ANALYSIS OF FISH MARKETING AND HOUSEHOLD WELFARE AMONG AQUAFARMERS IN SELECTED COUNTIES IN KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Master of Science Degree in Agricultural and Applied Economics of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this is my original work and has never been submitted in any academic institution for the award of any degree certificate.

Signature  Date: 26/06/2022

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Recommendation

This work has been submitted with our approval as the University Supervisors.

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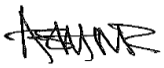
Signature  Date: 27/06/2022

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DEDICATION

I dedicate this work to my lovely parents, my wife, sons and family members who have shown me love, emotional support and understanding throughout this entire process.

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ABSTRACT

Capture fisheries and aquafarming are important in meeting the rising demand for white meat. They also contribute to improved income and nutrition among producers and consumers of fish, respectively. With the global fluctuation in capture fisheries, attention has been diverted towards aquafarming which has shown an increasing trend in the recent years. Despite this progress on the production side, there has been little effort made in the past to improve fish marketing to ensure a ready market for producers and easy access for consumers. Social networks play a key role in facilitating marketing through group formation and networking. In addition, lack of an effective marketing system for fish may result in high post-harvest losses with implication on household welfare. This study analyzed fish marketing and household welfare among aquafarmers for selected Counties in Kenya. The specific objectives of the study were (1) to characterize fish market outlets among aquafarmers, (2) to determine the effects of social networks on the choice of market outlets and (3) to assess the influence of post-harvest losses on farmer household welfare. The study used secondary data which was collected in Nyeri, Siaya, Kiambu, Kirinyaga and Kakamega Counties using semi structured questionnaires on a sample of 300 fish farmers. A multi stage sampling technique was used to select the respondents. Descriptive analysis, multivariate probit model and two stage least squares regression model were used to analyze objectives one, two and three respectively. Results indicated that majority of the fish farmers sold directly to consumers and retailers outlets. In addition, farmers who sold to wholesalers and collectors market outlets received better prices. Results of the multivariate probit model established that social networks captured by the number of farmer groups, membership to Farm Africa (non- government organization), number of years in a group and linkages with the fish market significantly affected the choice of market outlets. As expected, the findings from the study showed that post-harvest losses negatively affect farmer household welfare. Given the results, it is important that the government of Kenya in partnership with other stakeholders help to reduce bureaucracies such as scale of production, packaging and handling procedures in wholesaler and collector outlets. In addition, there is need for extension officers to offer training and technical advice to farmers on the importance of group marketing. The findings underscore the importance of training and provision of credit facilities to enhance fish marketing. In addition, reduction of post-harvest losses through investment in preservation facilities would result in better prices and overall improvement in household income.

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2SLS	Two Stage Least Squares
3R	Resilient, Robust and Reliable
AU-IBAR	African Union Inter-African Bureau for Animal Resources
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GOK	Government of Kenya
KNBS	Kenya National Bureau of Statistics
IIA	Independence of Irrelevant Alternatives
K-MAP	Kenya Market Led Aquaculture Program
MNL	Multinomial Logit Model
MOA	Ministry of Agriculture
MVP	Multivariate Probit Model
NGOs	Non-government organizations
OLS	Ordinary Least Squares
SSA	Sub Saharan Africa
TCE	Transaction Cost Economics

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Capture fisheries and aquafarming are significant in meeting the rising demand for white meat. These production systems contribute to high incomes and improved nutrition among producers and consumers of fish, respectively (Golden *et al*., 2017; Opiyo *et al*., 2018). Globally, aquaculture and capture fisheries supply 17 percent of animal proteins, which are important in the human diet and support livelihood of about 12 percent of the world total population (FAO, 2018).

Cai and Leung (2017) indicate that the global capture fisheries has been declining gradually over the years from 92.2 million tonnes in 2011 to 89.6 million tonnes in 2016. This resulted from increased fishing due to high population growth, unemployment, open access to fisheries and use of destructive fishing gears which affected the stock of fish (Opiyo *et al.,* 2018). On the other hand, the global aquaculture production has been rising over the years at an average rate of 8.2 percent per annum in the last three decades and forms a large proportion of fish currently consumed by humans (Awuor *et al*., 2019).

In Africa, the average fish consumption is estimated to be 8.9 kg *per capita*, which is below the world average of 20 Kg *per capita* (FAO, 2018). This means that the region would therefore need 2.49 million tonnes of fish to meet the total fish demand of 31 million tonnes by the year 2050 (Obiero *et al*., 2019; Tran *et al*., 2018). In the year 2017, the value of fish and fish products which Africa imported was 3.7 percent of the global fish imports (AU-IBAR, 2016). In Kenya, capture fisheries and aquaculture sector contribute about 0.8 percent to the national Gross Domestic Product (GDP), employs about 500,000 people directly and support the livelihood of about two million people indirectly (KNBS, 2019).

Fish consumption in Kenya has been decreasing from an average of 6 Kg *per capita* in 2011 to 4.0 Kg in 2018 (KNBS, 2018). This is likely as a result of high prices and the dwindling stock of fish. This low consumption is below the recommended average of 20 Kg *per capita* (Opiyo *et al*., 2018). In 2017, the total fish consumption in Kenya was estimated at around 188,000 MT (KNBS, 2019). Appendix 2 shows the trend in capture fisheries and aquaculture in Kenya between 2008 and 2018. The increase in aquaculture production between 2009 and 2011 was probably due to the Economic Stimulus Program (ESP) which was introduced in 2009. In the program, the Kenya government spent Kenya Shillings 1.12 billion on aquaculture, which was used to construct fish ponds, purchase fingerlings and feeds, develop hatcheries as well as promote extension services (Ringa & Kyalo, 2013).

Capture fisheries on the other hand has declined, probably due to the anthropogenic activities along the water bodies. The Ministry of Agriculture announced a comprehensive plan to increase the national *per capita* fish consumption from 4.0 Kg per year to 10.0 Kg as part of the ongoing nutrition campaign in boosting the immunity against corona virus (MOA, 2020). However, this plan to increase fish consumption could further increase the current supply deficit.

Aquaculture production in Kenya has been declining since 2014. This is probably due to reduced interventions by the Kenyan government in promoting aquaculture. However, the trend in production is different in various parts of the country. There is high aquaculture production in Bungoma, Busia, Kakamega, Siaya, Kiambu, Meru, Kisii, Kisumu, Nyeri, Murang'a, Kirinyaga and Embu Counties compared to others like Lamu, Elgeyo Marakwet and Kitui Counties where aquaculture is on the decline (State Department of Fisheries, 2016). On the other hand, the Kenyan government has put much emphasis in aquaculture research by the introduction of the Kenya Marine and Fisheries Research Institute in 1979. This institute is strategic to the fisheries and aquaculture sector in Kenya in supporting the livelihood of many people and contributing positively to food security through creation of employment and hatching of fingerlings for fish production (KMFRI, 2017).

Moreover, the Government of Kenya in the Second Medium-Term Plan (2013-2017) of the Vision 2030 placed emphasis on the value of marine resources. The government introduced measures that ensured enforcement of fishing regulations and effective management practices to improve the potential for the fisheries and protect the biomass of fish. In addition, the blue economy blue print, which is one of Kenya's Big Four Agenda is a policy tool that was adopted in 2017 to help achieve vision 2030 development agenda. The blue economy concept recommends methods for use in aquaculture such as cage culture (that is found in lakes, dams, ocean and rivers), aquaponics or greenhouse, pens, breeding and restocking of commercially indigenous species (Blue Economy, 2017).

Much of the efforts by the government of Kenya have largely focused on the production side with less emphasis on marketing. Fish marketing plays a key role in meeting the goals of food security, sustainable agriculture as well as in alleviating poverty (Nyaga *et al.*, 2016). Smallholder farmers have had challenges in penetrating markets, due to challenges from market liberalization. As a result, only few farmers sell to formal markets since they practice subsistence production (Nyaga *et al*., 2016). Aquafarmers have continued to experience challenges in selling fish from their farms due to inadequate investment in the market, including storage facilities and preservation methods (Meena, 2014). This limits the

ability of the farmers to sell fresh fish which attracts higher prices. Furthermore, organizing aquafarmers to access and actively participate in the market remain a big challenge facing fish farming (Mohammed *et al*., 2019). As a result, due to the highly perishable nature of fish, it has been observed that most aquafarmers have challenges accessing formal market outlets, with middlemen taking advantage and offering relatively lower prices for the fish, hence reducing farmers' income.

Social networks play an important role in facilitating fish marketing through group formation. Kamau *et al.* (2018) points out that fish marketing has not been well organized, hence there is need for developing networks that would facilitate access to fish market. Social networks through group formation have the potential of increasing the bargaining power of aquafarmers hence reducing barriers to entry in any potential market. In addition, it helps to reduce transaction and information costs in decision making and on market outlets respectively (Sigei *et al*., 2015; Stutzman et *al*., 2017). On the other hand, aquafarmers have continued to experience high post-harvest losses due to challenges in accessing the market. A study done by Tesfey and Teferi (2017) indicated that huge amount of post-harvest losses were as a result of inadequate storage facilities, poor handling and mismanagement, high transport costs and outdated preservation methods. Without an assured market, large quantities of fish end up spoilt with implications on farmer's income (Nyaga *et al*., 2016). This contributes to a loss in welfare of these farmers.

1.2 Statement of the problem

Various government interventions in aquaculture have resulted in increased fish output. However, little effort and investment have been made outside the farm to ensure a ready market for producers and ease of access for consumers in an effort to fully unlock the potential in fish farming. Studies indicate that social networks have potential to reduce transaction costs in decision making, limits entry barriers to potential markets and increases the bargaining power of aquafarmers Although social networks may be important, its role in fish marketing has not been clearly established. Further, lack of an efficient marketing system especially for highly perishable products like fish implies potential for high post-harvest losses and reduced incentives to production with implications on farmers' welfare. Given the above, this study aims at establishing the relationship between social networks and the choice of market outlets and the influence of post-harvest losses on household welfare.

1.3 Research objectives

1.3.1 General objective

To contribute towards improved fish marketing and farmer welfare in selected counties in Kenya.

1.3.2 Specific objectives

i. To characterize fish market outlets among aquafarmers in selected counties in Kenya.
ii. To determine the effects of social networks on the choice of fish market outlets among aquafarmers in selected counties in Kenya.
iii. To assess the influence of post-harvest losses on household welfare of aquafarmers in selected counties in Kenya.

1.4 Research questions

i. What are the characteristics of fish market outlets among aquafarmers in selected counties in Kenya?
ii. What are the effects of social networks on the choice of fish market outlets among aquafarmers in selected counties in Kenya?
iii. What is the influence of post-harvest losses on household welfare of aquafarmers in selected counties in Kenya?

1.5 Justification of the study

Aquafarming has the potential to meet the increasing demand for fish and hence fill the existing gap between demand and supply. Aquafarming contributes positively towards nutrition and food security among fish consumers and producers respectively. This study analyzed the effects of social networks on fish market outlets. Further, it analyzed the influence of post-harvest losses on household welfare. This study provides information on availability of market outlets that would ensure profitability of fish in the market. Furthermore, the results from this study will be useful in informing relevant policies and interventions by the government and other agencies to enhance investment in fish market infrastructure. This includes development and availability of adequate storage facilities, effective post-harvest handling equipment and modern preservation methods that would reduce the amount of losses and increase fish production. Lastly, this study contributes towards achievement of sustainable development goals number one and two of zero poverty and hunger respectively.

1.6 Scope and limitation of the study

This study was carried out in Nyeri, Siaya, Kiambu, Kirinyaga and Kakamega Counties. The data was collected in 2018. The sample included farmers with fish production systems such as cages, ponds and tanks. A sample size of 300 respondents was used. The study was limited to farmers who produced and sold fish for a period of one year and the questionnaire in appendix 1 was framed to help in the recall process. While the results for this study can be applicable to other counties that have favorable climatic conditions for aquaculture activities and high population that is potential for fish market, its generalization for the entire country may be limited.

1.7 Operational Definition of Terms

Aquaculture- a method of fish farming that involves breeding, rearing and harvesting of fish through the use of cages, ponds, tanks and integrated systems.

Cage Culture- this is a method of aquaculture production system in which fish is held in floating net pens.

Capture Fishing – a method of harvesting fish directly from the natural resources such as fresh water and marine environments.

Collector outlet – this is a market outlet where farmers come together as one entity and sell their fish

Consumer outlet- this is a market outlet where farmers sell fish directly to consumers

Fish farmer – this refers to an individual whose core farm business is fish farming, own fish production system and makes major decisions that pertains fish production.

Fish production- this refers to the farming of fish for commercial purposes.

Household welfare- this refers to wellbeing of the farmers; the number of assets a farmer has. It is directly affected by household income.

Market outlet- this refers to the target individual or business where the aquafarmer sells fish. Aquafarmers can either sell directly to the consumers, retailers, wholesalers, supermarkets, processing companies, brokers, and institutions among others.

Pond Farming- this is an artificial shallow structure filled with water that is used for fish farming.

Post-harvest losses- quantity or quality losses in the commodity that makes the commodity to be scarce or nutrient-deficient for use by human.

Retailer outlet- this is a market outlet that receives fish from farmers then later sell to consumers.

Social Networks- It is the structure of the relationships that ranges from social acquaintances to close bonds.

Tank Farming- this is a method of aquafarming where a tank, bowl or pool is filled with water for breeding and harvesting of fish.

Wholesaler market – this is a market outlet that purchases large quantities of fish from farmers, producers and vendors, stores them in storage facilities and finally sell to either retailers and other businesses

CHAPTER TWO
LITERATURE REVIEW

2.1 Empirical literature

This section highlights the critical review of the related studies. It highlights the research gap that this study intends to fill. It includes concept of aquaculture production, contribution of aquaculture to the livelihood of aquafarmers, factors affecting market outlet choices, effects of social networks on the choice of market outlets and the influence of post-harvest losses on household income in fish farming.

2.1.1 Aquaculture Production

Fish production is one of the oldest agricultural subsectors in Kenya, introduced in the early stages of pre-independence. Initially, aquaculture was practiced as a subsistence means of supplementing proteins in rural areas of Kenya. It was mainly a non-commercial approach promoted as a family subsistence (Mukami, 2010). However, this has changed over the years as demand for and production of fish in Kenya is relatively high. Imported fish traditionally replace the declining output. However, Kenya has the potential and favorable conditions for aquaculture production for the local market when they have the right resources, including technology, inputs, and knowledge (Nzevu *et al.*, 2018).

Aquaculture is defined as the rearing and propagation of aquatic organisms under the control of humans (Mukami, 2010). According to Worm (2006), aquaculture is a method of breeding, rearing and harvesting of fish through the use of cages, ponds, tanks and integrated systems. Aquaculture production is of increasingly importance over the years. It has played a great role in food nutrition and security. In sub Saharan Africa, aquaculture was introduced with the intention of generating additional income, improving nutrition in the rural areas as well as increasing diversification of farm activities to compensate losses as a result of crop failures (Nzevu *et al.*, 2018). In most countries, aquaculture has faced several challenges including lack of quality seeds and feeds as well as inaccessible market. On the other hand, several efforts have been made by various governments in Sub Saharan Africa in providing more support for aquaculture to increase economic growth, food security and poverty

alleviation. According to Nzevu *et al.* (2018) approximately 43% of Africa continent has the capability of producing African Catfish, Tilapia as well as Carp Culture.

Aquaculture production can take place in a variety of culture systems, the most common of which are extensive, semi-intensive, and intensive aquaculture (Nguka *et al*., 2017). Tilapia, common carp, and African catfish are among the common fish species cultivated in this system. Fish farmers need the necessary resources, such as capital, land, technology, and labor, to produce optimally. In addition to these characteristics, socio-demographic and institutional factors such as aquaculture experience, education level, land tenure, participation in group organization, and fish occupation all have a role in the farmers' fish productivity efficiency. Africa has not been able to fully utilize the potential in aquafarming. Africa contributes about 0.1% of the global aquaculture production (Rabuor *et al*., 2006). In Kenya, aquaculture production has been able to contribute towards sustainable use of capture fisheries by offering alternative solution to the deficit in fish supply. Furthermore, it has been able to ease the pressure from fishing activities emanating from the natural resources.

According to the Food and Agriculture Organization of the United Nations (FAO), global annual food fish consumption has climbed by 1.5 percent, greatly surpassing global population growth of 1.7 percent. According to the Food and Agriculture Organization (FAO), global fish consumption increased by 3.1 percent on average between 1961 and 2017. A rate twice that of global population growth of 1.6 percent over the same time period, and greater than other protein sources (meat, dairy, milk, and so on), which grew at a rate of 2.1 percent per year. Food fish consumption *per capita* increased by 1.5 percent each year from 9.0 kg in 1961 to 20.5 kg in 2018. (FAO, 2020). In low-income food-deficit countries (LIFDCs), where Kenya is inclusive, consumption of fish products increased from 4.0 kg to 9.3 kg in 1961 and 2017, respectively. In 2017, fish consumption accounted for 17 % of the global population's intake of animal proteins and 7 % of all protein foods consumed. Globally, fish and fish products provide more than 3.3 billion people with 20 % of their average *per capita* protein intake compared to other sources (FAO, 2020).

The Kenyan government has initiated various efforts in the past in promoting aquaculture activities in order to improve the livelihood of the farmers. In the year 2010, the Kenyan government implemented the Economic Stimulus Program that involved many smallholder aquafarmers (Ringa & Kyalo, 2013). In the program, the Kenyan government spent 1.12 billion on aquaculture which was used to construct fish ponds, purchase fingerlings and feeds, develop hatcheries as well as promote aquaculture extension services.

This increased the number of fish farmers from 4,742 to 49,050 and the number of fish ponds also increased from 7,530 to 69,998 (Ringa & Kyalo, 2013).

2.1.2 Contribution of aquaculture to farmer livelihood

Aquaculture contributes positively to the livelihood of the poor through creation of employment opportunities and increased income. Aquaculture is labor intensive as it is commonly practiced in the rural areas and utilizing low level of technology (Jacobi, 2013). Aquaculture creates employment opportunities from the various enterprises and improving the livelihood of farmers (Edwards, 2000). According to FAO (2018), aquaculture contributes towards poverty alleviation and poverty alleviation in most of the developing countries. In addition, it has been able to increase food supply by providing high nutritional food to many households. Investment in aquaculture has been able to decrease the risks associated with agricultural production, enhances sustainability of the farm and rural development.

Investment in the new production technologies, new products and efficient management practices results in a lot of benefits for both consumers and the producers (Kumar *et al*., 2018; Kumar & Engle, 2016). As a result of increased financial stability among aquafarmers, households have a stronger purchasing power with better access to the resources. According to Edwards (2000), aquaculture contributes to the livelihood of rural poor household by providing high nutritional value food especially for the vulnerable groups such as women and children. Aquaculture farms in the rural communities are focused on improving the living standards of the farmers through poverty alleviation and food security (Rajee & Mun, 2017). The level of connectivity to markets and the extent of accessibility to transportation facilities may influence the livelihood strategies in an area and the way aquaculture can impact on livelihoods (Acheampong *et al.,* 2018).

Nzevu *et al*. (2018) did a study on the contribution of fish farming to household wellbeing of fish farmers in Kitui County. Results established that households engaged in commercial fish farming received several economic benefits. About 46.3% of the households attained food security from fish farming, whereas 31.5%, 14.8% and 7.4% of the households attained income generation, dietary diversification needs and utilization of idle land. This implies that majority of the farmers practiced fish farming mainly for food security and income generation. The findings revealed that fish farming improved the quality of livelihood of farmers in areas including, health care, ownership of assets as well as education of the children.

Although trade in fish and fish products is becoming increasingly vital for most countries' food security and economic development, data on the informal cross-border fish trade is scarce. However, as with all informal economic activity, the informal fish trade has been overlooked and neglected in many national and regional programs, resulting in the obscurity of such a vital portion of the fisheries sector. The overall real worth of trade is difficult to determine due to a lack of information on the value of informal fish trade. As a result, the importance of the fish trade is underestimated and neglected in national policy, resulting in less attention to the sector due to figures that are significantly lower than the actual situation on the ground (Kumar & Engle, 2016).

2.1.3 Factors affecting choice of market outlets

Ofuoku *et al*. (2008) did a study on information utilization among the rural fish farmers in Central Agricultural Zone of Delta State, Nigeria. The study established that farmers have access to information on water treatment, stocking operation, feed formulation technologies. Farmers are motivated to enhance productivity and expand subsistence farming into commercial production when they have reliable market outlets. Producers market their products through a variety of channels, including wholesalers, retailers, consumers, cooperatives, associations, and other marketing channels, who ensure that agricultural production reaches the final consumer. The study recommended that extension agency should encourage all the fish farmers to subscribe to fish farmer groups that were present in the state. This would make the farmers to access information on the choice of the market outlet.

Kawala *et al*. (2018) did a study on the determinants of fish market channels in the case of Busia border, Kenya. In the study, a probit model was used to determine the factors influencing choice of fish trader's marketing channel. The study explored formal and informal channels as the only outlets in the analysis. Sorting, grading, storage, shipping, coordinating sales, and providing credit are all intermediation tasks performed by marketing outlets. Marketing outlets play an important role in the production and distribution of agricultural products. Wholesale marketing outlets, for example, strive to increase the efficiency of marketing systems by purchasing farm food in large quantities and then selling it to other retailers and consumers who need these produce in smaller quantities. Distance to the market, volumes of fish sold per month. payment mode, membership in fish marketing organizations, size of the household, availability of alternative sources of income were significant in determining the choices of the marketing outlet choice.

Nyaga *et al*. (2016) carried out a study on factors influencing the choice of fish marketing channels by farmers in Kirinyaga, Kenya. Multinomial logit model was used in analyzing neighbors, trader and direct market channels. However, fish farmers always sell to more than one market channel, hence models that consider choice of more than one channel is necessary. The results showed that being a male farmer increases the likelihood of selling fish directly to the market place as opposed to selling fish to the neighbors. This is attributed to the fact that men have more access to financial services than women hence they would easily move their products from the farm to the market centers. Further, the results showed that distance to the market has a negative influence on the possibility that the farmer were able to choose to sell fish directly to schools, fish mongers as well as retailers. However, the numbers of ponds were found to positively influence farmers to sell to traders and also sell in group.

Awuor *et al*. (2019) examined the market linkages and distribution channels of cultured, captured and imported fish in Kenya. The study indicated that farmers will sell their surplus to marketing outlets if their production exceeds their household consumption. Farmers must choose a marketing outlet to sell their food. In order to increase profit potential, the farmer considers which marketing channel to use and then takes a decision based on strong business motivations. It was established that fish farmers sold to retailers, wholesalers and processors marketing channels. I addition, the study established that most of the fish farmers were literate which makes them able to express themselves and well equipped in assessing market trends and market channel. The study also found out that fishers that were belonging to marketing organization were either selling to processors. The study further established that fish trade was mostly common with women.

Shewaye (2016) conducted a study on factors affecting the market choices of haricot beans in Southern Ethiopia. The study used multivariate probit model for analysis. The farmers used direct consumers, rural assemblers and urban traders marketing outlets as outlets in selling beans. In the study, results indicated that distance to the nearest market positively affected the possibility of choosing assembler outlet and negatively affected the probability of choosing urban outlet. In addition, access to credit, membership of a cooperative society and information on prices affected the probability of the farmers to choose urban market outlet.

Mohammed *et al*. (2019) did a study on the determinants of the choice of market outlets among tomato farmers in South Gonda, Ethiopia. The study highlighted the need to develop effective marketing channels to deal with the perishable nature of tomatoes. Results

of multivariate probit model revealed that age of the household head, household size, distance to the market, access to credit, education level, ownership of transport facility and proportion of land allocated to tomato farming significantly affected the probability of choosing consumers, retailers, collectors as well as wholesaler market outlet. Some of the policy interventions that were drawn from this study include the need for government and other stakeholders to emphasize on strengthening rural-urban infrastructure, increasing land allocation for tomato, strengthening both formal and informal education as well as enhancing the accessibility of credit by farmers.

Dlamini-Mazibuko *et al*. (2019) did a study on factors that affect the selection of marketing channel strategies by smallholders' vegetable farmers in Swaziland. The study used multivariate probit model in analyzing determinants of marketing channels participation. Results indicated that marketing outlet choices are substitutes hence farmers were able to select one market outlet choice of over the other. However, the selection is based on several factors including assets ownership, risk attitudes, transaction cost, institutional variables and market attributes. The study recommended that stakeholders and policymakers need to improve information on marketing and infrastructure development in enhancing participation in markets.

Honja *et al*. (2017) conducted a study on the determinants of market outlets choices of smallholder mango producers in Southern Ethiopia. Focus group discussions, personal interviews as well as group discussions were used to capture adequate data. The study used multivariate probit model in the analysis. The results revealed that distance to the market, size of the family, prices, access to market information, quantity of mango produced and access to off-farm income were important determinants in decision to choose consumer, collector, retailer, and wholesale market outlets choices at given significant levels. It was recommended that important variables affecting choice for consumer and wholesale market outlets need to be promoted in ensuring that mango producers maximize their economic benefits.

Mwembe *et al.* (2021) carried out a study to determine the factors that affect the choice of market outlets of agroforestry based mango based farmers in Kenya. The findings established that these farmers had a challenge in accessing profitable market outlets. Multivariate probit model results reported that education level, price, age of the household, access to credit and gender was significant on producers' choice of farm gate market outlet choice. On the other hand, quantity of mango sold, price, transportation costs and negotiation costs was significant on the choice of middlemen, while price and cost of transport significantly affected the producers' choice of local traders. Lastly, education level, distance

to the market, age, income, negotiation costs and off-farm income were found to significantly affect the choice of town market outlet choice. The findings from this study indicated that town market outlet was considered a better market outlet since it offers better returns despite the several barriers that are associated in accessing the outlet.

Chala and Chalchisa (2018) did a study on the determinants of the choice of vegetables market outlets among small holder farmers in Ethiopia. The study used multivariate probit model for analysis. The study argued that households with large household size requires large quantities of food hence would make farmers prefer market outlets that would buy small quantities of vegetable. The results from the study indicated that larger household size was an indicator of better labor endowment since the household members are able to travel to distant markets so as to access outlets that are in other parts. In addition, the study revealed that more family size enhances the ability of the farmers to distribute vegetables to restaurants, kiosks as well as different units which later affect vegetable production.

Addis *et al.* (2019) carried out a study on small holder wheat market outlet choices in Amhara, Ethiopia. The multivariate probit model revealed that education level, family size, extension contact, and membership of cooperative group, quantity supplied, farming experience was significant on the various market outlets. The study revealed that there is need to have more extension service, enhance cooperative membership in order to increase the production capacity of the members thereby making them to have a better market outlet.

Vykhaneswari and Devi (2019) carried out a study on the determinants of milk farmers' participation in different marketing channels in India. Multinomial logit analysis was used for analysis, where the results revealed that distance to the market, price of milk and the availability of training facilities significantly affected the choice of marketing channel. The study suggested that there is need to reduce transaction costs, provide training and extension services as well as improve the milking infrastructure so that the small scale farmers can compete with other farmers.

Kumi (2017) did a study on the influence of market outlets of the profitability of tomato value in Ghana. The study showed that choice of marketing channel is crucial in tomato marketing system that has so far gotten little attention. Tomato producers were found to sell their fruit to a variety of market outlets, such as local assemblers, wholesalers, and processors, as well as direct marketing to retailers and consumers (Kumi, 2017). Since tomato produce is perishable and need proper storage facility, the marketing outlet chosen has a

significant impact on the level of risk, transaction costs, returns, uncertainty, and post-harvest losses within the marketing system, eventually affecting profitability.

2.1.4 Effects of social networks on the choice of market outlet

The analysis of social networks assumes that relationships are important. It maps and measures both formal and informal relationships that are necessary in understanding factors which facilitates and impedes knowledge flow (Serrat, 2017). Social capital is a glue that is used to hold society as one, without it there is no human well-being and economic growth. According to Cote and Healy (2001) emphasis has been placed on the role of networks as well as civil norms in various definitions. Studies indicate that social network is found on personal relationships maintained by the households influencing production decisions, economic outcomes and the marketing outlet decisions (Kamau *et al*., 2018; Odetola *et al.*, 2015).

Stevens *et al*. (2015) did a study on the influence of social networks on small scale fishermen's enforcement of sea tenure in Pearl Lagoon. The study found out that the level of network cohesion and the existence of the bridging ties affect the cooperation on resource management, conflict resolution, influence on decision making, information sharing, monitoring as well as enforcement of rules and regulations. This study thus supports the idea that information sharing is an important aspect in marketing.

Turner and Stead (2014) did a study on the influence of social networks on the fisher's behavior in Northumberland, England. The study used quantitative social network analysis so as to compare the structure of information sharing networks. The results revealed that there were different networks used for sharing information and that many of the fishers reported to share information with networks displaying different levels of cohesiveness. It was established that the ability to accept the agricultural extension services, the size of the person's network size and the structural position of an individual within a network influence information sharing and hence market access.

Odetola *et al.* (2015) did a study on fish farming commercialization in Lagos State in Nigeria. The study showed the importance of cooperative societies in serving poor farmers in rural areas which could not be served well by formal institutions such as commercial banks and other government owned financial institutions. The formal institutions do not provide loan to the rural farmers since the farmers do not comply with bureaucratic procedures and the costs of services associated with lending. The study recommended the farmers should join the cooperative societies so as to facilitate fish commercialization.

Kawala *et al*. (2018) did a study on the determinants of fish market channels in Busia, Kenya. The study established that belonging to the fish traders' associations increases the likelihood of a farmer to choose a formal trade. This implied that farmers that belonged to marketing groups had high chances of selling to a formal trade channel, a decision which is considered to be rational. Farmers are encouraged to form their own organizations where they are in a position to promote formal trade. This is attributed to their uniform voice for bargaining for fair taxes and policies that would favor them. Sigei *et al*. (2015) mentioned that farmers that belonged to a marketing group were influenced to sell in urban markets while those who were not belonging to a group marketed in local market or even at farm gate.

Freeman *et al.* (2004) mention that community groups are much popular in the rural areas of Kenya. They help to provide most of the services that the government might be unable to deliver. At the same time, Snow and Buss (2001) indicated that some communities are much competent when it comes to the informal networks popularly known as "community self-help groups". The actions of these communities complement the efforts of the various agencies that are geared towards reducing poverty and improving the livelihood of people that are found in the rural areas. Social networks facilitate commercialization of fish by making it easy to acquire high breeds of the fingerlings, easy access of market for the farmers and it help to reduce transactions costs that are incurred while looking for information and bargaining for better prices (Snow & Buss, 2001). Repeated social interactions assist in reducing some of the opportunistic behavior. Further, social networks help to reduce risks that are present in the market and provide assistance to the farmers by providing access to storage facilities, transport, information and better terms of trade through creation of better relationships with the actors that are present in the various marketing chains (Freeman *et al.*, 2004).

2.1.5 Influence of Post-harvest losses on household income in fish farming

To varied degrees, post-harvest losses of fish can be found in all fisheries or value chains. Losses often result in lost income as well as a reduction in the availability of fish as a food source, making them a serious food security concern in Africa, where many people are hungry. Lack of knowledge and skills among producers, as well as poor access to infrastructure, equipment, and services such as water, ice, electricity, roads, and credit, are all key drivers of losses (Opiyo *et al*., 2018). Additional underlying reasons of loss include a lack of or insufficient market information, weak and unsupportive regulations, and socio-cultural factors. While percentage or monetary loss estimates are common, they are typically

generalizations of complex and dynamic circumstances. We need a more detailed picture of who, what, where, why, how, and when post-harvest fish losses occur because making intervention decisions based on these assumptions involves a risk. For example, losses are usually seasonal, occurring when there are excess catches or during the rainy season, when regular processing processes are less effective (Opiyo *et al*., 2018).

According to FAO, post-harvest losses in fisheries sector are highest among all other sectors (Diei-Ouadi & Mgawe, 2011). Fish losses may result into financial losses since poorly processed fish or spoiled fish are sold or discarded at a low price. The low price leads to low household income. Since there is high global demand for fish, a reduction in post-harvest losses would contribute significantly in satisfying the consumer demand for fish through improvement in quality and quantity of fish (Diei-Ouadi & Mgawe, 2011). In an effort to reduce the quantity of fish losses after harvest, farmers are encouraged to make an effort to make a small additional investment in better storage facilities without making large adjustments to their current storage methods. Farmers reported losses of up to 20% as a result of these basic enhanced techniques, which boosted the harvest and improved the quality of maize (Diei-Ouadi & Mgawe, 2011).

Tesfay and Teferi (2017) carried out a study on assessment of fish post-harvest losses in Tekeze dam and Lake Hashenge Fishery Associations in Northern Ethiopia. The results showed that the fishery associations were experiencing huge amount of post-harvest losses as a result of poor post-harvest handling, poor storage facilities as well as mismanagement. This contribute towards economic and nutritional waste in Ethiopia which was at a risk of protein malnutrition. In addition, high post-harvest losses lead to low household income and poor livelihood. The study proposed various measures to reduce post-harvest losses including introduction of retaining cages, proper management of the refrigerators, decreasing fish harvest when refrigerators are already full, easy access to storage area and refrigerated area, having full control of the refrigerators and separating the spoiled fish from the healthy fish were proposed. The study also proposed that there should be careful treatment in handling and processing of fish so as to increase the income that the farmers would receive. The study found out that preservation is an important aspect of the fishery associations.

A study carried out by Cole *et al*. (2018) on post-harvest fish losses and unequal gender relations in Zambia revealed that 65 percent of the fish that was extracted from capture fisheries was processed using the open-air sun drying technique and the smoking methods due to inadequate cold chains and longer distance between the point of harvest and the market. The results showed that women were experiencing three times physical losses

more than men. Fish losses among the fish value chain actors were averaging at 29.3 percent with the quality losses at 22.9 % and the physical losses at 6.4%. Diei-Ouadi and Mgawe (2011) indicated that in the Sub-Saharan Africa, majority of the fish losses are quality losses hence there is need for reducing post-harvest losses that would result into improvement of household income.

Bolorunduro and Adesehinwa (2005) did a study on the status of awareness and adoption for the disseminated improved post-harvest fisheries technologies among the fish processors in Northwestern Zone of Nigeria. The study revealed that only 43.1% of the responds knew about improved fish smoking kilns disseminated in the zone. Some of the constraints associated with this improved technology include scarcity of the kilns, high prices for the kilns and technical features of the kilns were difficult to understand. These improved fish processing technologies have the potential of reducing post-harvest losses which result into high household income.

Kumolu-Joh and Ndimele (2011) indicated that interventions that are aimed at improving product transformation require maintaining the quality standards of the product. Improvement in the fish processing technologies like improved fish smoking as well as improved drying methods are widely spread. This is consistent with a study that was done by Akintola and Bakare (2011) which recommended various ways of reducing post-harvest losses such as improving the handling and the processing methods, chilling with ice to reduce fresh fish spoilage. Ice is an effective cooling medium since it has a large cooling capacity for a given volume, it is affordable and it has the ability to cool fish faster due to its high intimacy with the fish.

2.1.6 Summary of Empirical Literature

In summary, studies have indicated that fish marketing is still not well organized hence a concerted effort is necessary to understand factors affecting the choice of market outlets and the effect of social networks on the choice of market outlets. The studies reviewed showed that distance to fish market, gender of the farmer, volume of fish sold payment mode, membership to organizations, access to alternative source of income and household size influence the choice of market outlets. Social network is important since it helps farmers to access information and increases the bargaining power of farmers selling in a given market outlet. Further, social networks through group marketing contribute towards farmers' ability to choose a formal market outlet. However, the effect of social networks on the choice of fish market outlets have not been evaluated. In addition, fish being a perishable commodity need

to have ready market and adequate preservation facilities which probably would reduce the amount of post-harvest losses. Thus, studies have not established the influence of post-harvest losses on household welfare.

2.2 Theoretical framework

This study was based on random utility theory. This theory is used in modeling the behavior of farmers where the decision is based on the level of utility maximization. Other theories such as expected utility theory and transaction cost theory (TCE) cannot be used in this case. Since expected utility theory provides a framework which considers the effect of uncertainty about outcomes of decision makers' including the attitudes towards risk, it does not accommodate uncertainty regarding tastes and preferences (Jeffrey, 1983). In addition, in computing the expected utilities, an agent must have a complicated understanding of the available actions, the various outcomes, and the values of those outcomes, as well as the knowledge that picking the optimal act is far more difficult than a good act. An agent can rank all possible outcomes in order of their likelihood of occurring. The agent's choices among the rated outcomes are shown in this order. If the preferences are consistent with certain axioms, a number can be assigned to each outcome. This number might indicate both its relative order and its importance among the outcomes, and the extent to which it differs from another. Thus, expected utility theory cannot be used in this case (Jeffrey, 1983).

According to Williamson (2008), transaction cost economics (TCE) maintain that institutions make arrangements of transactions that are aimed at minimizing costs. These arrangements may change with changes in nature and the source of transaction cost. Examples of transaction costs are the costs associated with negotiation, monitoring, acquiring information, coordination as well as contract enforcements. In aquaculture, transaction costs are categorized to be either information costs, collective fisheries costs in decision making, collective operational costs, transportation costs, storage costs among others. TCE assumes that individuals have opportunistic behaviors thus there is need for enforcement mechanisms to deal with such behaviors.

The aqua farmer is faced with multiple alternatives on where to sell fish. The attractiveness of any one market outlet within the choice set is dependent on several factors including financial performance and access to a particular market outlet. Random utility theory is used in quantifying preferences where farmers choose a particular method from a set of alternatives. It holds the assumption that the farmer would choose a technique that yield the highest utility from alternative techniques available. Greene (2003) indicate that random utility method can be used in modeling the behavior of a farmer whose decision is generated

based on utility maximization. This implies that the alternative choice on market outlet has different private costs and benefits, hence a different utility, to the aquafarmer. The farmer would choose market outlet provided that the expected utility he gets from it exceeds expected utility from other market outlets as shown.

$Y^* = Y_i, if\ V_i > V_j$…….....*Equation* (2.1)

$= Y_j\ , if\ V_i \leq V_j$

Y_i represent the market outlet i while Y_j is an alternative market outlet j. V_i and $V_j$are expected indirect utility values for market outlets i and j respectively. Y^*represent the market outlet that is actually chosen. The utility function is assumed to be known by each aquafarmer even though some of its components are unobserved. The unobserved part of the utility is considered as random variable. The expected indirect utility is modelled as the sum of the observed variables and the non-observable random part.

$V_i = \beta^1 iX_i + \varepsilon_i$ ……...*Equation* (2.2)

The choice utility of implementing an alternative market outlet can be written as;

$V_j = \beta^1 jX_j + \varepsilon_j$…….....*Equation* (2.3)

$\beta^1 i$ and $\beta^1 j$ are vectors of the parameters. The farmers can thus decide simultaneously whether to choose one or more market outlet conditional on the vectors of the explanatory variables X_i and $X_{j.}$ A multivariate probit model can thus be used to analyze the farmer's joint decisions on choosing a market outlet. From equation 2.2 and 2.3, the specification of the multivariate probit model therefore take the form:

$Y_{ij}^* = B_{ik}X_{ik} + \varepsilon_i(K = Y_1, Y_{2,}\ Y_n)$……. *Equation* (2.4)

Where $j = 1, 2, 3\ and\ 4$ are the market outlet choices while B_{ik} represent the vector of the parameters that shows the impact of changes of the independent variables, X_{ik} is the vector of independent variables and ε_i represents the random error. K shows the utility levels that is obtained from different market outlet choices.

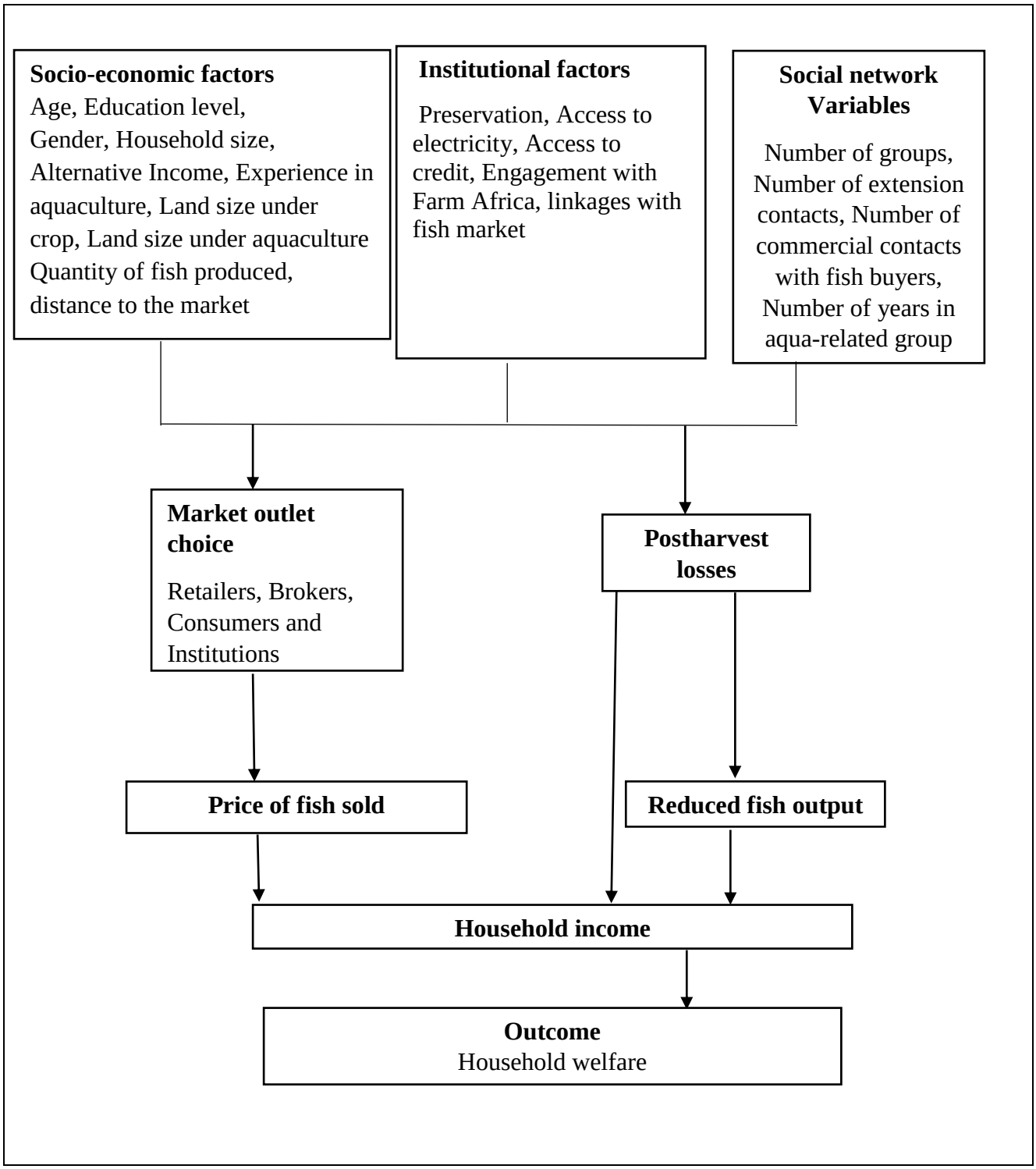
$Y_i = 1\ if\ Y_i^* > 0\ and\ 0, otherwise$……..... *Equation* (2.5)

Y_i^* is the unobserved latent variable showing the probability of choosing a given market outlet.

2.3 Conceptual framework

Figure 0.1**: Conceptual Framework** provides the conceptual framework for the study. The framework links the social networks affecting the choice of fish market outlets and the effect of post-harvest loss on household welfare. Socio-economic, institutional and social network factors are used as the control factors in analyzing the effect of explanatory variables on the dependent variable in the two cases. Aquafarmers selling in different market outlets, including, retailers, consumers, institutions or wholesalers receive different prices for fish. Further, social network factors include number of aqua-related groups, number of extension contacts, number of commercial contacts with the fish buyers and the number of years one is a member of aqua-related group.

Post-harvest losses are influenced by both socio-economic factors and institutional factors. Socio-economic factors include: age, gender, education level of the farmer, household size, experience in aquafarming, alternative income, quantity of fish produced, land size under crop, land size under aquaculture and distance to the market. On the other hand, the institutional factors include engagement with Farm Africa, preservation method used, access to credit, linkages with fish market. These factors determined the amount of fish in kilograms that is available for sale. The quantity of post-harvest losses is able to determine the prices and the income received by the farmers, which affect household welfare.



Shows the direction of influence

Figure 0.1: Conceptual Framework

CHAPTER THREE
RESEARCH METHODOLY

3.1 Study area

This study was conducted in selected counties in Kenya namely Kakamega, Siaya, Kiambu, Kirinyaga and Nyeri which were part of the regions where Farm Africa implemented aquaculture programs under 3R (Resilient, Robust, Reliable) Kenya project. Nyeri, Siaya and Kirinyaga counties were selected since they have water catchment areas and favorable climatic conditions suitable for aquaculture activities. Kakamega and Kiambu counties were chosen because they have high population which is potential fish market. The aim of the 3R project was to assess lessons and evidence from Food and Nutrition security programs such as Kenya Market–Led Aquaculture Program (K-MAP), horticulture and dairy that supported both competitive and market-oriented agriculture (Obwanga *et al*., 2018). In addition, the project offered training and assistance to rural communities in order to assist them in identifying and implementing effective solutions on farm issues. Below is a brief description of the study areas:

3.1.1 Nyeri County

Nyeri county has a population of about 759,164 persons, with 248,050 households and the average household size of 3 persons. The total land area is 3,285.7 Square Kilometers with population density of 194 persons per Square Kilometers (KNBS, 2019). It lies between longitudes 36°38’ East and 37°20’ east and between the equator and latitude 0°38’ south (GOK, 2018). The County borders Kirinyaga to the east, Nyandarua to the west, Laikipia to the north, Murang’a to the south, and Meru to the north east. The mean temperature is between 12°C to 27°C. The annual rainfall ranges between 1200mm- 1600mm during long rains and between 500mm-1500mm during short rains (G0K, 2018). The temperature and rainfall patterns are favorable for aquaculture related activities in the county. In addition, farmers in this county practice tea and coffee production as well as the horticulture and dairy farming. The average farm size is 4 hectares for large scale farmers and 0.7 hectares for smallholder farmers (GOK, 2018).

3.1.2 Siaya County

Siaya county has the population of about 993,183 persons with 250,698 households and average household size of 3.9 persons. The total land area is about 2,529.8 Square Kilometers and the population density of about 393 persons per Square Kilometers (KNBS, 2019). Siaya County borders Busia to the north west, Kisumu to the south east, Vihiga and

Kakamega to the north east and Homa bay to the south. It lies between latitude 0° 26’ north to 0° 18’ and longitude 33° 58’ east and 34° 33’ west (GOK, 2018). The county has major geomorphological areas such as dissected uplands, moderate lowlands and yala swamp. Siaya County Borders Lake Victoria which is potential for the practice of cage farming.

3.1.3 Kiambu County

Kiambu county has the total population of about 2,417,735 persons with 795,241 households and average household size of 3 persons. It has a total land area of 2,538.6 Square Kilometers and a population density of 952 persons per Square Kilometers (KNBS, 2019). Kiambu county borders Machakos to the east, Nairobi and Kajiado to the south, Nyandarua to the north west, Murang’a to the north and north east and Nakuru to the west (GOK, 2018). It lies between longitude 36°35 and 37°25’ east and latitudes 3°53’ and 1°45’ south (GOK, 2018). Kiambu county was selected because it borders Nairobi which is a metropolitan area and is a potential fish market.

3.1.4 Kirinyaga County

Kirinyaga county has a total population of about 610,411 persons with 204, 188 households and the average household size of 3 persons. The total land area is 1,478.3 Square Kilometers and the population density of about 413 persons per Squared Kilometers (KNBS, 2019). It borders Embu to the east and south, Murang’a to the west, Nyeri to the north west. The County lies between longitude 37° and 38° east and latitudes 0°1° and 0° 40° South (GOK, 2018). It has six major rivers that include Nyamindi, Sagana, Rupingazi, Ragati and Rwamuthambi suitable for aquaculture production since they can support pond, cage and tank systems.

3.1.5 Kakamega County

Kakamega County has a total population of about 1,867,579 persons with 433,207 households and the average household size of 4.3 persons. The total land area is 3020.0 Square Kilometers and population density of 618 persons per squared Kilometers (KNBS, 2019). It borders Siaya to the west, Vihiga to the south, Nandi and Uasin Gishu to the east, Bungoma and Trans Nzoia to the north (GOK, 2018). The County is the third largely populated after Nairobi and Kiambu (KNBS, 2019) hence it is a potential fish market. The County receive rainfall throughout the year with the annual rainfall ranging between 1280. 1mm to 2214.1 mm per year which is favorable weather conditions that is important for aquaculture. It lies between longitudes 34° and 35° east and latitudes 0° and 1° north. The

county has private hatcheries that supply quality fingerlings. Figure 0.1 below shows the map of the 5 counties.

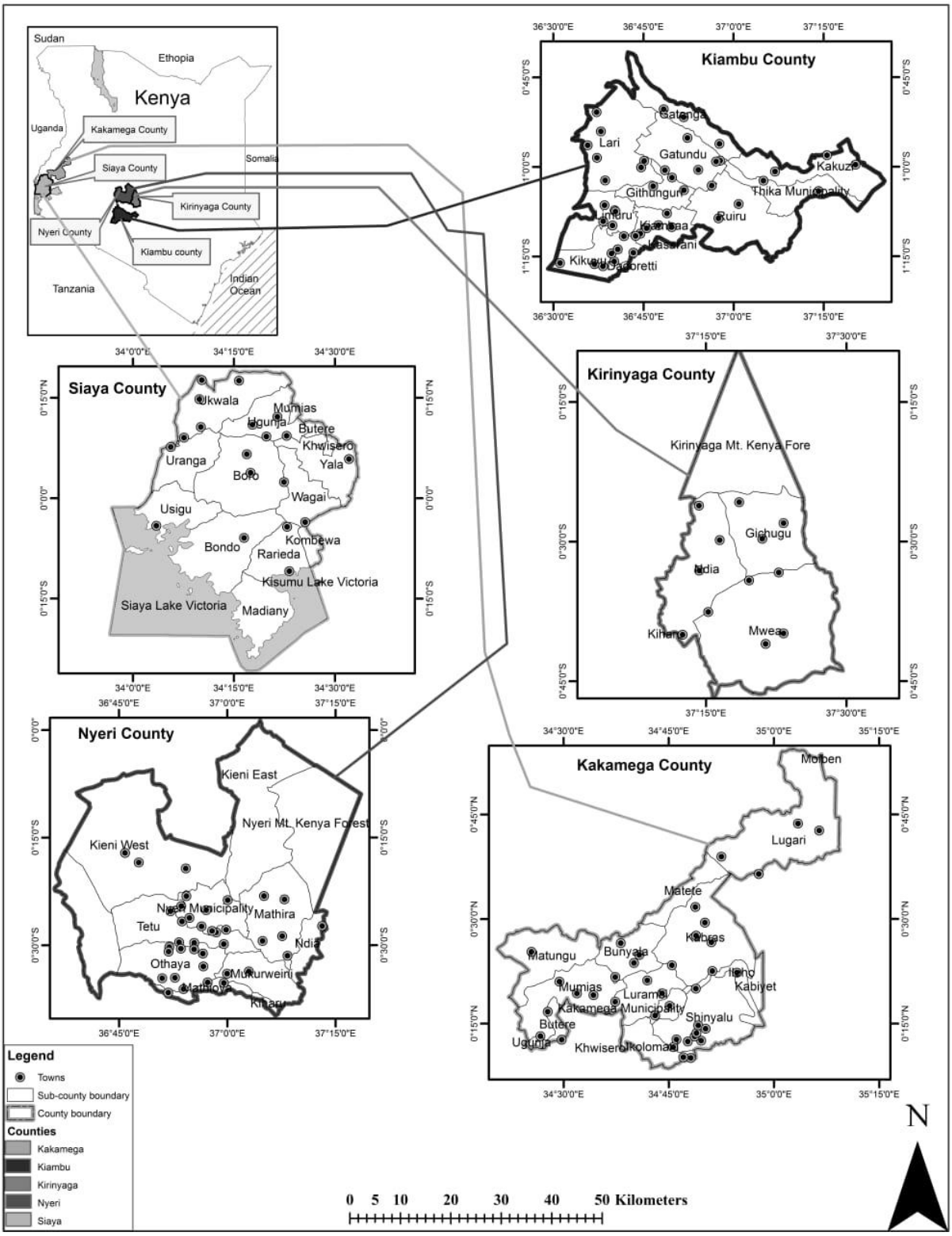


Figure 0.1: Map of the study area

Source: World Resource Centre

3.2 Sampling procedure and sample size

The target population consisted of fish farmers that were producing and selling fish between September 2017 and August 2018. The study adopted a multistage sampling method so as to get the desired sample size. In the first stage, purposive sampling method was used to select Nyeri, Siaya, Kiambu, Kirinyaga and Kakamega counties. These counties were considered because they were part of the counties where Farm Africa implemented aquaculture programs. In addition, they have favorable climatic conditions suitable for aquaculture and they have a high population which is a potential fish market. In the second stage, the Sub Counties where aquafarming was performing well were selected with the help of the County Government Fisheries Department. In Kiambu County, Kiambu and Kikuyu Sub Counties were selected, while in Kakamega County, Kakamega North and Kakamega East Sub Counties were selected. On the other hand, in Siaya County, Siaya and Bondo Sub Counties were selected, whereas Kieni East or Kieni West Sub Counties were selected in Nyeri County. In addition, in Kirinyaga County, Kirinyaga East and Kirinyaga Central were selected for the study. Lastly a systematic random sampling was used to select fish farmers in the selected Sub Counties with the assistance from the various Sub County Fisheries Officers. An alphabetical list was prepared using the farmer's first name where the names were serially numbered in getting the farmers to be interviewed.

The sample size was determined using the formula given by Kothari (2004) as illustrated in equation 3.1 below:

$$n = \frac{Z^2 pq}{e^2} \quad \text{..... Equation (3.1)}$$

Where n is the desired sample size, Z is the critical value (1.96) obtained at 95 percent confidence level, p is the proportion of population of interest (0.5). It is set at 0.5 so as to get a reliable and sufficient estimate while q is the weighting variable given by 1-p and e is the acceptable error. Kothari (2004) accepts an error of less than 10 percent thus this study used an error of 0.0566 which is precise hence a smaller sample size that could fit the budget for the study.

$$n = \frac{1.96^2 0.5 * 0.5}{0.0566^2} = 299.79$$

This was approximated to get a sample size of 300 fish farmers.

The farmers to be interviewed were calculated using the population size in the various counties according to the data from Kenya National Bureau of Statistics, 2009. Table 0.1 presents the distribution of sample size in the five counties.

Table 0.1: Distribution of Sample size in the Counties

County	Population	Percentage in proportion	Number of Households
Nyeri	693,558	12.98	39
Siaya	842,304	15.75	47
Kiambu	1,623,282	30.35	91
Kirinyaga	528,054	9.87	30
Kakamega	1,660,651	31.05	93
Total	5,347,849	100	300

3.3 Data collection

Data for this study was collected in 2018. The data was collected by Farm Africa in Kakamega, Siaya, Nyeri, Kiambu and Kirinyaga counties where they offered training to farmers on fish farming. Data was collected by the use of semi-structured questionnaires which were administered with the help of ODK survey tool to the selected aquafarmers. The data collection was aided by a team of trained enumerators. Data was downloaded as csv files from the survey tool and cleaned in Excel before being uploaded to STATA for further analysis. The data included information on farmer and farm characteristics, post-harvest losses, sales, buyer types, fish prices, trust, information factors, storage and transportation, market linkages, membership to organization (social networks), alternative sources of income and costs. The questionnaire which was used for this study is attached in appendix 1. The National Commission for Science, Technology and Innovation (NACOSTI) permit, attached in appendix 6 was obtained from necessary authorities for research approval in Kenya.

3.4 Validity of the instrument

A pre-test was done in Kakamega county before the actual interview to ascertain the validity of the instrument. In addition, a pilot study was done in Siaya and Nyeri counties to check on the reliability of the instruments used. The sampled questionnaires were rigorously

evaluated for precision and to check if they accurately represented the study's variables during the pilot research. The enumerators became familiar with the instrument thanks to a well-organized training session. This was able to reduce the chances of variable misrepresentation and misinterpretation. Additional qualitative and quantitative data through key informants was used to validate the data that was collected.

3.5 Data analysis

Descriptive analysis was done using Excel and econometric analysis through STATA.

3.5.1 Analytical framework

Objective 1: To characterize fish market outlets among aquafarmers.

This objective was analyzed using descriptive analysis. Descriptive statistics such as mean, standard deviation, frequency, chi square, tables and charts were used to characterize fish market outlets. Further, socio-economic factors, including age, gender, education level of farmers, household size, experience in aquafarming, alternative income received, volume of fish sold, price of fish sold, land size under aquaculture and distance to the market were used in characterizing the market outlets. Institutional factors considered included engagement with Farm Africa, access to preservation facilities, access to credit, linkages with fish market, number of commercial contacts with fish buyers, number of years one is a member of aqua-related group and number of extension contacts.

Objective 2: To identify the effects of social networks on fish market outlets among aquafarmers

Social network was measured in terms of the number of groups that the aquafarmer belonged to, the number of extension contacts, number of commercial contact with fish buyers and the number of years one is a member of aqua-related group and membership to Farm Africa. Market outlets included, retailers, individual consumers, collectors and wholesalers. Most aquafarmers produce different fish types, including African catfish, rainbow trout, cyprinus carpio, fingerlings tilapia and fingerlings catfish and therefore the choice of market outlet for the main type of fish produced was considered for the analysis. Farmers can choose more than one market outlet hence multivariate probit (MVP) model was considered to be appropriate in the analysis. MVP allows for the possible correlation in decision to participate in more than two market outlets. It is assumed that there is correlation and interdependence in the aquafarmers' choice on the market outlets (Lin *et at.,* 2005).

Complements (positive correlation) and replacements (negative correlation) between the various market outlets was a source of correlation.

Farmers need to consider a set of all the possible outlets, hence would choose the particular outlet that will maximize utility. This model assumes that addition or removal of alternative categories of outcome does not affect the odds of the remaining outcomes. In addition, the odds of choosing an outlet over the other do not depend on the outlet that is chosen. Univariate logit or probit cannot be used in this study since it assumes that the error terms are distributed independently hence ignoring the correlations amongst the outcomes hence leading to inefficient parameter estimates (Corsi & Salvioni, 2012). Ignoring the correlations when analyzing the simultaneous choice on the market outlets can lead to biased and incorrect estimates of the standard errors.

A closer model is multinomial logit model. However, it cannot be used in this since it is used in modeling of nominal outcome variables, in which the log chances of the variables are modelled as a linear combination of the explanatory variables. The Independent from irrelevant alternatives attribute (IIA) is assumed by the multinomial logit regression model, which means that the probabilities of a choice over the reference do not have to depend on other alternatives. This assumption is put to the test when multinomial models are used to describe discrete choice model possibilities (Odhiambo, 2018). In addition, multinomial logit model does not make any assumptions about normality, linearity, or homogeneity of variance of independent variables, allowing for more robustness (Madhu *et al*., 2014).

A multivariate probit model thus can be used to analyze the farmer's joint decisions on choosing a market outlet. The specification of multivariate probit model takes the form:

$Y_{ij}^{*} = \alpha_0 + \alpha_1 S_i + \varepsilon_i$ ..... *Equation* (3.2)

Y_{ij}^{*} is the unobserved latent variable showing the probability of choosing a given market outlet, α is the vector of parameters, S_i is exogenous variables, including the number of organizations a farmer belongs, household size, gender, years of education, age, alternative income, experience, volume of main fish sold, land size under aquaculture, preservation method used, distance to the market, linkages to fish market, trust in businesses, trust in Cooperatives, access to credit, number of extension contacts, price of fish, engagement with farm Africa, number of commercial contacts with fish market and number of years in aqua-related group, while ε_i is the random error term.

The error terms in the different market outlet choices are assumed to be correlated. The error terms follow a multivariate normal distribution with a mean of zero and a variance covariance matrix ε with a value of 1 in the leading diagonal. The multivariate probit normal distribution is (0, Ω) and the symmetric covariance matrix given as:

$$\Omega = \begin{matrix} 1 & p_x1_x2 & p_x1_xn \\ p_x2_x1 & 1 & p_x2_xn \\ p_xn_x1 & p_xn_x2 & 1 \end{matrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{Equation}\ (3.3)$$

The off-diagonal elements allow for correlation across the error terms of several latent equations which shows the unobserved characteristics that affect the choice of the alternatives. Table 0.2 shows the variables, their description, measurements and the expected signs.

Table 0.2: Variables for the Multivariate probit model

Variables	Description of Variables	Measurement of Variables	Expected Sign
Dependent			
Y_{ij}^{*}	Choice of market outlets (retailer, consumer, collector, wholesaler)		
Independent			
Farmorg	Number of organizations aquafarmer belongs	Continuous	+
Hhsize	Number of people in a household	Continuous	+/-
f_gender	Gender of the farmer	Dummy	+/-
f_edu	Years of education	Continuous	+
Age	Age of the farmer	Continuous	+/-
Altincome	Income from other sources in the last one year	Continuous	+/-
Exp	Experience in aquaculture in years	Continuous	+
vol1	Quantity of fish produced in Kilograms	Continuous	+
landsize aqua	Size of land under aquaculture in acres	Continuous	+
Preserv	Access to preservation facilities	Dummy	+
Distance	Distance to the nearest market	Continuous	+
Linkfhmkt	Access to linkages with the fish market	Dummy	+
Acccredit	Access to credit	Dummy	+
Context	Number of contacts with extension officers	Continuous	+
Price	Price of main fish in different market outlets	Continuous	+
Farmafri	Engagement with Farm Africa	Dummy	+
contact_fish	Number of commercial contacts with fish buyers	Continuous	+
farmorg_year	The maximum number of years one is a member of aqua-related group	Continuous	+

Objective 3: To assess the influence of post-harvest losses on household welfare

To address this objective, instrumental variables (IV) method, specifically the two stage least squares (2SLS) regression analysis was used. The influence of post-harvest losses on household income cannot be predicted directly since post-harvest loss is endogenous in the model, hence the use of IV method. The IV method is used when at least one of the right hand side variables in a regression model is correlated with the error term. This method is

appropriate given the possible reverse causality between post-harvest loss and household welfare. The technique of Ordinary Least Squares (OLS) cannot be used in this case given the apparent violation of the exogeneity assumption. While there are other indicators of household welfare, including Gross Domestic Product, household expenditure and assets, household income was preferred since it is simpler to report and can be conveniently obtained for larger samples.

The method of 2SLS proceeds in two stages, where the first stage involves regression of the endogenous variable as a function of all exogenous variables including the IV. The second stage involves estimating the original model using predicted values from the first stage in place of the endogenous variable or as IV for the endogenous variable. A valid instrument must be highly correlated with the endogenous variable, but not with the error term.

In the first stage of the 2SLS, the instruments which include access to fish preservation facilities and distance to the nearest market were regressed on the endogenous explanatory variable (post-harvest loss) in computing the estimated predicted post-harvest loss. The structural equation for this model is given as shown in equation 3.4:

$$Y_i^* = \beta_0 + \beta_i X_i + \beta_i Z_i + \beta_i R_i + \lambda_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (3.4)$$

where R_i represents post-harvest loss while β_0 is a constant. β is a vector of parameters whereas X_i represents exogenous variables, including age, years of education, gender, household size, distance to the market, land size under crop, land size under aquaculture, linkages to fingerlings market, access to income from other businesses and access to income from off-farm labour. Z_i represent instrumental variables, including access to fish preservation facilities and distance to the nearest market, while λ_i is the error term. The first stage equation of the 2SLS was represented in equation 3.5 below:

$$R_i = \beta_0 + \beta_i X_i + \beta_i Z_i + \lambda_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ (3.5)$$

The predicted value of post-harvest loss was therefore used in the second stage to estimate the influence of post-harvest losses on household income as illustrated in equation 3.6. The endogenous variable was replaced with the predicted value obtained in stage one. OLS was then applied to the structural equation so as to obtain consistent estimates of the parameters.

$$Y_i^* = \alpha_0 + \alpha_i X_i + \alpha_i prdctpsthlos + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textit{Equation (3.6)}$$

where Y_i^*represents household income, *prdctpsthlos* is the predicted post-harvest loss; α_0 and α_i are the estimated coefficients andμ_i is the error term. Table 0.3 shows the variables that are used in 2SLS.

Table 0.3: Variables for the 2SLS

Variable	Description of Variables	Measurement of variables	Expected Sign
Dependent			
Y_i	Household income in Ksh.		
Independent			
Age	Age of the farmer	Continuous	+
f_edu	Years of education	Continuous	+
f_gender	Gender of household head	Dummy	+/-
Hhsize	Number of people in a household	Continuous	+/-
Land size crop	Size of land under crop/livestock	Continuous	+
land size aqua	Land size under aquaculture	Continuous	+
Own farm	Ownership of land (Dummy, 1=Yes, 0=No)	Dummy	+
linkfdmkt	Access to linkage with feed market	Dummy	+
linkfhmkt	Access to linkages with fish market	Dummy	+
accotherb	Access to income from other businesses	Dummy	+
accofflab	Access to income from off-farm labour	Dummy	+
Endogenous Variable			
Post-harvestlos	Kilograms of fish lost after harvest	Continuous	+
Instrumental Variables			
distance	Distance to the nearest market	Continuous	-
preservation	Access to fish preservation facilities	Dummy	+

3.5.2 Diagnostic tests

Multicollinearity and heteroscedasticity tests were conducted to verify the validity of the model used. Multicollinearity occurs when the independent variables are highly

correlated. In detecting for the presence of multicollinearity, variance inflation factor (VIF) was used to test for correlation between two or more independent variables as well as the strength of correlation. VIF value of 1 is good for the model since it indicates no correlation existing between the independent variables, VIF values between 1 and 5 indicates moderate correlation which requires no measures to be taken. On the other hand, VIF value of more than 5 indicates critical value of multicollinearity. Some of the potential solutions to solve multicollinearity are combining independent variables linearly and carrying out analysis for highly correlated variables including partial least squares and principal component analysis. Breush pagan test was used in testing for heteroscedasticity. Heteroscedasticity problem result where the error terms are not randomly distributed among the range of the independent variables. Durbin and Wu- Hausman test was used to test for endogeneity. F-test was used to test for the validity of the instrument. Good instruments satisfy the condition in equation 3.7:

$\mathrm{Cov}(Z_i, \varepsilon_i) = 0$ …….. (*Equation* 3.7)

Z affects the dependent variable only through the exogenous variables.

Bad instrument however satisfies the condition in equation 3.8.

$\mathrm{Cov}(Z_i, \varepsilon_i) \neq 0$ …….. (*Equation* 3.8)

where β_{IV} need to be asymptotically inconsistent. Sargan test and Basman tests were used to test for over-identifying restrictions and F test was used to test for validity of the instrument,

CHAPTER FOUR
RESULTS AND DISCUSSION

This chapter presents the findings of the study. The chapter is organized into three sub-sections according to the specific objectives. In the first part, the characteristics of fish market outlets are presented followed by the analysis of the effects of social networks on the choice of market outlets. In the last section, the results of two stage least squares on the influence of post-harvest losses on household welfare are presented.

4.1 Characterization of Fish Market Outlets

Table 0.1 presents the percentages of fish farmers who sold in the various market outlets in the four counties, including, retailers, consumers, collectors and wholesalers' outlets. It also presents the mean prices of fish sold in the various market outlets. Most of these fish farmers in Siaya, Kakamega, Nyeri, Kiambu and Kirinyaga counties had been exposed to some of the services offered by Farm Africa. These products and services, include training on aquaculture, credit and provision of inputs. Thus, the data was thus generalized to reflect on characteristics of farmers in these counties.

Table 0.1: Description of Fish Market Outlets

Choice	**Fish marketing outlets**							
	Retailers		**Consumers**		**Collectors**		**Wholesalers**	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Yes	93	34.96	193	72.56	43	16.17	45	16.92
No	173	65.04	73	27.44	223	83.83	221	83.08
	Mean	**Std. dev**	**Mean**	**Std. dev**	**Mean**	**Std. dev**	**Mean**	**Std. dev**
Price	328.15	112.62	338.77	108.53	461.16	319.89	415.78	141.40

Freq denotes frequency

The results indicated that most fish farmers sold to consumer market outlet, which was chosen by 72.56 percent while 34.96 percent, 16.17 percent and 16.92 percent of fish farmers sold to retailers, collectors and wholesalers, respectively. A possible reason is that consumer and retailer outlets are easily accessible by most farmers compared to collectors and wholesaler markets. This result is consistent with Dlamini-Mazibuko *et al*. (2019) which indicated that the procurement requirements by the formal markets, such as registration and payment of taxes act as a hindrance in accessing these market outlets leaving farmers with no option but to sell directly to consumers. However, these results are different from the findings

by Nyaga *et al*. (2016) which established that fish farmers sold about 49%, 29% and 22% of their fish to neighbors, direct market and traders, respectively.

The price of fish was found to be high in collector market with a mean price of Kshs. 461 per kilogram while the mean price was lowest in retailer market at Kshs. 328 per kilogram. In addition, the mean prices of fish in consumers and wholesalers market outlets were Kshs.339 and Kshs.416 per kilogram, respectively. This implies that collectors and wholesaler market outlets offered better prices as compared to other outlets. These results are similar to Louw *et al.* (2017) which found out that wholesaler market outlet offers better prices of fish compared to other outlets.

Table 0.1 presents the results of farmers' education level, 0.7 percent of fish farmers had no formal education, while 39.7 percent had college or higher education. The majority of fish farmers with college or higher education had adequate skills and training in entrepreneurship, indicating that they were receptive to new ideas, including aquafarming. The results are in conformity with Mutura *et al*. (2015) findings that education plays a key role in embracing of agro-venture given that highly educated farmers are more likely to understand the required information than their less educated counterpart.

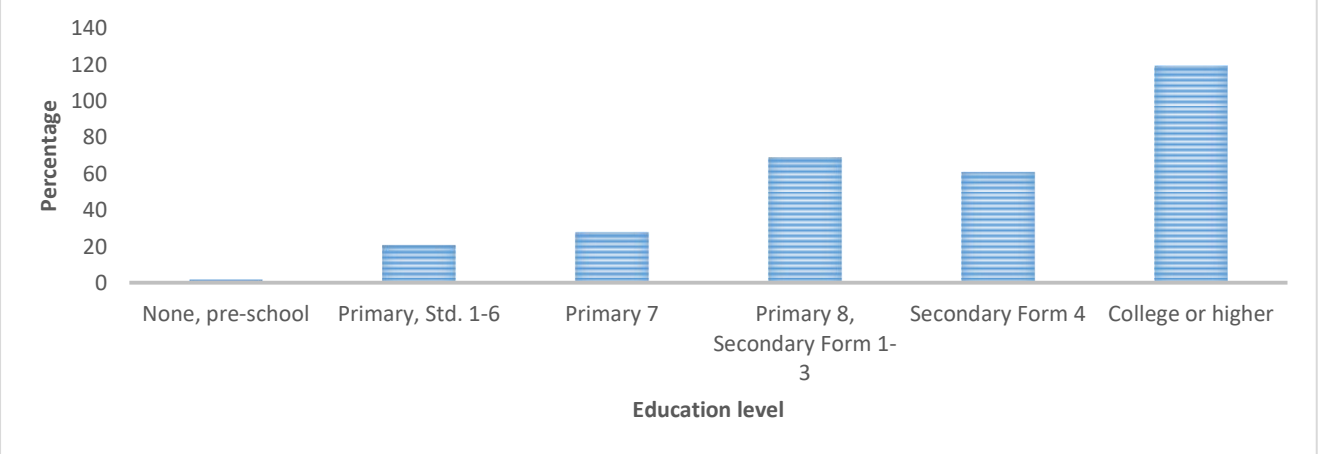


Figure 0.1: Education level of the farmers

4.1.1 Household Characteristics by Market Outlets

Table 0.2 indicates descriptive statistics, particularly of socio-economic variables, including age, household size, number of groups, education (years of schooling), experience in aquaculture, land size under aquaculture and number of commercial contacts with the buyers. The statistics were expressed in form of mean, standard deviation and probability value of these variables on retailers, consumers, collectors and wholesalers market outlets.

Table 0.2: Descriptive Statistics on Continuous Variables

		Retailers		Consumers		Collectors		Wholesalers	
Variables		Mean(Std. dev)	Pr	Mean(Std. dev)	Pr.	Mean(Std. dev)	Pr.	Mean(Std. dev)	Pr.
Age	Yes	48.40(13.27)	0.002***	53.17(13.77)	0.031**	50.09(14.62)	0.327	54.22(12.90)	0.250
	No	53.97(14.12)		49.00(14.44)		52.39(13.95)		51.57(14.27)	
Household size	Yes	6.39(3.16)	0.068*	5.94(3.05)	0.849	5.79(3.19)	0.760	7.2(3.42)	0.002***
	No	5.67(2.97)		5.86(3.06)		5.95(3.03)		5.66(5.28)	
Groups	Yes	1.38(1.17)	0.000***	1.96(1.41)	0.239	2.91(1.44)	0.000***	3.02(1.22)	0.000***
	No	2.37(1.46)		2.19(1.51)		1.85(1.38)		1.82(1.40)	
Education	Yes	11.14(3.73)	0.002***	12.19(3.54)	0.200	12.37(3.85)	0.475	12.73(3.09)	0.135
	No	12.50(3.27)		11.58(3.35)		11.96(3.43)		11.88(3.56)	
Experience	Yes	3.92(5.31)	0.001**	4.75(3.70)	0.007***	8.77(8.06)	0.000***	8.36(6.39)	0.000***
	No	5.95(4.49)		6.55(6.99)		4.57(3.65)		4.61(4.26)	
Off-farmIncome	Yes	389531	0.404	419412	0.461	447533	0.933	651349	0.028***
	No	465859		491416		437561		395969	
Land sizaqua	Yes	576(1364)	0.008***	1048(1986)	0.420	2185(4735)	0.002***	1962(3427)	0.013**
	No	1417(2866)		1323(3467)		919(1682)		952(2208)	

Table 4.2 Contd….									
Comm_contact	Yes	16.56(63.43)	0.807	15.24(54.61)	0.860	15.63(30.33)	0.993	20.07(62.41)	0.495
	No	15.03(38.13)		16.42(25.76)		15.56(51.19)		14.65(45.12)	

***, **, * denotes statistical significance at 1%, 5% and 10 % level respectively, Pr. denotes probability, the number in the parenthesis () denotes the standard deviation

The results indicated that the average age of farmers selling to retailer outlet was 48 years, while consumers, collectors and wholesalers had an average age of 53, 50 and 54 years, respectively. This suggests that the majority of fish farmers were adults. These adults are perceived to be mature in terms of decision making, and they would be ready and willing to participate in aquaculture, both in areas on production and marketing, hence they would choose the best market outlet. Age was also found to be significant in retailer and consumer market outlets, with 1 percent and 5 percent significance levels, respectively.

The mean household size for aqua farmers selling to retailer market outlet was 6.4, while the mean household size for aqua farmers selling to consumers, collectors and wholesaler market outlets were 5.9, 5.8, and 7.2 respectively. The mean household size for aqua farmers in these market outlets is higher than the mean average of 3.9 members per household in Kenya (KNBS, 2019). The mean household size for aqua farmers selling to retailer and wholesaler market outlets was significantly different from other market outlets at 10 percent and 1 percent significant levels, respectively. This is attributed to the fact that larger household size enhances market participation through provision of cheap labor as well as experiencing the multiple market outlets (Abu *et al*., 2016).

In terms of the number of farmer groups, results indicated that mean number of aqua-related organizations for farmers in retailer market outlet was 1 whereas the mean number of aqua-related organizations for farmers in consumer, collectors and wholesaler outlets were 2, 3 and 3 respectively. Results indicate that there is statistical significance in the average number of farmer groups in consumer, collectors and wholesaler market outlets at 1 percent level. This is attributed to the fact that farmers who belong to groups take advantage of bulking hence benefit from economies of scale as emphasized by many institutional economics (Williamson, 2008).

In terms of the number of years in schooling, the findings indicated the mean years of schooling for aqua farmers selling to retailers and consumers were 11.1 and 12.2 respectively, whereas aqua farmers selling to collectors and wholesalers were 12.4 and 12.7 respectively. This implies that fish farmers with many years of schooling were mostly selling to collectors and wholesalers. However, most of these farmers had formal education with implication of having enough skills and entrepreneurship abilities which exposes them to training on aquafarming. There was a significant difference in the mean years of schooling of farmers that were selling to retailer outlet at 1 percent level from other market outlets.

In terms of the land size under aquaculture, results indicate that the mean land size under aquaculture for fish farmers selling to retailers, consumers, collectors and wholesalers were 576.3, 1048.2, 2185.0 and 1962.6 acres, respectively. The land size for fish farmers selling to retailers and collectors market outlets were significantly different from other market outlets at 1 percent significant level whereas farmers selling to wholesalers were significantly different from other market outlets at 5 percent significant level. This could be attributed to the fact that farmers with large acres of land under aquaculture would be able to produce more output hence are more likely to sell in market outlets that purchase large quantities of fish at higher prices. This result is similar to Tefera (2014) which indicated that households with larger land size increases the likelihood of farmers choosing consumer market outlet.

In terms of experience in aquaculture, results indicated that the average year of experience under aquaculture for farmers selling to retailer outlet was at 3.9, whereas those selling to consumer, collector and wholesaler market outlets were 4.8, 8.8 and 8.4, respectively. Furthermore, the years of experience was significant in the four market outlets at 1 percent significant level. According to Olaoye *et al.* (2016), farmers with more years of experience were able to forecast market situations, where they sell their products at high prices.

The result shows that there were farmers who did not have off-farm income in the last one year while the maximum off-farm income in the last one year was 6,000,000. The mean off-farm income of the aqua farmers selling to retailer market outlet was 389,531.2 whereas the mean off-income of aqua farmers selling to consumer, collector and wholesaler market outlets were 419,412.7, 447,533.1 and 651,349 respectively. The results indicate that the mean off-farm income was higher for fish farmers selling to wholesaler market outlet since farmers selling to this market outlet have more income and therefore are likely to venture into other income generating businesses. Results indicated that the mean off-farm income of farmers selling to wholesaler outlet was significantly different from other outlets at 5 percent level. A possible reason is that farmers who are involved in off-farm activities are likely to have adequate resources that might facilitate them in meeting the bureaucracies under wholesaler market outlet.

Commercial contacts refer to communication or contacts which takes place in establishing and maintaining a business relationship with the fish buyers. The number of commercial contacts a farmer has with buyers informs the decision to sell in a particular market outlet. The results indicate that the mean number of commercial contacts farmers had with fish buyers was higher in wholesaler market outlet. A possible reason for this is that

farmers selling to wholesaler outlet have frequent meetings with buyers on possible areas of concern in marketing. Commercial contacts with the buyers is important since farmers with more frequent commercial contacts are able to know more about the market outlets hence offer better prices for their produce (Wosene *et al.,* 2018).Table 0.3 shows the categorical variables on market outlets based on percentage and Chi-square under study. The variables considered include gender, preservation, linkages with fish market, access to value addition and access to credit.

Table 0.3: Descriptive statistics on Categorical Variables

		Retailers (N=93)		Consumers (N= 193)		Collectors (N= 43)		Wholesalers (N =45)	
Variables		**%**	x^2	**%**	x^2	**%**	x^2	**%**	x^2
Gender	Male	90.32	2.139	84.97	0.732	88.37	0.223	84.44	0.123
	Female	9.68		15.03		11.63		15.56	
Farm Africa	Yes	30.11	2.496	40.41	4.732**	41.86	0.644	37.78	0.040
	No	69.89		59.59		58.14		62.22	
Preservation	Yes	25.81	11.180***	38.34	0.377***	48.84	1.882	68.89	19.615***
	No	74.19		61.66		51.16		31.11	
Linkfish_market	Yes	8.60	9.174***	15.03	5.394**	39.53	15.216***	40.00	16.783***
	No	91.40		84.97		60.47		60.00	
Acc to value addition	Yes	74.19	0.6859	70.47	0.1175	76.74	0.8078	64.44	1.1499
	No	25.81		29.53		23.26		35.56	
Access to credit	Yes	56.99	1.2842	43.01	0.000***	74.42	0.1218	31.11	10.0982***
	No	43.01		56.99		25.58		68.89	

*****, **, * denotes statistical significance at 1%, 5% and 10% level respectively, % denotes percentage,** x^2 **represents Chi-Square**

Gender is important in fish farming. The results indicated that majority of fish farmers were males. The percentage of male farmer selling to the four market outlets were higher than the percentage of female fish farmers selling to these market outlets. This is consistent with Brummett *et al*. (2010) which found out that male aquafarmers commonly participate in acquiring properties, including ponds, cages and tanks.

This study revealed that 30.11%, 40.41%, 41.86% and 37.78% of fish farmers in retailer, consumers, collectors and wholesalers market outlets respectively had engagement with Farm Africa. The results revealed that majority of fish farmers selling to different market outlets did not have any engagement with Farm Africa. This is an indication that majority of the farmers do not have adequate training as well as technology, inadequate credit and input which is provided by Farm Africa. The Chi-square results revealed that there was significant association between farmers who had engagement with farm Africa from those with no engagement with Farm Africa in consumer market outlet at 5 percent level. Farm Africa has been able to set up networks of aqua shops in disseminating quality equipment and inputs as well promoting the adoption of aquaculture best practices for improved production. In addition, it helps in strengthening the marketing systems as well as policy environment that can make farmers turn their ponds into profitable enterprises (Obwanga *et al*., 2018).

Fish preservation is important in fish marketing due to the fact that fish is a highly perishable commodity. Results from the study indicate that percentage of fish farmers who sold to retailers, consumers, collectors and wholesalers who had access to preservation facilities were less compared to the percentage of fish farmers who did not have access to preservation facilities. This is an indication that most farmers still do not have access to preservation facilities and technologies hence the fish would end up spoiled. On the other hand, the Chi-square results indicated that there was association between farmers practicing fish preservation and retailer, consumer and wholesaler market outlets at 1% significant level. This is attributed to the fact that fish farmers who had access to preservation facilities are more likely to sell to wholesaler market outlet. On the other hand, farmers who did not have capacity to preservation facilities mainly sold to consumers and retailers since these outlets buy fish in small quantities. Farmers selling to wholesaler outlet are likely to use modern preservation facilities, including cold rooms as well as fridges, unlike farmers selling to retailer and consumer outlets who mostly use icing, sunlight or salting in preserving fish.

Linkages with fish market are important in the fish value chain. It provides the producers with a guaranteed outlet for fish and capital while at the same time ensures traders have a steady fish supply (Pomeroy *et al.*, 2017). The percentage of aqua farmers who had linkages with fish market were 8.6%, 15.0%, 39.5% and 40.0% in retailers, consumers, collectors and wholesalers market outlets respectively. Further, the Chi-square results indicate that there was significant association between linkages with fish market outlets and retailer, consumer, collector and wholesaler market outlets at 1%, 5%, 1% and 1% respectively. This implies that majority of fish farmers in these outlets did not have linkages with fish market hence had unreliable fish market outlet. Linkages with fish market get informed about new opportunities in the different market outlets.

In relation to access to value addition, results revealed that 74.2%, 70.5%, 76.7% and 64.4% of aqua farmers who did value addition sold to retailers, consumers, collectors and wholesalers. A possible reason is that farmers preferred value addition since it is attracting better market prices and improves the quality of fish. Value addition in fish farming provides farmers with the opportunities of reducing post-harvest losses, having additional revenue and job creation. This confers with Emana *et al.* (2017) which found out that value addition of potato was positively significant with the chances of choosing wholesaler and collector market outlet.

Access to credit is important for aqua farmers since it enhances the financial capacity of the households in purchasing the farm inputs hence increases output. Results found out that 57.0%, 43.0%, 74.4% and 31.1% of the aqua farmers in retailers, consumers, collectors and wholesalers had access to credit. This implies that majority of the farmers who had access to credit sold to collectors. Credit is important in acquiring of technologies and inputs that are used in fish production hence these farmers would produce large quantities of fish. Further, this implies that credit makes farmers to have more economic resources that would make them to get involved in formal marketing. The Chi-square results indicate that there was significant association between access to credit and wholesaler market outlets at 1 percent significance level. However, studies indicate that access to credit influence the probability of farmers to choose collector market outlet than wholesaler market outlet (Taye *et al.*, 2018).

4.1.2 Causes of post-harvest losses

Figure 0.2 below indicates the causes of post-harvest losses.

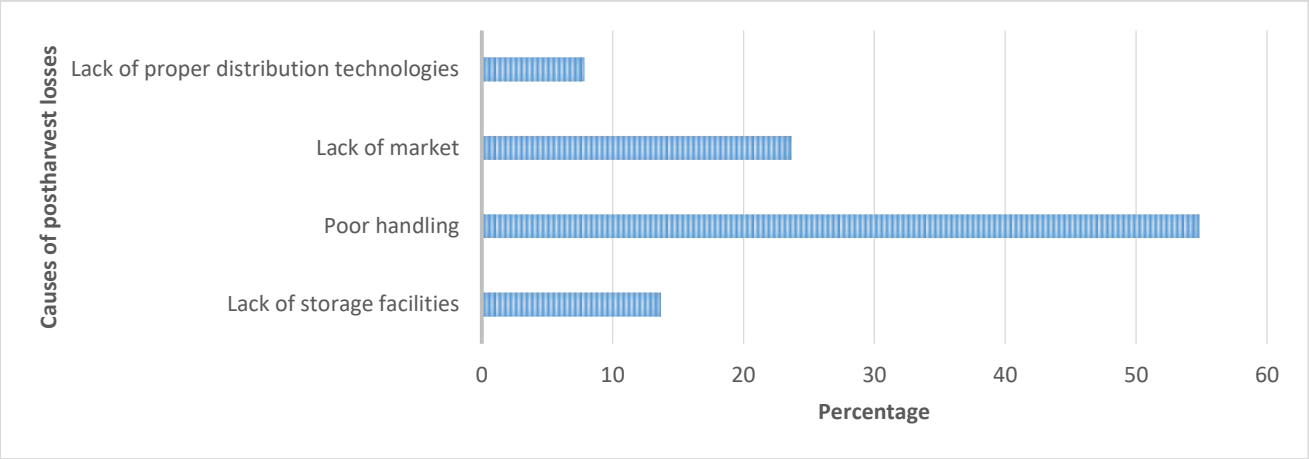


Figure 0.2: Reasons for post-harvest losses

Results indicated that majority of the farmers (54.8%) attributed post-harvest losses to poor handling of fish. This is possibly due to the fact that poor handling lead to microbial contamination, thus increasing the spoilage of fish. About 23.7% of the farmers attributed post-harvest losses in fish to lack of market. Some fish farmers do not have access to the market probably due to inadequate information as well as other barriers that prevent them from finding the right market. On the other hand, 13.7% and 7.8% of the farmers indicated that they experienced post-harvest losses in fish due to lack of storage facilities and poor distribution technologies. Post-harvest losses make fish to be discarded or sold at relatively lower prices because of loss of quality or due to dynamics in the market.

4.1.3 Reasons why farmers engage in aquafarming

Figure 0.3 presents the reasons why farmers practice aquafarming. Results indicated that 42.5% of the farmers practiced aquafarming mainly as a source of the income and livelihood. This is possible since farmers get income from fish farming, which they use to cater for family needs, including education, health care and purchasing household's assets. On the other hand, 34.6% of the farmers practiced aquafarming mainly for food. This implied that there were reduced pressure on other sources of protein food, particularly beef, mutton as well as poultry meat., hence farmers were able to have diet diversity. About 15.8% and 7.1% of the farmers practiced aquafarming for nutritional purpose and to increase the increase demand of fish, respectively.

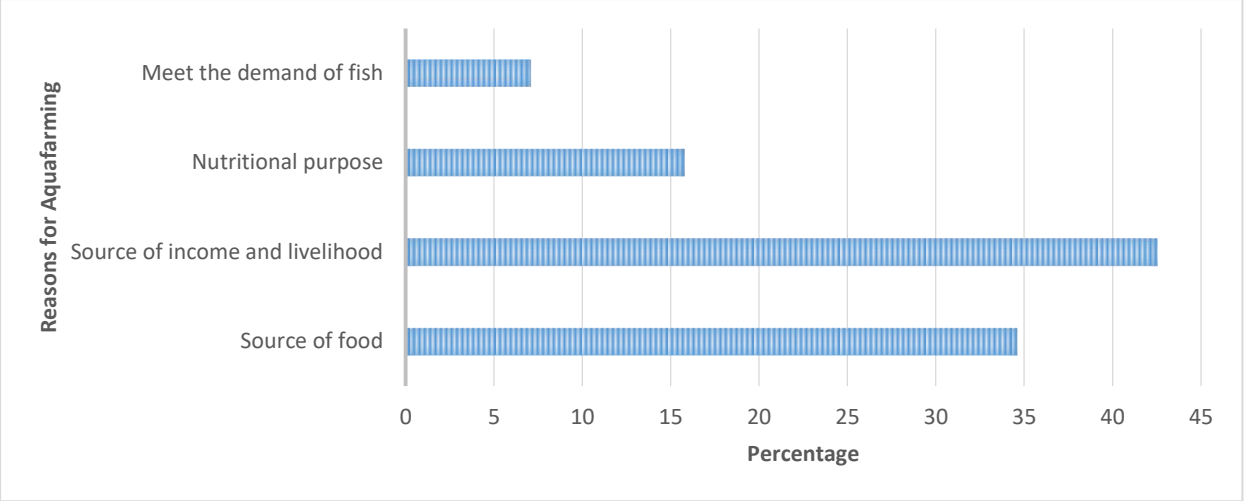


Figure 0.3: Reasons for Aquafarming

4.2 Effects of Social networks on fish market outlets

Social network in this case was captured by the number of groups that the aquafarmers is a member, extension contacts, commercial contacts with fish buyers, membership to Farm Africa and the number of years one is a member of aqua-related group. However, household characteristics were also controlled for in the model. The effects of social networks on fish market outlets was analyzed using multivariate probit model. Variance inflation factor (VIF) was used to diagnose the problem of multicollinearity. According to Jim (2017), VIF of above 10 confirms the presence of multicollinearity. Appendix 3 presents VIF for the explanatory variables where the results indicated a mean of 1.18, thus confirming the absence of multicollinearity. Breusch- pagan test was used to determine the presence of heteroscedasticity. Probability value of less than 0.1 indicate the presence of heteroscedasticity. The results indicated that x^2 (1) = 6.06 while the Prob> x^2 = 0.0139, hence confirming the presence of heteroscedasticity. The graphical results further confirm that there was a pattern in distribution of the errors as illustrated in appendix 5. This problem was corrected using robust standard errors. Table 0.4 presents the results on multivariate probit model on the analysis of social networks on fish market outlets.

Table 0.4: Results of the Multivariate Probit Model

	Retailers		Consumers		Collectors		Wholesalers	
Variables	**Coeff.**	**Rob.Std. Err**	**Coeff.**	**Rob. Std. Err**	**Coeff.**	**Rob.Std. Err**	**Coeff.**	**Rob. Std. Err**
Gender	-0.589**	0.297	0.216	0.262	-0.266	0.326	0.252	0.347
Household size	0.020	0.032	0.067*	0.039	-0.056	0.038	0.077**	0.032
Age	-0.009	0.007	0.012	0.008	-0.005	0.008	0.003	0.008
Experience	-0.034	0.022	-0.022	0.020	0.071***	0.022	0.029	0.021
Farm Africa	0.001	0.197	0.574**	0.239	0.033	0.222	-0.299	0.200
Landsize aqua	-0.132***	0.039	0.044	0.038	-0.040	0.042	-0.012	0.046
Distance	0.000	0.001	0.001	0.001	0.001	0.001	-0.003**	0.001
Extension contact	-0.084***	0.022	-0.184***	0.040	0.100***	0.025	0.038	0.025
Commercial contacts	0.002	0.002	-0.001	0.002	-0.000	0.002	-0.000	0.002
Linkages with fish market	-0.779***	0.294	-0.218	0.265	0.757***	0.257	0.491**	0.228
Quantity sold	0.162**	0.082	-0.137*	0.075	0.225**	0.087	0.112	0.095
Education	-0.062**	0.028	0.001	0.032	0.016	0.036	0.036	0.032
Access to credit	0.114	0.209	-0.359*	0.215	-0.048	0.224	0.509**	0.224
Number of groups	-0.277***	0.074	-0.074	0.072	0.238***	0.085	0.205***	0.073
Off-farm income	0.026	0.022	-0.002	0.020	-0.006	0.024	0.003	0.027
Preservation	-0.305	0.202	0.098	0.222	-0.087	0.228	0.766***	0.237
Number of years in a group	-0.017	0.023	-0.062**	0.029	-0.023	0.026	0.033	0.020

Table 4.4 Contd….									Numbe
_cons	1.413*	0.759	1.258	0.782	-3.094***	0.935	-4.346***	0.978	r of

observations =266, L.R test x^2 (6) = 39.8795, Wald x^2 (68) = 360.41, Log pseudo likelihood = -350.76704, Prob> x^2 = 0.0000. *, ** and *** represents 1%, 5% and 10% significant levels, respectively

Multivariate probit model was estimated jointly for four binary dependent variables, including retailers, consumers, collectors and wholesalers market outlets. The Wald x^2 test (x^2 (266) = 360.41, p = 0.0000) was significant at 1 percent level implying that the subsets of the coefficients of the model was jointly significant. The number of observations were different from 300 due to non-response by some households. Furthermore, the Wald Chi-square test indicated that the explanatory power of the variables that were included in the model were satisfactory. The multivariate probit model fit the data well, similarly, the model was significant since the null hypothesis that the choice of the four market outlets is independent was rejected at 1% significant level. The likelihood ratio test in the model (x^2 (6) = 39.8795) prob > x^2 =0.0000) was significant, indicating that there was independence between fish market choice decision (rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0), hence there was joint correlations for the estimated coefficients across the equations. The off-diagonal elements of the covariance matrix were significant, indicating that there were unobserved heterogeneities that influence the decision to participate in different fish market outlets. Similarly, the correlation coefficients in the error terms were significant, following a normal distribution with zero conditional mean. This implies that the decision to choose one market outlet affect the decision to choose another market outlet.

Based on the results of multivariate probit model, most of the variables were significant in more than one market outlet. Results indicated that number of groups, number of years in a group, number of extension contacts and membership to Farm Africa were found to be significant in the different market outlets. In addition, other household characteristics including, gender of the farmer, household size, experience in aquaculture, land size under aquaculture, distance to the market, linkages with fish market, quantity of fish produced, education level of the farmer, access to credit and access to fish preservation were found to be significant in the different market outlets.

Gender of the farmer had a negative significant in retailer market outlet at 5 percent level. Results established that being male decreases the likelihood of selling to retailer market outlet by 58.9 percent. A possible reason is that male farmers are risk takers hence they are able to search markets that are competitive and in distant places, hence are unlikely to sell to retailers. In addition, those who control resources in most homesteads are male farmers hence they participate in day to day business decision making. This finding is similar to Sigei *et al*. (2015) who established that female farmers unlike their male counterpart face constraints

which are gender specific such as household chores, hence limit them from accessing the best markets for their products.

Household size was found to be positively and significantly influence the likelihood of choosing consumer and wholesaler market outlet at 10 and 5 percent level, respectively. Results indicated that an increase in household size by one unit increases the probability of selling to consumer market outlet by 6.7 percent as well increases the likelihood of selling to wholesaler market outlet by 7.7 percent. Aqua farmers with large household size prefer selling to wholesaler outlet; since large household size is assumed to have plenty labor force that is able to facilitate transportation of fish to the final market place. The results are consistent with Tewodros (2014) which indicated that large family size has better labor endowment, which enables households to travel to reach wholesalers in the nearby markets.

Experience in fish farming was found to be positively significant in collector market outlet at 1 percent level. Results further establish that a unit increase in experience increases the chances of selling to collector market outlet by 7.1 percent. Experience in farming improves bargaining power in the market, hence ensuring that farmers are able to make the best decisions on fish production and marketing. This is attributed to the fact that experience helps aqua farmers to adjust their marketing link; hence they would probably choose collectors which offer lucrative price deals. This study concurs with the study done by Wosene *et al.* (2018) which highlights that experienced farmers are more knowledgeable of cost and benefits that are associated with marketing outlets, hence they will prefer selling to collector market outlet.

Membership to Farm Africa is positively significant in consumer market outlet at 5 percent level. Being a member of Farm Africa increases the probability of selling to consumer market outlet by 57.4 percent. This is because Farm Africa implemented extension programs, where fish farmers were enlightened selling to market outlets which offered relatively better prices. In this case, farmers selling to consumer market outlet received relatively better prices compared to those selling to retailer outlet. Farm Africa offered training to farmers on the fish production systems, including cages, ponds and tanks (Obwanga *et al*., 2018). In addition, farmers who are members of Farm Africa were aware of the market prices in different outlets.

Land size under aquaculture was found to be negatively significant in retailer market outlet at 1 percent significant level. Further, the findings from this study revealed that an increase in land size under aquaculture by an acre decreases the probability of selling to retailer market outlet by 13.2 percent. This is attributed to the possibility that farmers with

large land size produce more fish, hence would sell in market outlets that afford to buy fish in large quantities. The finding is similar to Abate *et al*. (2019) who established that an increase in land size allotment by one unit decreases the probability of selling to retailer market outlet.

Distance to the market negatively influences the likelihood of selling to wholesaler market outlet at 5 percent level. The results further indicated that a unit increase in the distance to the nearest market decreases the probability of selling to wholesaler market outlet by 0.3 percent. The negative sign implies that fish farmers living far away from the market are less likely to sell to wholesalers. Selling fish to wholesalers requires adequate transportation facilities as well as labor endowment necessary to reach wholesalers which increases the costs associated with marketing. This implies that farmers located far from the market would sell to market outlets that are close to them thus avoiding wholesaler outlet which is inaccessible. In reality, most aqua farmers prefer selling fish to the nearest market since it reduces the time spent in transportation, saves on transportation cost and reduces the chances of fish spoilage. Mburu *et al*. (2007) established that the longer the distance to the market, the higher the transportation cost, hence higher cost of milk marketing. This finding is in line with Tarekegn *et al.* (2017) that increase in distance to the market, makes farmers prefer selling to nearby outlets that are not associated with higher transportation costs.

The number of extension contacts positively influenced the probability of selling to collector market outlet at 1 percent significance level and negatively influenced the probability of selling to retailer and consumer market outlet at 1 percent significance level. The results further suggest that a unit increase in the number of extension contacts increases the probability of selling to collector market outlets by 10 percent. This is attributed to the fact that farmers who mostly sell to collector outlet are organized in groups where they get extension services from various stakeholders. In addition, farmers with many extension contacts may probably know about many market outlets which offer better prices for their produce. On the other hand, results indicated that a unit increase in the number of extension contacts reduces the probability of selling to retailer and consumer market outlet by 8.4 and 18.4 percent, respectively. A possible reason is that farmers with many extension contacts avoid selling directly to consumers and retailers who buys fish in small quantities and at low prices. Nyaga *et al.* (2016) established that fish farmers who had gone through training had access to extension services and were able to attain quality requirements as well as adequate information about the traders within the country, thereby selling to profitable market outlets. Similar results were obtained by Wosene *et al*. (2018) implied that extension service increases the chances of farmers to acquire important market information that would enable

them to choose the best market outlet. Farmers that received more extension contacts were less likely to sell fish to consumer market outlets and more likely to sell in other market outlets. The results confirm the notion which implies that extension service acquired by the farmer on marketing increases the farmer's willingness to participate in lucrative marketing outlets (Otieno *et al*., 2009).

Access to linkages with the fish market is important in fish marketing since it ensures that producers have steady market for their fish. It was found to be positively significant in collectors and wholesaler at 1 percent and 5 percent levels, respectively and negatively significant in retailer market outlet at 1 percent significant level. This implies that access to linkages with fish market increases the probability of selling in collectors and wholesaler markets by 75.7 percent and 49.1 percent, respectively and decreases the likelihood of selling to retailer market outlet by 77.9 percent. Farmers that are linked to the fish market have advantage of selling to outlets which offer better prices. This finding is consistent with Awuor *et al.* (2019) that effective market linkage between aqua farmers and other stakeholders have benefits, including assured price and market.

Quantity of fish produced negatively influenced the likelihood of choosing consumer market outlet at 10 percent significance level. Results indicate that a unit increase in quantity of fish produced decreases the likelihood of selling to consumer market outlet by 13.7%. This implies that when the quantity of fish produced increases, farmers would avoid selling to consumer market outlet since this outlet demand small quantities of fish for consumption. On the other hand, the quantity of fish produced positively influence the likelihood of selling to retailer and collector market outlets at 5 percent significance level. The positive sign indicates that a unit increase in quantity of fish produced increases the probability of selling to retailer and collector market outlets by 16.2 percent and 22.5 percent, respectively. In addition, results indicate that farmers preferred selling to collectors due to the ability of this outlet to purchase large quantity of fish at fair price. This implies that when the quantity of fish produced is large, farmers would prefer selling to market outlet that buys large volume of fish at fair price. This is attributed to the fact that farmers selling to collectors has benefits such as bulking hence enjoying economies of scale. According to Timothy (2006), the amount of fish produced influence the choice of marketing channel. This finding is in line with Wosene *et al.* (2018) which indicated that quantity of agricultural product produced positively affected lucrative market outlets.

Education level (number of years that aqua farmers have spent in school) is negatively significant in retailer market outlet at 5 percent level. The findings established that a unit

increase in the year of schooling decreases the probability of selling to retailer market outlet by 6.2 percent. The negative relationship between the year of schooling and retailer market outlet implies that educated farmers make informed decisions on choosing the best marketing outlets; hence farmers would sell fish after considering the marketing margin as well as the marketing cost. This is similar to Mutura *et al*. (2015) which highlighted that education is considered as important indicator of social change, where it increases knowledge and skills useful in collecting and interpreting information necessary in making more productive and marketing decisions.

Access to credit was positively significant in wholesaler market outlet at 5 percent level and negatively significant in consumer market outlet at 10 percent level. This indicate that access to credit increases the probability of selling to wholesaler market outlet by 50.9% and decreases the probability of selling in consumer outlet by 35.9 percent. Credit provides farmers with the ability to enhance their capacity of production, thereby enhancing fish marketing The results established that farmers who had access to credit were likely to sell to wholesalers. Similarly, access to credit decreases the chances of selling to consumers. This implies that fish farmers that had access to credit were able to produce large volumes of fish, hence would sell to wholesaler market outlet, that mostly buy fish in large quantities. Farmers who did not access credit produced fish in small quantities, hence end up selling to consumer market outlet. The result is consistent with Mmbando *et al*. (2016) which indicated that access to credit increases the probability of maize producer to sell to traders in nearby market as well as wholesalers in nearby towns.

Number of farmer groups was found to be positively significant in collectors and wholesaler market outlets at 1 percent level. However, number of farmer groups was negatively significant in retailer market outlet at 1 percent. Further, results indicate that an additional farmer group reduces the probability of selling to retailer market outlet by 27.7 percent. On the other hand, additional farmer group increases the probability of selling to collectors and wholesaler market outlet by 23.8 percent and 20.5 percent respectively. This is due to the fact that farmers who belong to several farmer groups are likely to have information on market outlets which offers better prices for the produce. These groups are mainly involved in production and marketing of fish. They train farmers on practices such as joint buying of inputs of fish production and bulking, hence they are able to gain advantage of economies of scale. These findings are consistent with Nyaga *et al*. (2016) which established that membership to groups is associated with the likelihood of farmer's selling to the traders' channel unlike neighbor's channel. Further, this study is in conformity with

Tsourgiannis *et al*. (2008) which highlighted that group membership promotes unity and sense of belonging in empowering the bargaining and negotiation for better trading terms, hence leading to reduced transaction costs.

Access to preservation facilities is positively significant in wholesaler market outlet at 1 percent level. This means that access to preservation facilities increases the probability of selling to wholesaler market outlet by 76.6 percent. This is attributed to the fact that preserved fish are likely to stay longer before spoilage, hence farmers have enough time to transport fish to wholesaler market outlet, which buys in bulk and offers better prices. Most of the fish farmers selling to wholesaler outlet uses modern facilities, including fridges and cold rooms for storage facilities. This is in line with Wosene *et al*. (2018) that found out preservation had a positive and significant relationship with wholesaler market outlet.

Number of years in a cooperative group was found to be negatively significant at consumer market outlet at 5 percent level. Further, results indicated that a unit increase in the number of years in a group decreases the likelihood of selling to consumer market outlet by 6.2 percent. This is attributed to the fact that farmers with many years in a group are more knowledgeable on costs and benefits that are associated with fish marketing outlets. Fish farmers join groups for several reasons including, easy access to inputs, extension services, having collective sales and for social reasons. Experience in cooperative groups helps the farmers to adjust their marketing link, in search of other alternative outlets that offer better prices for fish (Wosene *et al.,* 2018). This is similar to Jari and Fraser (2009) which indicated that farmers with many years in group are able to share information and broaden the social capital within the group, hence they can be able to reach distant places.

4.3 Influence of Post-Harvest Loss on Household Welfare

2SLS was used to examine how post-harvest losses influences household welfare. In this model, household income was used as an indicator of household welfare. Other factors that were controlled for in the model included gender of the household head, household size, age, education level, land size under aquaculture, land size under crop, access to off-farm income, linkages with the fish market and linkages with the feed market. The likelihood ratio test in the model (x^2 (11) = 261.43) prob > x^2 =0.0000) was significant, indicating that the association between the independent variables were statistically significant. R-Squared and Root Mean Squares of Errors (RMSE) were as the determining coefficients of the model. Results indicated R-squared value of 52.35 percent, implying a higher percentage of variability of the independent variables. However, 2 SLS model does not take into account

the number of variables used to fit in the model, thus RMSE was considered appropriate. The RMSE was 80.12 percent, hence the model was considered fit.

In testing for the presence of endogeneity, Durbin and Wu- Hausman tests were conducted, where Durbin (score) x^2 (1) = 7.14422 (p= 0.0075) and Wu-Hausman F (1,253) = 6.98261 (0.0087). These p values were less than 0.05, hence the null hypothesis that post-harvest loss was exogenous variable was rejected indicating that post-harvest loss was endogenous in the model hence we can rely on the results of the two stage least squares. In addition to post-harvest losses, age, land size under crop and ownership of land significantly affected household income.

Access to preservation facilities and distance to the market were used as instruments in the model. In testing for the strength of the instruments, results indicate that the partial R-Square was 54.31%, hence the model was fit. The F statistics (25.70) was statistically significant, thus the null hypothesis that the instruments were weak was rejected hence the instruments were considered strong.

Table **0.5** presents results used in testing for the strengths of the instruments.

Table 0.5: Testing for weak Instruments

Variable	R-Squared	Adjusted R-Squared	Partial R-Squared	F(2,253)	Prob > F
post-harvestloss	0.2345	0.1982	0.5431	25.69966	0.0038

Minimum eigenvalue statistic = 25.69966

Critical Values		# of endogenous regressors:1		
Ho: Instruments are Weak		# of excluded instruments:2		
2SLS relative bias	5%	10%	20%	30%
		(not available)		
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.93

Sargan and Basman tests were used in testing over identifying restrictions. The p values for Sargan and Basman tests were 0.3542 and 0.3654, respectively. The p values were large indicating failure to reject the null hypothesis of no over-identifying restrictions, implying the validity of the instrument set.

Table **0.6** presents the results of the first stage of the 2SLS model. Access to preservation facilities and distance to the market were treated as instruments of post-harvest loss. Results indicate that both access to preservation facilities and distance to the market were significant in the first stage regression of 2SLS.

Table 0.6: Results of First Stage Regression (2SLS)

Post-harvest loss	**Coeff.**	**Std.Err.**	**P>|Z|**	**95% Confidence Interval**	
Gender	-152.685	114.771	0.185	-378.714	73.344
Household size	24.909*	13.344	0.063	-1.371	51.188
Age	-5.699*	3.051	0.063	-11.709	0.310
Ownership of land	-488.109***	79.728	0.000	-645.123	-331.095
Access to off-farm income	-28.050	90.111	0.756	-205.512	149.412
Land size aquaculture	47.0549***	16.607	0.005	14.34914	79.76065
Land size crop	72.864	60.549	0.230	-46.380	192.109
Linkages with fish market	61.318	101.863	0.548	-139.289	261.926
Linkages with feed market	66.2099	78.608	0.400	-88.599	221.019
Years of schooling	5.091	11.483	0.658	-17.524	27.705
Instrumental Variables					
Distance to the market	2.429 ***	0.787	0.002	0.879	3.979
Access to preservation	-144.706**	88.639	0.014	-319.270	29.858
_cons	468.417	246.308	0.058	-16.658	953.493

Note: *,**, *** represents 10%, 5% and 1% significance level, respectively

Household size was found to be positively significant on post-harvest loss at 10 percent. This is explained by the fact that farmers with more household size divert their money to other uses, hence do not invest in buying storage facilities and other preservation facilities that would reduce the amount of fish post-harvest losses. This is different from Adisa *et al*. (2015) that mentioned that high household size provides labor force necessary in ensuring fish is stored in ice and other cooling facilities.

Age is an important variable in aquafarming because there is a general increase in the proportion of older people and a decline in the proportion of younger people practicing aquafarming. Age was found to be negatively significant on post-harvest loss at 10 percent level. This implies that an increase in the age of the fish farmer by one year reduces the amount of post-harvest loss by 5.7 percent. This is attributed to the fact that older farmers

have more experience on better ways of handling post-harvest losses. The older farmers engage in activities, such as feeding, security of fish stock and fish harvesting. This finding is in line with Adelaja *et al*. (2018) which indicated that age was negatively significant on the amount of post-harvest loss of fish. However, Alwang (2005) established that older people are more reserved and rigid about introducing and accepting innovations, which has an impact on their agricultural operations as well as grain post-harvest loss. At the same time, younger farmers are also better educated and informed on how to regulate and reduce post-harvest cereal losses.

Ownership of land was negatively significant on the amount of post-harvest loss at 1 percent level. The results indicated that fish farmer who own land were experiencing less post-harvest losses. This could be attributed to the fact that title deeds give farmers with the ability to register as farmers in groups as well as the ability to develop fish farming activities include pond construction, stocking, and restocking. This is similar to Jebet (2017) which explain that farmers who own land is able to schedule when to do routine management operations on such ponds, resulting in well-maintained ponds, thus reducing the quantity of post-harvest losses.

Results indicated that land size under aquaculture was positively significant on the amount of post-harvest loss at 1 percent level. The size of fish ponds, cages and tanks has a great bearing on the quantity of fish produced. High quantity. This could be attributed to the fact that farmers who produces higher quantity of fish do not end selling all the quantities produced, hence leading more spoilages and post-harvest loss. This is similar to Adisa *et al*. (2015) which mentioned that larger area of plantation under yam increases the quantity of yam harvested and the chances of post-harvest losses due to inadequate storage facilities and poor handling.

Results found at that access to fish preservation was negatively significant on the quantity of post-harvest loss. This could be attributed to the fact that fish farmers who had preservation facilities had ice blocks, cold rooms and other fish preservation facilities that were important in storing fish in good quality. Similarly, studies indicate that preserved food products are more stable, permit high diet diversity, improves the level of digestibility and gives buyers ability to choose a variety of products as well as range of vitamins and minerals (Kiaya, 2014). This increases the willingness of the traders to purchase from farmers with preserved fish since they are preferred by most buyers.

Distance to the market was positively significant on post-harvest loss at 1 percent level. The positive relationship implies longer distance to the nearest market translates to

longer time taken to transport fish. During transportation of fish, large quantities of fish end up spoiled thus leading to more post-harvest losses. Studies reveals that farmers would choose marketing points near the farm as long as they are more accessible (Bardhan *et al.,* 2012). The finding by Ismail and Changalima (2019) indicate that the mode of transportation determined the quantity of post-harvest losses in agricultural commodity which affected profitability. A similar research by Sheahan and Barrett (2017) indicated that poor road infrastructure is attributed to high post-harvest losses in most of the sub-Saharan countries. This finding is closer to Ansah *et al.* (2018) which established that post-harvest loss management positively influences the welfare of farmers. Table 0.7**: Results of the 2SLS Estimation**

Household income	**Coef.**	**Std.Err.**	**P>|Z|**	**95% Interval**	**Confidence**
Post-harvest loss	-0.001***	0.000	0.000	-0.002	-0.001
Gender	-0.033	0.159	0.838	-0.344	0.279
Household size	0.012	0.020	0.541	-0.027	0.052
Age	-0.011**	0.005	0.015	-0.020	-0.002
Ownership of land	0.583***	0.222	0.009	0.148	1.018
Access to off-farm income	-0.067	0.115	0.560	-0.292	0.158
Land size aquaculture	0.037	0.027	0.169	-0.016	0.090
Land size crop	0.153*	0.081	0.059	-0.006	0.312
Linkages with fish market	-0.136	0.131	0.301	-0.394	0.122
Linkages with feed market	0.018	0.102	0.858	-0.181	0.217
Years of schooling	0.013	0.015	0.372	-0.016	0.043
_cons	13.065***	0.346	0.000	12.387	13.742

Number of observations = 266, Wald x2 (12) = 345.83 Prob> x2 = 0.0000 R-squared = 0.6625, Root MSE = 0.67437, Note: *, *** represents 10% and 1 % significance levels, respectively

presents results of the second stage regression of influence of post-harvest loss on household welfare.

Table 0.7: Results of the 2SLS Estimation

Household income	**Coef.**	**Std.Err.**	**P>|Z|**	**95% Confidence Interval**	
Post-harvest loss	-0.001***	0.000	0.000	-0.002	-0.001
Gender	-0.033	0.159	0.838	-0.344	0.279
Household size	0.012	0.020	0.541	-0.027	0.052
Age	-0.011**	0.005	0.015	-0.020	-0.002
Ownership of land	0.583***	0.222	0.009	0.148	1.018
Access to off-farm income	-0.067	0.115	0.560	-0.292	0.158
Land size aquaculture	0.037	0.027	0.169	-0.016	0.090
Land size crop	0.153*	0.081	0.059	-0.006	0.312
Linkages with fish market	-0.136	0.131	0.301	-0.394	0.122
Linkages with feed market	0.018	0.102	0.858	-0.181	0.217
Years of schooling	0.013	0.015	0.372	-0.016	0.043
_cons	13.065***	0.346	0.000	12.387	13.742

Number of observations = 266, Wald x^2 (12) = 345.83 Prob> x^2 = 0.0000 R-squared = 0.6625, Root MSE = 0.67437, Note: *, *** represents 10% and 1 % significance levels, respectively

As expected, the coefficient of post-harvest loss was positive and statistically significant in the household welfare model at 1 percent level. The results indicated that a unit increase in post-harvest losses decreases household income by 0.1 percent. This finding is in line with the earlier assumption that farmers with high post-harvest losses are likely to have low household welfare (Getu *et al*., 2015). The time taken between harvesting of fish, preservation facilities and delivery of fish to the final market place determines the level of post-harvest losses. Ideally, high post-harvest losses translate to low volume of fish that is available for sale as well as general loss in quality leading to relatively lower incomes. As a result, inadequate storage and preservation facilities expose fish to damage before they reach the final market.

Age of the farmer was found to be negatively statistically significant at 5 percent level. An increase in the age of the farmer by a year decreases the household income by 1.1

percent. A plausible reason is that younger farmers are receptive to new ideas in the market and are less risk averse hence they would probably take new ideas that are related to fish production and marketing. This finding ties with Langyintuo and Mungoma (2008), that as the farmer get older, they usually become risk averse hence they will not be willing to venture into new areas that they are not sure of. At the same time, younger farmers are more flexible in their decision making process in adapting to new farming practices.

Ownership of land was found to positively significant at 1% significance level. Results indicate that access to land ownership increases household income by 58.3%. Land ownership is related to crop, livestock and aquaculture production. Land ownership is expected to influence participation in aquaculture activities and income generation activities. Farmers who own good proportions of land are able to access credit thus can be able to diversify into various income generating activities, including non- farm activities. The results are consistent with Winters *et al.* (2017) which indicate that improved land access is directly linked to agricultural production hence would improve the household welfare.

Land size under crop was found to positively influence household income at 1% significance level. Results indicate that a unit increase in land under crop increases household income by 15.3%. A plausible reason is that increase in farm size increases the output per unit of labor which translates to higher quantities of fish produced thus increase in total income by the farmers. Medium sized farms are more commercialized than the small sized farms in both input market participation as well as sale of the output. This confirms with the results by Noack and Larsen (2019) which indicate that farmers with large farm size are more likely to have more income.

CHAPTER FIVE

CONCLUSIONS AND POLICY RECOMENDATION

5.1 Conclusions

Descriptive analysis on market outlets indicate that majority of the fish farmers sold directly to consumers, followed by retailers, wholesalers and collector market outlets respectively. Consumer and retailer market outlets are popular among these farmers probably due to less transaction costs that are involved in these channels. In addition, these outlets are readily accessible and can afford to purchase small quantities of fish that are produced by most farmers. On the other hand, fish farmers received better prices in wholesalers and collector market outlets. However, these outlets are coupled with bureaucracies, which include compulsory group membership, scale of production, packaging, handling procedures and processing that cannot be adequately met by many fish farmers.

Results of the second objective on the effects of social networks on the choice of market outlets show that retailer market was largely affected by linkages with the fish market and number of groups, while consumer market was affected by membership to farm Africa and the number of years in a group. On the other hand, linkages with the fish market and number of groups affected both collector and wholesaler market outlets. The number of years in a group is perceived to allow farmers to share information as well as broaden the social capital within the group. Similarly, group increases the bargaining and negotiation power for better marketing terms, hence farmers belonging to many groups were able to sell to lucrative market outlets. Fish farmers who were members of Farm Africa were trained on fish farming and marketing, thus were enlightened about the market outlets to sell their fish depending on the quantities of fish produced. Farmers who have linkages with fish markets enjoy benefits, including assured market and high prices. Other factors that affected the choice of market outlets include gender, household size, experience in aquafarming, land size under aquaculture, distance to the market, number of extension contacts, quantity of fish produced, education level of the farmer, access to credit and access to preservation facilities.

The diagnostic tests show that the post-harvest loss is endogenous in the household income model. Results of the 2SLS indicate that post-harvest loss negatively and significantly influence household welfare. Holding other factors constant, reduced post-harvest loss lead to increased household income and possibly improve household welfare. The study found that age of the farmer negatively influenced household welfare. On the other hand, ownership of land and land size under crop positively and significantly affected household income.

5.2 Recommendations

The study provides important information to policy makers and other stakeholders in the quest to meet the increase supply and excess demand of fish through aquafarming. In order to achieve this, policies need to be drawn that would enhance both production and marketing of fish. Efforts to promote fish marketing need to focus on enterprise and distributional systems through sufficient incentives and financial support to facilitate access to high value markets. Further, the government and various stakeholders need to reduce bureaucracies, which include scale of production, packaging, handling procedures in wholesaler and collector market outlets to enhance access.

To enhance social network among the farmers, government and other entities could empower farmers through training on the advantages of social networks and group marketing compared with individual engagement in the market. The private sector could establish fish collection centers for farmer groups in some of the potential areas to encourage farmers to sell fish at a better price. Farmers who belong to groups usually market their fish collectively, hence giving them advantage of accessing market outlets which offer better prices. There is also need to offer training as well as technical advice on aquafarming practices and marketing to farmers by ensuring there is faster flow of information. As a result, farmers will be equipped with valuable information on quality, quantity and prices of fish in the various market outlets.

There is need to create linkages with the fish market in ensuring there is improved trading relationships, improved efficiency as well as reduced post-harvest losses. This would encourage farmers to sell their fish to collector and wholesaler market outlets that offer better prices for fish. In addition, the government and other non-government organizations should organize trainings to fish farmers in an effort to enhance fish marketing. Land ownership was significant in determining whether the farmer can put own cages, ponds or even tanks, thus determining the quantity of fish produced. To increase land ownership among farmers, government should increase provision of title deeds as an incentive to increasing household welfare. Title deeds act as collateral in situations where one need to apply for credit in banks and other financial institutions. In addition, the financial institutions should increase access to credit by reducing requirements for loan applications to allow farmers invest in preservation and storage facilities, research into low cost processing technologies that address quality without moving up the prices of fish. Further, the government needs to pay attention to the needs of the farmers by developing adequate infrastructure facilities, including electricity and construction of railway and good road network.

5.3 Further Research

This study proposed the following areas for further research.

i. To determine farmer profitability under the different market outlets in fish value chain.
ii. To determine the effects of the choice of market outlets on household welfare.

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APPENDICES

Appendix A: Questionnaire

Consent

Hello my name is Jack Odhiambo Malit from Egerton University. I am conducting a survey of the economic activities of people in this area working in the aquaculture sector on behalf of Farm Africa. Participation in this survey is important since your views are important in informing relevant policies and intervention to enhance market access by potential fish farmers engaged in pond-cage-tank production system.

Module 1: Questionnaire Identification

1.1 Name of the enumerator:

1.2 Name of the farmer:

1.3 Mobile number:

1.4 Date:

1.5 Starting time:

1.6 Ending time:

1.7 Name of the county:

Module 2: Farmer characteristics

2.1 Gender of the household head ☐ Male ☐ Female

2..1.1 Gender of the respondent ☐ Male ☐ Female

2.2 Are you a household head ☐ Yes ☐ No

2.2.1 What is your position in the household head

☐ Head ☐ wife

☐ Sibling ☐ others (specify)

2.3 Age of the household head (in years) ……

2.4 What is your highest level of education ……..

None ☐ Prim☐ ☐ndary ☐ry colleges University

2.5 How many years have you spent on your schooling/education?

2.6 How many people have lived in your household for at least 6 months in the last 12 months?

2.6.1. Of these people, how many earn income?

2.6.2 Of these people, how many earn income?

2.7 Do you have any other form of occupation? ☐ Yes ☐ No

2.8 Which year did you start aquaculture farming?

2.9 What is the main reason for engaging in aquafarming?

2.10 Which type of fish do you consider to be the main fish type in your farm?

Tilapines ☐ African Catfish ☐ Rainbow trout ☐

Cyprinus carpio ☐

2.9 Have you had any engagement with Farm Africa?

Module 3: Farm Characteristics

3.1 Do you own land for aquaculture production? ☐ Yes ☐ No

3.2 How much land does your household use for aquaculture production?

3.3 How much land does your household use for crop/livestock production?

3.4 How much did you spend on water for aquaculture production in the last 12 months?

3.5 Have you received extension contacts in the last 12 months? ☐ Yes ☐ No

3.6 How many extension contacts did you have in the last 12 months?

Module 4: Post harvest losses

4.1 How many kilograms of Tilapines did you lose after harvest in the last 12 months?

4.2 How many kilograms of African catfish did you lose after harvest in the last 12 months?

4.3 How many kilograms of Rainbow trout did you lose after harvest in the last 12 months?

4.4 How many kilograms of Cyprinus carpio did you lose after harvest in the last 12 months?

4.7 What was the main reason for post-harvest losses in the last 12 months?

4.8 What did you do with post-harvest losses?

4.9 Please specify other use of post-harvest losses?

Module 5: Sales

5.1 How much Tilapines did you produce in total in the last 12 months in Kilograms?

5.2 How much Tilapines did you sell in total in the last 12 months in Kilograms?

5.2.1 What was the average price per Kilogram of Tilapines sold in Ksh?

5.3 How much African catfish did you produce in total in the last 12 months in Kilograms?

5.4 How much African catfish did you sell in total in the last 12 months in Kilograms?

5.4.1 What was the average price per Kilogram of African catfish sold in Ksh?

5.5 How much Rainbow trout did you produce in total in the last 12 months in Kilograms?

5.6 How much Rainbow trout did you sell in total in the last 12 months in Kilograms?

5.6.1 What was the average price per Kilogram of Rainbow trout sold in Ksh?

5.7 How much Cyprinus carpio did you produce in total in the last 12 months in Kilograms?

5.8 How much Cyprinus carpio did you sell in total in the last 12 months in Kilograms?

5.8.1 What was the average price per Kilogram of Cyprinus carpio sold in Ksh?

Module 6: Buyers

6.1 What is the main type of fish produced in your farm? ☐

6.2 What portion of that harvested fish type produced did you sell in the last 12 months to:

Wholesalers ☐ Retailers ☐

Brokers ☐ Individual Consumers ☐

Module 7: Fish prices

7.1 Of the main fish type produced, what price did you receive per Kilogram from:

Wholesalers ☐ Retailers ☐

Brokers ☐ Individual Consumers ☐

Module 8: Information

8.1 Do you have access to credit? ☐ Yes ☐ No

8.2 Do you have access to value addition? ☐ Yes ☐ No

8.3 Do you have access to extension services related to aquacul☐ ☐Yes No

Module 9: Storage and transportation

9.1 Do you preserve your fish after harvesting? ☐ Yes ☐ No

9.2 How do you preserve your fish after harvesting?

9.3 How much did you spend in preservation in the last 12 months?

9.4 What is the distance from your farm to the fish market?

9.5 How much did you spend in transportation in the last 12 months?

Module 10: Market linkages

10.2 Do you have linkages with feed market? ☐ Yes ☐ No

10.3 Do you have linkages with fish market? ☐ Yes ☐ No

10.4 How many commercial contacts did you have with the fish buyers in the last one year?

Module 11: Membership of organizations

11.1 Are you or your spouse a member of aqua related farmer/cooperative organization?

Yes ☐ No ☐

11.2 Since what year?

11.3 What were your reasons for joining the farmer organization?

11.4 To what other type of organization did you or any of your household member belong?

11.5 What is the total number of organizations you and your household member belong?

Member 12: Alternative sources of income

12.1 Did you or your household have access to income from other farm activities in the last 12 months? Ye☐ N☐

12.1.1 How much income did you get from other farm activities in the last 12 months?

12.2 Did you or your household have access to income from remittances in the last 12 months?

Yes ☐ No ☐

12.2.1 How much income did you get from remittances in the last 12 months?

12.3 Did you or your household have access to income from pensions in the last 12 months?

Yes ☐ No ☐

12.3.1 How much income did you get from pensions in the last 12 months?

12.4 Did you or your household have access to income from on farm activities in the last 12 months? Yes ☐ No ☐

12.4.1 How much income did you get from on farm activities in the last 12 months?

12.5 Did you or your household have access to income from own business in the last 12 months?

Yes ☐ No ☐

12.5.1 How much income did you get from own business in the last 12 months?

12.6 Did you or your household have access to income from off-farm paid labour in the last 12 months? Yes ☐ No ☐

12.6.1 How much income did you get from off-farm paid labour in the last 12 months?

12.7 Did you or your household have access to income from on-farm paid labour in the last 12 months? Yes ☐ No ☐

12.7.1 How much income did you get from on-farm paid labour in the last 12 months?

12.8 Did you or your household have access to income from other income sources in the last 12 months? Yes ☐ No ☐

12.8.1How much income did you get from income from other sources in the last 12 months?

Module 13: Costs

13.1 How much money did you spend in total on sinking pellets in the last 12 months?

13.2 How much money do you spend on floating pellets in the last 12 months?

13.3 How much money did you spend in total on mash in the last 12 months?

13.4 How much money did you spend in total on home-made ratios in the last 12 months?

13.5 How much money did you spend in total on household left overs in the last 12 months?

13.6 How much money did you spend in total on green water in the last 12 months?

13.7 How much money did you spend in total on other feed in the last 12 months?

13.8 How much money did you spend in total on antibiotics in the last 12 months?

13.9 How much money did you spend in total on organic fertilizers in the last 12 months?

13.10 How much money did you spend in total on inorganic fertilizers in the last 12 months?

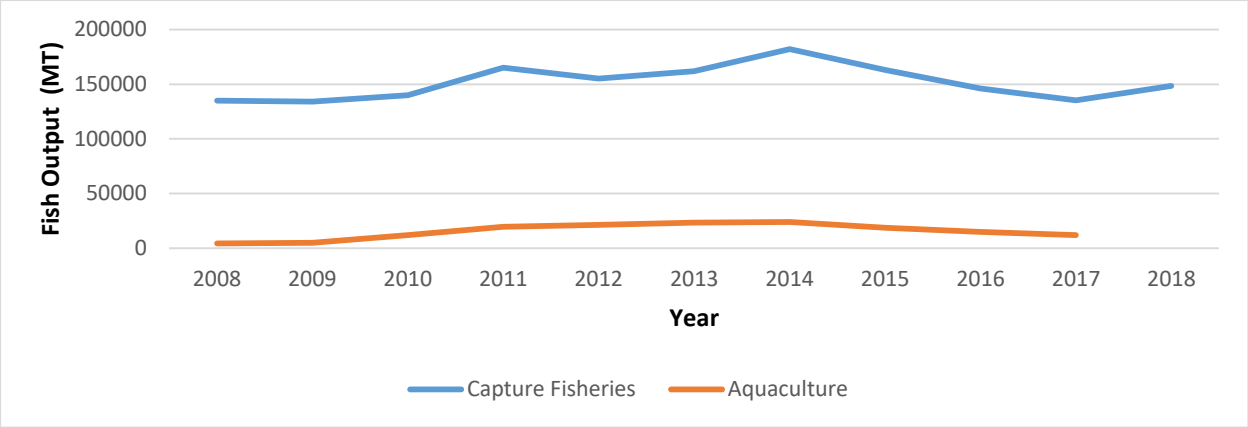
13.11 How much money did you spend in total on anthelminthic agents in the last 12 months?

13.12 How much money did you spend in total on disinfection in the last 12 months?

13.13 How much money did you spend in total on aquaculture production system in the last 12 months?

13.14 What are other costs incurred towards hosted cages in the last 12 months?

Appendix B: Capture fisheries and aquaculture production in Kenya in Metric tonnes



Source: FAO (2020)

Appendix C: Variance Inflation Factor

Variable	VIF	1/VIF
log_landsizeaq	1.53	0.654088
preservation	1.35	0.738075
Experience	1.34	0.743790
Age	1.32	0.757212
Log_quantity	1.24	0.805048
distance	1.18	0.847326
Number of groups	1.17	0.854715
Access to credit	1.14	0.874852
Farmafrica	1.14	0.880700
Household size	1.13	0.881567
Commercial contacts	1.11	0.902640
F_edu	1.11	0.903481
Extension contacts	1.09	0.917087
f_gender	1.09	0.920791
linkfishmarket	1.07	0.930341
Log_altincome	1.07	0.934358
Years_group	1.03	0.967332
Mean VIF	**1.18**	

Appendix D: Post Estimation Tests in Two Stage Least Squares

Tests of endogeneity

Ho: variables are exogenous

Durbin (score) x^2 (1) = 8.93982 (p = 0.0028)

Wu-Hausman F(1,254) = 8.83339 (p = 0.0032)

Tests of over identifying restrictions:

Sargan (score) x^2 (1) = 0 .858405 (p = 0.3542)

Basmann x^2 (1) = 0.819096 (p = 0.3654)

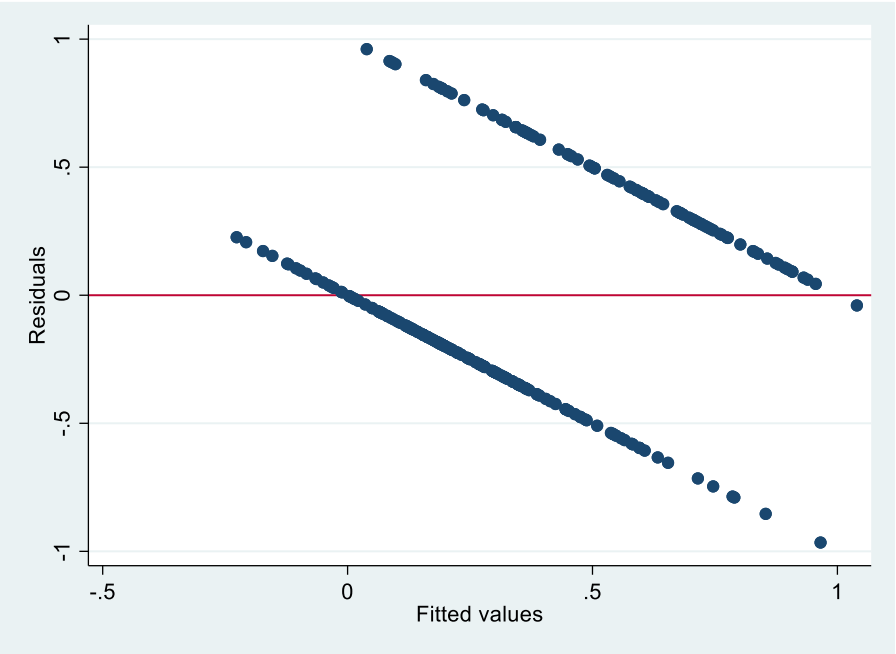
Test of the validity/strength of the instruments

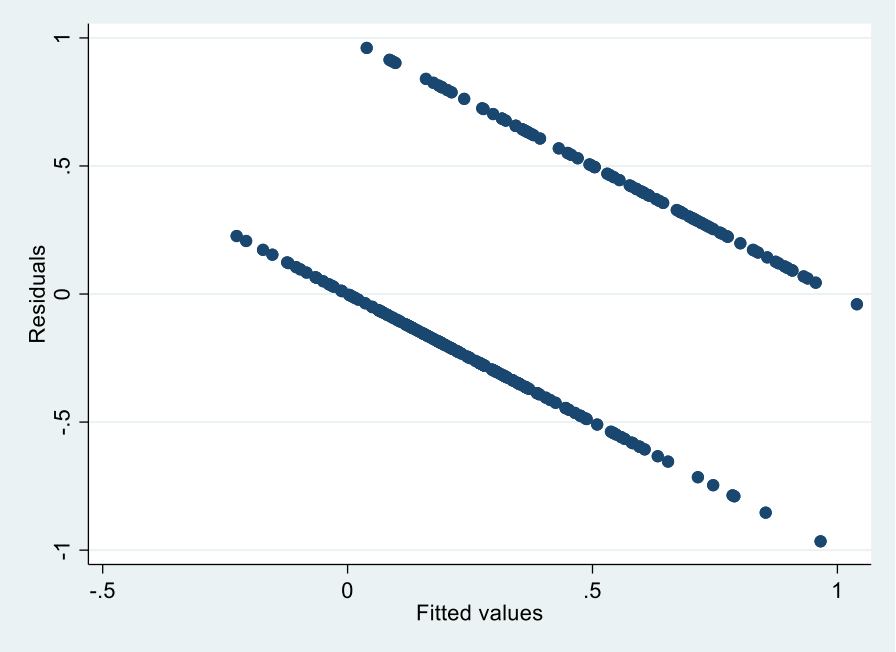
Variable	R-Squared	Adjusted R-Squared	Partial R-Squared	F(2,253)	Prob > F
post-harvestloss	0.2345	0.1982	0.5431	25.69966	0.0038

Minimum eigenvalue statistic = 25.69966

Critical Values	# of endogenous regressors:1			
Ho: Instruments are Weak	# of excluded instruments:2			
2SLS relative bias	5%	10%	20%	30%
		(not available)		
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.93

Appendix E: Tests for Heteroscedasticity





Appendix F: Nacosti Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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Date of Issue: **28/July/2021**

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Appendix G: First Research Publication

Social Networks and the Choice of Market Outlets among Aquafarmers in Kenya

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Abstract

Capture fisheries and aquafarming contribute to improve income and nutrition among producers and consumers of fish, respectively. With the global fluctuation in capture fisheries, attention has been diverted towards aquafarming which has shown an increasing trend in the recent years. Despite this growing trend, the average per capita fish consumption in Kenya is still far below the recommended level. In response, several efforts have been initiated by the government of Kenya towards promoting aquafarming to increase fish production. However, fish marketing has remained unaddressed over the years in Kenya. Social networks play a key role in facilitating marketing through group formation and networking. This paper attempts to analyze fish marketing by determining the effects of social networks on the choice of market outlets among aquafarmers. The paper used primary data which was collected in Nyeri, Siaya, Kiambu, Kirinyaga and Kakamega Counties using semi structured questionnaires on a sample of 300 fish farmers. A multivariate probit model was used in analyzing the effect of social networks on market outlet choices. Fish farmers mainly sold to retailers, consumers, collectors and wholesalers. Results indicated that the number of farmer groups, membership to Farm Africa, number of years in a group and linkages with the fish market affected the choice of market outlets. The paper recommends the need to reduce bureaucracies in group registration as a way of enhancing the benefits that accrue from group marketing. In addition, the paper underscores the importance of extension service, increased training and provision of credit facilities to farmers to enhance fish marketing.

Subject Areas

Economics

Appendix H: Second Research Publication

RAAE

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Acta Oeconomica et Informatica
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REGULAR ARTICLE
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INFLUENCE OF POSTHARVEST LOSSES ON HOUSEHOLD WELFARE AMONG AQUAFARMERS IN KENYA

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ABSTRACT

Research background: The trend in aquafarming has been increasing over the years, thereby meeting the deficit in fish production caused by capture fisheries. Aquafarming is a source of income and food for most Kenyan populations. Despite the increased fish production, postharvest losses in fish production have remained a challenge over the years. These postharvest losses resulted from high transport costs, poor preservation methods, inadequate storage facilities, and poor handling and mismanagement. The postharvest losses result in quality and quantity losses in fish production, thereby affecting the income received by farmers.
Purpose of the article: This paper analyses the effects of postharvest losses on household welfare among aquafarmers in Kenya.
Methods: Primary data was collected in Kiambu, Kirinyaga, Nyeri, Kakamega and Siaya Counties in Kenya. Semi-structured questionnaires were used to collect the data on a sample size of about 300 farmers. This study used a two stage least square was used to analyse the effects of postharvest losses on household welfare. Access to preservation facilities and distance to the market were considered instrumental variables in the model.
Findings & Value added: Results indicated that postharvest losses were negatively significant on household welfare. On the other hand, farmer's age, ownership of land, and the size of land under crop were also significant on household welfare. Due to inaccessible markets, postharvest losses result in to decline in farmers' income, hence welfare loss. The study recommended investment in preservation facilities and road infrastructure to reduce the number of postharvest losses in fish in an attempt to improve the welfare of farmers.

Keywords: aquafarming; household welfare; postharvest loss
JEL Codes: C12; C36; C83