pond siltation and poor pond maintenance (Shitote *et al.,* 2012).

Busia County had a poverty index of 64.2% in 2012 as compared to the national poverty index of 45.9%, which was attributed to food insecurity and was ranked the eighth-most food-insecure county in Kenya (Kundu *et al.*, 2016; WFP, 2016). These higher insecurities could be drawn from Sitawa's (2019) study by observing that the failure to involve family members in the management of fish farms has a negative influence on fish production and sustainability. Additionally, Mugah (2020) acknowledges that Busia County experienced limited or lack of extension service provision to most small-scale fish farmers.

The small-scale fish farmers face many challenges such as expensive low-quality inadequate feeds and fingerlings affecting the socio-economic performance in Busia County (Shitote, *et al.,* 2012). According to Kundu *et al.* (2016), the government policy on fish farming and the political will does not emphasise the importance of the social significance of fish farming and the provision of extension services and the existence of inferior technologies are not controlled to enhance quality. Western Kenya has only one government institution that produces reliable quality seed (Wakhungu Fish Farm at Bumala in Busia County, Kenya) that cannot sustain all fish farmers in Busia County and neighbouring Counties (Kundu *et al.,* 2016).

1.2. Statement of the Problem

Busia County is one of the Counties around Lake Victoria – a fresh water lake - whose residents practice fishing as the main source of livelihood is fishing. Fish has become a main source of animal protein that is accessible to the burgeoning human population. There is a high demand for fish for subsistence consumption and commercial purposes. Moreover, owing to inadequate employment opportunities in Kenya, Busia residents opted to venture into freshwater aquaculture as their alternative livelihood and source of animal protein. Busia County has received massive investment in the promotion of freshwater aquaculture through pond construction and caged aquaculture in Lake Victoria (Odende *et al.*, 2022). Notwithstanding, there have been challenges with the sustainability of freshwater aquaculture. Moreover, despite the County Government of Busia investing an estimated Kes 600 million (US $ 5.76 million) freshwater aquaculture trails behind (Kenya News Agency, 2019 July). Some farms produce fish fingerlings, fish feeds or both, however, access to fish quality fingerlings, quality fish feed and extension servicers is a challenge that lingers in Busia County.

There are previous studies by Akwanyi *et al*., (2019) Socio the economic characteristics of fish farmers influencing sustainable livelihoods in Kakamega, Shitote *et al*, (2012) on fish farming household food security and livelihoods in Western Kenya, and Rurangwa *et al*., (2018) on review and analysis of small-scale production in East Africa among others. The research has focused on small-scale commercial aquaculture and factors affecting fish farming development. From the foregoing previous studies, there was a scarcity of findings that explained freshwater aquaculture performance and household socioeconomic performance in Busia County. This study, therefore, sought to assess the influence of fresh water aquaculture on household socio-economic performance in Busia County, Kenya.

1.3.Research Objectives

1.3.1. Overall objective

The overall objective of the study was to assess the influence of freshwater aquaculture on household socioeconomic performance in Busia County, Kenya.

1.3.2. Specific objectives

The study was guided by the following specific objectives:

1. To determine freshwater aquaculture performance in Busia County;
2. To establish the effect of freshwater aquaculture on household socio-economic performance in Busia County; and
3. To evaluate the aquaculture technology strategy used to promote household socioeconomic performance in Busia County.

1.4. Research Questions

The study was guided by the following research questions

1. What is the extent of freshwater aquaculture performance in Busia County?
2. How does freshwater aquaculture affect household socio-economic performance in Busia County?
3. To what extent does freshwater aquaculture technology strategy contribute to household socioeconomic performance in Busia County?

1.5. Justification and Significance

The study was conducted in Busia County because it is one of the Counties within the Lake Victoria Basin that has embraced aquaculture. There is a large number of fishing communities that have the potential to use freshwater aquaculture to influence house socioeconomic performance. Due to this backdrop, this study assessed freshwater aquaculture's influence on household socio-economic performance. Therefore, the findings of this study will inform the communities involved in fresh water aquaculture on the sustainable methods of enhancing socio-economic performance.

The findings will also add more valuable information and knowledge on the socio-economic factors and other technological challenges and effectiveness influencing household socio-economic performance to various stakeholders such as the Ministry of Agriculture, Livestock and Fisheries and also the County Government on Sustainability of the fresh water aquaculture. Therefore, the findings and recommendations will aid the formulation and strengthening of policies governing aquaculture and household socio-economic performance.

1.6. Scope of the study

The study was conducted in Busia County on the influence of freshwater aquaculture on household socio-economic performance. The study targeted a study population of household heads, the County government of Busia, the Ministry of Agriculture, Livestock and Fisheries of Kenya and other stakeholders in fish farming such as the Fish Farming Enterprise Productivity Program; and Kenya Climate Smart Agriculture Program in Busia County. The study mainly focused on fish farming as part of aquaculture in Lake Victoria in Busia County. The study was carried out between August 2021 and December 2021. The Unit of analysis was based on household heads within the fish farming population in Busia County, Kenya.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter presents reviewed literature from scholarly articles that are related to aquaculture and household socioeconomic performance. The thematic areas covered included: freshwater aquaculture extension services; household social-economic status in relation to aquaculture activities and the aquaculture technologies impacting freshwater aquaculture and household socioeconomic performance. Additionally, the chapter explains relevant conceptual models with regard to the developed conceptual framework.

2.2. Freshwater Aquaculture

The world is experiencing increasing demand for fish products while the sector has faced numerous challenges in capturing fisheries due to stagnation (Ertör and Ortega-Cerdà, 2015). The Food and Agricultural Organisation (FAO) postulates that the future of global fish supply lies in aquaculture currently accounts for almost half of the world's fish food production and is projected to contribute more than 60 per cent of fish for human consumption by 2030 (FAO, 2014; Mathiesen, 2015; Engle, Quagrainie and Dey, 2016). According to the Organisation for Economic Co-operation and Development (OECD), fisheries and aquaculture products globally support the livelihoods of more than 530 million people (OECD, 2014). Aquaculture has been increasing at a significant rate of 6.2 per cent since the year 2000 with Asia accounting for the bulk of global production (Bacher, 2015).

The aquaculture sector is tremendously stimulating the development of rural communities' livelihood opportunities for the rural poor by addressing social and economic issues: poverty, employment and food security (Béné*et al*., 2015). In Peru, the freshwater aquaculture of trout (*Oncorhynchus mykiss*), tilapia (*Oreochromis niloticus*) and black pacu (*Colossoma macropomum*) is maximising the household socio-economic performance for the Peruvian population (Avadí and Fréon, 2015). However, the freshwater aquaculture sector is having an increasingly difficult expansion.

Aquaculture development and growth in Africa have been declining despite the vast aquatic resources that flourish on the continent (Ababouch and Fipi, 2015). Since the introduction of aquaculture to Africa, there have been a lot of innovations, technological advancement and progress in the areas of genetics, seed propagation, pond construction and farm management in general (Koge*et al.*,2018). However, many political, economic and technical issues are obstructing the development and promotion of aquaculture in Africa (Ababouch and Fipi, 2015).

In relation to sampled African Countries in Aquaculture, Egypt as a desert country, has a long history of aquaculture and is the leading producer, especially of freshwater aquaculture in Africa (Soliman and Yacout, 2016). Additionally, aquaculture in Egypt is considered the only viable option for reducing the current gap between the production and consumption of fish. The aquaculture practices in Ghana are intensive at both small-scale (pond) and large-scale (cage), tilapia species (*Oreochromisniloticus*) accounting for 90 per cent of fish farmed and African catfish (*Clariasgariepinus*) (Kassam, 2014). The studies stipulate that the main challenges experienced by African countries in freshwater aquaculture include poor pond management, resource use conflicts (water and land), unreliable source of fish fingerlings, poor quality and accessibility of fish feed and aquaculture sustainability issues (Soliman and Yacout, 2016; Asiedu *et al.*, 2017).

Kenya is endowed with a vast network of aquatic resources comprising freshwater lakes and rivers and an extensive ocean resource base (Opiyo *et al.*, 2018). The fisheries and aquaculture sector contribute about 0.8 per cent to the Gross Domestic Product (GDP), providing important livelihood opportunities for the rural poor by improving the local economy as well as supplementing protein sources (Kundu *et al.*, 2016). Kenya's Vision 2030, together with other policy frameworks recognises aquaculture (fish farming) as a source of food security, poverty reduction, and employment creation (Ogello and Munguti, 2016). Freshwater fish account for close to 98 per cent of Kenya's reported aquaculture production and is ranked the fourth major producer of aquaculture in Africa. The study conducted by the Government of Kenya noted that the Western Kenya region records some of the highest rates of poverty and malnutrition, however, the region has a high potential for aquaculture development (Munguti *et al.*, 2014). However, the freshwater aquaculture sub-sector has seen a decline performance of total fish output dropping by 19.8 per cent from 18.7 tonnes in the year 2015 to 14,952 tonnes in 2016 (Opiyo *et al.*, 2018).

2.2.1. Freshwater aquaculture extension services performance

The extension services are essential in policy-making, planning, and management in aquaculture through cooperative involvement between the fish farmers and the government agencies (Krause *et al.*, 2015). Aquaculture in Bangladesh has experienced poorly executed extension services that have hurt most of the low-income fish farmers (Belton *et al.*, 2015). The study by Rickard *et al.* (2018) stipulates that boom-and-bust cycle production in aquaculture can cause unwanted societal effects - disease outbreaks, food safety recalls, or natural disasters. The limited extension services have seen aquatic pollution, fish disease, genetic degradation of aquaculture species, a decline in comparative profitability, a lack of knowledge of market risks, and financial crises (Jennings *et al*., 2016). These studies do not expound on the importance of extension services to curb negative outcomes on freshwater aquaculture, which this study intends to establish.

Aquaculture is struggling to realise its high biophysical potential in Africa due to the lack of achieving food security and economic growth (Chan *et al.*, 2019). Moreover, Béné *et al.* (2016) acknowledge that a lack of technical advice and weak policies contribute to poor performance in aquaculture in Africa's sub-Saharan countries. Government policy enforcement in aquaculture is highly required to improve aquaculture performance in Africa (El-Sayed *et al.*, 2015). There is no enabling environment, the decision-making process is biased it excludes poor fish farmers, and the roles of stakeholders and their responsibilities are not clear (Béné *et al.*, 2016). Fish farming and processing in Malawi is still poorly developed hence resulting in post-harvest losses due to the lack of adequately trained personnel and fish farmers.

Freshwater aquaculture in Eastern African countries is affected by inadequate capacity building and limited social acceptance of fish culture and consumption (Munguti *et al.*, 2014). Moreover, in most of these Eastern countries, the role of aquaculture in livelihood is still relatively low (Rothuis *et al.*, 2014). Nigeria has experienced decreasing yield, inefficient management of fish management policy, inadequate technical and commercial knowledge, thereby limiting its production potential (Chilaka *et al.*, 2013). Based on the studies, it is clear that extension services in freshwater aquaculture in Africa are essential; however, little has been mentioned on the ways of improving extension services as well as the underlying causes of poor extension services in African countries, which this study intends to establish.

Lake Victoria has seen a continuous decline in wild fish stocks due to overfishing (Njiru *et al.*, 2014). Kenya has the potential to produce fish through aquaculture thus, it has been prioritized and ranks as one of the four core functions of the department of fisheries (Munguti *et al.*, 2014). The lack of a comprehensive aquaculture policy and inadequate extension officers has contributed to inadequate information for fish farmers in Busia County (Aloo *et al.,* 2017). Aquaculture practice in Kenya despite being the fourth producer of farmed fish in Africa experiences a lack of inadequate extension service constraints due to inadequate knowledge of aquaculture (Kundu *et al.*, 2016).

Busia County is ranked eighth food insecure after Turkana, Samburu, Tana River, Baringo, and West Pokot Counties one spot above Siaya County, investment in freshwater aquaculture is vital. Soree (2017) notes that Busia County has been affected by climate change thus fish farming activities stand at 3 per cent, which is an indicator of the decline. Studies by Makori *et al.* (2017) and Soree (2017) were conducted in Busia County on fish farming; however, none of them looked at the roles of extension services to freshwater aquaculture and its influence on socio-economic performance, which this study examined.

2.3. Freshwater aquaculture household socioeconomic performance

Fish and inland waters are traditionally public resources; whilst inland aquaculture is not a traditionally acceptable practice that denies the public access to natural resources (Junior *et al.*, 2018). Government regulatory policies and social acceptance are critically important to the growth and development of aquaculture (Krause *et al*., 2015). Inland fish serve as a major source of protein, essential fats, and micronutrients for hundreds of millions of people, particularly in rural communities (Youn *et al.,* 2014). Aquaculture activities are important in poverty prevention for marginalised populations including ethnic minorities, the rural poor, and women (Weeratunge *et al.*, 2014). The growing pressure on fish due to the ever-increasing population has led to the growth of the aquaculture sector, leading to a significant increase in socio-political conflicts mainly concerning finfish aquaculture (Carter, 2018).

There is compelling evidence that affirms aquaculture to be a global economic powerhouse that provides livelihoods and can be a driver of positive social development (Hambrey, 2017). However, aquaculture practices, as well as modification of the ecosystem may also cause social and environmental problems – water pollution, ecosystem degradation, livelihoods and social network change and violation of labour standards (Bush *et al.*, 2013; Orchard, Stringer and Quinn, 2015; Ertör and Ortega-Cerdà, 2015). A great deal of contextual variability around aquaculture in communities remains unanswered in most developing countries, which was the focus of this study (Osmundsen and Olsen, 2017).

A major constraint to the development of aquaculture in Africa is the lack of infrastructure, political problems, slow or deficient bureaucracies, and pollution (Rurangwa *et al.*, 2015). Resource conflicts can rapidly arise when traditional users feel that aquaculture is encroaching on their patch (Obwanga *et al.*, 2017). Egypt faces resource challenges (water and land) which have a grave effect on fish farming and have negatively influenced the socioeconomic performance of the country in the sector (Soliman and Yacout, 2016). Ghana struggles with the sustainability of freshwater aquaculture due to poorly executed policy on fish farming as well as promoting small-scale fish farmers (Koge *et al.,* 2018).

Kenya majorly practices semi-intensive freshwater aquaculture (pond culture) that was accelerated by the government programme Economic Stimulus Programme (ESP) in 2009 received an investment of USD 215 - 2019 May exchange rate (Lagat, 2017). It was observed by Sitawa (2019) that most small-scale fish farmers excluded family members in the management and maintenance of the fish ponds which, resulted in poor performance and hence conflict. Society plays an important role in enhancing the productivity of aquaculture activities. There has been an enteric lack of political goodwill to support small-scale fish farmers as well as a lack of providing subsidies on high feed costs (Kioi, 2014). Shitote *et al.* (2012), found that the majority of fish farmers had poor pond management knowledge and the high cost of fish fingerlings and feeds. Besides, Shitote *et al.* (2012) reported that most non-fish farmers in Siaya County experienced more food shortages than fish farmers.

The reviewed literature provides the importance of aquaculture for rural communities; however, there is a limited understanding of the social dynamics that influence the adoption of new aquaculture practices. There is little knowledge about the impact of different degrees of aquaculture on livelihoods and social networks, and what this means for the resilience of these communities and their ability to self-organise in response to change. The new ways of anthropogenic influence on global freshwater resources such as the installation of hydropower, dams and agriculture activities affect fishing activities.

2.4. Freshwater aquaculture technology performance

Technology is a seamless component of social systems making it attractive to understanding production systems like aquaculture (Bush and Marschke, 2014). Moreover, technology and natural conditions determine the choice of sites and species to be produced

(David *et al.*, 2015). Poor knowledge of fish feeds and feeding technology is one of the major constraints in the expansion of aquaculture (Golden *et al.*, 2016). More than 70% of the total global aquaculture production is dependent upon the supply of external feed inputs (Tacon and Metian, 2015). The expansion and intensification of aquaculture production, like any other food production sector, also depend on processes of technological innovation (Troell *et al.*, 2014). The importance of innovation to the ongoing success of the aquaculture industry remains poorly understood (Béné *et al.*, 2016).

Aquaculture is an acceptable technology in the Egyptian economy and covers different production systems including semi-intensive, intensive culture in ponds, and tanks, intensive production in cages and traditional extensive production systems (Soliman and Yacout, 2016). Moreover, there has been a rapid expansion in support activities such as local feed mills and hatcheries that made the sector more sophisticated and diverse. Ghana has a serious investment in aquaculture whose improved performance is attributed to the availability of quality fingerlings and fish feed, which are reliable and accessible (Kassam, 2014). Nevertheless, small-scale pond aquaculture has not had any significant impact in alleviating poverty in most poor families. The cost of fish feeds, inadequate financial capital, lack of technical knowledge and insufficient farm equipment are big deterrents to rural aquaculture development in Uganda (Kasozi *et al.*, 2014; Banga *et al*., 2018). Further, the importance of using locally appropriate technologies when making fish feeds and locally appropriate fish species that can survive on locally available feeds is of much importance.

Fish feed accounts for at least 60 per cent of the total cost of aquaculture production, hence overreliance on external purchases slows the pace at which aquaculture is advancing in

Africa (Cai *et al.*, 2017). Waite *et al.* (2014) observed that to improve and increase the productivity of aquaculture in Africa, fish feeds should be made with locally available products. Most of the aquaculture feeds have relied on exotic ingredients thus overlooking the locally available feeds, hence the study evaluated the underlying causes therein.

The rapid growth of aquaculture in many parts of Kenya has necessitated a high demand for quality fish seed for the commonly cultured species; African catfish and Nile tilapia (Nyonje *et al.*, 2018). Apart from limited knowledge of modern aquaculture technology, the Kenyan aquaculture sector still suffers from an inadequate supply of certified quality seed fish and feed, incomprehensive aquaculture policy, and low funding for research (Munguti *et al.*, 2014). There is still usage of fish stocks that are genetically similar or inferior to wild or undomesticated stocks due to the unavailability of quality seeds affecting aquaculture performance (Amankwah *et al.*, 2016). Nevertheless, the availability of quality fish seed is still a major prerequisite for sustainable aquaculture. One of the most pressing challenges in aquaculture is the unavailability of efficient and inexpensive farm-made feeds for different stages of fish development (Munguti *et al*., 2012). Kundu *et al.* (2016) opine that the lack of sufficient and good-quality fingerlings seriously limits the growth and development of farming enterprises where fingerlings sourced from fish farmers are stunted.

The study has reviews of literature relating to socio-economic factors affecting household socio-economic performance, the influence of aquaculture extension services on household socio-economic performance, and the effectiveness of aquaculture technologies on household socio-economic performance. While many studies have focused on economic development from aquaculture, there was the need to investigate how the households as part of the society transform in relation to both social and economic dimensions from the aquaculture in Busia County, Kenya.

2.5. Freshwater Aquaculture Models

2.5.1. A basic aquaculture value chain

The aquaculture extension in Africa focuses on the knowledge and skills required to grow fish. Husbandry techniques and some on-farm processing to reduce spoilage or add value are the main focus with some exposure to hatchery techniques. However, sustainable aquaculture development policy objectives call for the linkage between production and markets. Appropriate extension services tailored to the capacity needs of the various actors along the emerging aquaculture production-market value-chains, therefore, become indispensable (Fig 2.1).

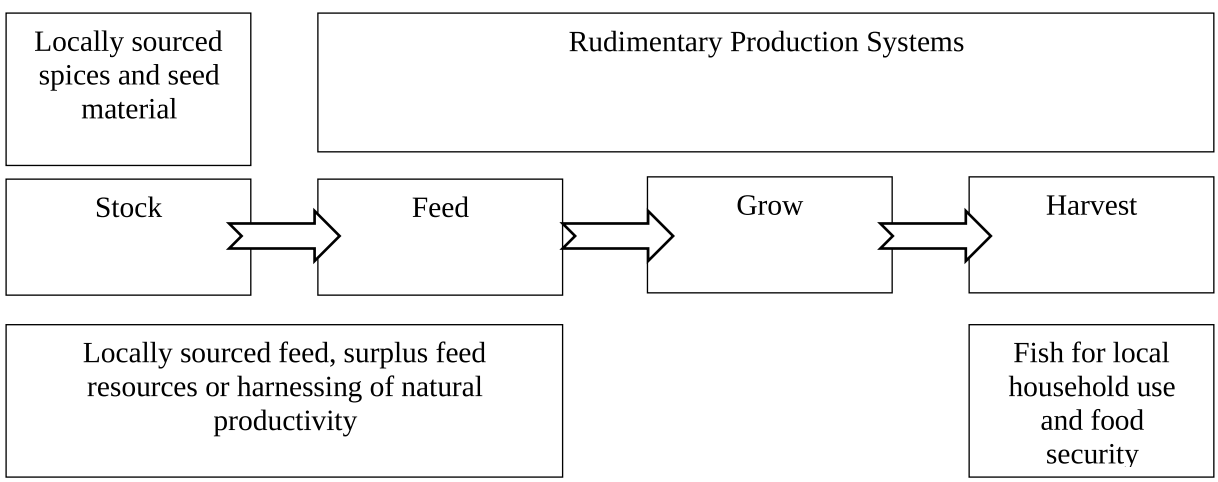

Figure 2.1: A basic aquaculture value chain Model for fresh water aquaculture and household socio-economic performance in Busia County, Kenya.

Source: AUIAAR (2019)

The most basic aquaculture value chain is often established and driven by the need for food security. In such a basic value chain, seed and feed resources are usually obtained locally at low or no cost and applied in a low or no-cost production system. In relation to the study, the model of the basic aquaculture value chain focuses on knowledge and skills. The knowledge and skills are needed by the farmers from the extension services hence increasing production in quality and quantity. The increase in production therefore is geared towards the improvement of households' social and economic wellbeing though sustainable fresh water aquaculture in Busia County.

2.5.2. Aquaculture Technology Model

The adoption of fish farming technology is dependent on the soil type, availability of fresh water, the environment for fish farming and the socioeconomic potential of the locality. Analytical framework showing the linkages and interaction between extrinsic variables (**a**–**d**) and intrinsic variables (**e**), and the influence of the intervening variable (**f**) in the decision-making process of aquaculture technologies and potential livelihood impacts of technology adoption. The aquaculture technology model provides for these variables (Figure 2.2).

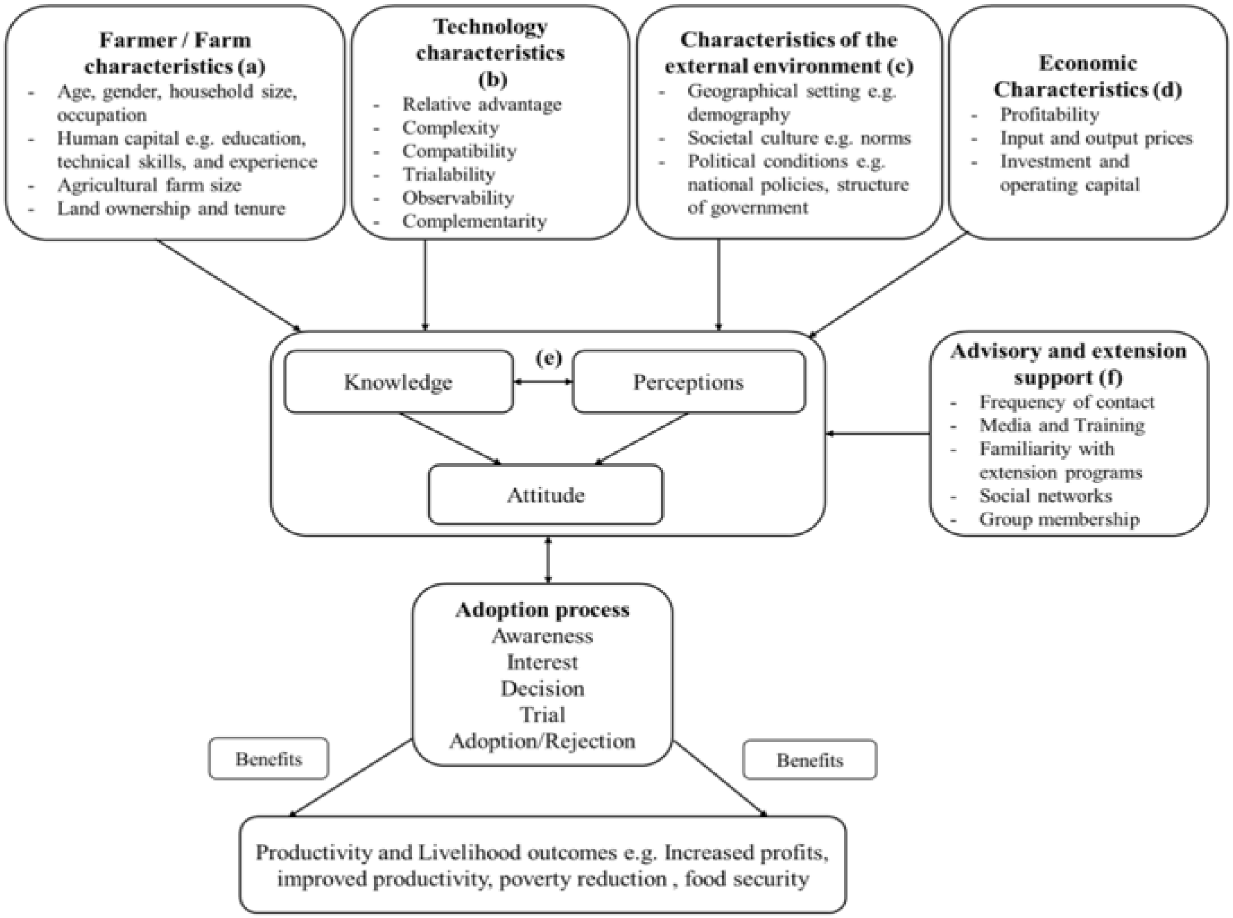

Figure 2.2: An Aquaculture Technology Model for Freshwater Aquaculture and Household Socio-economic Performance in Busia County, Kenya.

Source: Obiero *et al*., (2019)

The aquaculture technology model (ATM) fosters technological adoption in aquaculture. According to Bush and Marschke (2014), technology is a seamless component of social systems making it attractive to understanding production systems in aquaculture. In relation to the study which sought to determine the influence of fresh water aquaculture on household socio-economic performance, technological improvement is key to sustainable aquaculture for socio-economic performance.

The study therefore objectively evaluated the effectiveness of the various aquaculture technologies such as technologies used in the production of inputs - fish (fingerlings) seeds and feeding and how that enhances household socio-economic performance in Busia County, Kenya.

2.6. Conceptual Framework

This conceptual framework has been designed to prioritise pertaining to the assessment of the influence of freshwater aquaculture on household socio-economic performance in Busia County, Kenya. The independent variable was freshwater aquaculture, which looked at the extension services and aquaculture technologies. The dependent variable was household socioeconomic performance which looked at the (Education level, household income, and employment). The intervening variable comprised government policy on aquaculture i.e., Kenya Vision 2030 and Fish Farming Enterprise Productivity Program guided the development of the conceptual framework (Figure 2.3). According to Lemaitre *et al*., (1999), economic and social development is a process by which the economic wellbeing and quality of life of a community or an individual are improved from well-designed objectives. This study sought to determine the influence of aquaculture in fresh water based on the knowledge and skills that exist from extension services. Additionally, the study focused on technological adoption and tested on their effectiveness with regard to social and economic transformation based on economic improvement and improved quality of life of the individual households in Busia County, Kenya.

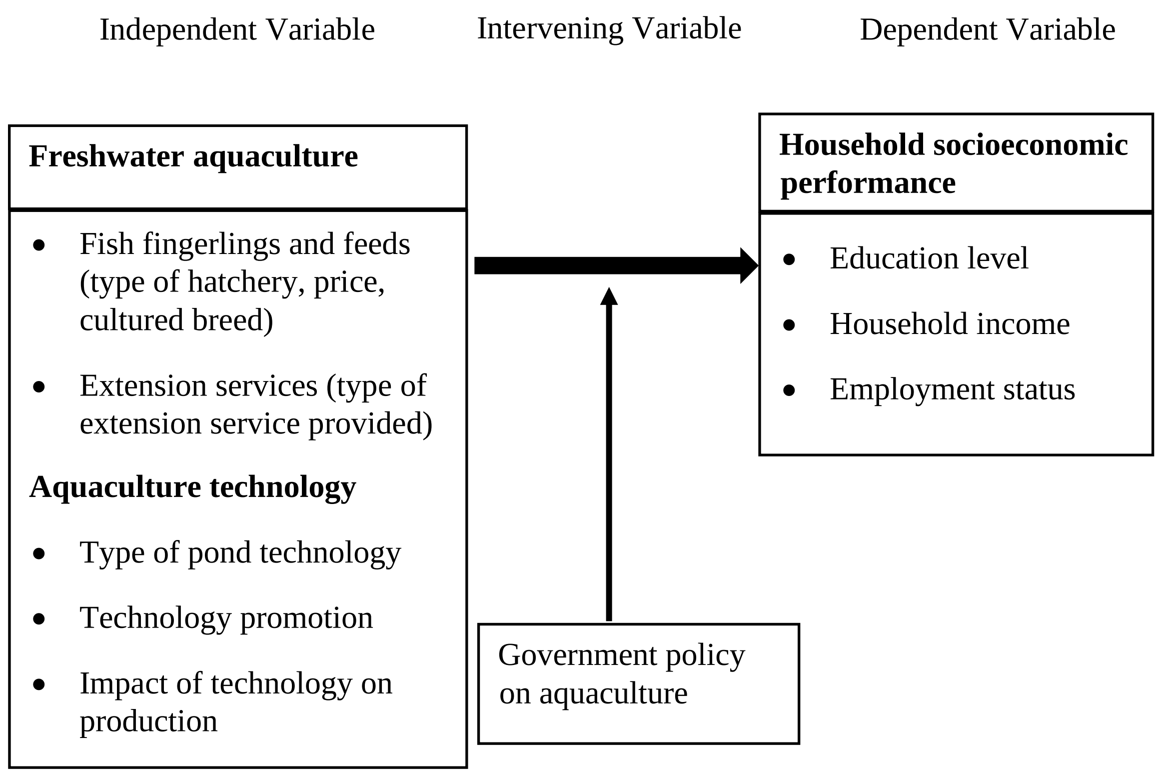

Figure 2.3: Conceptual framework on the relationship between fresh water aquaculture and household socio-economic performance in Busia County, Kenya.

Source: Author, 2019

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

This chapter describes the research methodology of the study. It contains information on the research design, study area, study population, sampling techniques and sample size, data collection instruments, reliability and validity, data analysis and presentation procedures and ethical considerations of the study.

3.2. Study Site

Busia County is situated in western Kenya bordering Bungoma County to the North, Kakamega County to the East and County Siaya to the South East, Lake Victoria to the South West and the Republic of Uganda to the West. It lies between Latitude: 0^0 00' N to 0^0 50' N and Longitude: 34° 00' E to 34° 30' E. Busia County is traversed by the Great North Road and Trans African Highway. Busia County has two main entry and exit border towns – Busia and Malaba. Busia County is a native to Luhya and Teso-speaking people are the majority and the Luo, Kikuyu, Somali and Kisii. Christianity is the main religion in the country followed by Islam. Busia County headquarters is at Busia Town and it covers an estimated area of 1,695.3 square kilometres

3.2.1. Economic activities

Busia mainly practices agriculture and aquaculture. It has a large mass of land that is arable. Busia County is well endowed with wetlands, rivers and the Lake Victoria. Food crops commonly grown in Busia County on a small scale are maize, beans, sweet potatoes, millet and cassava. Cash crops grown are cotton, tobacco and sugarcane. Fishing is a major economic activity in Busia with Lake Victoria being the main source of both Nile Perch and Tilapia.

3.2.2. Agricultural extension services

Busia County has an organized extension service, where the lowest extension unit is found in the wards. The County has two farmer training institutions namely; Busia Agricultural Training Centre and Wakhungu Fisheries Training Centre. These institutions have the mandate of training farmers on various agricultural technologies. They also carry out farmer outreach extension activities and farm demonstrations.

3.2.3. Ecological conditions

Busia County has sandy loam soils and dark clay soils cover the Northern and Central parts of the county. Other soil types are sandy clays and clays.

3.2.4. Climatic conditions and elevation

Busia County receives an annual rainfall between 760 millimetres (mm) and 2000 mm. The temperatures for the whole county are more or less homogeneous. The annual mean maximum temperatures range between 26°Celcius and 30°Celcius while the mean minimum temperature ranges between 14°Celcius and 22 °Celsius. Busia County mainly falls in the Lake Victoria Basin with an altitude of about 1,130 metres and about 1,500 metres (m). Busia County is served by River Malakisi, River Sio and River Nzoia.

3.2.5. Water resources

Rivers and springs are perennial in Busia County. Most parts of Busia County have a high potential for groundwater due to the presence of many permanent boreholes. The average depths of striking water vary depending on the geology of an area. There are numerous springs and rivers which form the sources of the various streams in the sub-county. Many households in rural areas have access to water from protected springs.

3.2.6. Population

Busia County has a population of 893,681 people. The population density is 527 persons per square km (GoK, 2019). There is a high population growth rate and thus the population in the county is expected to have gone high.

3.2.7. Land-use patterns

The major land use in the county is for crop production and livestock farming. With the increasing population in the county, the land currently being used for forestry and agriculture is being converted into human settlements.

3.2.8. Employment

Despite several interventions, the creation of adequate, productive and sustainable employment continues to be the greatest economic challenge for Busia County. The county has an unemployment rate of over 66.7% (Busia CIDP, 2018).

3.2.9. Acreage under food and cash crops

The broad agricultural production systems in the county include crop cultivation, livestock rearing and fisheries. Agriculture is the most important sector in the County as it provides for over 65% of the total earnings. Most people in the County are employed either directly or indirectly in this sector. Part of the available farmland is taken up by sugarcane farming as a cash crop. The total farming acreage is 155,990 acres of food crops while 29,525 acres is under cash crops. The average farm size in the county is 1.71 acres.

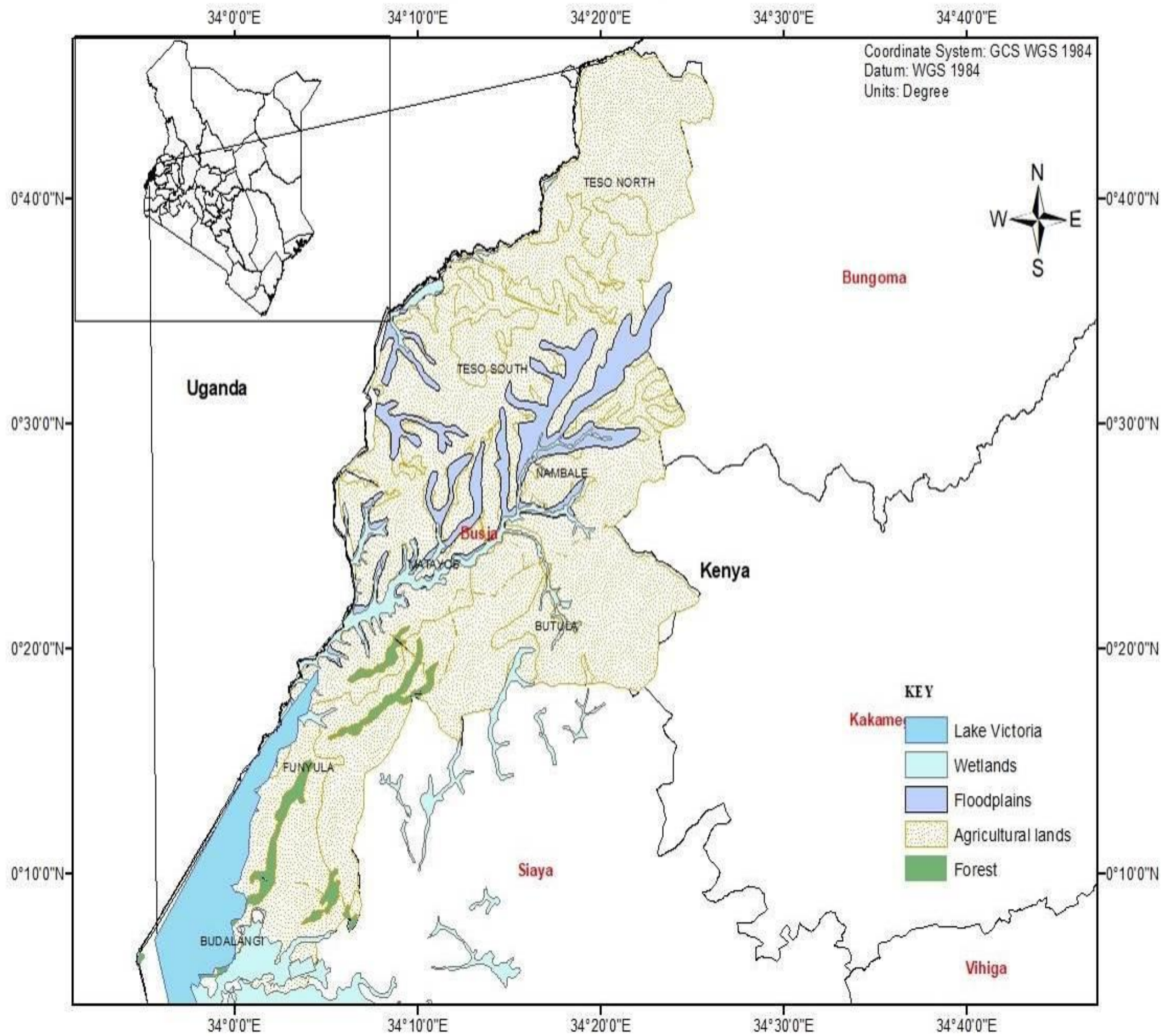

Figure 3.1: Map showing the location of Busia County in Kenya

Source: Author (2019)

3.3. Research Design

The descriptive survey design was used to guide this study on freshwater aquaculture on the household socioeconomic performance in Busia County. The advantage of descriptive research design precisely and orderly describes a freshwater aquaculture influence on household socioeconomic performance in Busia County. It was able to answer questions on what, where, when and how questions guiding the study. Moreover, it is flexible to use correlation and the Chi-Square test of independence to test the association of the variable under study. This method was capable of describing the existing perceptions, attitudes, behaviour or values of individuals within a household, the socio-political interference, the extension service providers and the technologies used for fish farming aquaculture.

3.4. Study population

The study determined the influence of freshwater aquaculture on the socioeconomic performance of house-holds in Busia County, Kenya. Busia County has about 198,152 households with an average household size of 4.5. Bunyala Sub County and Teso South Sub County have 19,039 and 36,569 households and 4.5 and 4.6 average household sizes respectively (KNBS, 2019). The target population was the households in Bunyala and Teso South sub-counties of Busia County in Kenya. Key informants were made of the director of the Department of Fisheries – in Busia County and two extension officers each from the surveyed sub-counties of Teso South and Bunyala in Busia County. Table 3.1 shows the target sub-counties, study population and population proportions.

Table 3.1: Study population in Busia County.

Sub-county	Number of Households (N)	Proportion
Bunyala	19039	0.342
Teso South	36569	0.658
Total	55608	1.000

Source: GoK (2019)

3.5. Sampling Strategy

A purposive sampling technique was used to select the study site. Busia County was purposively selected for the study because it was among the top eight most socially and economically affected counties in Kenya while it has the potential to increase social and economic performance through the contribution of the benefits of fresh water aquaculture (WFP, 2016). According to KNBS (2019), Busia County has 198,152 households: Bunyala Sub County 19,039 and Teso South Sub County 36,569. Busia County has 7 sub-counties Nambale, Matayos, Bunyala, Teso South, Teso North, Butula and Samia. However, Bunyala and Teso South are the most beneficiaries of freshwater aquaculture through pond systems and aquapark technologies (WFP, 2016). Households in the study areas of two sub-counties were sampled using a multi-stage proportional random sampling approach (Table 3.2). Fisher's formula was used to calculate the household sample size for the study.

The sample size was calculated from the study population of 55,608 proportionately distributed in the two sub-counties – Bunyala (0.342) and Teso South (0.658). Owing to the population size exceeding 10,000, Fisher's sample size formula of 10,000 and above was applied.

Equation ………1

$$N = \frac{Z^2pq}{e^2}$$

$$N = \frac{1.962*0.5*0.5}{0.05^2}$$

$$n = 384$$

n is the sample size

N is the target population size

e is the margin of error (0.05)

***Z*=1.96**

p and q are 0.5 (for maximum variability)

Table 3.2: Sampling Frame

Population Units	**Proportions**	**Sampling strategy**	**Sample size**
Households			384
Bunyala sub county	0.342	Simple random	131
Teso South sub-county	0.658		253
Ministry of Agriculture, Livestock and Fisheries		Purposive	1
Sub County Directors of Fisheries		Purposive	2
Sub County Extension officers		Purposive	2
FGD respondents(3FGDs)		Quota sampling	8-12

Source: Researcher, 2019

3.6. Data Collection

This section gives an account of the instruments that were used in collecting data on the field by the researcher. The researcher collected data using structured questionnaires for household heads, focus group discussion guides for household heads and interview guides for key informant interviews.

3.6.1. Structured questionnaire

A structured questionnaire (Appendix II) with both closed and open-ended questions was used to collect data from the household heads in Busai County.

3.6.2. Interview guide

In-depth face-to-face interviews were done using interview guides for Key informants. KIIs were preferred in this study to compliment household questionnaires' findings. The interview guides were used to source information from the County Fisheries officers (Appendix III), and the Agricultural extension officer (Appendix IV).

3.6.3. Focus group discussions

Focus group discussions (FGDs) guides composed of different gender and groups of 8 participants (Appendix VIII) was used for an open discussion of the influence of fresh water aquaculture on household socio-economic performance in Busia County.

3.6.4. Photography

The study used photography to capture the study area and the freshwater aquaculture practices in Bunyala Sub County and Teso South Sub County in Busia County, Kenya. The data collection instruments that were utilized are summarized in Table 3.3.

Table 3.3: Data collection framework

Study Population unit	Sampling method	Sample size	Data Collection tool	Appendix Number
Household heads	Proportionate simple random	384	Questionnaire	II
Extension Officers Sub County Fisheries officers	Purposive Purposive	2 2	KII Interview guide KII Interview guide	III IV
Kenya Climate Smart Agriculture Project	Purposive	1	KII Interview guide	V
FGD	Quota Purposive	8-12	FGD Guide Observation checklist	VIII

3.7.Validity and Reliability

3.7.1. Validity

To ensure validity, the research instruments employed the method described by Brink *et al*. (2006). The research supervisors were also helpful in examining the content constructing the research instruments and advising the researcher on the content validity. Their views assisted in the review of the questionnaire, FGDs, KII guide and observation checklist and their opinions and suggestions were incorporated later in the final version of the instruments (Brink *et al.*, 2006).

3.7.2. Reliability

The term reliability refers to a measure of the degree to which a research instrument yields consistent results (Mugenda and Mugenda, 2003). To establish reliability, a pilot study comprising 10 respondents which is 10% of the sample size was carried out in the Bondo sub-county in Siaya County. The accuracy and consistency of the instruments were verified and any ambiguity that was realized was removed. This involved administering the instruments to households of the fish farmers in areas with similar characteristics to the sampled study area. Interviews were conducted among the aquaculture stakeholders. The feedback obtained during the pilot study was used to correct and re-align the instruments on errors and omissions as well as clarifications, and to check the validity and reliability of the instruments.

To measure the reliability, the Alpha (Cronbach, 1975) technique was employed. In this approach, a score obtained in one item was correlated with scores obtained from other items in the instrument; Cronbach's Coefficient Alpha was computed to determine how items correlate among themselves. Cronbach's Alpha is a general form of the Kunder-

Richardson (K-R) 20 formulae. The use of the K-R 20 formula in assessing the internal consistency of an instrument is based on the split – half reliabilities of data from all possible halves of the instrument. The use of the K-R 20 formula reduces the time required to compute a reliability coefficient in other methods. Its application also results in a more conservative estimate of reliability; the estimated coefficient of reliability of data is lower. The K-R formula is as follows:

$$\frac{KR_{20} = (K)(s^2 - \sum s^2)}{(S^2)(K-1)} \quad \text{………………..Equation 2}$$

Where;

KR_{20}= Reliability Coefficient of internal consistency

K= Number of items used to measure the concept

S^2= Variance of all scores

A high coefficient implies that items correlate highly among themselves meaning there is consistency among the items in measuring the concept of interest. This is sometimes referred to as homogeneity of data whereby the researcher can confidently depend on the information gathered through various sources of data adopted for the study. Alpha (Cronbach, 1975) is a model of internal consistency based on the average inter- item correlation. The instrument was divided into two parts using even and odd numbers. A large value of alpha (preferably greater than 0.6) indicates a high level of consistence of the instruments in measuring the variables. The co-efficient of internal consistency above 0.6 is considered good. The instrument was then adjusted based on the findings of the pilot test and the final version developed thereafter attained a correlation value of 0.7.

3.8. Data Processing, Analysis and Presentation

Both quantitative and qualitative data were collected (Table 3.2). Quantitative data were coded and analysed by IBM version 25.0 Statistical Package for the Social Sciences (SPSS). Analysis of quantitative data is the numerical representation and manipulation of observations to describe and explain the phenomena (Ary *et al.*, 2013). Data were analysed at a 0.05 significance level. This allowed testing of the statistical significance of the influence of freshwater aquaculture on socio-economic performance in Busia County. The resulting frequencies and percentages were presented using tables and figures. Qualitative data were mainly collected by open-ended questions, which were first classified based on common attributes/themes. The data were then coded and entered into an appropriate computer package for analysis. Key informant guide data sheets were transcribed and used to triangulate the observed trends in quantitative data.

Table 3.4: Summary of statistical techniques

Specific Objectives	Measurable Variables	Research Design	Data analysis Method
Objective One	• Fish fingerlings and feeds • Extension services (type of extension service provided)	Cross-sectional	Frequencies and per centages Chi-Square and Pearson Correlation
Objective Two	• Household size • Cost of input and income • Access to finance and markets	Cross-section	Frequencies and % Logistical Regression
Objective Three	• Type of pond technology • Technology promotion • Impact of technology on production	Cross-section	Frequencies and % Pearson Correlation

Source: Researcher (2019)

3.9. Ethical Considerations

The researcher obtained permission from the School of Disaster Management and Humanitarian Assistance, Institutional Research and Ethical Committee (IREC) at Masinde Muliro University of Science and Technology and the Directorate of Postgraduate Studies. The researcher also obtained a research permit from the National Council of Science, Technology and Innovation (NACOSTI). The researcher submitted a letter to the directorate of Fisheries of Busia County that sought permission to research households practising fish farming in Bunyala and Teso South sub-counties. Confidentiality of information and anonymity of data recording was assured. The researcher ensured the confidentiality of individual participants was protected by concealing their names and other personal details. The respondents were informed of the nature of the study before the commencement of the process.

3.10. Limitations and delimitation

The study experienced the following limitations

i. The study was conducted during the coronavirus period, hence there was a limitation with the association freely hence there was the possibility of postponement of the meeting as scheduled.

ii. There was a language barrier in some areas thus the researcher sought the help of an interpreter during such cases

3.11. Assumption of the study

The study was carried out based on the following assumptions:

i. Freshwater aquaculture receives adequate extension services and technologies promoting fish farming.

ii. Household socioeconomic performance has promoted

iii. Freshwater aquaculture influenced household socioeconomic performance.

CHAPTER FOUR

FRESHWATER AQUACULTURE PERFORMANCE IN BUSIA COUNTY, KENYA

4.1. Introduction

This chapter presents findings and discussion of freshwater aquaculture performance (fingerling and feeds and extension services).

4.2. Fish fingerling and feed acquisition for fresh water aquaculture

The study investigated where small-scale households acquired the fish fingerlings and the type of fish fingerling hatcheries.

4.2.1. Fish fingerlings

4.2.1.1. Type of fish fingerling hatchery

The study sought to understand where household got their fish fingerling either government hatcheries or private hatcheries. The findings are presented in Figure 4.1.

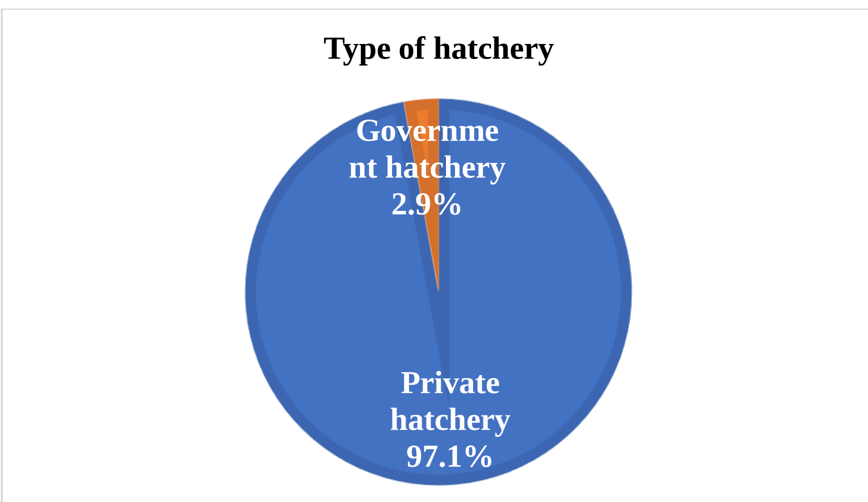

Figure 4.1: Type of fingerling hatchery

According to this household survey, 97.1% of the farmers interviewed acquired their fish fingerlings from private hatcheries. The catchment areas for fish fingerlings extended as far as Vihiga County and Uganda. Busia County as at the time of this assessment had only one government fish fingerling hatchery (Wakhungu Hatchery) - located in Bumala area, Samia sub-county of Busia County. Therefore, Wakhungu hatchery with only 2.9% of the fish farmers 'accessing fish fingerlings from it was not able to sustain the burgeoning number of fish farmers in Busia County. This view was also supported by a key informant stating that:

> "… Wakhungu Fish farm has not been well maintained and hence was producing poor quality fish fingerlings. This discouraged many farmers from acquiring fish fingerlings from Wakhungu Fish Farm. Therefore, fish farmers have had to go far even into Uganda to secure fingerlings."

Moreover, these findings have shown that Busia government had not invested much in fingerlings production after programmes such as PALWECO and WKCDD were decommissioned. Therefore, without commitment to investing in quality fish fingerlings production, this gap in fingerlings production will be inevitable. Koge *et al.* (2018) findings also observed that projects that were funded to improve fish production continued to dwindle when the program ended. Opinions from the focused group discussion indicated that:

> "… Farmers have been over-relying on help and funding from the donor organisation. Such behaviour made farmers, not own projects and realise the value in fish farming regarding fish fingerling production at home."

Another member in the FGD forum added that:

> "… Fingerling production for a long time was centralised, which made it difficult to access especially farmers from Teso South. This demoralised farmers to invest in fish farming and take the programs lightly."

Fingerling production is an African problem where many governments have failed to invest in hatcheries that would otherwise address the shortages of quality fingerlings (Koge *et al.*,2018). Therefore, the private sector took advantage of the government's non-committal investment in quality fish fingerlings production and they have dominated the sector. The key informant stated that:

> "… In Bunyala sub-county, there are two privately run fish hatcheries – Rudacho and Hydo – that produce fish fingerlings for both cage aquaculture and pond aquaculture. However, the quality of fingerlings is still an issue and the supply is still not enough to serve farmers in Bunyala sub-county where most of the fish farmers cross Lake Victoria to Uganda for fingerlings."

The plate below shows the fish hatchery farm at the shores of Lake Victoria in Port Bunyala (Port Victoria) in Bunyala Sub County in Busia County. The researcher appears in the photo.

Plate 4.1: A private fingerling production farm in Bunyala Sub County in Busia County

Source: Researcher (2019)

4.2.1.2. Price of fingerlings

The study investigated the prices of fingerlings in order to establish whether the cost was favourable for the households in Bunyala and Teso South sub-counties. The results are presented in Figure 4.2.

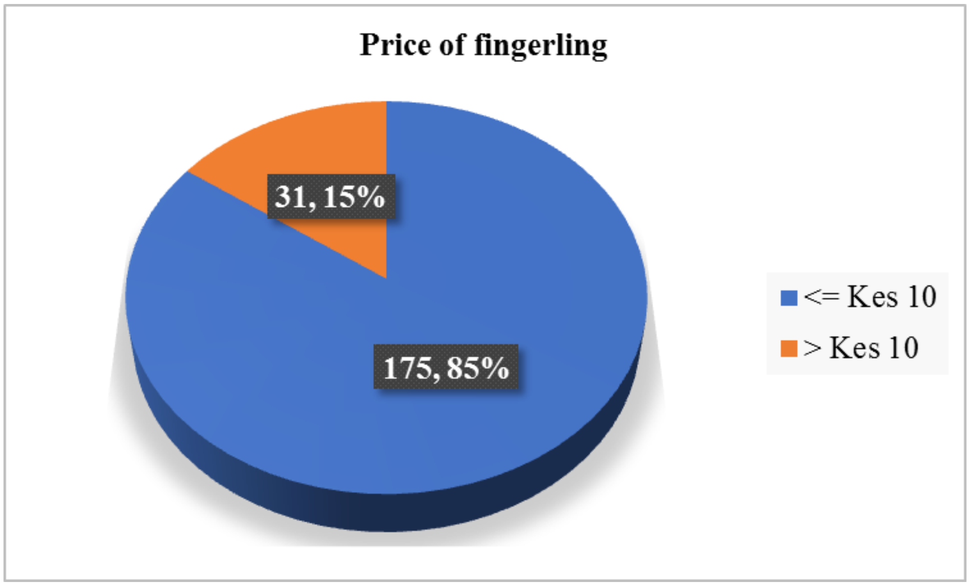

Figure 4.2: Price of a fingerling

Source: Researcher (2019)

From the findings in Figure 4.2, it was clear that 85% of the households practising fish aquaculture bought a fingerling at Kenya shilling of 10 or less (USD 0.066, rate 2023). However, only 15% of them bought a fingerling for more than Kenya shillings 10. The study observed that fish farmers were travelling long distances to acquire fish fingerlings. The transportation charges make fish farming to most farmers an expensive endeavour. Shitote *et al.* (2012), found that the households were grappling with the high cost of fish fingerlings which discouraged their involvement in fish farming. The study revealed that the private sectors, which dominated fingerling production for fish farmers in Teso South and Bunyala sub-counties were not regulated and could overprice fingerlings. To reiterate the observation of the fish farmers, a key informant stated that:

> "… Farmers go outside Busia County to purchase fingerlings. Mostly, farmers from Teso South go to Vihiga County to acquire fish fingerlings. Moreover, here in Teso South sub-county, there is no single fish fingerlings production centre. We need at least one here at Simbachai."

Consequently, another key informant stated that:

> "… Farmers from Bunyala sub-county acquire their fish fingerling from Wakhungu fish farm. We have other new fish hatcheries established such as Rudacho Fingerling Production farm and Hydro Hatchery in Bunyala sub-county, which we hope will address the deficit in Busia County."

The main challenge that Busia County smallholder fish farmers experience is the high cost of quality fish fingerlings. In Teso South, at the time of the data collection, there were no fish hatchery farms; however, Kamarinyang Aqua Park was under development. Therefore, all the farmers practising semi-intensive fish farming acquire fingerlings from fish hatcheries in Vihiga County. The future of global fish supply lies in aquaculture currently accounts for almost half of the world's fish food production (FAO, 2014; Mathiesen, 2015; Engle, Quagrainie and Dey, 2016). This has made it expensive for small-scale fish farmers. Therefore, the key informant added by stating that:

> "… Farmers from Teso South are really emphasizing the need to have a fish hatchery near them because they cover long distances to purchase fingerlings, where transportation fee increases their challenges."

This study concurs with the previous study by Rurangwa *et al.* (2015), that the major constraint to the development of aquaculture is the lack of infrastructure for fingerlings production and the lack of political goodwill for convenience and quality assurance. It is of great concern for most of the households practising fish farming to acquire fish fingerlings, despite having Wakhungu Hatchery - a government facility for fingerlings production in Busia County. Moreover, the hatchery is not conveniently located for most fish farmers in Teso South sub-county and Bunyala sub-county. The findings suggested that at least every sub-county in Busia County should have a fish hatchery for fingerlings production in order to promote fish farming and improve households' socioeconomic performance.

4.2.1.3. Preferred type of fingerlings

The researcher investigated whether the farmers in Bunyala and Teso South sub-counties preferred monoculture or mixed-cultures. The findings are shown in Figure 4.3.

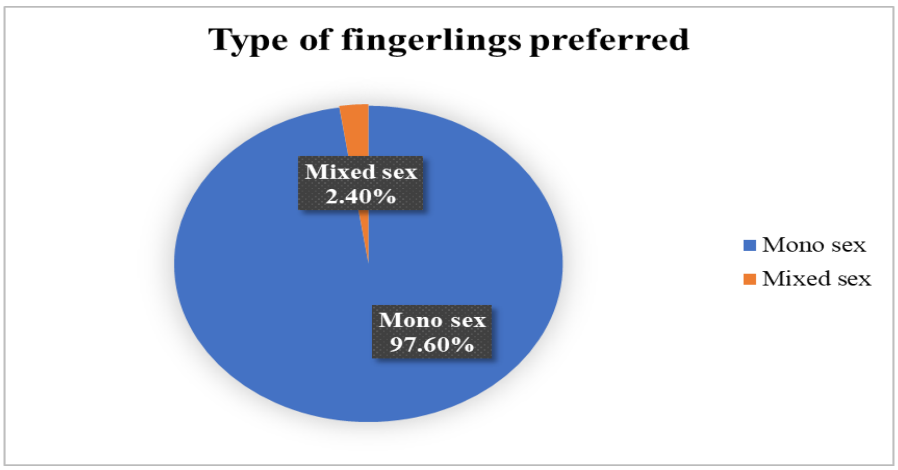

Figure 4.3: Preferred fingerling sex cultured

Source: Researcher (2019)

According to the household survey (Figure 4.3), 97.6% of the households interviewed found that they preferred mono-sex fingerlings over mixed-sex. It was stated that they endeavoured to avoid overcrowding in the pond and maximise quality production. This finding concurred with Fry *et al.* (2014), that mono-sex fingerlings grew faster with minimal competition in the pond. Besides, fast growth, the mono-sex fingerlings grew bigger thus promoting quality production and high yield. Key informant corroborated this finding by stating that:

> "… Mixed-sex does not work better in small spaces where ponds have limited dissolved oxygen. We have been educating small-scale farmers to embrace mono sex which has better returns."

Mono-sex aquaculture is important for smallholder households because it promotes production by eliminating the competition for pond resources and mating deprivation. It is known that globally, there has been a decline in marine and capture fisheries (Mathiesen, 2015). Therefore, there is a global campaign seeking households to invest in freshwater aquaculture. This indicates that socio-politics are essential in supporting aquaculture by educating and supporting smallholder households to embrace and practise aquaculture at the convenience of the lands. This finding was echoed by a key informant, who stated that:

> "… Culturing males and females in the same pond promotes competition for resources and mating rites. As such, fish production is affected, which hurts the profits of the farmers."

While emphasizing their observations, another key informant added that:

> "… You have seen the ponds, they are small therefore to maximise the available space and yields, mono sex is preferred. We always remind the farmers to invest in mono sex that will assure them maximum benefits."

The study revealed that to maximise the profits and investments made in aquaculture, especially pond culture, mono sex is the best way to go for most scale smallholders. However, it was indicated that mixed-sex culture is preferred for cage aquaculture in Lake Victoria. Some of the farmers in Bunyala sub-county who were made up of 2.4% observed that they preferred mixed-sex. Cage aquaculture assures enough circulation of oxygen and space for fish to reside addressing space challenges experienced in smallholder ponds.

Moreover, to achieve poverty reduction and nutrition promotion for smallholder farmers, this study observed that the goodwill from both county and national governments and the support from the family members in fish farming promotes more investments and human resources in fish farming. It is known that Kenya has a vast network of inland freshwater; this could be tapped to mitigate poverty in most rural parts of Kenya. The findings acknowledge that both the national and county governments' goodwill and social acceptance are important in promoting aquaculture. This is also a notion that is shared by Krause *et al*., (2015).

The researcher, therefore, computed a correlation to determine the strength and direction of the relationships between hatcheries selling fingerlings, the price of fingerlings and the sex of fingerlings preferred (Table 4.1).

Table 4.1: Correlation of fingerling hatchery, price of fingerling and preferred sex for breeding

		Fingerling hatchery	Price of a fingerling	Fingerling sex preferred
Fingerling hatchery	Correlation Coefficient	1.000		
	Sig. (2-tailed)	.		
	N	384		
Price of a fingerling	Correlation Coefficient	.073	1.000	
	Sig. (2-tailed)	.298	.	
	N	384	384	
Fingerling sex preferred	Correlation Coefficient	.027	-.066	1.000
	Sig. (2-tailed)	.697	.343	.
	N	384	384	384

Source: Researcher (2019)

Correlation tests were that fingerling hatchery and price of a fingering, $r = 0.072$, $p = 0.298$; fingerling hatcher and preferred sex of fingerlings (mono sex or mixed sex), $r = 0.027$, $p = 0.697$ and price of a fingerling and preferred sex preferred, $r = -0.066$, $p = 0.343$. This meant that fingerling hatcheries, the price of a fingerling and the sex of the fingerlings did not influence each other. Household socioeconomic performance of freshwater aquaculture separately depends on the cost of fingerlings. Therefore, the availability and reliability of quality fingerlings ensured household socioeconomic performance (Kassam, 2014).

4.2.2. Fish feed

The study investigated where fish feed was purchased and the prices for the feed per kilogram. According to the household survey, it was established that all the fish farmers interviewed purchased fish feeds from Agrovet shops near them. The Economic Stimulus Project of 2009, the Western Kenya Community Driven Development Programme (WKCDD) and the Programme for Agriculture and Livelihoods in Western Communities (PALWECO) invested heavily in aquaculture (Irungu, 2015). This gave the Agrovet shops a ready market for fish feed in Busia County. The findings showed that fish feeds were readily available. The key informant observed that:

> "… Agrovet shops are available at least in every sub-county in Busia County. These agrovet shops stalk fish feeds because of the increased number of households practising fish farming in Busia County." KII

Another key informant stated that:

> "… We also purchase fish feeds in bulk and give them to farmers who pay in instalments to enable them to acquire the feeds conveniently and at a fair price." KII

Plate 4.2: Fish feeding in Teso South Sub County

Source: Researcher (2019)

4.2.2.1. Price of fish feed

The findings showed that all the households had access to fish feeds from the local Agrovet shops. The fish feeds were a challenge price-wise to small-scale farmers in Bunyala and Teso South sub-counties. The cost of fish feeds per kilogram was found unsustainable; it was expensive for most rural farmers as they were expected to feed about one thousand fingerlings with four kilograms of feeds per day depending on the age and size. Therefore, most farmers were unable to sustain the momentum. The unreliable source of quality and accessibility of fish feed and aquaculture sustainability issues affect the price of feeds which affects household socioeconomic performance (Soliman and Yacout, 2016; Asiedu *et al.*, 2017). It was established from the key informant stating that:

> "… I have received reports from the extension officers at sub-counties saying that farmers are overwhelmed by the high cost of fish feeds. In fact, they wish to have a fish feed industry locally in order to address the high cost of feeds."

Having known that fish feeds were one of the main challenges for rural farmers, it was prudent to investigate the price of feed per kilogram in Teso South and Bunyala sub-counties. The finding is illustrated in Figure 4.4.

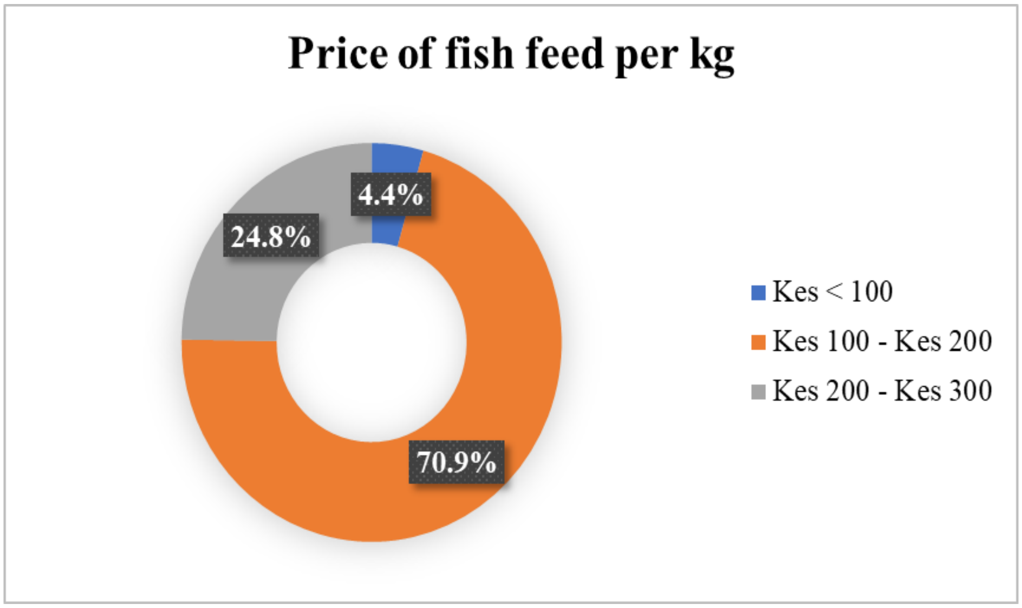

Figure 4.4: Price per kilogram of fish feed

Source: Researcher (2019)

According to the household survey (Figure 4.4), 70.9% of the fish farmers interviewed were purchasing fish feed between Kes 100 and Kes 200 per kilogram. This also indicated as per the data that 70.9% of the fish farmers purchased a twenty-five kilogram of fish feed at Kes. 3,300. This was quite steep to farmers hence affecting freshwater aquaculture (Shitote *et al.* 2012). This is the standard price range of the feeds depending on the diameter of the feeds. However, it was established that 4.4% of the fish farmers interviewed, purchased a kilogram of fish feed at less than Kes 100. This price was common in Bunyala sub-county where a few farmers procured their fish feed from the sub-county fisheries offices, which, thus, had incentives. These findings were corroborated by the key informant, who stated that:

> "… The average cost of the feeds in Busia County by most of the agro vet shops is Kshs 120 per kilogram of feed. Our department procures these feeds and sells them to farmers at Kes 88, mostly in Bunyala sub-county." KII.

It was observed that in the past there was a pervasive lack of political goodwill to support small-scale fish farmers as well the lack of subsidies on fish feed costs (Kioi, 2014). However, the findings in this study show that the county government of Busia through its directorate of fisheries is trying to subsidise the fish feeds in Bunyala sub-county – a sub-county endemic to floods. The household interviews showed that farmers were complaining about the high prices of fish feeds. The cost of fish feeds was one of the big deterrents to freshwater aquaculture development (Kasozi *et al.*, 2014; Banga *et al*., 2018). The key informant interview triangulated these findings where it was stated that:

> "…Households are struggling to purchase the feeds which are quite expensive for most of them. Remember, they are the rural poor trying out aquaculture for change. Securing feed is challenging to some until they even feed them food remains as an alternative."

Rom the foregoing, it was established that households were interested in pursuing freshwater aquaculture considering the affordability of fish feed. Feed plays an integral part in increased fish production which essentially improves the income of the households. Fish feed accounts for at least 60 per cent of the total cost of aquaculture production (Cai *et al.*, 2017). Subsiding the cost of fish feeds encourages many households to take up freshwater aquaculture.

4.3. Freshwater aquaculture extension service performance

For aquaculture to thrive, the provision of extension services is of utmost importance. Therefore, the study sought to establish whether households practising fish farming in Busia County received aquaculture extension services. Figure 4.5 presents the household results. Results indicate that the majority of the respondents had received extension services at 97.6% while just 2.4% had not received any extension services from the extension service officers.

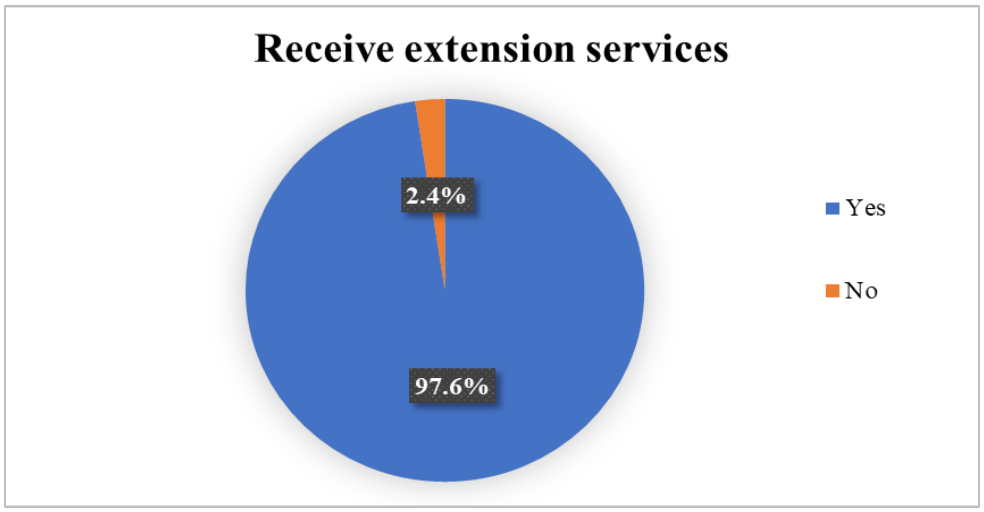

Figure 4.5: Freshwater aquaculture extension services

Source: Researcher (2019)

Findings revealed that there is a high number of households farming fish that were in close contact with the extension service officers. Studies have shown that extension services are the embodiment of improved aquaculture farming globally (Wang *et al.*, 2020). Farmers need information on the management of fish ponds and fish cages to maximise production. The aquaculture business requires planning in order to establish the benefits, the time taken and the investment amount for profit realization. The key informant stated that:

> "… As a department, we are striving to empower households to farm fish as it does not require a lot of space to maximise income and livelihood diversification."

These findings are in line with a previous study by Krause *et al*. (2015) that indicated that extension services are critical for planning and management in aquaculture. It could be shown from this finding that there are excellent extension services among the households practising fish farming, which has promoted household socioeconomic performance.

4.3.1. Type of aquaculture extension services

The study investigated the type of extension services that the households in Busia County were provided with. These services were on pond management, record keeping, marketing, backyard pond management, feed management, value addition and fingerling production. The results in Table 4.2 show that pond management was ranked highest at 96.1%, record keeping at 92.7%, Marketing at 77.7%, Field management at 25.7%, Value addition at 12.6% while fingerling production was rated at 1.5% by the respondents on socio-economic performance in Busia County.

Table 4.2: Type of aquaculture extension services

Type of extension services	Frequency (n)	Per cent (%)	Rank
Pond management	369	96.1	1
Record keeping	356	92.7	2
Marketing	298	77.7	3
Backyard pond management	224	58.3	4
Feed management	99	25.7	5
Value addition	48	12.6	6
Fingerling production	6	1.5	7

Source: Researcher data (2019)

4.3.1.1. Fish pond management

From the results in Table 4.2, findings reveal that the majority 96.1% of the households received pond management extension services to promote and improve quality fish production. This was ranked the number one aquaculture extension service provided to rural farmers as expected to boost fish production and minimise losses. Some of the management services as evident from the respondents are training households on the importance of keeping the ponds from weeds, predators and thieves. Fish also blossom when served with sufficient sun light, the water must be well aerated, with enough nutrients and a clean environment. According to a key informant, it was stated that:

> "… Pond cleaning especially before restocking the fingerlings is a very important determinant of the fish growth. With this regard, a well-maintained and managed fish pond, households are assured a positive return on their investment."

From this study, the pond management aspect is given priority by the extension service providers in Busia County. To address the depravity of proteins among the rural poor and build a secure socioeconomic performance among rural households, training on proper fish pond management becomes a centrepiece. The pond management has helped control pond pollution, improved the living conditions of the many local farmers, increased fish production, improved profits for fish farmers and promoted the production of quality fish. These findings concur with Béné *et al.* (2016) that good extension services that are technical and practical promote performance in aquaculture. It was also stated by the key informant that;

> "… I always tell farmers to keep their ponds clean to avoid predators snooping around the ponds since a clean pond promotes circulation of dissolved oxygen. So, it is important to maintain a clean environment around ponds and avoid the congestion of fish in the pond." KII.

4.3.1.2. Record keeping

According to the findings in Table 4.2, 92.7% of the farmers were trained on the record-keeping of their fish stocks, input costs (fingerlings and feeds) and sells. Record keeping is important in accounting and establishing the profits from the freshwater aquaculture business. This finding concurs with the previous study that the success of an enterprise greatly depends on effective record-keeping skills (Olatunji and Ogunremi, 2016). From this finding, record keeping was an aspect that was of importance to households practising fish farming. It was due to this notion that key informants in Busia County offices supported the finding by stating that:

> "…We understand that good bookkeeping and accountability of the farms' activities gives a good measure of the performance of the fish farm. So, we have our extension officers in every sub-county who train farmers on record-keeping frequently to increase the yield and farm's performance."

Record keeping determines the socioeconomic performance of the households. Thus, this finding established the value and the importance of record keeping that determines the profitability of fish farming. The County Government of Busia hence prioritised the need to train the fish farmers in record keeping as a means to improve and promote their socio-economic performance. The findings also corroborate a previous study in Nigeria that revealed that record-keeping was the assured measure of profits (Nyong, 2021).

4.3.1.3. Marketing of fish products

The findings from Table 4.2 have shown that extension services rendered towards marketing for fish products were ranked third with a score of 77.7%. For the business to thrive, marketing is at the forefront. Therefore, extension services cannot be complete without providing information and training on market identification, assessment and execution. The results showed that farmers were given this important component of a successful aquaculture business. A member of the FGD noted that:

> "… Fish farmers have a farmgate market where buyers throng to the farmers' farms during fish harvest and purchase the fish. Refrigeration is the main challenge that disadvantages farmers in selling fish at the markets."

The finding further revealed that marketing sought to alleviate the waste of fish and improve the socioeconomic performance of the households. It is known that fish and fish products are in high demand as compared to the supply (Nzevu, 2019). This is an area that performs well both in the rural and the urban areas. Considering the importance of Omega 7 and grain activity growth among babies and children, the demand will also be high. This finding thus shows that households have a good marketing strategy that works for them to mitigate against losses of their products whereas the farm gate market strategy was the only method in use at the time of the study.

4.3.1.4. Backyard pond management

From the findings, backyard pond management was ranked fourth with a score of 58.3%. Backyard ponds are becoming common as they are convenient and take up small spaces. Besides, backyard ponds promote major fingerling production. The results in Table 4.2, suggested that backyard ponds were the future technology that could be used to make fingerlings. This strategy could address the problem of fingerling shortages and high prices as observed in section 4.2 sub-section 4.2.1.

4.3.1.5. Feed management

Feed management, which is the main concern and challenge for the households in Bunyala and Teso south sub-counties, was ranked fifth with a score of 25.7%. None of the households processed their feeds. This is an area that extension services have hardly invested in. From the field, it was observed that households were in dire need of learning how to make their local fish feeds of high quality that would save them from the expensive feeds from the local Agrovet shops. The only extension services the household received were extended to the appropriate feeding patterns. Thus, fish were required to be fed at least twice a day (morning and evening). Moreover, four kilograms of feeds were used per day - whereby two kilograms were used in the morning and the other two kilograms in the evening. Proper fish feeding boosted the price of fish per weight. Feeding was the determinant of the weight of the fish hence the price and profit thereof. The opinion of key informants pertaining feeding program stated that:

> "…Fish feed poses the main challenge for the surveyed farmers. We train farmers on feed rationing according to the number of fingerlings or grown fish in a pond and thus determine the feed conversion ratio."

A member's opinion in the FGD indicated that:

> "… Fish feed in expensive to acquire from the local Agrovet shops. It will help us farmers to boost aquaculture, especially ponds if we have access to affordable feed. Better yet have fish feed factories in each sub-county in Busia to help farmers access affordable feed."

This finding concurs with the study by Nzevu (2019), which revealed that in Kenya, aquaculture had been failing due to the unavailability of extension services for feed, production.

4.3.1.6. Fish value chain

The extension service provided towards the fish value chain scored 12.6% and ranked sixth in the list (Table 4.2). The fish value chain is an important determinant in increasing income and promoting freshwater aquaculture. Therefore, the fish value chain increases profits and encourages households to invest in aquaculture. However, from the field observation, none of the households was practising fish value chain production. However, it was observed that there were fish value chain production centres that were still in the process such as the fish value chain at Simbachai in Teso South. It has been shown (Nzevu,2019), that aquaculture has been failing in Kenya due to the unavailability of the fish value chain production. The establishment of the fish value chain production industry at Simbachai Teso South could be the answer towards promoting household socioeconomic performance. The finding shows an improvement in the fish value chain in Busia County. This could greatly improve if every sub-county of Busia County could invest in fish value chain production. In previous studies, Busia County had inadequate extension services that led to poor aquaculture outcomes as well as households' interest in aquaculture (Kundu *et al.,* 2016; Aloo *et al.*, 2017). The findings were corroborated by a member's opinion of the FGD, stating that:

> "… Extension services have impacted the fish value chain, especially with the construction of Fish value chain production at Simbachai in Teso South."

At the time of carrying out this study, it found that many households from the surveyed sub-counties had invested in aquaculture. This comes in the wake of the Aquaculture Business Development Programme and the Kenya Climate Smart Agriculture project's interest in enhancing fish production and the value chain in Busia County (Plate 4.3).

Plate 4.3: Fish value chain production Simbachai in Teso South Sub County.

Source: Researcher (2019)

4.3.1.7. Fish fingerling production

Fingerling production ranked seventh and scored 1.5%. From the results, findings in Table 4.2, reveal that the extension services on fish fingerlings were never given priority in Bunyala sub-county and Teso South sub-county. These are critical areas to focus on as many fish farmers face many challenges in this area. Despite the challenges in fingerling production, the households were satisfied with the extension services offered. Fish fingerling production is the foundation that promotes aquaculture and improves rural household socioeconomic performance.

The farmers observed that extension services improved household living standards by increasing the production of fish. The extension service has enhanced fish production and promoted the pond management skills of the farmers.

The researcher computed a logistical to ascertain the strength of the association and the direction of the association among the variables under the aquaculture extension services (Table 4.3).

Table 4.3: Logistical Regression on the provision of extension services

Variables		Provision of extension services from the government		Exp(B)	95% CI for EXP(B)	P-value
		ESR	ESNR			
Pond management	Trained Not trained	198 3	0 5	**2.67**	1.09 – 6.52	**0.000**
Feed management	Trained Not trained	53 148	0 5	**1.03**	1.00 – 1.06	0.183
Record Keeping	Trained Not trained	186 15	5 0	0.974	0.95 – 1.00	0.526
Marketing	Trained Not trained	160 41	0 5	**1.12**	1.01 – 1.24	**0.000**
Value addition	Trained Not trained	26 175	0 5	**1.03**	1.00 – 1.05	0.39
Fingerling production	Trained Not trained	3 198	0 5	**1.03**	1.00 – 1.05	0.783
Backyard pond management	Trained Not trained	120 81	0 5	**1.06**	1.01 – 1.12	**0.007**

ESR = Extension services received; ESNR = Extension services not received

Source: Researcher (2019)

It is shown from Table 4.3 that there is a significantly increasing association between the provision of extension services and the provision of training on pond management (OR = 2.67; 95% CI (1.09 – 6.52); $p < 0.001$) and marketing of fish sold at the farm gate (OR = 1.12; 95% CI (1.01 – 1.24); $p < 0.001$). This meant that from the receipt of extension services on pond management by fish farmers in Bunyala and Teso South sub-counties as the sampled location of study, were 2.67 times more likely to increase fish production among the trained households as compared to households that had no training on fish pond management. Likewise, it could be stated that households with training in fish products marketing especially during fish harvesting were 1.12 times more likely to invite buyers at the farm gate sales thus improving the economy of the households in both Bunyala and Teso South sub-counties.

The researcher also noted that households that had training on feed management, value addition and fingerling production were 1.03 times more likely to improve their socioeconomic performance as compared to the households without training in the aforementioned areas. These findings on feed management, value addition and fingerling production were thus insignificant associated with the provision of extension services. Furthermore, it was established that households with training in backyard pond management technologies were significantly 1.06 times more likely to improve their socioeconomic performance as compared to households that had no prior training in backyard pond management. However, households that received training on record keeping insignificantly influenced socio-economic performance. This showed that households with training in recording keeping were 0.974 times less likely to improve their socioeconomic performance as compared to households without training.

CHAPTER FIVE

EFFECT OF FRESHWATER AQUACULTURE ON HOUSEHOLD SOCIO-ECONOMIC PERFORMANCE IN BUSIA COUNTY, KENYA

5.1. Introduction

This chapter presents the results and discussions in accordance with the second specific objective on household socioeconomic performance in Busia County, Kenya. it looked at the sociodemographic characteristics of the household economy.

5.2. Household socio-demographic factors

The researcher investigated the socio-demographic characteristics of the participants focusing on gender, age and level of education. This was an important determinant of the influence of freshwater aquaculture among the households practising aquaculture. Table 5.1 shows the socio-demographic characteristics of the surveyed households.

Table 5.1: Socio-demographic characteristics of the households

Socio-demographic characteristics		Frequency (n)	Per cent (%)
Gender	Male	227	59.2
	Female	157	40.8
Age distribution	<= 35	134	35.0
	> 35	250	65.0
Level of education	Primary	220	57.3
	High school	145	37.9
	Diploma	13	3.4
	Bachelor's degree	6	1.5

Source: Researcher (2019)

5.2.1. Gender

According to the household survey (Table 5.1), 59.2% of the farmers were male while 40.8% were female. Household representatives had an almost homogenous distribution regarding gender. The gender distribution shows compliance with the constitution of Kenya 2010 where women are encouraged to participate in any socioeconomic sphere for a sustainable society and growth. It is known that an enabled woman translates to improved family social development, economic empowerment and incoming assurance through freshwater fish production. This could be related to the findings by Béné *et al.* (2016) on gender equality in the social and economic development of the country.

5.2.2. Age of the household participants

With regard to the age of the household participants, the study established that 65% of the household participants were aged above thirty-five years (Table 5.1). This study found that the older peoples' socioeconomic activity lies in farming as compared to the individuals aged below 35 years old. This is a true reflection of fish farming perception in Kenya as supported by UNDP (2018) that the average age of fish farmers is 60 years. In other words, young adults and youths hardly participate in freshwater aquaculture as a form of employment. However, from the foregoing, 35% of the household participants aged between 18 – years to 34 years (youth category as per AFIDEP, 2018) had made their investment in freshwater aquaculture. This could have been made necessary through the previous programs by PALWECO and WKCDD that required youths to form groups and come up with a viable project that would attract funding.

5.2.3. Education level

According to the households surveyed, all the farmers had a formal education with some having basic training in aquaculture farming. Specifically, 57.3% had a primary level of education, 37.9% had a secondary level of education and 4.9% tertiary level of education. Education is at the epicentre of social and economic performance. Through education, the promotion of freshwater aquaculture and its benefits to the household easily gets the attention of households seeking an alternative source of livelihood. Moreover, education enhances research by households regarding the acquisition of inputs and the markets of fish and fish products. From the foregoing, it was established that the households surveyed had a basic knowledge of aquaculture. Cage and pond aquaculture technologies were being practised.

5.2.4. Household sizes

In reference to Figure 5.1, the respondents rated household size at 18% as a factor that influences freshwater aquaculture on household socio-economic performance.

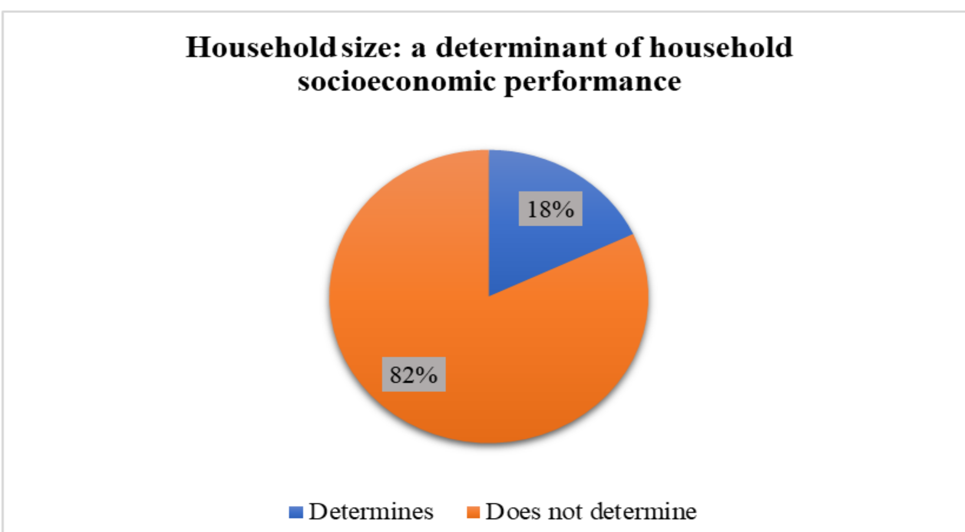

Figure 5.1: household size – a determinant of household socioeconomic performance

Household size entails the number of family members in a given household from the parents to the children. Household size implies the well-being of the household. Research by Diedrich *et al.* (2019) found that an implication of larger household size is the lower quality of life i.e., poor health reduced literacy levels, high dependency levels, low nutrition, poor child care, over-exploitation of natural resources and low social status in the society. It was therefore established that household size was perceived as not the main concerned by the respondents in the study area. From the key informant, it was stated that:

> "… Household size plays a big role in both the economic and social status of a household. The bigger the household size, the increased levels of dependency and overexploitation of the available natural resources." KII.

According to Fusco and Islam (2020), household size is an important determinant of whether a household is in poverty because in measuring poverty, household size is a factor. Additionally, household size depends on the cost of children, wages, government transfers and preferences. It, therefore, relates to the fact that large household sizes may consequently result in the household's inability to function well socially and economically (Abdulkadir, 2021). It therefore resonates with the findings from the field that the majority of the households that had a higher number of family members were not involved in fish farming or if they were involved then at a lower level i.e., in terms of the number of ponds. According to an FGD participant;

> "… Just like in other parts of African Countries, the majority of the households in the study area have a larger number of children. Children are regarded as the source of wealth and dictate one's status in society. This might be our main undoing because as much we may try to improve our economic status in the community using fish farming, a good chunk of what we can use to invest more in fish farming is consumed hence the usual poverty cycle amongst us." FGD.

Findings show that in Busia County, there are approximately 198,152 households. Out of the total number of households, on average, each household has about 4.5 sizes for each household (GoK, 2019). From an FGD forum, a member stated that:

> "… Busia County is one of the Counties with a high number in terms of household sizes in the Western part of Kenya. This is attributed to its cultural belief of wealth for having the high number of children which increases significantly the household size."

The household size therefore significantly plays a role in socio-economic performance with regard to the livelihood practised like fresh water aquaculture in Busia County. However, in other research, there exists an opportunity in the high household size with regard to the labour needed during farming practices (Abdulkadir, 2021). It is believed that the high number translates to a workforce that should reduce the production cost given that one would not higher workers to attend to fish farming while he/she has free labour.

5.2.5. Family inclusion

Results in Figure 5.2 shows that just 2% of the respondent regard family inclusion in the fresh water aquaculture as a factor influencing household socio-economic performance in Busia County.

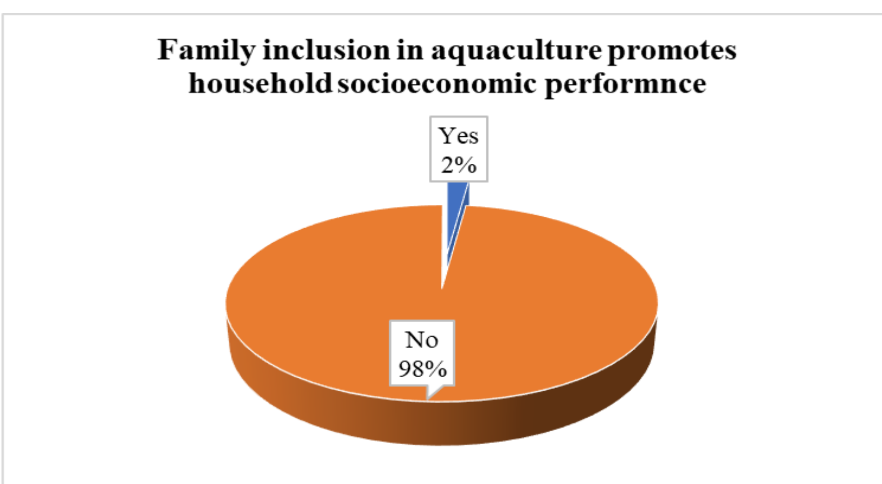

Figure 5.2: Family inclusion in aquaculture promotes household socioeconomic performance

It therefore means that the majority of the respondents did not regard family inclusion as a factor that influenced household socioeconomic performance. Family inclusion entails the incorporation of other family members in freshwater aquaculture activities. Family inclusion offers a unique opportunity to ensure food security, improved livelihoods, better managed natural resources and help achieve sustainable social and economic wellbeing of the individual households and the community in general (FAO, 2019).

The study established that with regard to freshwater aquaculture, the majority of the respondents do not prefer the inclusion of other family members in the whole process but just at some stages of management of the fish farming activities. The study found out that respondents do not include other family members at the initial stages i.e., in the decision-making and investment stages but just during implementation taping on the workforce expected to provide labour. According to Osondu and Jeoma (2014), in African countries, many household heads do not prefer including other family members in any business as it is regarded as a recipe for conflicts during the management of fish farming activities. This resonates with the findings from focus group discussions where the participants unanimously agreed that there is a high possibility of conflicts occurring when family members are all included in the management of the business. From an FGD participant;

> "… Household heads shy away from including other family members in the management of their fish farming business due to fear of conflict of interest between and among family members. However, the majority if they have to include them then it is done when intensive labour is required."

In the event family members were included in the daily activities of fish farming then there would be an increase in conflict of interest hence reducing output. Aquaculture activities were important in poverty prevention for marginalised populations including ethnic minorities, the rural poor, and women but family tussles and conflicts hamper the household socioeconomic performance (Weeratunge *et al.*, 2014). Output reduction means that there would be a significant reduction in profit that will wholesomely reduce the economic performance of the fish farming activity hence translating to reduced quality of life of given households in Busia County, Kenya.

5.3. The implication of inputs and outputs

To understand household socioeconomic performance, it was important for the researcher to investigate the implications of inputs and outputs. Results in Figure 5.3 reveal that 45% of the households felt that there was a concern over the cost of inputs (pond development, price of fingerlings and feeds) and output (weight of fish, selling price profit margin). Well, 55% of the households had no concerns regarding the implication of inputs and outputs.

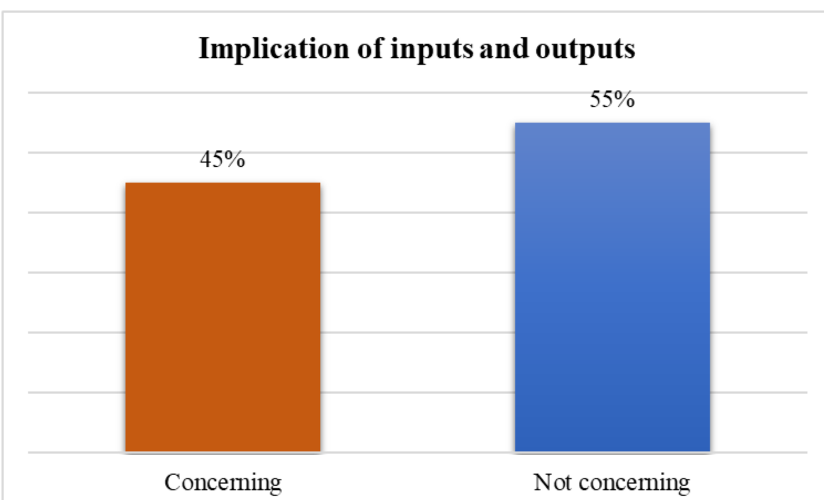

Figure 5.3: Implication of inputs and outputs on household socioeconomic performance

Source: Researcher data (2019)

With reference to Figure 5.3, findings reveal that the majority of the respondents pointed out the prices of both input and output as a concern in aquaculture and with regard to household socio-economic performance. According to the respondents, there exists a high cost of inputs such as fingerlings, feeds and in construction of the basic infrastructure of fish ponds. The results in this study resonate with the findings by Udeze *et al*., (2021) whereby it was established that an increase in the cost of input increases the cost of production hence increasing output prices. This, therefore, reduces the demand of the fish harvested hence the low market. According to the key informants, it was stated that:

> "… Cost of inputs and outputs from fish and fish products has reduced economic wellbeing of households involved in freshwater aquaculture in Busia County."

More than 70% of the total global aquaculture production is dependent upon the supply of external feed inputs (Tacon and Metian, 2015). This must be aligned with the local capacities of the household heads in order to attract their involvement and improve their household socioeconomic capabilities and performance. Households in Busia County were concerned with the availability of fingerling, feeds and management of the pond to enhance their socioeconomic performance owing to the scarcity of main resources. Looking at Busia County poverty index of Busia County rose from 70% to 83% (KNA, 2022). Additionally, another key informant - Sub County fisheries officer from Bunyala - added by stating that:

> "… If the cost of fish (output) goes up then the intended consumers may shift preference to other food from fish. There is a highly likely chance that fish markets grown in ponds to dwindle hence possible abandonment of fresh water aquaculture."

From the opinions of members from an FGD in Bunyala, a member stated that:

> "… Households are poor in this area of Bunyala while there is a potential of empowering them economically through the natural resources that exist in this area like water in the Lake and River Nzoia through Fish Farming."

Another member of the FGD forum observed that:

> "… installation of a fish pond is quite expensive considering the excavation, laying of linings for some, and fencing to keep away predators. Thus, pond infrastructure becomes a bit unaffordable to the majority of the households."

It was noted from the discussion that despite the high cost of inputs, there were some of the inputs that were manageable by the households that are found within their environment for fish feeding programs. A member of the focus group discussion stated that;

> "… We are conversant with some of the fish food such as food remains, earth worms which can be given to the fish. But it is quite tasking nonetheless."

Key informant – County fisheries officer – noted by stating that:

> "… price of a single fish fingerling trade at around Kes 10 or slightly above up to Kes 15. Households well informed of the benefits of fish farming/ aquaculture always endeavour to secure high-quality fingerlings to promote their socioeconomic performance."

This resonates with the findings by Akwanyi *et al*., (2019) that revealed that most households in aquaculture who had sponsorship from the Fish Farming Entrepreneurship Project in the construction of fish ponds, 85% bought fingerlings at <=10 shillings while just 15% bought at >10 shillings. The study however established that the fingerlings and fish feeds may be affordable to many households involved in fresh water aquaculture but the transportation cost increases the overall cost hence making it more expensive. The study was corroborated by the key informant interview that:

> "…Most fish farmers about 90% of them source their fish fingerlings from other Counties like Vihiga, Bungoma and Siaya Counties in Kenya." KII

MORE: It therefore translates that if the majority of the households struggle with the acquisition of the inputs, then they will increase the output price which might not be affordable to the consumers and if they have to sell at the normal price then they run at a loss hence low economic power that eventually affects the social dimension of the households such as low quality of life and increased illiteracy levels.

5.4. Access to finance

To establish the influence of financial access on household socio-economic performance, results in Figure 5.4 indicated that 35% of the respondents agree that there was limited access to finance by households.

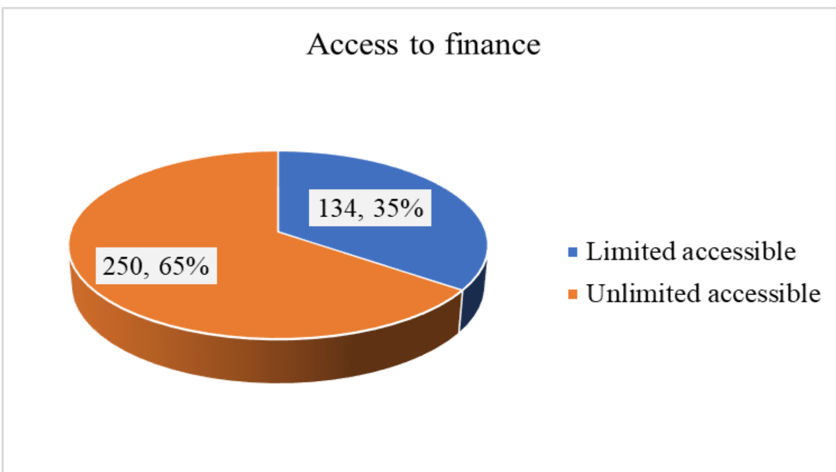

Figure 5.4: Impact of access to finance on household socioeconomic performance

The foregoing findings in Figure 5.4, indicate that there has been an improvement in the access to finance by households. It meant that there has been trust between households in Busia County in agriculture and aquaculture endeavours. According to Dmirguk-Kunt *et al.*, (2008), for economic performance, there is a need for financial inclusion where individuals and households can take advantage of the existing financial services to invest in development opportunities like in fresh water aquaculture for socio-economic transformation at the individual, household and even at community levels

The study established that some of the financial access points are the various banks like equity and Co-operative for credits and insurance that provided the households with the necessary services to establish or expand fish farming. However, according to Beck *et al*., (2010), households may have access to financial access but fail to use them hence derailing the socio-economic development from any livelihood. Additionally, the study added that one household may be willing to use the financial services but lack access.

According to this study, the findings reveal that financial access has been available however there has been very minimal usage of the services therefore rendering most households unbanked. According to the World Bank (2019), individuals or households may equally have indirect access to financial services where one may use another person's account or already use a substitute financial service. Therefore, giving access doesn't automatically translate to the usage of the services available from the providers. This is in tandem with Nwaru (2004) who found out that there may be financial access but failure to use it due to other cultural or religious reasons.

According to a key informant, a sub-county fisheries officer, access to finances for households in the study area is available but usage of the services is impartial. He attributed this to the wrong perception of those who had earlier defaulted. However, the Key informant confirmed that there is an experience in the increase in the use of financial services. He reiterated that there lies an opportunity for the creation of awareness and sensitization on the use and importance of the available financial services and sustainable management to economically improve the households and increase their performance in general. According to an FGD participant;

> "… Many credit facilities for farmers in the study area however, the majority of them are hesitant to use the services due to high-interest charges. Some of the household heads also have the wrong attitudes towards the facilities and services based on the stories they have heard from the previous users who defaulted. She added that there is a need for an agreement on reduced charges just for fish farmers to assert confidence and increase the majority usage."

In reference to the availability, usage indirect usage and non-usage of the financial services that are accessible, the study revealed that the few who embraced the usage through direct access to the financial services were mostly individual heads of households who had alternative sources of income. It, therefore, suffices that they had security for access to financial services and were confident enough to use them. The study, therefore, revealed that these households had more established fish farming hence increased output helping them to make more profit to empower them economically and socially in equal measures.

5.5. Fish markets

To understand the social and economic performance, it was important for this study to establish a fish market in the surveyed sub-counties of Busia County. From the study, it was established that all the households surveyed sold their fish harvested at the farm gate. It was argued that the farmers would invite potential buyers during fish harvest and trade with them *in situ*. This is the common mode of business transaction among the small-scale households practising fish farming in Busia County. It is also an indication that households surveyed had no fish value chain production and storage facilities. Thus, the opinion from the FGD forum, a member stated that:

> "…The local households do not have coolants for fish storage. And this is to everyone seated here. So, we always organise farm gate sell during fish harvest. Fishmongers come to procure during fish harvest announced dates."

A key informant observed that:

> "… there are plans to put up factories at least one in every sub-county. We have one factory in Teso South though not yet operational, for fish value chain, sorghum, cassava among others."

5.6. Fish price

The researcher investigated the price of a kilogram of fish to determine its household socioeconomic performance. The findings are shown in Figure 5.5.

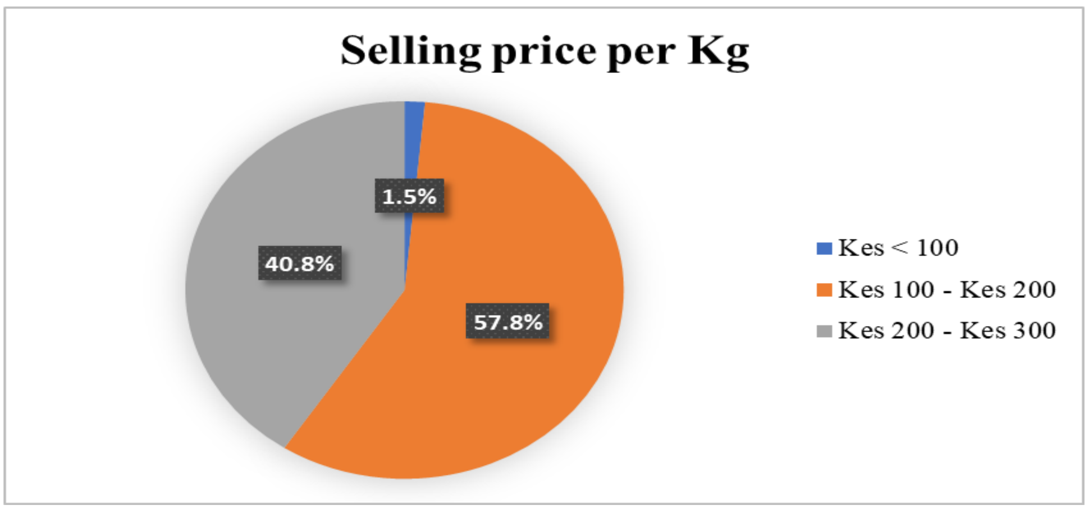

Figure 5.5: The fish price per kilogram

Source: Researcher (2019)

According to the household survey (Figure 5.5), 57.8% of the farmers interviewed sold a kilogram of fish between Kshs. 100 and Kshs. 200. The price determination was based on the weight of the fish as well as the condition of the pond from which the fish were harvested. Most of the ponds from the surveyed sub-counties were not well kept and maintained hence affecting the price of the fish per kilogram. Pool management is at the centre of quality fish production and weight conversion. Shitote (2012) states that poor maintenance of fish ponds by fish farmers affects price determination and thus negatively influences socio-economic performance. The study observed that the pricing of fish is crucial in determining the socioeconomic performance of fish farmers. Comparing the prices of one kilogram of fish from the pond and one kilogram of fish from Lake Victoria at Port Bunyala (Victoria), lake fish of similar species as pond ones were sold at Kes 300 per kilogram while 59.2% of the pond ones were sold at less than Kes. 300. The comparison was the opinion of a Key informant who stated that:

> "… Fish from the lake goes at Kes 300 per kilogram. This is unlike fish from the ponds where farmers sell them cheaply. I can imagine that we have not done so much to help them set good pricing models that can be replicable by all farmers for uniformity."

Therefore, lake fish attracted better pricing as compared to pond fish, which could mean that lake fish have better weight and access to natural food systems. With regulated pricing and value chains in aquaculture, the sector tremendously stimulates the rural economies for the rural poor. This observation concurs with Béné *et al*. (2015) that promoting aquaculture solves malnutrition among the rural poor and promotes socioeconomic performance. The indulgence of the aquaculture stakeholders of Busia County and the political goodwill encourages the growth of the fish farming economy. a result of political goodwill to alleviate poverty through income-generating aquaculture and improve protein contents for households in Busia County. Furthermore, the key informant stated that:

> "… The County Government of Busia through the executive arm, the governor, has invested heavily in aquaculture as one of the key areas of economic development of the rural population. About six hundred million

> Kenyan shillings have been invested in aquaparks in Teso South sub-county and Samia sub-county."

The study sought to determine whether there was any significant relationship between the price of fingerlings, the price of feeds and the price of harvested fish. Spearman correlation was therefore performed and the findings are presented in Table 5.2.

5.7. Correlation of fish fingerlings prices, feeds, harvested fish

The researcher computed a correlation test of the price of fingerlings, feed and harvested fish to determine the strength of the relationships and the direction of the relations.

Table 5.2: Correlation of price of fish fingerlings, price of feeds, price of harvested fish

			Price of a fish fingerling (Kes.)	Price of fish feed per kg (Kes.)	Fish price per Kg in (Kes.)
Spearman's rho	Price of a fish fingerling (Kes)	Correlation Coefficient	1.000		
		Sig. (2-tailed)	.		
		N	384		
	Price of fish feed per kg (Kes)	Correlation Coefficient	0.058	1.000	
		Sig. (2-tailed)	0.411	.	
		N	384	384	
	Fish price per Kg in (Kes.)	Correlation Coefficient	0.152*	0.011	1.000
		Sig. (2-tailed)	0.029	0.876	.
		N	384	384	384

*. Correlation is significant at the 0.05 level (2-tailed). I USD exchange rate of Kes 104.1877 in 2019

Source: Researcher (2019)

The findings in Table 5.2 show that there is no relationship between the price of a fish fingerling and the price of fish feed, *r* = 0.58. However, there was a significant positive low relationship between the price of fingerling and the price of harvested grown fish. This implied that what causes the low relationship, would be due to the high cost of inputs that translates into a low profit margin for households. Concerning prices of fish feed per Kilogram and the price of harvested grown fish, there was no relationship.

The results reveal that in a correlation significance at 0.05, prices of fish fingerlings were not significant to prices of fish feed and market prices of fish per kilogram in Kenyan shillings at 0.411 and 0.029 respectively. The study found that other key factors play a great role in terms of input and output prices. Inflation and other key market dynamics such as market demand and supply were identified as some of the factors that dictate the prices. A member at the FGD forum stated that:

> "…When there is inflation starting from the global markets, it's obvious that the local markets will also be affected therefore fish farmers may buy fish fingerlings at a high cost but end up selling the output at a low price while there are those who may buy the fish feeds at high prices but sell their fish at low prices and vice versa." FGD.

The study learnt therefore that there is a significant variation with regard to time and place relating to input and output prices of aquaculture. Ideally, there should be a positive relationship where an increased input should lead to increased production hence increased earnings for profit making by the fish farmers. However, according to FAO (2009), both social and economic factors have exacerbated the reduced production such as family conflicts on the management of the fish farming and inaccessibility of some financial services therefore leading to a negative relationship between input and output of fish from the aquaculture. Other factors that were identified from FGDs in the study area are diseases, amount of fish feeds, predators and parasites. These factors may lower the output, therefore, increasing the prices of both inputs and inputs based on the demand or supply expected in the market.

CHAPTER SIX

FRESHWATER AQUACULTURE TECHNOLOGY STRATEGY PROMOTING AQUACULTURE PERFORMANCE IN BUSIA COUNTY, KENYA

6.1. Introduction

This chapter discusses the aquaculture technologies performance. It presents results and findings of various fish pond technologies as implemented in freshwater aquaculture and household socio-economic performance. The study was interested in the use of freshwater aquaculture technology strategy i.e., the pond technology (type of ponds, knowledge of the technology, impact of the technology on household socioeconomic performance) to enhance the performance among households in Busia County.

6.2. Pond technology

The study investigated the aquaculture technologies performance in freshwater aquaculture and household socioeconomic performance. Figure 6.1 summarises the findings.

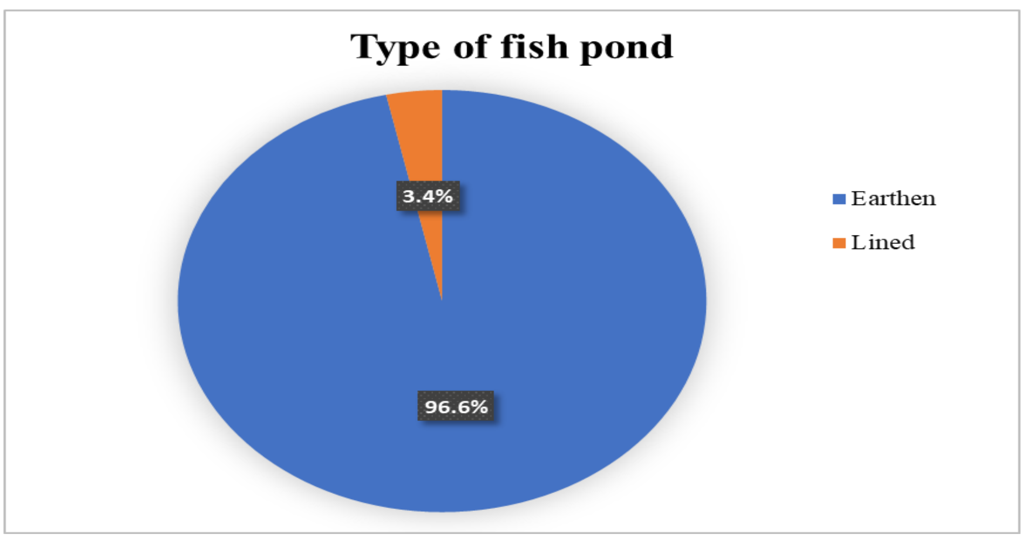

Figure 6.1: Fish Pond Technology

Source: Researcher (2019)

From the findings in Figure 6.1, semi-intensive pond technology was commonly used in Busia County. This was said by 96.6% of the respondents owing to the initial installation cost being quite manageable to households as compared to an intensive fish farming strategy. Aquaculture is an acceptable technology which covers different production systems including semi-intensive, intensive culture in ponds, and tanks, intensive production in cages and traditional extensive production systems (Soliman and Yacout, 2016). For this study, most households were poor households and would only practice semi-intensive pond culturing that essentially provided them with the source of proteins and income mainly sold at farmgate. The technology was mainly earthen because it hardly required any finishing that involved concrete or cover which would increase the cost of pond construction and development. Lined pond technology involves after excavation of the pond to line up to disallow water seepage into the ground. Earthen pond preference came from the FGD forum where a member stated that:

> "… Households in Bunyala Sub County and Teso South Sub County are the rural poor. We have had privileges where in 2009 we received an economic boost from the economic stimulus programme. That was the beginning of the high numbers of earthen ponds. But we are trying to move to lined ponds once receive support on the same."

This study observed the majority of the respondents had invested in simple technology (earthen ponds) that are most common in western Kenya as compared to lined ponds. Nevertheless, small-scale pond aquaculture has not had any significant impact in alleviating poverty in most poor families. Ther is many challenges faced by these earthen ponds that are rarely guarded to rid predators and thieves from accessing them. From a key informant, it was stated that:

> "… The local households do not have the luxury of purchasing liners. They are expensive for these farmers. Instead, they use earthen ponds that are readily available to them."

Backyard pond technology mostly made of concrete is being advocated to households practicing fish farming. The rapid growth of aquaculture in many parts of Kenya has necessitated a high demand for quality pond technologies that are appropriate and manageable by households (Nyonje *et al.*, 2018). Takes minimal space and minimizes risks and predators. Currently, most households are encouraged to have backyard ponds encouraging fingerling production. It is known that despite the efforts put forth to address fingerling production at local levels and convenient to farmers, the innovation remains a challenge in Busia County hence making most farmers dependent upon an external supply of fingerlings as well as feeds (Tacon and Metian, 2015; Béné *et al.*, 2016). Technological innovation, therefore, becomes critical at this point in Busia County, thus, backyard ponds for fries and fingerlings production are recommended. This study noted the crucial role played by technological innovation towards households practising farming convenience and affordability of the fingerlings.

6.3. Aquaculture technology and knowledge promoters

The study sought to investigate the promoters of aquaculture technologies in Busia County. Table 6.1 illustrates the findings.

Table 6.1: Aquaculture technology and knowledge promoters

Aquaculture promoters	Frequency (n)	Per cent (%)
Technology promoter		
Government	280	72.8
Donor programmes	104	27.2
Knowledge promoter		
Donor programmes	347	90.1
Other fish farmers	37	9.9

The results in Table 6.1 showed that promoters of the freshwater aquaculture technologies were the County Government of Busia as said by 72.8% of the households surveyed. On the other hand, the donor programmes promoted freshwater aquaculture activities as noted by about 27.2% of modern aquaculture technologies. One of the most pressing challenges in aquaculture is the unavailability of efficient technologies that are affordable and increase production for farmers' benefit (Munguti *et al*., 2012). This led to the use of fish nets designed specifically to keep away predators and protect fish to thrive in ponds.

Knowledge promoters with relation to the existing technologies and donor programs were rated at 90.1% followed by the use of other fish farmers at 9.9%. There have been donors such as PALWECO which was providing education on fish farming and ways to improve income for the poor households. Since the closure of these donor organisations, there has been a reduction in fish production hence affecting aquaculture. From the foregoing findings, it was indicated that the government (both national and county) have been at the forefront of familiarising household with aquaculture technologies that increase income and livelihood at the household level.

Presently, there is limited knowledge of modern aquaculture technology (Munguti *et al.*, 2014). Backyard ponds made of concrete mainly for fish fries and fingerlings production are encouraged to empower households to save on the cost of inputs and realise an increase in profits. Besides, concrete ponds are encouraged in the compounds that are away from predators and thieves easily accessible to households and easily monitored for any anomalies. From the FGD forum, a member stated that:

> "… Pond nowadays can be constructed above the surface which are within our compounds. Such technology has helped involve all household members

in managing the pond and fish. Now this is what we call family involvement and bonding. The family appreciates the business."

Another member of the FGD added by stating that:

> "… Extension services that we receive from government officials through Kenya Climate Smart Agriculture Project and donor programmes ABPD has contributed to a positive engagement of household in pond aquaculture and cage aquaculture."

This study noted the role of the directorate of fisheries in Busia in providing extension services that informed farmers of the locally appropriate aquaculture technologies. This was corroborated by the key informant's opinion of the subject stating that:

> "… The department ensures that what we tell our farmers, we have already tested and it worked. Looking at backyard ponds, we know that the farmers can rear their fingerlings which will increase production due to the reliability of fingerlings."

The survey also revealed that donor programmes such as the Aquaculture Business Development Programme and the Kenya Climate Smart Agricultural Project (ABDP) carried out the promotion of knowledge of fish farming technologies. These programmes were an important addition to feed and fingerling production and the fish value chain. It is known that fish feed accounts for at least 60 per cent of the total cost of aquaculture production, hence overreliance on external purchases slows the pace at which aquaculture is advancing in Busia County (Cai *et al.*, 2017). This study notes the importance of locally appropriate technologies when making fish feeds and local fish species that can survive on locally available feeds. Households practising fish farming have increased immensely in Busia County, thus, there is a high demand for quality fish seed for commonly cultured species such as Tilapia species.

6.4. Impact of aquaculture technologies on production

The study sought to impact aquaculture technologies by fish farmers with regard to production. The results in Figure 6.2 show that the majority of the respondents 73.8% had experienced an increase in fish production while 26.2% had not experienced an increase in fish and related products by the use of the technologies.

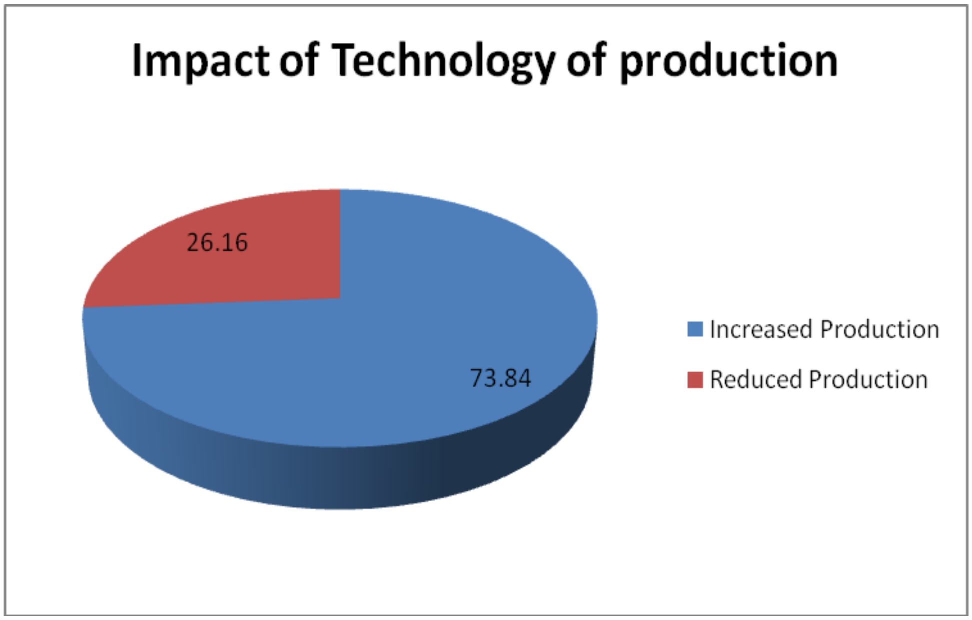

Figure 6.2: Impact of the technology on production

Source: Researcher (2019)

Findings from the respondents reveal that the majority (73.8%) indicated that there has been an increase in fish production in Busia County. The increase could be attributed to the increased fish protein demand in Busia County and neighbouring Counties. Moreover, the blossoming population has encouraged an increased need for fish. According to Akwanyi *et al*., (2019), the increasing demand for fish in the recent past has led to new and dynamic ways of increasing production. The technology in spawning and harvesting became mandatory for farmers in order to maximise profits. There was a corroborated opinion from the key informant which stated that:

> "… The department of fisheries is investing in marketing and value addition for fish produced to maximise the profits from the proceeds. The prices are still low for many farmers because the yield's quality is still below average and hence not attractive to increased prices.

Whereas another key informant stated that:

> "… We have tried to take farmers to fish processing plants and hatcheries to acquaint themselves with the knowledge on value addition and technologies involved in order to increase the production and improve the yield."

The Aquaculture Business Development Programme (ABDP), in Busia County, aims at building the capacity for feed cottage industries and fingerling production that was introduced under the ESP program. In that regard, the ABDP conducted a needs assessment survey in Bunyala sub-county in line with their programme scopes. This led to the ABDP making promises to households in Bunyala sub-county that it would make fingerlings available to them for free as well as fish feeds. However, from the FGD forum, it was stated by a member that:

> "… This year, as we speak, farmers have not stalked fingerlings in their fish ponds. All farmers in my area were promised fingerlings and feeds, because the needs assessment that was conducted, was premised on inputs. Sadly, we are yet to receive the inputs."

Another member of the FGD stated that:

> "… The interests of the donor programme working currently in Busia County regarding aquaculture hardly lie in the provision of free fingerling and feed. Instead, the focus lies on pond liners and predatory nets. Feeds and fingerlings are the main challenges for farmers, not liner and predatory nets."

The most challenging technology for households as stipulated by the findings in this study lies in the inadequacies in the availability of quality fish seed. This is a prerequisite for sustainable aquaculture that results in a lack of sufficient and good quality fingerlings.

According to Kundu *et al.* (2016), this shortage seriously limits the growth and development of the households' farming enterprise where fingerlings sourced from fish farmers are stunted. Promoting fish production and household fish farming requires quality fingerling production and an adequate and prompt supply of fish feeds in Busia.

6.5. Correlation of fish aquaculture technology

The study analysis computed field data to provide the relationship between variables under fish pond technologies. The results presented in Table 6.2 indicate that fish pond technology has a significant relationship (r = 0.242 +-SE; p < 0.01) with the time taken to adapt to the fish pond technologies, high significance (r = 0.314+-SE; p < 0.01 with where one learnt about the technology, and no significance r = 0.066+-SE; p > 0.01 on whether technology increased fish production or not. Additionally, the time taken to adapt to new technology is of no significance (r = 0.88+-SE; p > 0.01) to where one got to know about the technology but of low significance (r = 0.205+-SE; p < 0.01) to whether technology increased fish production.

Table 6.2: Correlation of aquaculture technology in terms of type fish pond technology, aquaculture technology promoters and influence of pond technology on fish production

Aquaculture technology		Fish ponds technology	Aquaculture technology promoter	pond technology on production
Fish ponds technology	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	384		
Aquaculture technology promoter	Pearson Correlation	.319**	1	
	Sig. (2-tailed)	.000		
	N	384	384	
Influence of pond technology on production	Pearson Correlation	.066	.650**	1
	Sig. (2-tailed)	.357	.000	
	N	384	384	384

From the correlational analysis, findings show that fish pond technology has a significantly low positive association with aquaculture promoters ($r = 0.319$, $p = 0.000$). This meant that fish pond technology use is lowly predicted by the promoters of aquaculture technologies. This could also mean that the promoters of aquaculture technology have not seen the need to invest in a fairly expensive technology that could contribute to households opting out of the aquaculture business, However, there is an indication of a positive trajectory that may be realised in the next five years with regards to persistent aquaculture technology propagation to households to see the need to invest pond technology that assures improvement in fish production. Fish pond technology on the other hand had no association with the influence of pond technology on production ($r = 0.066$, $p = 0.357$). This could have meant that the technology could be affected by other external factors that could or could not affect the production of fish.

Aquaculture technology promoters had a fairly strong significant positive association with the influence of pond technology on production ($r = 0.650$, $p = 0.000$). This meant that aquaculture technology promoters influence the aquaculture technology on production. Therefore, the study reports that aquaculture technology promoters must continue sensitising the households on the importance of taking advantage of the current and emerging technologies in aquaculture.

Technology in aquaculture is of significance because it is an attempt to increase production (73.84% - Figure 6.3). The increased aquaculture production is additionally expected to increase sales hence increased profit that would make the farmers and specific households who adopt the technologies improve both economically and socially. According to McClanahan *et al.*, (2015), socioeconomic performance is a measure based on a reduced dependency ratio, an improvement in the poverty index, improved food security and increased job creation.

Type of fish pond technology and with regard to Busia fresh water aquaculture, there exist two types of technologies i.e., the earthen and lined technologies. According to the findings, the majority are involved in earthen technology. This is attributed to the cost of establishing the fish ponds where the majority of the respondents preferred the earthen because it's cheaper compared to the lined. According to Usman, Girei and Tari (2016), earthen ponds are the nearest natural type of pond where fish eat natural food like worms making them also grow faster. Agreeably, a Key Informant, as fisheries officer, added that most farmers prefer earthen because it is of low-cost maintenance and easy to manage water systems. It, therefore, means that other factors have contributed to the increased production of fish better than the type of technology employed. According to a participant in an FGD in Bunyala;

> "… As much as technology is meant to increase the production of fish, there are other factors like knowledge, quality fingerlings, feeds and better management of the ponds that will increase the yield. There are farmers with different technologies employed but they all end up with increased yield during harvesting."

Adaption of new technology has significance though negative in influencing the increase in fish production in Busia County. According to Nguyen (2016) technological advances in aquaculture i.e., in genetic improvement of farmed species, control of reproduction, breeding and feeding have made tremendous improvements in aquaculture globally. However, according to the fisheries officer in Busia County, it was stated that:

> "… Technological advances have not had a positive impact and are not a guarantee for fish production increase. The non-improvement as expected may be as a result of a delay in the adoption of the new technologies by households." KII

This therefore resonates with the findings from the respondents who indicated that technological improvement is key. However, a member from the FGD stated that;

> "… positive result of technological improvement may only be realized subject to the speed of adoption of the technology. The faster the households adopt the various technological advancements the faster the production will increase and the slower they adopt or lack of adoption the lower the production from the fish farming." FGD.

Conservatism and wrong attitudes towards technological improvement in freshwater aquaculture were identified as some of the factors that may affect the faster adoption of the technologies, therefore, reducing production. However, it was affirmed that there was an improvement in the adoption of the technologies giving rise to production at a lower rate. The rapid growth of aquaculture in many parts of Kenya has necessitated a high demand for quality fish (Nyonje *et al.*, 2018). Embracing aquaculture technologies as a strategy contributes to improved household socioeconomic performance. For improvement in adoption of the fish farming technologies, there is a need for concerted intensive and extensive sensitization of the farmers on the need to adopt the new technologies. Therefore, when households need to be taught well regarding fish aquaculture technologies that promote production and improve household income, the households strive to accommodate the technologies and embrace the training to improve performance (Amankwah *et al.*, 2016). This thus leads to improvement in their households' socio-economic performance.

The study learnt that various farmers had received training on various technologies from various organizations and institutions. Training households was important to endeavour to increase the production of fish by households. The Key informants from the directorate of fisheries stated that:

> "… the County Government of Busia through devolution has made it easy in terms of access to every household hence having the majority getting the necessary training and information." KII

Information sharing on the technologies used to enhance the performance of freshwater aquaculture was mandatory to advance performance and promote the sustainability of aquaculture. Waite *et al.* (2014) observed that to improve and increase the productivity of aquaculture in Africa, fish feeds should be made with locally available products. This meant that there should be locally appropriate technologies that will help fish affordable feed and fingerlings.

CHAPTER SEVEN

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

7.1. Introduction

This chapter summarizes the results of the study, derives a conclusion and provides recommendations for policies to the government and all stakeholders in aquaculture for sustainable household socio-economic performance.

7.2. Summary of the findings

The first objective summarises that private hatcheries (97.1%) were the main providers of fingerlings to households interested in freshwater aquaculture. The price of a fingerling was averaging at Kes 10; however, adding transportation costs to secure fingerlings made it quite expensive for a farmer to sustain. Monoculture was given prominence as a mitigative strategy for the sustainability of the fish in the pond. Regarding fish feeds, they were readily available in local agrovets; however, the cost of procuring feeds was quite high for the farmer. Extension services were provided to 97.6% of the households in the areas studied. Pond management was the most extension services provided (96.1%), the importance of record keeping (92.7%), fish marketing (77.7%) and backyard pond management system (58.3%).

With regard to the second objective which was to determine the household socioeconomic performance, only 18% of household sizes determined their household socioeconomic performance. The cost of inputs and market prices of fish and fish products was of concern to 45% of the households that participated in the study. Access to finance was limited to 35% of the households, which meant that there was a great improvement in the financial sector extended loans into aquaculture. The fish markets were only farm gates whose price per fish was averaging between Kes 200 – Kes 300 (1 USD = 104.1877 Kes, 2019).

The third objective sought to determine aquaculture technology performance in Busia County. Earthen pond technology constituted 96.9% of the aquaculture pond technology. Aquaculture technology promotion was mainly done by government line departments in charge of fisheries. Knowledge promotion was done by the donor organisation working in aquaculture systems.

7.3. Conclusions

Private sector hatcheries are the main distributors of fingerlings to farmers which could have contributed to the higher price of a fingerling; where also considering the transportation cost of the precious fingerlings. Monoculture fish is given prominence in mixed cultured fish production due to the elimination of competition over feeds. Agrovets are the main providers of fish feeds to farmers; however, the feeds are expensive to small-scale farmers in a household. Pond management, recording keeping and marketing were the main extension services accorded to households surveyed.

Household sizes partially determined household socioeconomic performance. The cost of inputs and market prices of fish and fish product was the average determinant of household socioeconomic performance. Households had access to financial support such as loans designed for aquaculture ventures. At the time of the investigation, households were marketing fish at the farm gate whose price per fish was averaging at Kes 200 – Kes 300.

Earthen pond technology was the main technology practised by the households in the study area. Government and donor organisations were the main promoters of technology and aquaculture knowledge respectively. Aquaculture technology positively impacted fish production.

7.4. Recommendations

Owing to the low investment in hatcheries by the national and county governments of Busia, there is a need to rethink the installation of government hatcheries in all sub-counties for ease of accessibility and affordability in order to promote the sustainability of aquaculture. Extension services hardly touch on the production of fish feed, thus, there is a need to educate farmers to use locally available resources to make quality fish feeds to realise profits.

The cost of inputs is quite high for the local household farmers; thus, it is an area that the County Government of Busia to look into and help reduce the cost. Investment in local industries that produce fingerlings and feed should be the first approach to promote aquaculture in every home. Access to finance was quite improved, it will be even better for banks to facilitate loans to all households investing in aquaculture not only for local markets but also regional and international markets.

Earthen pond technology is dominant, however, there is a need for subsidised lined pond systems to have as many farmers moving to lined ponds that are secure and safe for the fish and farmer. Governments (national and county) should continue propagating messages about the technologies to households.

7.5. Suggestion for further research

i) A study needs to be conducted correlating the influence of fresh water aquaculture on household socio-economic performance between Busia and Kisumu County, Kenya

ii) There is a need for a study to be conducted on the socio-political influence on household fresh water aquaculture.

iii) A study needs to be conducted on the perception and adoption of new technologies in fresh water aquaculture

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APPENDICES

APPENDIX I: Key Informant Interview Guide on the influence of freshwater aquaculture on household socioeconomic performance in Busia County, Kenya

Dear Respondent

The interview takes about 10 minutes to obtain responses on the matter.

1 What is the highest level of education level

2. Are you an aquaculture expert or have had experience in it?

3. If No (from Q.2, what motivates you to venture into freshwater aquaculture issues?

4. are there challenges with freshwater aquaculture?

5. If yes (from Q. 4), what are some of these challenges faced by farmers practicing freshwater aquaculture?

5 Do you some of the institutions rearing and selling quality fingerlings to farmers? Can you list them, please?

6. Where do most farmers buy their fish seeds/ fingerlings?

7. Between the mono-sex and mixed-sex types of fingerling, which one is mostly bought seeds

8 Where do you buy your fish feed

9 What is the average cost of fish feeds in Busia County?

11 Are there extension services being offered by the county government of Busia?

12 What type of extension services are provided?

13 In your own opinion, are the extension services offered satisfactory?

18 What type of farming system is being currently used?

19 Are there new technologies being adopted in the past 5 years?

20 Does the technology influence fish production?

APPENDIX II: Questionnaire on the influence of freshwater aquaculture on household socioeconomic performance in Busia County

Dear Respondent

My name is Douglas Atamba Miima, a Master's Degree student at Masinde Muliro University of Science and Technology pursuing Disaster Management and Sustainable Development. I am conducting academic research on the influence of freshwater aquaculture on socio-economic performance in Busia County. I am seeking your assistance in gathering data on it. The study seeks to establish the influence of small-scale fish farming on the local socio-economy in the county. The interview takes about 10 minutes to obtain responses on the matter.

Kindly tick in the space provided (√) the correct answers or give the required information where specified.

SECTION A						
Personal Information (please tick appropriately)						
1	Gender	Male		2 The age bracket of the respondent	(18-25) yrs	
		Female			(26-35) yrs	
					(36-45) yrs	
					(46-55) yrs	
					(56 and above)	
3	Highest education level achieved	KCPE/ Primary				
		High School				
		Diploma				
		Bachelor's Degree				
		Master's Degree				
		Doctorate				
		Other (Specify)				
4(a)		Yes				

<table>
<tr><td></td><td colspan="2">Did you study agriculture or a related course in school?</td><td colspan="3">No</td><td></td></tr>
<tr><td>4(b)</td><td colspan="6">If No specify where you got the motivation to venture into fish farming.</td></tr>
<tr><td colspan="7">SECTION B</td></tr>
<tr><td colspan="7">5. What challenges do you face in fish farming (tick where appropriate 1 being least challenging while being most challenging)</td></tr>
<tr><td colspan="2"></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="2">Cost of inputs</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Provision of extension services</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Accessibility of market</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Use of new technology</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">COST OF INPUTS (please tick appropriately)</td></tr>
<tr><td colspan="7">Fish Seed/Fingerling</td></tr>
<tr><td rowspan="5">6</td><td rowspan="5">Where do you buy your fish seeds/ fingerlings?</td><td>Government hatchery</td><td></td><td rowspan="5">7 How much do you buy the fish seed/ Fingerlings</td><td rowspan="2">Less than 5</td><td rowspan="2"></td></tr>
<tr><td>Private hatcheries</td><td></td></tr>
<tr><td>Self-propagation</td><td></td><td>5-10</td><td></td></tr>
<tr><td rowspan="2">All the above</td><td rowspan="2"></td><td>10-15</td><td></td></tr>
<tr><td>More than 15</td><td></td></tr>
<tr><td rowspan="2">8(a)</td><td colspan="2" rowspan="2">What type of fingerling do you buy</td><td colspan="3">Mono sex</td><td></td></tr>
<tr><td colspan="3">Mixed-sex</td><td></td></tr>
<tr><td>8 (b)</td><td colspan="6">Explain</td></tr>
</table>

Fish Feed			
9	Where do you buy your fish feed?		
10	How much do you buy the fish feed per Kg in Kshs	Below 100	
		100-200	
		200-300	
		Above 300	
11	What is your Feed Conversion Ratio (FCR)		
SECTION C			
PROVISION OF EXTENSION SERVICES (please tick appropriately)			
12(a)	Have you ever received extension services from the government?	Yes	
		No	
12(b)	If YES how often do you get the services?	Monthly	
		After every 3 months	
		After every 6 months	
		Yearly	
	Others (Specify)		
13	What type of extension services have you received?	Pond Management	
		Feed management	
		Record Keeping	
		Marketing and value addition	
13(a)	List any other 1. 2. 3.		
14	Are you satisfied with the extension services offered?	Yes	
		No	
14(a)	If NO which areas and give a reason		

15	Do you think the provision of extension services can/has improved production in fish farming?	Yes	
		No	
15(a)	If YES explain		
SECTION D			
ACCESSIBILITY TO MARKET (please tick appropriately)			
16	Where do you sell your fish?	Farmgate	
		Restaurants	
		Supermarkets	
		Fish Processing Plant	
		Other(specify)	
17	How much do you sell your fish per Kg in Ksh?	Below 100	
		100-200	
		200-300	
		Above 300	
18	How do you determine the price of fish?		
SECTION E			
USE OF NEW TECHNOLOGY (please tick appropriately)			
19	What type of farming system do you currently have on your farm?	Intensive system	
		Semi-intensive system	
		Extensive system	
20	What new technologies have you adopted in the past 5 years? 1. 2.		
21	How long did you take to adapt to the technology you are using	1 month	
		3 months	
		6 months	

		1 year	
		Other(specify)	
22	Where did you learn about the above-mentioned technology?	Government Fisheries officers	
		Donor programmes	
		Internet	
		Other Farmers	
23	How much did it cost to adopt the technology?		
24	Did the technology influence your fish production?	Yes	
		No	
24(a)	If YES how explain?		
	SUSTAINABILITY OF YOUR FISH FARMING BUSINESS		
25	What is your annual turnover	Less than 50,000	
		50,000-100,000	
		Above 100,000	
26	Do you make a profit from your business	Yes	
		No	
27	Share your comments on what should be done to make fish farming more profitable for small-scale farmers.		

Thank you

APPENDIX III: Permission by the School of Disaster Management and Humanitarian Assistance to conduct a study on the assessment of the influence of freshwater aquaculture on household socio-economic performance in Busia County

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Masinde Muliro University of Science and Technology (MMUST)

OFFICE OF THE DEAN

School of Disaster Management and Humanitarian Assistance (SDMHA)

Our Ref: CDS/G/0003/12 ***Date***: 19th March, 2021

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

REF: PERMISSION TO CARRY OUT RESEARCH – DOUGLAS ATAMBA MIIMA

This is to confirm that **DOUGLAS ATAMBA MIIMA** is a bonafide student in the Department of Disaster Management and Sustainable Development at the School of Disaster Management and Humanitarian Assistance (SDMHA) of Masinde Muliro University of Science and Technology (MMUST) pursuing a Masters Degree in Disaster Management and Sustainable Development currently in his final year of study.

He is carrying out a research project titled ***"Influence of freshwater aquaculture on the household socio-economic performance in Busia County, Kenya."***

Any assistance accorded to him is highly appreciated.

Yours sincerely,

DEAN
SCHOOL OF DISASTER MANAGEMENT &
HUMANITARIAN ASSISTANCE
(SDMHA)
Date..................Sign...........................

Prof. K. Onkware
Dean, SDMHA

APPENDIX IV: Approval Letter from the Directorate of Postgraduate Studies to conduct a study on the assessment of the influence of freshwater aquaculture on household socioeconomic performance in Busia County.

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

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Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

20th April, 2021

Douglas Atamba Miima.
CDS/G/003/2012
P.O. Box 190-50100
KAKAMEGA

Dear Mr. Miima.

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your Master's proposal entitled: ***"Influence of Fresh Water Aquaculture on Socio-economic Performance in Busia County, Kenya"*** and appointed the following as supervisors:

1. Dr. Edward Mugalavai - SDMHA, MMUST
2. Prof. Jacob W. Wakhungu - SDMHA, MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director of Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Disaster Management and Humanitarian Assistance Graduate Studies Committee and Chairman, Department of Disaster Mitigation and Sustainable Development. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of two years from the date of registration to complete your Master's thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours Sincerely,

Dr. Consolata Ngala.
DEPUTY DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

APPENDIX V: Research Permit to study the influence of freshwater aquaculture on household socioeconomic performance in Busia County.

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **618594**

Date of Issue: **15/September/2021**

RESEARCH LICENSE

This is to Certify that Mr.. Douglas Atamba Miima of Masinde Muliro University of Science and Technology, has been licensed to conduct research in Busia on the topic: INFLUENCE OF FRESHWATER AQUACULTURE ON HOUSEHOLD SOCIOECONOMIC PERFORMANCE IN BUSIA COUNTY, KENYA for the period ending : 15/September/2022.

License No: **NACOSTI/P/21/12950**

618594

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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