AN ANALYSIS OF FISH FARMING POST ECONOMIC STIMULUS PROGRAM IN KIBWEZI,

MAKUENI COUNTY, KENYA

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DECLARATION

I, Paul Shikoli Wesonga, do declare that this thesis is my original work and has not been submitted to any University for any academic award.

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DEDICATION

This work is dedicated to my children Serina, Breann, Stuart and Byron and my sisters Catherine and the late Judith for their encouragement and unrelenting support to complete the doctoral studies.

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ABBREVIATIONS AND ACRONYMS

ADIS	African Dryland Institute for Sustainability
AFFA	Agriculture Fisheries and Food Authority
ASALs	Arid and Semi-Arid Lands
BCR	Benefit Cost Ratio
CAADP	Comprehensive African Agriculture Development Programme
DALF	Department of Agriculture, Livestock and Fisheries
ESP	Economic Stimulus Program
ESR	Expense Structure Ratio
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GM	Gross Margin
GRR	Gross Revenue Ratio
ILO	International Labour Organization
KIs	Key Informants
KNBS	Kenya National Bureau of Statistics
MALF	Ministry of Agriculture, Livestock and Fisheries
MCFD	Makueni County Fishery Director
MOA	Ministry of Agriculture
MOALFS	Makueni Ministry of Agriculture Livestock and Food Security
NASALP	National Arid and Semi-arid Lands Policy
NEPAD	New Partnership for Africa Development
NR	Net Revenue
ROR	Rate of Return
TC	Total Cost
TR	Total Revenue
SWOT	Strengths, Weaknesses, Opportunities and Threats

ABSTRACT

Communities living in Arid and Semi-arid Lands (ASALs) face many challenges such as poverty, food insecurity and malnutrition, and limited means of livelihoods. This has been worsened by the rapid changing climate that has reduced communities' resilience on pastoral livelihood. One of Kenyan government strategy to pastoral adaptation due to poor livestock returns, increased population settlements and youth unemployment has been the promotion of aquaculture along the permanent rivers of ASALs. This study analyzed the fish farming component of Economic Stimulus Program (ESP) in Kibwezi Makueni County, Kenya. The specific objectives were to: i) analyze the status of the fish farming in Kibwezi, Makueni County, ii) determine factors influencing adoption of fish farming in Kibwezi, iii) determine the profitability of ESP fish farming adopters and, iv) determine the best alternative crop to fish farming system to use water resource in ASALs. To achieve these objectives, a structured questionnaire was administered to 146 ESP farmers, several traders and consumers. A situational analysis identified two major strengths: black clay soils that are good for earth pond development and pond water waste which can be used for irrigation. Weaknesses identified were poor selection of fish pond sites, inappropriate technology (adaptive fish breeds and types) and poor socio-economic status of fish farmers. Opportunities included public-private collaboration in research, infrastructure development, extension services, proximity to permanent rivers and wildlife conflict management. An analysis of the status showed that 46.6 percent of the fish farmers enrolled under ESP promotion (2009-2012) were still practicing fish farming in 2014. Ninety four percent of these farmers practiced tilapia monoculture on a semi intensive system. Females represented 41 percent of the sampled fish farmers. About 95 percent of the ponds were built between 2009 and 2012 with 58.9 percent of them being of the earthen type. The study using descriptive statistics and the Logit model, assessed current 2014 data, and determined the factors influencing adoption of fish farming. The Logit analysis identified distance to fish markets (0.001), education levels of the farmer (0.004), distance to input markets (0.004), group membership (0.012) and age (0.020) of the farmer to significantly influence adoption of fish farming. The study observed a very short value chain because harvested fish was always sold in its fresh form with limited processing. About 27 percent of farmers had an average annual net cash income of Kenya Shillings (KES).24, 707.14. Farmers who stocked at least 5 fish per square metre were profitable. The study found that catfish was the most profitable culture fish and it was a close competitor of tomato production. The study recommends that fisheries extension officers promote fish farming to farmers who are located in areas with black clay soils and close to permanent sources of water. The information from this study may be appropriately used for aquaculture development in Semi and Semi-Arid Lands (ASALs).

Key Words: ASALs, fish farming, profitability, ESP, logit, catfish, tilapia, tomatoes, Kenya

CHAPTER ONE: INTRODUCTION

1.1 Background

Africa's fish production is about 5.7 percent of world total production, that is, aquaculture, catches and landings combined (FAO 2014). In Africa, tilapia and catfish are the fish of choice for farming. Tilapia leads with between 70 to 80 percent of freshwater fish production in Egypt, Namibia, Senegal, Morocco and Uganda, but in Nigeria catfish leads with over 70 percent (Ponzoni, R.W and Nguyen, N.H, 2008). The above-mentioned countries both export and import fish in some form. African fish production levels are well below the demand of the African consumers that rely on local catches to meet their needs (FAO, 2013). According to FAO, 2012, Kenya has a 6.6Kilograms fish per capita consumption compared to 16.6Kilograms for the developed world and 17.7Kilograms for some Asian countries. This implies that as country we are deficient in the consumption of fish, a major source of protein nutrients. Food nutrition insecurity continues to be a major problem in the developing world, specifically Africa (Hecht and Jones, 2009) that had 6.8 Kilograms fish per capita in 2000 (Ronnback *et al.,* 2002).

Aquaculture is the farming of aquatic organisms in inland and coastal areas, involving intervention in the rearing process to enhance production with individual or corporate ownership of the stock being cultivated (Food and Agriculture Organization (FAO), 2005). The two categories of finfish farmed are herbivorous and omnivorous. Herbivorous and omnivorous finfish are defined as fish species that have low protein requirements of less than 20 percent that can be derived from both plant and animal sources (Tacon A and Metian M; 2009). This group includes grass carp, common carp, other cyprinids, tilapias, milk fish and catfish, all of which require around 5 percent fishmeal content in their feeds.

It has been over 100 years since aquaculture was introduced in Kenya, but there are still some fundamental implementation problems, key among them is that no objective studies are done before its introduction in an area (Omondi *et al.*2004). Secondly it is not clear whether the donor programs attain their objective or reach the intended beneficiaries as observed by Maina *et al.* (2012). Kenya exports processed Nile perch and other assorted fish; however, most of the exported fish is not affordable to the majority of the local consumers. Thus there is high demand for affordable fish but limited supply. The Kenyan government promoted aquaculture during the 2009--2012 Economic Stimulus Program (ESP) in 160 constituencies and Kibwezi constituency in Makueni County was among them. The ESP is anchored on the economic pillar of Kenya Vision 2030 (Republic of Kenya (GoK), 2007). The economic pillar has many sectors; among them is the agricultural sector where fisheries are a sub sector, which is part of the vehicle to be used to achieve a national economic growth of 10 percent annually.

1.2 Statement of the Problem

Rural communities are normally challenged by food insecurity and unprofitable livelihood strategy that the government selected fish farming as an alternative   Fish farming was promoted nationwide through the ESP between 2009 and 2012. It was envisaged that fish farming would support food security and increased income especially for ASALs. Kibwezi in Makueni County is one typical area where fish farming was introduced. A couple of years after closing the ESP, the status of fish farming is not known or documented. The adoption after the ESP head start is not known, the profitability or otherwise of the new industry is not documented, and the industry as a complement or supplement of other hitherto alternative crops is not clear.

1.3 Objectives of the Study

The main objective of the study was to evaluate the role of fish farming in Makueni County and generate information for fish enterprise selection for ASALs. The specific objectives were to:

1. analyze the status of fish farming in Kibwezi, Makueni,
2. determine factors influencing adoption of fish farming in Kibwezi, Makueni,
3. determine the profitability of ESP fish farming adopters, and
4. determine the best alternative crop to fish farming in ASALs.

1.4 Research Questions

The following four research questions were answered:

1. What is the status of fish farming in Kibwezi, Makueni?
2. What were the factors influencing adoption of fish farming in Kibwezi, Makueni
3. Was fish farming profitable for adopters in Kibwezi, Makueni?
4. What was the best alternative crop to fish farming in ASALs?

1.5 Justification

The study was important because fish farming has the potential to bridge the gap between wild capture fisheries and fish demands of ever increasing Kenyan population. As the population grows there is need to secure more sources of quality protein foods. Prior to the introduction of ESP, the Kenyan government had signed up with the Comprehensive African Agriculture Development Programme (CAADP). The CAADP was rolled out by New Partnership for Africa Development (NEPAD) in 2002 (NEPAD, 2010) with the main objective of assisting Sub-Saharan countries harmonize their agricultural sector polices to achieve faster economic growth. Membership in CAADP required African countries to commit a minimum of 10 percent of their national budgets into agriculture, which was supposed to raise agricultural growth by at least 6 percent per annum. The overall CAADP's goal was to eradicate hunger and reduce poverty, but according to Randal (2012) CAADP has not be successful. The other program that addressed extreme hunger and poverty was Millennium Development Goals (MDGS) that had promised to halve hunger by 2015 through implementing Target 1 and Target 3 while Target 7- was supposed to ensure environmental sustainability (UN, 2015). The Kenyan Vision 2030 through ESP invested in aquaculture development which was expected to encourage investment along the value chain thus making fish farming a viable commercial venture, but the returns have been minimal (GoK, 2013[a]). The World Bank (2012) estimated that 34.8 percent of the Kenyan people lived below the poverty line (proportional of people whose income is below one US. dollar a day). Goal 3 was to promote gender, equality and empowerment of women had not been met by 2013. Given the foregoing discussion, promotion of fish farming would provide a high protein nutritional value, especially for vulnerable groups such as young children less than 5 years old, pre-school children, expectant and lactating mothers. Secondly it was supposed to stimulate trade, employment of youths and women thus uplifting their economic status above the poverty line. In Kenya, these vulnerable groups are predominantly rural and poor (GOK, 2014) especially in the ASALs. Identified opportunities and constraints along the value chain provided relevant information that takes advantage of good fish farming practices, which will increases aquaculture adoption. Best fish farming practices will lead to profitable operations and sustainable fish enterprises in ASALs. Adoption implies an enterprise is sustainable. Sustainability is considered to consist of viability and profit (benefit). Fish farming is an enterprise that demands huge investments in physical, human and financial capital as noted by Leonard and Blow (2007), thus accounting of ESP public funds is imperative. This study builds on the goals of Kenya Vision

2030 socio-economic pillars and Sustainable Development Goals: Goal 1-eradicate extreme poverty, Goal 2- zero hunger, Goal 5- gender equality and Goal 8- decent work and economic growth (UNDP, 2015). It is hoped that fish farming will be an additional livelihood enterprise for ASALs communities.

1.6 Study Assumptions

The study was carried out with the assumption that all respondents willingly participated and volunteered required information. Secondly, that information given was accurate, and relevant to meet the study objectives. Lastly, the respondents' data would be confidential.

1.7 Organization of the Thesis

This thesis is organized into five chapters. Chapter One: -Introduction; Chapter Two: - Review of the literature; Chapter Three:-Methodology; Chapter Four:-Results and discussion and Chapter Five:-Summary, Conclusions and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of Fish Production

2.1.1 Global Fish Production

According to “The state of world fisheries and aquaculture” (FAO, 2014), projected total global fish production (capture fisheries plus aquaculture) for the year 2015 to be 179 million tonnes compared to 146 million tonnes in 2010 and 131million tonnes in 2000. This means that growth in global fish production has dropped from the annual rate of 2.7 percent during the last decade (1990-2000) to 2.1 percent per year between 2000 and 2010 and to 1.6 percent per year between 2010 and 2015. Global capture production continues to stagnate, while global aquaculture production has been increasing at a slower rate. Out of the 48 million tonnes, increase in total global fish production from 1999/2001 to 2015, 73 percent will come from aquaculture, which was projected to account for 39 percent of global fish production in 2015 (up from 27.5 percent in 1999/2001).

2.1.2 Fish Farming Development in Africa 1900 to 2014

The white settlers introduced fish farming in Sub- Saharan Africa in the 1900s starting with Kenya then spreading to other colonies thereafter (FAO, 2010). Egypt had an already developed aquaculture subsector that still leads in farmed fish production in Africa to date. The White Settlers accelerated fish farming in the late 1940s and during the 1950s especially in Madagascar, Nigeria, Zambia, Ivory Coast (Cote d’Ivoire), Kenya, and Cameroon. Following the wave of independence and self-rule by many African countries, there was a period of neglect in fish farming except for Madagascar, Ghana, Nigeria, Kenya and Cameroon. However, in the period between 1970 and 1980s, fish farming became marginalized in Kenya (MOA, 2009). It then rebounded in 2010s under the Economic Stimulus Program (ESP) of 2009 to 2012 (MOA, 2013).

Many attempts to promote fish farming as a livelihood strategy to address food insecurity and poverty in Africa have had insignificant success. The majority of these fish farming projects were supported by overseas donor funds concerned with poverty reduction and improved national food security in alternative protein sources. The major donor agency is the Food and Agriculture Organization (FAO) of the United Nations in partnership with the respective national governments (FAO, 2010). These Donor agencies had good intentions, but did not involve local stakeholders who face many production constraints in sustaining fish farming as an alternative livelihood strategy. In all, the success rate of fish farming has been low in a majority of the Sub-Saharan African Countries as noted by Jagger and Pender (2001).

2.1.3 Fish Farming in Kenya 1900s to Present

Fish farming was introduced in Kenya by the European Settlers for the purpose of sport fishing at the start of 1900s and it evolved to static water pond culture of Tilapia fish in 1920s, later supplemented by common carp and catfish (Balarin, 1985). Trout was subsequently introduced for stocking in rivers, dams and ponds. The colonialists set up two fish farms in 1948 at the Sagana fish farm (for warm water species) and Kiganjo trout farm (for cold water species). Mari culture was introduced in the late 1970s with the establishment of the Ngomeini Prawn farm as a pilot project. Fish farming in Kenya was made popular in 1960s through the "Eat more fish campaign". The popularity of fish farming dwindled in 1990s and early 2000s until the emergence of the Economic Stimulus Program (ESP) during the period between 2010 and 2012

(GOK, 2009). Both the Vision 2030 and the National Arid and Semi-Arid Lands Policy (NASALP), under the economic pillar, have identified fish farming as one of the agricultural sub- sectors that can contribute towards food security and an alternative dryland livelihood strategy (GOK, 2011). Kenya's annual aquaculture production exceeded 12,000 metric tonnes (Mt) in 2010 (FAO, 2010). The former Ministry of Fisheries Development (MOFD) disaggregated the total of 12,153Mt of fish into: Nile tilapia 9,115Mt, African catfish 2,118Mt and carp 729Mt. These were harvested from 23,478 ESP ponds and 8,399 Non ESP ponds (MOFD, 2010). By 2013, according to the Kenya National Bureau on the Statistics, Kenya's total fish production was 152,711, tonnes of which 23,501 tonnes came from aquaculture (KNBS, 2014) as a result of adopters of the concluded ESP in 2012.

2.1.4 Fish farming in Makueni County

2.1.4.1 Pre-ESP Promotion

Prior to 2009 it is estimated that Makueni had less than 100 fish farmers (MCFD 2014). These farmers had smaller ponds in their homestead and along the permanent river basins. The key farming enterprises in Makueni County were Horticulture, livestock, poultry, sand/quarry mining and subsistence farming of cereal crops like maize and beans (MOA, 2010).

2.1.4.2 During ESP Promotion 2009-2012

The ESP that promoted fish farming in Makueni was implemented in 2009-2011 under the Fish Farming Enterprise Productivity Program (FFEPP). Makueni County has six constituencies and four of them were assigned 300ponds each, remaining two 100 ponds a piece (MOF, 2009). The county had registered 1400 fish farmers of which 316 were in Kibwezi during the ESP subsidized period 2009-2012. Under the ESP, about 140 sub-counties countrywide were each assured of a minimum of 200 constructed fishponds measuring 300square metres. Most of the fish ponds constructed in Makueni County are either earth ponds mainly along the riverbanks of River Kibwezi, or liner ponds mainly at institutions and farmers' homes (MCFD, 2014). The County constructed large earth dams in Mbooni Constituency that were publically stocked with fingerlings. Polyculture practice was done in the large earth dams that are restocked with Nile Tilapia and African Catfish by the County Fishery Department. Local communities or fish farmer groups manage the large earth dams. In the standard ESP fishponds (300 square metres), monoculture was practiced with Nile Tilapia preferred over Catfish. By the end of 2012, a total of 1,586 new fishponds had been constructed with no public hatchery in Makueni County (MOA 2013).

2.1.5 Strength, Weakness, Opportunity and Threats

The strengths, weaknesses, opportunity and threats are commonly referred to as SWOT (Thompson and Strickland, 1993). The strengths and weaknesses focus on the present factors within an industry, while opportunities and threats reflect how the influence of the external environment affects an industry. In this study, fish farming is the targeted industry.

2.1.5.1 Strengths and Opportunities

Strengths and opportunities are the advantages available or can be tapped to improve the operations of an enterprise. Okechi and Jensson (2004) and Olaoye *et al*. (2013) found group membership and being educated were strengths to fish farming. Group membership enables the farmer to share relevant farming information with peers, which enhances his farming skills. Education makes it easier for the farmer to access, read and adopt new technology. In Njagi *et al.* (2013) observed that government subsidies and good policies governing specific agricultural sectors opportunities that stimulated growth. In Kibwezi the government had promoted fish fishing as discussed earlier.

2.1.5.2 Constraints

Constraints can be grouped into weakness or threats. Weaknesses are negative internal factors that affect current operations of the fish enterprise while threats are negative external factors that impact on fish farming. Studies done by Maina (2012) and (Ngugi *et al*.2007) independently identified lack of processing and preservation facilities as the main weaknesses. The same authors also found that high feed cost, inadequate extension services, poor quality fingerling and limited credit access were the key threats to fish farming.

2.2.6 Fish Farming Systems

There are four types of fish farming systems as follows: extensive, semi-intensive, intensive and integrated used in aquaculture. Extensive fish farming uses little or no input during the production stage. In Kibwezi, fingerlings are stocked in ponds, dams, or public water reservoirs and left to fend for themselves on available natural foods. Both low stocking densities characterize this farming and harvest yields. In Kenya, tilapia and catfish form the highest percentage of the stocked fish type with postharvest average yield of between 500 to 1500 kilograms per hectare per year (Maina, 2012). Small-scale fish farmers in Makueni County normally are in this category because they lack the ability to secure credit to finance large scale or intensive fish farming operation

Semi intensive fish farming system is where water is channeled or pumped into various forms of ponds (earthen, liner or concrete) and used as holding units for fish production. There is some use of fertilizers and lime added in the ponds to stimulate natural productivity and to buffer pond water pH. Supplementary feeds like floating cereal bran and fish feed is always incorporated into the production systems. According to Mbugua, (2002), annual average harvest yield from this system ranges between 0.5 to 1.5 Kilograms of fish per square metre for six to nine months. Intensive fish farming is where key inputs, that is, financial resources coupled with managerial co-ordination, are practiced on the fish farm. It requires a lot of quality water to maintain the necessary oxygen levels for the fish. Thus it is done best in ponds that have flow-through water pathways. Available land occupied by pond area is fully utilized. Intensive fish farming uses raceways, floating cages and various types of ponds/tanks as holding units. The farmer monitors fish health, diseases, parasites, and predators and takes appropriate measures to counteract the problem. Every effort is made to ensure that fish are fed properly with supplementary feeds, harvested at the right time and disposed of in a coordinated manner. These types of operations are associated with high value fish production like trout farming. Depending on management coordination by the individual farmers, it can produce between 10 to 50 kilograms per square metre per year (FAO, 2010). No farmer in Kibwezi was observed or documented using this system.

Integrated fish farming is where unusable by products of livestock/crop enterprises are recycled into other enterprises thus maximizing both the economic and ecological returns of all enterprises. Lightfoot and Noble (1993) and Lightfoot and Pullin (1995) found that small scale integrated farming systems are more efficient at converting feeds into fishmeal and produce fewer negative environmental impacts than purely commercial fish farms. Prein (2002) concurs with the above authors where his studies showed that combination of fish farming with crop and livestock production in integrated agriculture is a more sustainable agricultural model for small holders in developing countries. In Kibwezi use of pond water waste and use of livestock byproducts was a common feature of fish farming.

2.2 Factors influencing adoption of fish farming

A number of socio-economic and cultural factors can influence profitability of fish farming such as age, sex, capital (physical, human, financial) and marital status, as noted in the following studies: Jean *et al.*(2004), Okechi (2004), Munyala (2011), Ukoha (2010), Jagger*et al.* (2001) and Asmah (2008).

2.2.1 Age

Studies by Olowosegun *et al.* (2004) and Olaoye *et al.* (2013) in Nigeria have shown that majority of fish farmers are in the two age brackets of 31to 40 years and 41 to 50 years. This is because the 31 to 50 years bracket is considered the most productive and economically active age bracket. The above is supported by recent studies in Kenya by Maina *et al.* (2014) that found that 49.7 per cent of the fish farmers are within age bracket of 30-50 years.

2.2.2 Gender and Marital Status

Gender plays a significant role in fish farming as noted by Brummett *et al.* (2010) studies which indicated that it is a male dominated enterprise. Other studies (Ekong, 2003; Fayoya, 2000; and Oladoja *et al.*, 2008) note that it is an enterprise mainly engaged in by married people.

2.2.3 Education

On education, Olaoye *et al.* (2013) asserts that fish farming is dominated by an educated elite class as evidenced in his study done in Oyo State, Nigeria where 87.3 percent of the fish farmers had at least a tertiary education. Generally, fish farming requires a vast knowledge of both technical and scientific nature for the enterprise to be successful.

2.2.4 Value Chain of Fish Farming

A value chain can be defined as the full range of activities, which are required to bring a product or service from conception, through the different phases of production, delivery to final customers, and final disposal after use (Kaplinsky and Ponder2001). The chain actors who actually transact a particular product as it moves through the value chain include input suppliers (e.g. land, fingerlings, feeds, fertilizers, labour, water and irrigation), farmers, traders, processors, transporters, wholesalers, retailers and final consumers (Hellin and Meijer, 2006). In this thesis, fish value chain actors consisted of input suppliers, farmers, processors, traders and consumers. Studies on fish marketing by FAO (2010), Amadiva *et al.* (2010), Okechi and Jensson(2004) indicated that most of small-scale fish farmers’ harvests are sold at the farm gates or ponds with buyers being private individuals and institutions (schools, eating places) within the vicinity. They are characterized by few unreliable outputs and limited storage facilities, which result in very low incomes for their fish harvest. Also the farmed fish market chain is very short with fish farmers facing either producers –consumer or producer- retailer –consumer scenario (Ngugi *et al.*, 2007 and Amadiva *et al.*, 2010).

2.2.5 Theory of adoption and diffusion

Diffusion theory is a standard way of communication strategy in spreading innovation Rogers, 1983). The theory explains the process by which a new idea or practice is communicated through certain channels over time among members of a social system (Beal *et al.* 1955). It describes that different people adopt or reject an innovation depending on various factors such as the relative advantage, complexity of the innovation, trial-ability, observability and time. The theory explains that some people will accept an innovation or technology while others will not. This is because the fraction adopting an innovation is approximately normally distributed as in Figure 2.1and more often they are found in social groupings. Diffusion is a special type of communication in which a new idea or new product is accepted by the market.

According to this theory the process of diffusion takes an S-shaped curve since some innovations have slower rates of adoption than others. Thus classical diffusion model developed by Beal *et al.* (1955) in the early 1950s had five stages of adoption process: awareness, interest, evaluation, trial and adoption. Rogers added a “confirmation” stage following adoption (Rogers and Shoemaker, 1971) and a “re-innovation” stage between adoption and confirmation in his 1983 and 1995 books (Rogers 1983, 1995). The classical 1954 diffusion model noted differences that made people adopt innovations at difference time span and utilize varying amounts and sources of information Several scientists (Beal and Rogers (1954), Rogers (1954), Bohlen (1959) and Moore (1999). conceptualized adoption into five categories of adopters that were assigned a percentage share: Innovators (first 2.5%), early adopter (next 13.5%), early majority (next 34%), late majority (next 34%) and late adopters or laggards (last 10%) as show in figure 2.1

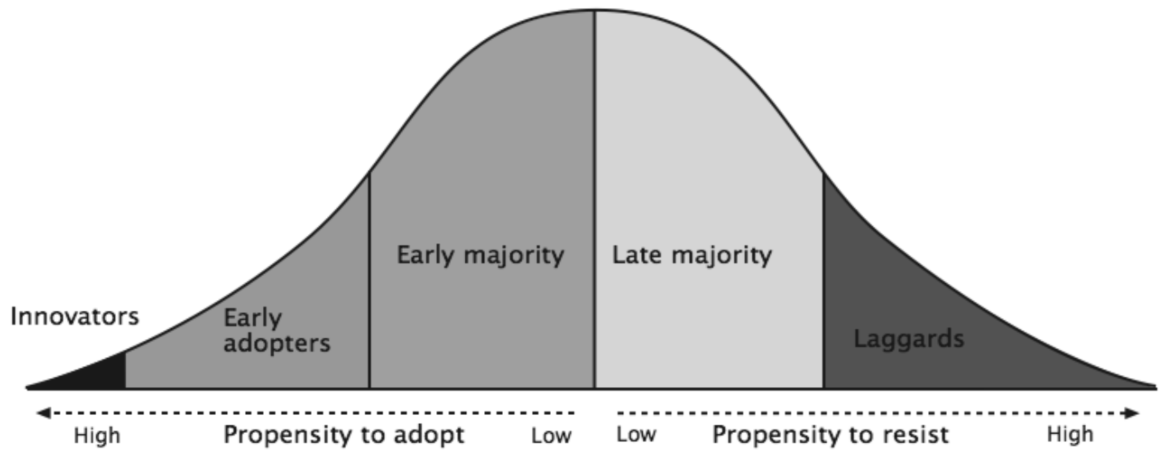


Figure 2.1: Adoption of innovation groups. Source: Rogers, (1999).

Adoption rate is the relative speed with which members of a social system adopt an innovation. It is normally measured as the number of individuals who adopt a new idea in a specified period such as a year (Rogers, 2003).

2.3 Profitability of Fish Farming

2.3.1 Profitability of Fish Farming

Most of the fish farming studies in Africa have been in high potential areas (Asimal *et al.* (2010), FAO (2013), Engle *et al.* (2009) and Jagger and Pender (2001) where water is not a problem. These studies found that water availability and accessibility had a positive impact on survival rates and profitability of fish farming. Access and availability to funding sources studies by

Ukoha (2010) in Abia State in Nigeria showed that it had a positive input to fish farming. This finding confers with Adewinyi *et al.* (2010) study done in Ogoni State, Nigeria.

When net fish income is not sufficient for reinvestment in the fish farming enterprise, it is considered unprofitable. For the venture to be considered profitable, the net income must also cater for basic households' consumption and saving needed. The main goal of starting an enterprise is to realize a profit or gains. This applies to all forms of enterprises inclusive of fish farming. When dealing with fish farming enterprise, diligent management of biological aspects of production is very critical, so are the economic and financial aspects of the fish farming. A researcher must analyze the viability of the proposed fish enterprise and continue to monitor the enterprises' financial health from initiation to the final market. Net Fish Income (NFI), Gross Margin (GM) and profitability ratios will be used to compare the costs and returns of the fish enterprise among the adopters and non-adopters farmers and also to compare profitability from an alternative enterprise (Tomatoes) in the study area.

2.3.2 Financial Records and Statements

Records play an important part of ensuring that objective accounts of all farm activities are documented for business, regulatory and future uses. For business purpose, a farmer needs both costs and revenues of any given enterprise to enable him to determine his profitability.

There are four types of financial records (Engle, 2009) as follows: cash flow budgets, enterprise budget, income statement and balance sheet. Each statement meets certain needs of operating the enterprise. Enterprise budgets normally provide projected estimate details of the overall profitability of the operation, while cash flow budget seeks to show the enterprise's ability to make payments when due. Income statement shows the picture of profit or losses of an enterprise over a given time period, this could be monthly, quarterly, semi-annual, or annually. In a fish farming case, monthly, quarterly and semi-annual income statements will be appropriate periods. This is because most of the farmed fish are harvested after six months in Kenyan warmer zones that include; ASALs, Lake Victoria basin and Coast. The monthly income statement guides the farmer in monitoring his expenses against the projected harvest revenue. Lastly, the balance sheet summarizes the capital position and solvency of the business, which highlights ones' net worth. In this study, we used the income statement records since we sought to determine the profitability of fish farming over a given year.

2.3.3 Gross Margin (GM)

Gross margin (GM) for fish farming is the difference between the Gross Fish farming Income (GFI) and the Total Variable Cost (TVC) of fish farming.

Therefore; GM = GFI – TVC

Where: GM = Gross Margin for fish farming

GFI = Gross Fish farming Income

TVC = Total Variable Cost of fish farming

2.3.4 Net fish income (NFI)

Net Fish Income (NFI) gives an overall level of profitability of the fish enterprise.

Therefore; NFI = TR - TC

Where: TR = Total fish revenue

TC = Total fish farming Cost

The net fish income and profit will be used interchangeably to mean the net cash income derived from the fish enterprise.

2.3.5 Profitability Ratios

Profitability ratios are normally used to assess a business's ability to generate revenues and returns compared with its expenses and other relevant costs incurred during a specific period. When these ratios are higher than a competitor's ratio or than the company's ratio from a previous period, this is a sign that the company is doing well (Okwu and Acheneje, 2011). The profitability ratios such as: Benefit cost ratio or analysis (BCR), and profit cost ratio (PCR) are used to measure profitability.

Benefit Cost analysis is the term that either refers to helping to appraise, or assess the case for a project, program or policy proposal before making economic decisions of any kind (Olukosi and Erhabor, 1989). From the above definition, the process involves, whether explicitly or implicitly, weighing the total expected costs against the total expected benefits of one or more actions in order to choose the best or most profitable option.

2.3.6 Profitability and Viability of Fish Farming

The goal of any farmer or entrepreneur is to have a Benefit Cost Ratio (BCR) greater than one since it implies that the enterprise is profitable. Studies done in Nigeria by Olagunji *et al.* (2007) and Emokaro and Ekunwe (2009) show that most fish farming enterprises are profitable in that country. Studies done in Kenya by Amadiva *et al.*(2010) show a decimal profitability amongst small scale farmers.. Asmah (2008) analyzed the development potential and financial viability of Ghana aquaculture and found that a majority of commercial farmers' enterprises were profitable, while most subsistence fish farmers in high potential areas were unprofitable. The study noted that aquaculture was hampered by cost of feeds and fingerlings, lack of technical knowhow and poor management practices among non-commercial farmers. Studies on tilapia farming, a comparison of enterprise profitability between Ashanti and BrongAfhafo regions by Asimah *et al.* (2010) showed that farmers who constructed their own ponds and used supplementary feeds had a higher positive net profit.

2.4 Fish farming as an Alternative Livelihood Option

2.4.1 Livelihood

Livelihood is a means by which a household secures a living, which includes doing one or a variety of enterprises. Conway (2011) distinguishes what household livelihood is between developed countries and developing countries as noted below: In developed countries, it normally is a mix of one or two adults working for an employer at set remuneration package. In the developing countries, a livelihood consists of a range of production and income generating opportunities on and off their farm. Rural communities are normally confronted with a lot of uncertainties, food insecurity and harsh living climatic conditions that governments or donor assistance and family remittance is a major component of their survival strategy. Here, disasters occur frequently such that the government is always seeking out programs that can sustain resilience of alternative livelihood strategy. It is on the above premise that aquaculture was being promoted through the Economic Stimulus Program between 2009 and 2012.

2.4.2 Tomatoes

Makueni has diverse farming activities that include agricultural crops, livestock and fishery Tomato accounted for 6.72% of the total Kenyan horticultural crops (GoK, 2012). Makueni annual tomato production was 17,552 Metric tons in 2012 mostly grown using open field production system (HCDA, 2013). In determining an enabling environment for fish farming a costs and returns' comparison of fish farming with tomato farming was done. According to the Government of Kenya (GOK, 2009), the national average tomato production per hectare is 30.7

Metric tons. Average tomato production per hectares assumes two cycles of planting and a farmer maximizes on the utilization of recommended inputs. Makunike (2007) found out that one plant in a greenhouse has the potential of yielding 15 Kilograms (Kgs) at first harvest with a maximum potential of 60 Kgs at the end of one year. Six tomato varieties commonly grown in Kenya are Romana V F, Cal J, Onyx, Beauty, Money Maker and Anna F1 (KARI, 2007). In Makueni county Onyx, Cal J and Money Maker dominate the tomato produced due to their adaptability to the warmer climate (MOA, 2012). Onyx is preferred by farmers due to its added advantages of being a high yielder, longer shelf life and resistant to diseases/pests (Waiganjo *et al*, 2006). Based on Ricks' (1995) studies, best conditions for tomato production are as follow: low to medium rainfall or irrigation. Tomatoes are sensitive to frost and are easily killed by freezing temperatures. Wet conditions increases disease attack chances to tomatoes. Tomato grows well in a wide variety of soils with high organic matters, well drained and with a PH range of 5-7.5. Tomatoes require optima pollination temperatures of 20-24 degrees centigrade (night); and 15-35 degrees centigrade during the day. These ideal tomato growing climatic conditions is supported by a study lead by Musyoki (2005). Tomatoes provide vitamins C and A, can be eaten fresh or processed (CABI, 2005). Three major techniques used to determine comparative farm enterprise profitability are gross margin, budget analysis and return per unit input. These techniques are common partial measures selected although they do not follow the law of diminishing returns to scale (Whittaker *et al*, 1995). In this study, gross margin (GM) was used due to its simplicity and flexibility in determining enterprise profitability. Whittaker *et a*l, 1995 further stipulate that gross margin relies on a number of assumption that farmers used different production and technology; the sale price used were those current during the production period for each of the farm enterprise for each operator.

2.5 Conceptual Framework

The fish farmer has two options of either selling directly to consumers or traders. Fish sold at farm gate to consumers can be unprocessed or fried. Traders normally work from markets that involve processors, brokers, wholesalers and hawkers that deal with consumers. The consumer's demand influences the total revenue obtained from the fish farming enterprise.

The framework in Figure 2.2 below shows sustainability of the fish farming as a dependent variable on markets and consumers.

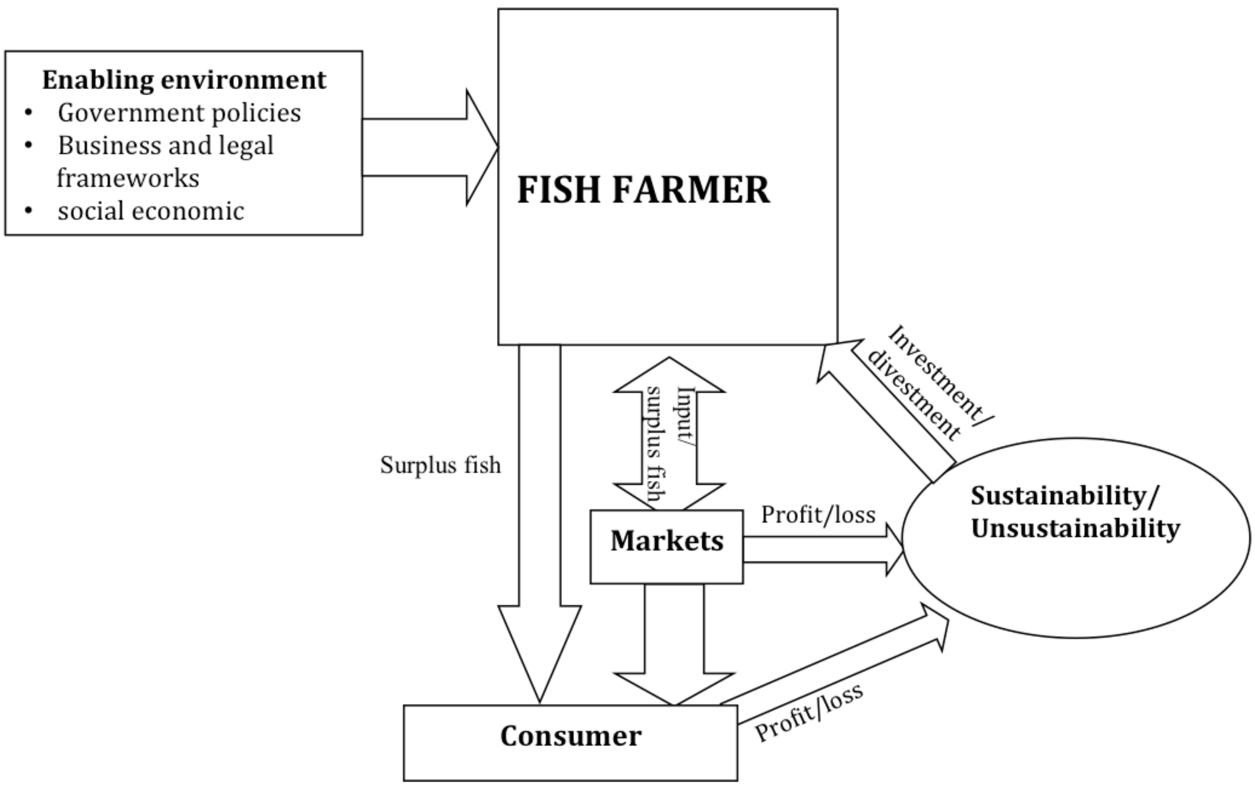


Figure 2.2: Conceptual framework showing value chain and sustainability of fish
Source: Author, 2015

The surplus traded in the markets as shown in figure 2.2 of the conceptual framework determined the profit or loss. The costs of production include; cost of labor inputs, units of feeds, land under fish farming, purchasing of fish stock, and cost of disease control. Government policies, political, business, and legal framework will impact on the costs of production.

CHAPTER THREE: METHODOLOGY

3.1 Study Area

Makueni County is located in the Eastern region of Kenya. The County borders Kitui to the East, Machakos to the North, Kajiado to the West and TaitaTaveta to the south. The County was formerly called the larger Makueni District. It is comprised of 9 Sub Counties which include: Makueni, Kathonzweni, Mbooni East, Mbooni west, Nzaui, Mukaa, Kilungu, Makindu and

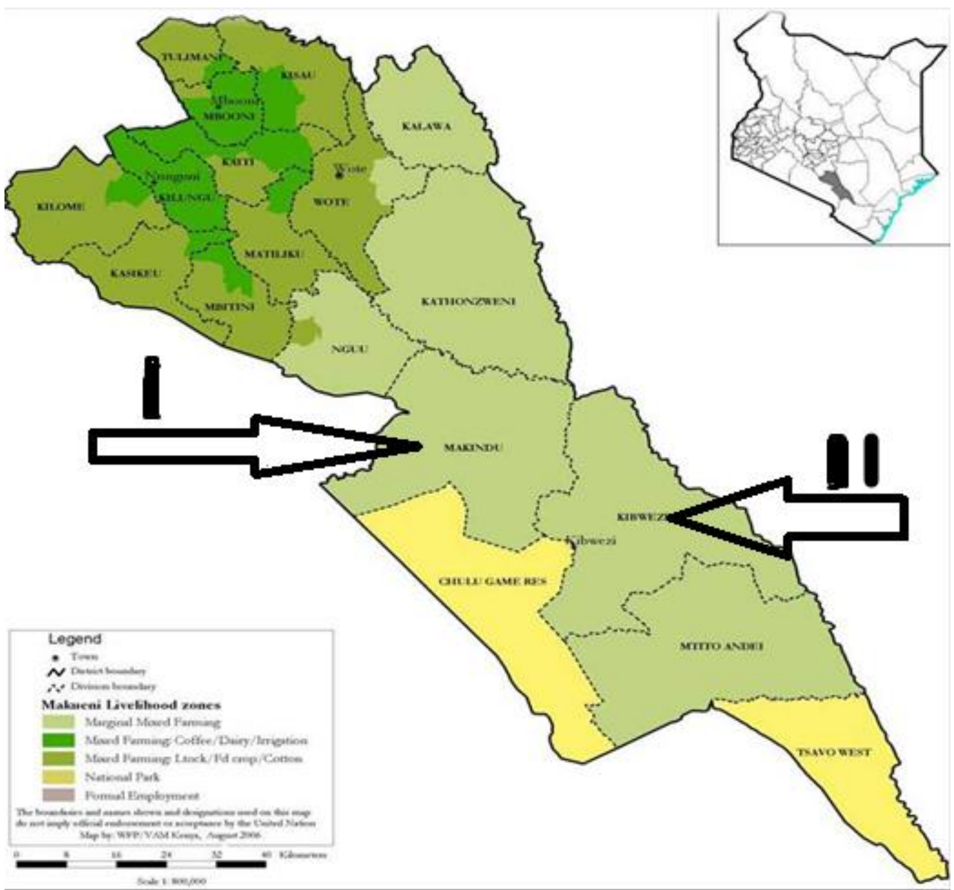


Figure 3.1: Map of Makueni County, Kenya, Showing the Study Area (KNBS, 2014)

Kibwezi. The County's population was 961,738 consisting of 468,298 males and 493,400 females (KNBS, 2014). This is an increase from 887,253 persons as per 2009 population census

(KNBS, 2009) and an annual population growth rate of 1.4 percent, while the male to female ratio stands at 1:1.05. The area is mainly arid to semi-arid and experiences a bimodal rainfall pattern. The annual rainfall is bimodal with the short rains occurring in October-December and the long rains in March-May. The annual precipitation ranges from 200 to 600mm in the lower parts and 1340 to 1900mm in the upper parts. Based on Makueni County Department of Agriculture, Livestock and Fisheries (MALF, 2013) the crops grown in Makueni can be classified into five categories: industrial (cotton, coffee and sisal); cereal (maize, sorghum and millets); pulses (beans, pigeon peas, green grams, dolichos lab and cowpeas); root (sweet potatoes, cassava) and horticultural crops (mangoes, tomatoes, oranges, kale). Residents in the dryland areas of Makueni have traditionally kept cattle, sheep and goats as part of their livelihood assets. A majority of crop farmers also practice livestock farming. Aquaculture is an emerging enterprise for those farmers who have access to sufficient water (MCFD, 2013). The study was done in the larger Kibwezi that consists of Makindu and Kibwezi East Sub- Counties marked I and II respectively in Figure 3.1 of Makueni County. Larger Kibwezi was taken as a representative sample of the fish farmers in the County.

3.2 Research Design, Sampling and Data Collection Methods

This study used a cross-sectional (qualitative and quantitative) research design. The data collection process consisted of two main phases. The first phase was qualitative interviews with key informants selected from stockholders involved in fish farming. The descriptive research enables the researcher to study a small part of the population and make general observations on the entire population (Cooper and Schindler, 2006). The quantitative data analysis technique was used to obtain results about variable relationships. This method allows flexibility in the data collection process and use of questionnaire as the main instrument.

3.2.1 Target Population

The target population of the study was a "whole" from which the sample was picked. The target population included registered fish farmers, and key actors of the fish value chain. This study focused on fish farming, and therefore 1225 beneficiaries of Economic Stimulus Programme (ESP) formed the farmer target population of which 316 were in Kibwezi. The study also targeted representatives of fish chain actors that included input suppliers, processors, traders and consumers along the value chain.

3.2.2 Desired Sample Size

To determine a representative sample size for active and inactive fish farmers, Cochran (1963) formula for cross sectional studies was used. The formula is presented as follows:-

i) $n_o = z^2pq/d^2$

Where

n_0 = Minimum sample size

z = standard deviation (1.96) which corresponds to 95% confidence level

p= Expected probability of success.

q = 1- p

d = Degree of desired accuracy set at 0.05 significance level

$n_o = 1.96^2 \text{ X}0.1 \text{ X}0.9 / 0.05^2 = 138.2976$

$n_o = 139$

3.3 Sampling Procedures

Due to limited resources, purposive sampling was used to select two sub-Counties; Makindu and Kibwezi East out of the six sub-counties in Makueni. The study used both focus group discussion (FGD) and household questionnaires to acquire primary data from respondents while secondary data were obtained from Food and Agriculture Organization, government agencies and related scholarly journals.

Total sample size of the study was 335 representing different actors and the breakdown of respondents for each value chain actor that were interviewedwas as follows:

1. Key Informants (KI): Officials of Aquaculture association of Kenya (3), National Interior Ministry (5) and Makueni County Department of Agriculture, Livestock and Fisheries (MALF) (16) were purposively selected. These groups of KI were individually interviewed.
2. Focus group discussion (FGD): Fisheries officials (6) purposively selected at Wote (Makueni County Headquarters) and Fish farmers (9) randomly selected from Kibwezi.
3. Fish Farmers: Purposive sampling (Makueni/Kibwezi), Stratification (active/inactive). Cochran formula used (active or inactive), systematic sampling. (146).
4. Input Suppliers were purposively selected from fish farmers' feedback (6).
5. Processors were purposively selected from fish farmers' feedback (5).
6. Traders: The population was made up of all fish traders (wholesalers, brokers, retailers, eating places) who are stationed in selected Kibwezi towns (purposive) and those who frequent those towns during market day (19).
7. Consumers: simple random sampling was used to select 120 respondents that interacted with the sampled traders.
8. Purposive sampling to select farmer code 107 who provided six earth ponds and three plots each measuring 500 square metres that were used by the Researcher for the comparison between tomato and fish enterprises. The selection of farmer code 107 was

based on their financial ability to provide 70 percent of budgeted total cost for the trial experiments. The Researcher provided 30 percent of total costs

3.4 Data Sources

3.4.1 Primary Sources

Sources of primary data were observations, focus group discussions and interviews conducted in a field survey by use of questionnaires. The questionnaires were researcher administered with the assistance of trained enumerators for the various stakeholders: Input suppliers, key informants, fish farmers, processors, traders, intermediaries and consumers. Information needed to achieve the four objectives was captured by these questionnaires.

3.4.2 Secondary Sources

The main sources of secondary information were relevant journals, and books on aquaculture and fish value chain in drylands background information on the area of study. Other secondary data sources were Government of Kenya (GOK) ESP proposals, Ministry of Agriculture Livestock and Fisheries (MALF), FAO publications and previous surveys.

3.5 Methods of Data Collection

Gathering of primary data sources relied on quantitative methods and use of questionnaires or guide. Using purposive sampling, 18 key informants were interviewed and two focus group discussions (FGD). Key Informant questionnaire (Appendix 2) and FGD guide (Appendix 3) were used to facilitate discussion. The Focus Group Discussion(FGD) were divided into two groups: County agriculture officials and selected Kibwezi fish farmers. The county agricultural officials FGD was done at Wote on 11th September, 2014, while that of selected Kibwezi fish Farmers was done at Makindu on 12th September, 2014.

Profitability data were collected in February and March 2015 using semi-structure questionnaires administered to the respondents. The collected primary data included the cost of production and income generated from the sale of the fish. Regarding the amount of funds utilized by the government to support the projects secondary data were acquired from the government official records.

3.5.1 Data Analysis

Objective 1:To determine the status of fish farming in Kibwezi, Makueni: Descriptive and situational analyses were done. Frequencies, percentages and cross tabulations were used.

Objective 2:To determine factors influencing adoption of fish farming along the value chain in Kibwezi, Makindu. The collected data were analyzed using Statistical Package for Social Sciences (SPSS 22). The data were then subjected to a descriptive statistical analysis. Information on fish farmers' social and economic status was summarized in terms of central tendencies, frequency tables and cross tabulations. A binary logistic regression model was used. A logistic regression was run to infer the factors that influence fish farming in Kibwezi, Makueni County. Discrete choice models have been applied widely in analysis of socio-economic factors in agricultural activities. Studies on adoption have addressed various technologies including crop varieties and livestock breeds (Candel and Chakor, 1998; Kimenye, 2001). One of the weakness of discrete choice models is a possible loss of information if a binary variable is used as a dependent variable (Lynne, et al., 1988). The choice to adopt fish farming is a dichotomous dependent variable. The cumulative distribution function for a logistic random variable is given by Hill *et al.* (2008) as shown in Equation 1, Because the dependent variable lies between 0 and 1, the model is identified within a logit framework and maximum likelihood estimator is used in estimation (Kmenta, 1986).

The idea is to capture the effect of the change in the variable on the dependent variable, a decomposition can be done as follows: Two parts 1) the change in probability of the expected level of adoption of fish farming and 2) change in the elasticity of the probability of those farmers already in Economic Stimulus Programme (ESP) programme. Each of the terms can be evaluated at some value $X\beta_i$, usually at the means of the Xs.

Equation 1

$$(l) = P[L \leq l] = \frac{1}{1+e^{-1}}$$

The probability of fish farming adoption lies between 0 and 1.

$$Adoption\ of\ fish\ farming = \begin{cases} 1\ If\ a\ farmer\ an\ adopter \\ 0\ If\ a\ farmer\ is\ a\ non\ adopter \end{cases}$$

Probability that the observed value of Y takes the value of 1 given by Equation 2

Equation 2

$$P_j = \frac{1}{1 - e^{-\beta_0 + \beta_i X_i}} = \frac{\exp(\beta_0 + \beta_i X_i)}{1 + \exp(\beta_0 + \beta_i X_i)}$$

Where:

P_j=Probability of fish farming adoption

β_0 = Maximum likelihood estimate of the constant term

β_i =Maximum likelihood estimates of the parameters

X_i= Explanatory variables (AGE, GENDER, MSTATUS, EDUC, INCSOURC, MEMSP, CREDIT, EXTVT, FISHMKT, INPUTMKT). The probability that the observed value of Y=0 is given by Equation 3

Equation 3

$$1 - P_j = \frac{1}{1 + \exp(\beta_0 + \beta_i X_i)}$$

Where:

P_j=Probability of fish farming adoption

β_0 = Maximum likelihood estimate of the constant term

β_i =Maximum likelihood estimates of the parameters

X_i=Explanatory variables (AGE, GENDER, MSTATUS, EDUC,MLIHOOD, MEMSP, CREDIT, EXTVT, FISHMKT, INPUTMKT).

Logistic regression model is thus given by Equation 4

Equation 4

$P_j = \beta_0 + \beta_i X_i$

Where:

P_j=Probability of fish farming adoption

β_0 = Maximum likelihood estimate of the constant term

β_i =Maximum likelihood estimates of the parameters

X_i=Explanatory variables (AGE, GENDER, MSTATUS, EDUC, MLIHOOD, MEMSP, CREDIT, EXTVT, FISHMKT, INPUTMKT).

Variables used in the Logit Model

Age (AGE)

Fish farmers' age is expected to have an impact on his labor supply for fish production. AGE is also expected to have an impact to seek and secure off-jobs, which could increase the farmers' income. Younger people are stronger and are expected to be more productive than older people. The expected effect of AGE on adoption could be positive or negative.

Gender (GENDER)

The GENDER of the fish farmer is expected to have an impact on his ability to seek and secure an employment, it is presumed that males physically and are less discriminated in employment decisions than females. Male=1, female=0. The expected effect on adoption could be positive or negative.

Marital status (MSTATUS)

When married, it implies two adults in a household who are assumed to be working as team. A spouse could assist in fish production activities. Married=1, single=0. Expected effect on adoption is positive.

Education (EDUC)

Education is a social human capital which could impact positively on a farmers' ability to take good and informed production and technological decisions. Education levels fall in two: diploma and above=1, below diploma level=0. The expected effect on adoption is positive.

Main livelihood (MLIHOOD)

This is the primary occupation of the household head than it can be either salaried employment or self-employment. The earnings from this engagement could be used to boost investment in fish farming. The expected effect of MLIHOOD on adoption of fish farming is positive.

Membership group (MEMSP)

Societies or cooperatives are a vehicle of economic development for rural communities. Access to loans is dependent on membership of the society and it is expected that credit accessibility should increase the adoption. Membership=1, non-membership=0. The expected effect on adoption is positive.

Credit (CREDIT)

This is the ability of a fish farmer to obtain credit to invest in the fish operation. This could be from relatives, friends, cooperatives, banks, and government agencies. Accessibility to CREDIT could increase a farmers' ability to invest in fish farming. Farmers that had access to investment credit in the last year were coded=1, no access to credit=0. Expected effect on adoption of fish farming is positive.

Extension visit (EXTVT)

They number of contacts or visits an extension officer had with the farmer. It is postulated that high frequency contacts between the fish farmer and extension officer could increase uptake of new technology. The expected effect on adoption is positive.

Distance to fish market (FISHMKT)

Fish is a perishable product that requires delicate handling, thus markets that are local to the fish farmers are desirable given the absence of postharvest refrigeration facilities. Regional markets are less desirable since the farmer has to invest freight costs. Local=1, Regional=0. Expected effect on adoption can be positive or negative.

Distance to input supplier markets (INPUTMKT)

How far the distance of input suppliers is from the fish farmers' operation will determine a farmers' production cost in securing supplies for their operation. When input suppliers are close to the operation, it is cost effective to procure supplies. Input suppliers located in the county=1, input suppliers located outside the county=0. Expected effect on adoption could be positive or negative.

Objective 3: To determine the profitability of ESP fish farming adopters (positive deviants)

Primary data from the Fish farmers' questionnaire (appendix 5) section dealing with the Revenues and costs of fish farming was used. The quantitative analysis used gross margins, net fish income, benefit-cost ratio and profit analysis. Data on the Profit and Loss statement section of the questionnaire was entered and analyzed using Excel 2007 to get total revenue (TR), total variable costs (TVC), gross margins (GM), total fixed cost (TFC), total cost (TC), net cash income and net fish income (NFI).Total revenue was all income derived from the fish operation (tilapia sales, catfish sales and other fish related sales). Total variable costs were fingerlings, feeds, fertilizer, lime, labor, dyke/levee repairs and security personnel. Total fixed costs consisted of pond construction costs, management costs, interest paid on loans and pond lease costs where applicable. Total cost was the, sum of TVC and TFC. Net cash fish income was the difference between TR and TC. Net fish income was the difference between net cash income and loss on machinery of the water pump. Gross margin (GM) for fish farming was the difference between the total revenue (TR) and the total variable cost (TVC) of fish farming (GM = TR – TVC) while the gross margin ratio (GMR) is gross margin divided by total revenue (TR-TVC)/TR. A ratio of 0.35 or higher is considered desirable (Olasunkami, 2012).In profit analysis, Profit was the positive difference between total revenue and total cost of the fish enterprise (Profit = TR – TC), if negative then it was considered a loss. Profit-cost ratio (PCR) is total cost divided by total revenue (PCR= TC/TR), a ratio of 0.65or less is preferable (Olasunkami, 2012). Net Fish Income (NFI) was profit less non–cash adjustments to income plus gains/loss on capital assets sale. Benefit-cost ratio (BCR) is total revenue divided by total cost (BCR=TR/TC).

Objective 3: To assess the profitability of fish farming. This was done by using cost revenue s, gross margin analysis and profitability ratios and other financial analyses.

.**Objective 4a: To determine the best alternative crop to fish farming system to use water resource in ASALs.** The researcher collected fish and tomato profit and loss data for the stocked four earth ponds and tomato crop on the two plots. Comparable data of fish and tomatoes were collected between June, 2015 and May, 2016, variable expenses were entered by a Research Assistant on operating sheets over that period. Fixed costs were record on semi-structure questionnaire that was administered by the Researcher. Socio-economic, management practices and marketing information were derived from the fish farmers' questionnaire (Appendix 5) and the field survey was done between February and March, 2015Socio-economic, management practices and marketing information were derived from the fish farmers' questionnaire (Appendix 5) and the field survey was done between February and March, 2015. Regarding the amount of funds utilized by the government to support the projects, secondary data were used (MCFD, 2013).

Objective 4b: Comparison of fish and tomato enterprises in an enabling environment

A pilot trial was compared between fish farming and tomato farming. This was done to identify an alternative option for income generation for smallholder fish farmers who have access to water and income resources to do business.

Data for fish and tomatoes were entered and analyzed using Excel software. Data for tomatoes on the two plots and data for fish from four earth pond were used to compare the costs and returns between fish and tomatoes. Gross margins, net cash and net income for respective enterprises were computed and compared.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Status of Fish Farming in Makueni County, Kenya

4.1.1 Overview of Fish Farming

Based on the Key Informants interview with the County fishery official in September, 2014, the registered fish farmers were 1300 during the ESP subsidized period between 2009 and 2012. Out of 1300 farmers, 1225 started fish farming through ESP incentives spread between 2009 and 2012. It can be concluded that 75 fish farmers had been in fish farming prior to the introduction of Fish Farming Enterprise and Production Programme. After the subsidy period, the current County fish farming position includes 23 public dams stocked by the Fisheries Department and 850 fish farmers (MOALFS, 2014). Most of those fish farmers were concentrated in Kibwezi, which had 192 fish farmers. Most of the earth ponds in Kibwezi were situated along the river banks of Athi, Makindu and Kibwezi. Liner and concrete ponds were mainly at institutions and farmers' homes, while large earth and sand dams were in Mbooni.

4.1.2 Fish Ponds

A majority (52. percent) of the fish farmers used earthen ponds as presented in Table 4.1 which is consistent with studies done by Munguti *et al.*(2010), Mucai *et al.* 2011) and Ngugi *et al*.((2007). Earthen ponds are favored option by farmers in Africa because of the affordability in construction as compared to concrete and liner ponds.

Table 4.1: Types of fishponds constructed by farmers in Kibwezi

Variable	**Category**	**Number of farmers**	**Percent**
Type of ponds used	Earth	76	52.1
	Liner	41	28.
	Concrete	3	2.1
	Earth/liner	19	13
	Concrete/liner	5	3.4
	Concrete/earth/liner	2	`
	Total	146	100

Source: Field survey, 2015n n = 146

From Table 4.2 it is observed that only 2.1 percent of the fish ponds had been built before 2009, however with the ESP promotion the number shot up by 93.1 percent. However this increase has not translated into sustainable fish farming as it can be noted from Table 4.2 that by 2015 only 46.percent of farmers were actively engaged in fish farming and 47.9 percent had abandoned their fishpond. The high abandonment of fish pond might be due to manipulated selected fish pond sites that were not suitable for fish production as evident in the FGD and KI interviews. These findings are consistent with those of Howard (2007) who observed that 41 percent of fishponds in Kisii were abandoned

Table 4.2: Year fishponds were constructed and whether ponds are active or abandoned in Kibwezi, Makueni County

Variable		Frequency	Percent
Year pond built	Before 2009	3	2.1
	2009-2012	136	93.1
	After 2012	7	4.8
	Total	146	100
Fish Farmer status	Active	68	46.6
	Inactive	10	5.7
	Abandoned	70	47.9
	Total	146	100

Source: Field survey, 2015

4.1.3 Fish Fingerlings

Makueni County had seven private hatcheries with four of those located in Kibwezi, Mbenzei and Gikonyos in Kibwezi Town and Wethe Farm and Candy farm in Kiboko. These hatcheries had one major challenge, that of substandard methods of fingerling production. Two of those hatchery owners were revamping and updating their operations to mitigate the challenge. The county did not have a public operated hatchery. The study area had experienced 57 percent decline in sales of fish fingerlings. Based on the above discussion, it is apparent that fish farming has not attained its expected rate of adoption in the county.

Fish fingerlings were sourced from local private hatcheries 34.3 percent that specialized in catfish and tilapia, while 52.1 percent of the farmers bought their fingerlings from Machakos, Kitui, Sagana, Kibos, and Nairobi (Table 4.3). This made fingerling less accessible and costly to Makueni fish farmers. A study done by Adewuyi *et al.* (2010) in Nigeria concurs with the findings that not securing fingerlings locally increased their procurement costs.

Table 4.3: Sources of fingerlings for farmers in Kibwezi, Makueni County

Source	Percent out of 146	Average distance in km
Local (within Makueni County)	34.3	Less than 120
Out of County (Machakos, Kitui, Sagana, Kibos, and Nairobi)	52.1	Between 150 and 600
Uganda	13.6	Over 650
Total	100	

Source: Field survey, 2015

4.1.4 Socio-economic Status of Fish Farmers in Kibwezi

The findings in Table 4.4 show that 71 percent of fish farmers were within the age bracket of 30 to 59 years. These findings corroborate studies done by Okechi (2004), and Maina *et al* (2012.)

in Kenya.; Olowoegun *et al.* (2004), Olaoye *et al* (2013) and Osondu (2014)in studies done in Nigeria, which found a positive correlation between age and adoption of fish farming technologies

Table 4.4: Socio-economic characteristics of fish farmers in Kibwezi, Makueni County

Variable	**Category**	**Percent**
Age (years)	18-19	2.7
	20-29	13
	30-39	24.7
	40-49	26
	50-59	24
	Over 60	9.6
Gender	Male	58.9
	Female	41.1
Marital Status	Married	80.8
	Single	13.0
	Other	6.2
Education Level	Primary	30.2
	Post primary vocation	8.2
	Secondary	30.1
	Tertiary	21.1
	University	10.3
Main livelihood n=146	Subsistence farmer	7.6
	Salaried employment	36.2
	Business	34.8
	Informal employment	16.3
	Other	5.1

Source: Field survey, 2015 n = 146

for farmers below 50 years. Fish farming requires a lot of hard work and financial resources to cover the variable costs (feeds, labour etc).The youthful age provides the manpower of operating a fishpond while mid age farmers have the financial resources saved from their primary likelihood that could be invested into fish farming.

These results of male (58.9 percent) and female (41 percent) are inconsistent with most studies that show fish farming to be predominantly male. In Adewuyi *et al.* (2010) study in Ogun State of Nigeria where 87.7percent were male compared to 12.3 percent female. Other studies done in Kenya by FAO (2013)in Western Kenya and Njagi *et al.* (2013) in Meru, Kenya, found that males were disproportionately (72.7 percent males and 26.3 percent females) represented as fishpond owners. In Ghana, Asmah (2008) found out that only 95 percent of fish ponds were owned by males against 5 percent owned by females. The high representation of women fish farmers in Kibwezi mirrors findings by Mutambuki *et al.* (2014) where 31percent of fish farmers were female in a study done in Kitui, an area with almost similar socio-economic and ecological characteristics. The Kibwezi study is a significant contribution to aquaculture because it points to an area that could be used as a model of promoting gender parity in fish farming in ASALs. Secondly, there is a high probability that household members will be fed appropriately by mothers who own key protein sources. Over 58 percent of fish farmers had attained at least secondary level as shown in Table 4.4. These educational levels are consistent with studies done in Trans Nzoia County, Kenya by Kiumbua *et al* (2013) where farmers with over 12 years of education had a positive influence on fish farming. The reason for the high educational level is that fish farming requires high technical skills and knowledge.

These results differ from studies done by Asmah (2008) in Ghana and Njagi *et al.* (2013) in Meru, Kenya that found 44 percent and 56 percent of fish farmers respectively had only primary education. In Ghana, fish farmers had been rearing fish for ten years. Thus lower levels of education are compensated by longer years of farming experiences in the adoption of fish farming. In Kibwezi, fish farmers had been rearing fish between two to six years, which meant a majority of farmers relied on mastering fish management practices.

4.1.5 Makueni County Infrastructure Support for its Fish Farmers

The county did not have a public hatchery or a feed pellet plant as noted from the Key Informants results. The implication of this is that quality of fingerlings delivered to Kibwezi farmers could not be guaranteed. Poor quality fingerlings means average weight of fish harvested was low which affected gross margins of fish negatively. With no local feed pellet plant, fish feeds will continue to be unaffordable to farmers. This increases the probability of farmers not feeding the fish. The County had no plan of building a hatchery or feed pellet factory, however county officials were working with farmers to establish a cooling and refrigeration centre to assist farmers with postharvest storage.

4.1.6 Fish Management Practices by Fish Farmers in Kibwezi

The farming practiced was polyculture in the large earth dams that were restocked with Nile Tilapia and African Catfish by Makueni County Fisheries Department. The large earth dams were managed by local communities or fish farmer groups. A majority of fish farmers used fish pond size of 300 square metres. The main sources of water for farmers were permanent rivers at 45.6 percent followed by public piped water at 31.5 percent as shown in Table 4.5. Harvested rainwater was not a common option of filling fishponds although this has captured significant amounts of water to complement most used sources of water.

Table 4.5: Sources of water for fish farmers in Kibwezi, Makueni County

Source of water	**Frequency n=146**	**Percent**
Permanent river	67	45.9
Well or borehole	30	20.5
Piped	46	31.5
Harvested rainwater	3	2.1

Source: Field survey, 2015

The primary water used was pumped from permanent rivers, wells and boreholes, while gravity flow or raceways were rarely used. The three types of fish farming system practiced by fish farmers in Kibwezi were semi-intensive, extensive and integrated farming as shown in Table 4.6.Most farmers were using semi-intensive system as they dominant mode of production. Semi-intensive system incorporates supplementary feeding by the farmer after fingerlings have been stocked in ponds during a production cycle.

Table 4.6: Fish farming systems and fish types used by fish farmers in Kibwezi. Makueni County

Fish farming system	**Frequency**	**Percent**
Extensive	11	7.5
Semi-intensive	122	83.6
Integrated	13	8.9
Fish culture	Frequency	Percent
Tilapia	138	94..5
Catfish	8	5.5

Source: Field survey, 2015 n = 146

Integrated fish farming is where pond wastewater is used for irrigation and unusable by products of livestock and crop enterprises are recycled for fish production. This recycling maximizes process both the economic and ecological returns of all enterprises. Only 8.9 percent of farmers used the integrated system. Extensive fish farming is where ponds are stocked with fingerlings then left to fend for themselves on available foods. This was the least practiced system.

Monoculture was practised with Nile tilapia being stocked by 94.5 percent (Table 4.6) of fish farmers. The average weight of harvested mixed tilapia was 150 to 310 grams, which is below the recommended average weight of 500 grams (Mbugua, 2002). County extension officials had been encouraging farmers to shift from mixed tilapia farming to mono-sex male tilapia farming that weighs between 350-500grams after six months of growth (MOALFS, 2014). Tilapia and catfish are the two fish types reared as shown in Table 4.6. This result is consistent with Maina (2012) study in Kirinyaga County.

4.1.7 Marketing of Kibwezi Farmed Fish

Farmers normally weigh their fish by estimation and then sell them by the piece. Samples of fish sold at KES80.00 and KES 100.00 were weighed to get a representative average weight of 200grams and 250grams respectively. The results show that average price per Kilogram was KES 400.00 of fresh tilapia or catfish. Farmers normally sold 200 grams fish for KES 80.00 and KES 100 for a 250grams fish. The average harvested tilapia was 240 grams. About 92 percent of harvested fish was sold at local markets. Local markets are either where fish is sold at farm gate or at market centres located within the county. Regional markets are fish markets outside the county with Voi, Mombasa and Nairobi preferred by farmers. The high percent of harvested fish being sold in local markets could be due to minimum processing of the fish and limited cold postharvest storage facilitates that hindered farmers from seeking lucrative regional markets. There was very limited fish promotion by the farmers, especially, at the farm gate and local markets. Farmers that sold to distant markets of Voi and Gikomba, Nairobi did discount promotion based on bulk purchases of the buyer. Bulk buyers at the farm gate were normally brokers and fish hawkers. Brokers transported their fish to Voi. Nairobi or Mombasa for final sale. The fish hawkers sold to final consumers in the local markets. The fish hawkers could sell fish in its fresh or deep fried form. The majority of fish harvested in Kibwezi was done in July to September, and December to January, limiting steady fish supply during the year.

Kibwezi fish farmers were concentrated along the Emali to Mtito Andei corridor situated on main Nairobi to Mombasa paved roads. Fish farmers may benefit from the Standard Gauge Railway opened in 2017. Also Makindu to Wote had paved road, making key fish markets like Wote, Machakos, Nairobi, Voi and Mombasa easily accessible. There was minimum processing of the fish that was sold locally.

4.1.8 Strengths, Weaknesses, Opportunities, Threats (SWOT)

Responses of (KI (Appendix 2); FGD (Appendix 3); input supplier (Appendix 4 Q20, Q21); fish farmer (Appendix 5 Q16, Q17); processors (Appendix 6 Q5.1.7); traders (Appendix 7 Q4.1.3, Q4.14, Q4.16, Q5.9) and consumer (Appendix 9 Q4.6, Q4.7 Q4.8)) were used to develop a SWOT analysis as shown in Table 4.7.

Table 4.7: SWOT analysis of fish farming in Kibwezi, Makueni County, Kenya

SWOT
<u>Strengths</u>
1. Presence of black clay soils that are naturally good for earth pond development
2. Fish farming is environmentally friendly since water waste is used on agricultural farms
<u>Weaknesses</u>
1. Poorly selected of fish pond sites
2. Inappropriate technologies
3. Development of unused credit access in improving fish farming
4. A majority of selected fish farmers are resource poor to undertake a fish enterprise
5. Limited funds and use of credit facilities for fish farmer and extension services
6. Overreliance on public agencies to provide key input supplies (Fingerling, and feeds)
<u>Opportunities</u>
1. Changing feeding habits of the people
2. Proximity to permanent sources of water
3. Adequate supervision and monitoring potential : high extension visit with fish farmers
4. Potential for strategic public-partnership like hatchery development/ home feed development and collaborative research
5. Collaboration with Kenya Wildlife Services to reduce human-wildlife conflict (control elephants from destroying pond structures in search of water)
6. Catfish potential as a fish of choice in fish production.
7. County support in promoting fish farming through extension services, farmer in service training and grants.
<u>Threats</u>
1. Insufficient participation in planning, implementation and evaluation of fish farmers' programmes with other stakeholders-government
2. Inadequate and untimely release of county budget and grants for fish farming promotion
3. None dynamic responses to farmers' challenges- seed/feed quality, Water availability, liner costs
4. Unstable government policy
5. Weak professional and institutional linkage among fish farmers, research and extension
6. Conflict between fish farmers and other users (agricultural (crop/livestock human consumer and Industrial)

Source: Field survey, 2015

Ronnbeck *et al.* (2002) in a study done on the Kenyan Coast found that fish farming required a lot of trust and coordination so that small-scale producers could realize its benefits. Farmers might not have significant benefits in the form of better yields and revenues. This might have also contributed to the high dropout since majorities were not financially prepared to meet fish rearing costs.

4.1.10 Challenges faced by fisheries extension officers

The study interviewed two fisheries extension officers based in Kibwezi on challenges in the service delivery, the main one being lack of knowledge and skill in aquaculture. This has been overcome by in-service training in fishery development, extension and husbandry practices.

This number of extension officers was sufficient for Kibwezi. Kibwezi had 316 registered fish farmers and these were clustered along Emali to Mtito-Andei corridor (situated on the paved road of Mombasa to Nairobi). The study found that fish farmers had at least three 3-extension contacts during a rearing cycle (eight months). The number of visits was good given the scarce public resources. However, farmers noted that extension officers were not equipped in improving quality of fingerling sourced and training them to make affordable quality feeds. These challenges could be solved by use of specialists during farm demonstration in the area or the county could collaborate with private hatchery owners to improve fingerling quality. Makueni County continued to train fishery extension officers and further allowed able officers to pursue degree courses to enhance their knowledge and dissemination skills to farmers.

4.1.11 Sustainability of Fish Farming

The sustainability of fish farming in Makueni was promising for farmers that used earth ponds as compared to liner ponds. This conclusion is based on the study results showing that Makueni had 46 percent active fish farmers and 53.6 percent inactive farmers. Farmers in Kibwezi have embraced fish production as a form of income generating enterprise and on average 4.8 percent new farmers continue to construct new fishponds per year since 2013(MCALF, 2015). Farmers with liner pond were 90 percent of the abundant/inactive farmers. A majority of the ponds were built between 2009 and 2012 as noted in Table 4.2.A majority of farmers practiced tilapia monoculture on a semi intensive system. However, there was need to popularize catfish production in the area given its adaptability and fast growth.

A situational analysis-using SWOT identified main strengths to be catfish potential as first choice of fish production, excellent extension-farmer contact links, and private hatchery development. The major weaknesses identified were poor selection of fishpond sites, inappropriate technology and poor socio-economic status of fish farmers. Opportunities that could be exploited included public-private collaboration in infrastructure development, extension, wildlife conflict resolution and research among others. The key threats were inadequate fishery budget, unstable government policy and overreliance on government.

The strengths and opportunities support potential development for fish farming growth along the permanent river basin. This can be done by encouraging farmers to build more earth ponds because they are cheaper to construct and maintain than liner or concrete ponds. The feeding schedule was not strictly followed due to limited cash resources to buy feeds. Farmers were not utilizing credit loans to mitigate their low savings. Expensive feed and shortages of labor personnel had negatively affected total fish production. Inadequate feeding leads to fish underweight, while limited personnel to patrol the fish pond increased the predation rate by the predators. Farmers with liner ponds had a high failure rate which could be attributed to poor quality liners, high liner replacement cost, and most of those ponds were located in areas that were not viable for fish farming.

The County extension officers are adequate to service the farmers. But there is need to source breeding specialists to assist in producing high quality fingerlings by working with the local hatchery owners. Wildlife was a major threat to the development of aquaculture as was noted by farmers whose ponds were destroyed by elephants. The collaboration among the fish stakeholders was not coordinated and there was need to strategize the working relationship.

4.2 Factors Influencing Adoption of Fish Farming

The logistic regression predicted fish farming adoption or absence of it from a number of independent variables. The model parameter estimates were jointly significantly different from zero as shown by the Chi-square statistic in Appendix 10, that is, significant at 5 percent.

The logistic regression analysis for fish farming adoption in Kibwezi are shown in Table 4.8. The Wald statistic was used to test the significance of individual variables, which indicate education, fish markets and distance to input markets were significant at 1 percent level. Group membership and age significant at 5 percent level. The independent variable with most influence on model was fish markets (0.001***) followed by input markets (0.004***.)

Table 4. 8: Maximum Likelihood Estimates for Fish Farming Adoption Model in Kibwezi

Variable	Beta	SE	Wald	Exp (B)	P-Value
CONSTANT	-5.703	2.919	3.829	0.003	0.0500
AGE	0.023	0.018	1.633	1.023	0.020**
GENDER	-0.186	0.436	0.181	0.831	0.671
MSTATUS	-0.307	0.236	1.693	0.736	0.193
EDUC	-o.488	0.171	8.163	0.614	0.004***
MLIHOOD	-0.020	0.131	0.024	0.984	0.878
MEMSP	2.555	1.021	6.263	12.874	0.012**
CREDIT	0.408	0.356	1.307	1.503	0.253
EXTVT	0.189	0.386	0.222	1.206	0.637
FISHMKT	0.730	0.229	10.185	2.076	0.001***
INPUTMKT	-0.014	0.005	8.234	0.983	0.004***

** Significant at a=0.05, *** Significant at a=0.01. SE = standard error, Beta: = Coefficients

Source: Field survey, 2015

Using the constant and beta values of Table 4.9, the logistic model can be derived from Equation 4 and rewritten in Equation 5.

Equation 5

P_j=-5.703+.023AGE-0.186GENDER-0.307MSTATUS-0.488EDUC-0.02MLIHOOD+2.555MEMSP+.408CREDIT+.189EXTVT+.73FISHMKT+.014NPUTMKT

Where:

P_j=Probability of fish farming adoption

AGE= Age

GENDER= Gender of farmer

MSTATUS= Marital status of farmer

EDUC= farmers' Education level

MLIHOOD=Farmers' main livelihood

MEMSP= whether a farmer is member in a farmers' society

CREDIT =Farmer access to loans from banks or friends

EXTVT= number of contacts farmer has with extension service.

FISHMKT=Markets where fish is sold

INPUTMKT=Distance to the nearest input market

The P-values from Table 4.8 show five variables: FISHMKT (0.001), EDUC (0.004), INPUTMKT (0.004), MEMSP (0.012), and AGE (0.020) were statistically significant both at 1 percent and 5 percent levels. The other variables: GENDER, MSTATUS, MLIHOOD, CREDIT and EXTVT were insignificant to the model since their P-value is more than 0.05.education level of the fish farm household head negatively influenced the adoption of fish farming. A farmer with less education is likely not likely to adopt fish farming because it requires high skills

4.2.2 Main Livelihood (MLIHOOD).

The fish farmers' predominant livelihood choices were either business or a salaried professional at 34.8 and 36.2 percent respectively as shown in Table 4.4. This confirms other Kenyan studies done Ngugi et al (2000). The ability to have extra income from other sources should have influenced adoption of fish farming positively but MLIHOOD was negatively insignificant. This could imply that farmers were risk aversive.

4.2.3 Membership of a Farmer Society or Aquaculture Association (MEMSP)

Farmer societies/associations are network groups that promote common goals among farmers, which promote resilience. A majority of fish farmers, 92.5 percent are not members of farmers' society with only 7.5 percent being members. MEMSP had a positive influence on adoption at significant level of 1 percent implying farmers may not be aware of advantages of group dynamics or they belong to non-farming clubs.

Fish farmers who have membership in fish farming associations or cooperatives tend to be successful fish farmers (Akinbile, 1998). This is because of accrued benefits derived from group membership, which a loner farmer cannot attain. The same study noted that being member of fish farming association or cooperative was a positive influencing factor in the adoption of modern fisheries technology and poverty alleviation.

In Kibwezi, farmers are organized into various groups, but these groups tend to be dominant when there is no government support programs. It is important to note that ESP members are under- represented in farmers' organization this may translate into lower adoption rate. Membership groups provide a forum for networking enabling members to learn from each other's' experience.

4.2.4 Credit (CREDIT)

About 36.3 percent of the respondents had access to loans, either from friends or from banks. The rest had no access to credit. CREDIT was positively correlated implying that access to credit positively increased the probability of adoption. This finding is corroborated by Okechi (2004).

4.2.5 Extension Contacts (EXTVT)

The 146 respondent fish farmers had at least three contacts with the fisheries extension officer during the fish production cycle (8months). This study found EXTVT had a positive correlation on adoption, although it was insignificant. Most likely, the extension contacts were not informative on quality of fingerling and reliable source of credit. This is differs from Ngugi (FAO, 2000) who found that extension contact had a positive impact on fish production in high potential areas of Kenya.

4.2.6 Fish Markets (FISHMKT)

The fish were sold either in local market within Makueni County or in regional markets outside Makueni County. Fish market access was positively significant. This was expected given that when farmers have readily available and accessible markets, it promotes trade exchange. Fish farming thrives where there is a clear potential market and infrastructure in existence like the case of Uganda's small-scale fish farmers near Kampala and Jinja.

Fish is a highly perishable product that requires market certainty so that the farmer plans production and postharvest accordingly. When market became uncertainty, farmers cannot rely on a steady price and it increases their production risks. The fish market is crucial for fish farmers because of differential marketing costs and sale prices. Local markets were preferred over regional markets to maximize on gross margin by reducing freight cost. Regional markets had better prices and hence more profitable but only 18.7 percent of farmers used them. Three reasons for local market popularity were: low output per farmer, regional markets require huge quantities that can be accomplished only by large scale farmers or use of brokers who can assemble fish. Fish farmers were not organized to provide a steady supply of fish over a given period.

4.2.7 Distance to Input Markets (INPUTMKT)

Seventy one percent of fingerlings were sourced over 168 kilometers from farmers homestead. Input market was negative and significant at α=0.01, indicating that when input supplies were secured from far, a farmer was likely not to adopt fish farming. This was a major handicap to pond stocking because advanced plans had to be organized in the procurement of fingerlings. This was significant and inversely related to adoption of fish farming. This means that when inputs are scarce and not easily available, the probability of farmers to select fish farming is low. This may be attributed to logistic difficulties that increase costs of sustaining an activity.

The correlation results in Appendix 13 indicate no strong correlation among the independent variables. According to Kerlinger and Lee (2007) any pair of variables with a correlation of more than 0.7 should be discarded because stronger correlation affects the regression model's estimation, viability and interpretation. This analysis was done to eliminate uncertainty of the model that may arise from multicollinearity and therefore the issues of multicollinearity were ruled out. Tolerance and the Variance Inflation Factor (VIF) values were also used to check the non-existence of multicollinearity. Tolerance and VIF are more than 0.1 and less than 10 respectively for all variables, as shown in Appendix 14, therefore multicollinearity was further ruled out. According to Pallant (2011) tolerance of more than 0.1 and VIF of less than 10 respectively indicated no multicollinearity in a multiple regression analysis.

The model was evaluated through use of R-squared and Fitness test of the model and Appendix 11 is the summary of the model. The R squared value of 0.310 explains the level of variance of the dependent variable (adoption) that is explained by the model. This shows that 31 percent of the variance of adoption is explained by the independent variables. This is expected of cross-section data. The adjusted R squared gives the value of the population variance, it was not used since the sample size was greater than 30.Based on Hill *et al.* (2008) in cross sectional data R^2 Values from 0.10.-0.40 are very common even with much larger regression models as opposed to time series macroeconomic analysis where R^2 values of 0.90 or greater are common.

The second part of evaluating the model was by ANOVA in Appendix 12. This analysis was to determine the Fitness of the model. The computed F (10, 141) =5.891 and the P-value is .000. The F-value is 1.83 at a=0.05 significance level and while at a=0.01 significance level the F-value is 2.32. Since the Computed F-value is greater than tabulated F-value, thus model is a reliable predicator for adoption of fish farming.

4.2.8 Value chain actors and marketing routes

Fish farmers' value chain provided what happens on the ground that can lead into strategies for inclusion in sustainable fish farming into the chain that could enhance production and income streams in ASALs. Consumer node provides leads to where the fish can be sold and which markets before fish being harvested.

A total of 120 respondent consumers were interviewed and the results showed that 58.3 percent were males, 41.7 percent females 48.3 percent were married and living with their spouses. The mean age of the household head was 35.7 years old with an average household size of four. Eighty one percent of household heads (decision makers) had at least O-level education and above. Their main livelihoods were 46.7 percent salaried employment and 26.7 percent self-employed in off-farm businesses.

Fish farmers produced their fish within the Mtito Andei – Email corridor that is along the paved Nairobi tp Mombasa highway. These farmers were also agro-pastoralist dealing with horticulture production and livestock. Access to local markets was done by motorcycle, while those producers that sold their fish in Voi and Nairobi used pick-up. Traders who bought fish at the farm gate were mainly retailers who deep-fried the fish at the local markets within Kibwezi. Individual consumers were mainly local residents within a 4-kilometer radius. Traders and brokers collecting fish at the farm gate was not a common practice in Makueni. This could be attributed to two reasons; Fish production was low at individual level where a farmer was able to sell his harvest through word of mouth. Secondly, it was not cost effective for a broker to bridge the gap between producer and the outside market in terms of freight and preservation costs. However fish brokerage dominated the fish market in Gikomba, Nairobi. Makueni producers who had dealt with brokers at the Gikomba market were cautious and preferred to deal with individual traders to enhance their gross margins.

There were three levels of fish farmers, farmers who owned one pond and most of the fish was consumed by the family while the surplus was sold to friends and neighbours. These farmers had a gradual harvesting regime of fish to suit their consumption needs. The second group owned a pond and harvested their fish once and sold it to retail traders and neighbours. Third level consisted of farmers with three or more ponds that had staggered harvest programs. These producers were the ones who were well capitalized and sold both in the local and regional market. Other participants in the fish market included *boda-boda* who used motorcycles to transport retail traders from farm gate to their final destination. Fish cleaners hired by producers to clean fish sold to individual consumers. One producer had a contract with the UN Refuge service to supply 50-60 gram tilapia; however this arrangement was abandoned due to lack of a refrigerated van for transport. Value chain actors involved in the marketing of Makueni farmed fish are summarized in Table 4.9.

Table 4.9: Value chain actors involved in the marketing of farmed fish in Kibwezi, Makueni County

Type of fish markets	Description, pricing and actors involved
Farm gate	The main buyers were neighbours, friends and family members who bought a kilogram of fish (4-5 pieces of tilapia or 1-2 pieces of catfish) per outing. The average price was KES 200 per kilogram (average price of a 200 gram tilapia was KES 50.00 (US$0.50) and KES 100.00 (US$ 1.00) for a 550 gram catfish). Gutting, cleaning and descaling was done for these customers
Local	Local markets included sales done at the farm gate as well as those sold in markets located in Kibwezi. Fish sold at farm gate had minimum

	processing of gutting, cleaning and decaling for individual consumers but no processing was done for that sold to traders. Figure 4.1 best illustrates the value chain actors observed in this market. The average price for a 200 gram fish was US$*0.80 and US$1.00 for a 250gram tilapia. Traders included hoteliers and fish café owners, fish mongers, fish butchery and retail traders. Hoteliers preserved their stock by refrigeration and normally used fish for catering functions. Fish café owners bought stock that was sold and served either deep fried or boiled to sit-in customers. These café owners had challenges in storage of left over fish. Fish mongers deep fried their fish at strategic points in shopping centres and sold their stock to customers who carried the fish home for family consumption.
National	Fish is transported to Gikomba in Nairobi and Voi where fish was sold in bulk in its fresh form. In Gikomba, tilapia was sold six pieces or five pieces unprocessed for US$4.50. Catfish was sold at US$4.50 for a one kilogram cut fillet. In Gikomba producers were faced with the challenge of not selling their stock, which causes them to discount the sell price later in the day. At Voi market, price of fish per kilogram ranged from KES 350.00 (US$3.50) to KES 420.00 (US$4.20) depending on the day’s supply and demand. Actors involved were input suppliers, farmers, processors brokers, retail traders, and consumers as in Figure 4.2.

Figure 4.1: Local market fish Value Chain in Kibwezi, Makueni County

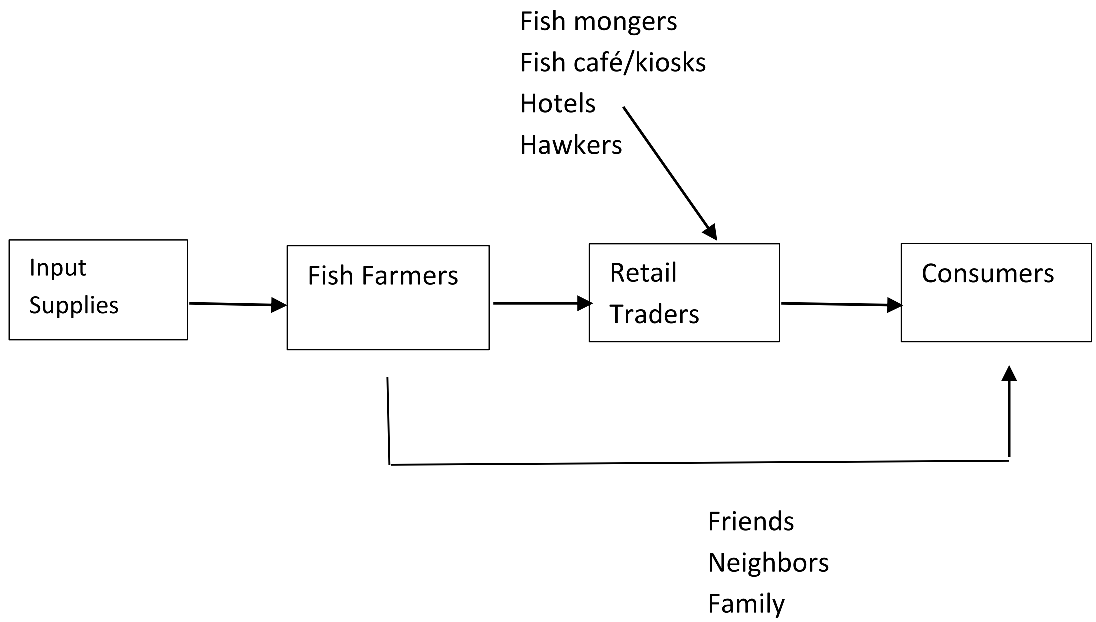
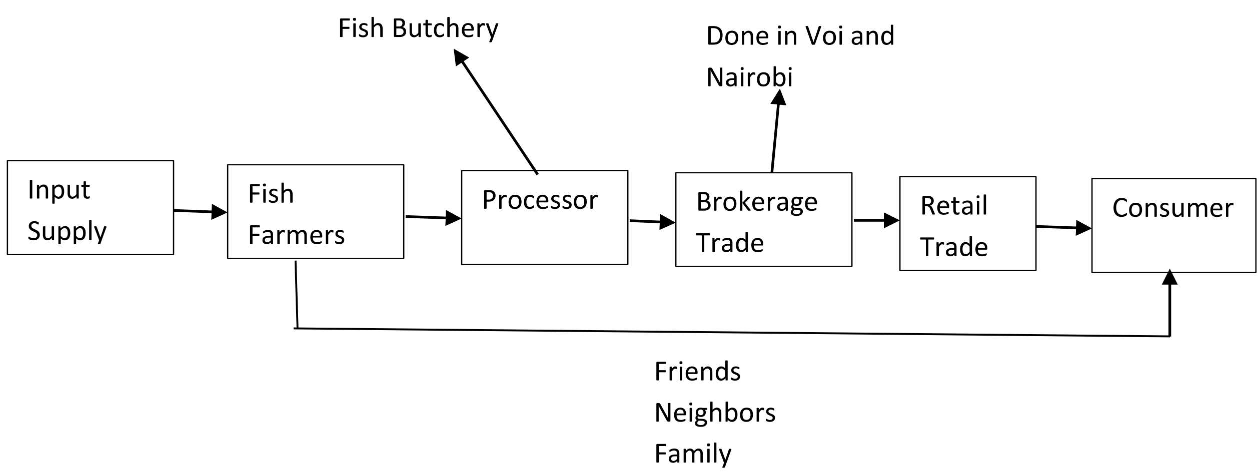


Figure 4. 2: National market fish value chain in Kibwezi, Makueni County



The fish value chain was divided into three stages: production, processing and marketing and sales. The value chain actors involved during the production stages were fish farmers, input suppliers, fisheries extension officers, boda-boda (motor bikes) cyclists and the public agencies (university researchers, county and national governments). Fish farmers sourced fingerlings and feeds from distance places. Feeds were expensive and the quality of fingerlings was not guaranteed. Fisheries extension officers provided the support information to farmers on a timely basis. This was complimented by university researchers who offered capacity building events for both farmers and extension officers.

The National government through the State Department of Fisheries and Blue Economy (SDFBE) has continued to fund aquaculture development to all the 160 consistencies that were enrolled in ESP (MALF, 2016). The SDFBE funds are channeled through the County Agriculture, Livestock and Fisheries portfolio, which is the implementing agency. The fish farmers could be grouped into two categories small scale and large scale (Ridler and Hishamunda, 2001). Small scale farmers were those whose annual average production output was below 500 kilograms of harvested fish. Large scale had an annual average production of over 500 kilograms of sold fish and owned three or more fish ponds measuring at least 300 metres squared. A majority of both small and large scale farmers used semi- intensive system in their fish management practices. Boda-boda played the role of delivering input suppliers from the local markets and transporting the water pump generator to the pond site. The production channels were high cost of feeds, water, and quality of fingerling stocked.

Key value chain actors during the processing stage were fish farmers, farm workers, traders, fish butchery and boda- boda cyclists. Small scale farmers who did not farmer workers performed the degutting, descaling and cleaning for individual customers, while traders did those functions themselves for all the fish bought. Large scale fish farmers used farm workers to process fish before being sold to individual consumers. Boda-boda cyclists played an important role in transporting the traders from farm gates to local markets or delivering the sold fish to the final consumer. The Fish butchery processed and packed their tilapia into 200, 250 and 500grams packets of degutted, descaled and cleaned tilapia. The catfish were filleted and packed into 500grams and one kilogram packets and preserved in freezers and refrigerators ready to be sold.

The majority of farmers' fish processing was characterized by minimum value addition because of lack of postharvest storage. The key issue with processing has been low production output that had discouraged investors to invest in postharvest storage facilities. The study found that limited production capabilities and restricted fish supply during the year hampered the marketing of farmed fish. This has made it difficult to invest in fish market promotions.

Based on the results of the consumer survey, consumers in Makueni preferred catfish that was above one kilogram in weight. The implication is that a catfish farmer has to rear catfish for a period of between nine months and one year when the average weight of catfish is 1.3kgs. Main reason for the preference was that a catfish of that weight tasted similar (fillet texture was firm and sweet) to the one captured from the wild. It is important that more research on fish taste been done to validate this consumer perception.

Fish markets infrastructure and management, in Kenya, institutional and policy bottlenecks impede the development and sustainable management of fish markets. For example the ESP built ponds and subsidized feeds without investing in postharvest storage cooling and refrigeration facilities. To have a viable fish markets farmers have to have easy access to good postharvest storage to preserve the surplus. Thus good postharvest cold surplus was a facility that would have encouraged fish farming.

On the management side, no stocking rotation among the farmers was organized such that the fish matured at the same time causing logistic problems in harvesting and fish oversupply in the local market. The problem was noted by county fisheries officials in pre-survey interviews

(MCFD, 2014) and progressive farmers are currently staggering their fish stocking. Local input infrastructures and long commuters to input markets present a major constrain of securing key inputs (Fingerling and Feeds). Fingerlings and feeds, the main inputs of fish production were sourced from distant input markets. Fingerling was mainly from Sagana and Western Kenya, this increased procurement costs for local farmers. Only a minority of farmers could afford to secure feeds from Nairobi. The added cost on the two items negatively impacted fish farming profitability.

4.3 Profitability of Economic Stimulus Program (ESP) Fish Farming Adopters in Makueni County, Kenya

4.3.1 Adopters

Adopters were fish farmers who had reared fish for over five years continuously (that is, since the inception of the ESP in the year 2009 and the enterprise is sustainable). Sustainability is evident if a farmer generated a profit (benefit) yearly from their fish enterprise.

Of the 146 fish farmers surveyed, 43.2 percent were still involved in fish farming as shown in Table 4.10

Table 4.10: Adoption of fish farming by farmers in Kibwezi, Makueni County

Farmers	Adoption			
	Adopters	**Percent**	**Non-adopters**	**Percent**
ESP (n=133)	53	39.8	80	60.2
Non-ESP (n=13)	10	76.9	3	23.1
Total (n=146)	63	43.2	83	56.8

Source: Field survey, 2015

Non- ESP members were 0.9 percent of the sampled fish farmers but 76.9 percent of these farmers adopted fish farming. The implication is that non-ESP Members might have been prepared (adequate resources) to undertake fishing farming.

4.3.2 Total Revenue

Table 4.11 gives the costs and returns of an average fish farmer in Kibwezi who reared their fish in standard ESP fish pond (300 square metres).

Table 4.11: Gross margin and net income (in KES) from a 300 square metre earth pond in Kibwezi, Makueni County, Kenya

Variable	Description	Kenya shilling KES.*
Total Revenue (TR)	236 Kgs @400 per kg	94,400.00
Fingerlings	1,000@KES 10.00	10,000.00
Feeds	400 Kgs @ KES 62.39	24,956.10
Labor	400 man hrs@ 60 per man hr	24000.00
Fertilizer(manure)	78.6 Kgs @ KES 7.00	550.00
Transport		1810.00
Total Variable Cost		61,316.10
Gross Margin		33,083.90
Tools (holes, slasher, matchete)		900.04
Commissions		5100.00
Fuel (for pumping water)	27.68 litres @ 89.99	2490.86
Total Costs		69,807.00
Net Cash Income		24,593.00
Annual Pond repairs		5000.00
Loss on machinery (pump)		2412.14
Net Fish Income		17,180.86

Source: Field survey, 2015; *KES100.00 = 1 US $

The Kenya Revenue Authority (KRA) does not allow annual depreciation for earth ponds, all expenses used in building or to rehabilitate a pond must be expensed in the annual accounting period.

Gross revenue was KES 94,400.00 per 300square metres. An average quantity of harvested fish was 236 kg sold at an average price of KES.400.00 per kg. The average weight of fish was 0.24kgfor Tilapia and 1.7kg for catfish. This average weight is important because it directly impacts on total output as observed in Adebayo *et al.* (2008) study in Nigeria. Hatchery owners also sold fingerlings at an average price of KES 7.00 for tilapia and KES 10.00 for catfish. Fish eaten at home or paid out in kind was included in total fish output as done by Asimah (2008).

4.3.3 Total Variable Cost

Total variable cost included fingerlings, feeds, labor fertilizer, fuel repairs and Dyke/levee repairs. Farmers did not use lime in their ponds. A farmer used on average 60 liters of fuel (about KES 6,000) to pump water to the earth fishpond per season. Comparable figures for Liner and concrete pond were not available due to poor record keeping. On average a farmer spent KES 5,000.00 to rehabilitate repairs an earth pond in preparation for the new season.

Studies done by FAO, (2010) and Olaoye *et al.*, (2013) on cost and return analysis showed that variable cost accounted for the highest proportion of total cost with fish feeds and fingerlings being the dominant variable cost items. In Olaoye *et al.* (2013), a study of catfish in Oyo State, Nigeria the proportion cost spent on feed and fingerling was as high as 87.26 percent of total variable cost. A frame survey of fish farmers done by FAO (2013) in the following Kenyan counties Busia, Bungoma, Kakamega, Vihiga, Siaya, Kisii, Nyamira and Migori, found that the cost of feeds and fingerlings constituted 76 percent of total cost.

4.3.3.1 Fingerling Cost

The unit cost of a tilapia was KES 10.00 for mono-sex and KES 7.00 for mixed-sex fingerlings, while catfish unit cost was KES 15.00. Stocking density of fingerlings in Kibwezi varied as presented in Table 4.12.

Table 4.12: Stocking density of fish ponds by farmers in Kibwezi, Makueni County

Type of fish	Fingerlings/m^2	Farmer	Percent
Tilapia n=77	3	41	53.2
	5	20	26.0
	10	15	20
	15	1	1.3
Catfish n= 9	3	1	1.3
	5	5	6.5
	10	2	2.6
	15	1	1.3

Source: Field survey, 2015 n = 86

A majority of tilapia farmers (53.2 percent) stocked 3 fingerling per square metre, while 20 percent of farmers stocked 10 fingerlings per square metre. Catfish stocking density was 5 fingerlings per m^2 for farmers with earth ponds, while one farmer with concrete ponds stocked 15 fingerlings per m^2.The farmers with higher stocking density were based along River Kiboko 3km north east of Kiboko market. These stocking densities are not within the recommended 3 fingerlings per square metre by Engel and Ngugi (2007). This high stocking density was not supported by intensive production system. Thus farmers with a higher stocking density might be maximizing on unit output yield instead of profit as was noted by Loosinger *et al.* (2000). The fingerling cost ranged between 7.7 to 33.9 percent of TVC. This is inconsistent with Neira *et al.* (2009) that had a range of 21 to 31 percent.

4.3.3.2 Feed Cost

Feeds utilized accounted for between 7.7 and 75. 9 percent of total variable cost (TVC) for the 80 sampled fish farmers with appropriate data, while their TVC values were between 35.9 to 61.9 percent. Sixty-six percent of farmers used commercial feeds bought at an average price of KES 67.50 per kilogram. Fifty percent of the farmers ordered the required feeds to meet their fish food needs. Table 4.13 gives a summary of feed type used by farmers.

Table 4.13: Feed types used in fish production in Kibwezi, Makueni County

Type of feeds	Frequency n=80	Percent
Commercial	53	66
Homemade	8	10
Combination	19	24

Source: Field survey, 2015

Fish farmers who owned and managed hatcheries relied more on homemade feeds using cereals such as wheat and sorghum as the primary energy sources while soya beans, sunflower and omena were used as protein sources. Eight percent of the farmers who relied on homemade feeds had an average production cost of KES 32.00 per Kilogram. In Neira *et al*. (2009) study of tilapia production, the total variable cost (TVC) was between 28 to 71 percent. The feed cost ranged 51 to 53 percent of TVC was for farmers who used pellet feeds.

4.3.3.3 Labour Cost

Fish farmers managed their fish farming activities using one or a combination of the following: family labor, hired monthly labor, hired monthly security labor, and labor in fertilizer application as in Table 4.14 in Kibwezi,

Table 4.14: Type of labour used in fish farming in Kibwezi, Makueni County

Labour type used	Frequency	Percent
Family members	44	37.
Monthly-operations	63	52.9
Monthly security	10	8.4
Casuals	2	1.7

Source: Field survey, 2015 n = 119

Fifty three percent of farmers used hired monthly labor that performed daily activities of fish farming. Another 37 percent of farmers involved family members to do daily operations of fish rearing. The average monthly wage was KES 7,500 with KES 6,000 being the minimum and KES 25,000 maximum. The labor cost ranged between 12.7 to 51.6 percent of TVC, this range was inconsistent with that of Neira *et al* (2009) that is 28 to 31 percent.

4.3.4 Gross Margin

The results of gross margin analysis revealed that 26.7 percent of the respondents had a positive profit as shown in Table 4.15

Table 4.15: Gross margins of adopters and non-adopters of fish farming in Kibwezi, Makueni County

			Adoption		Total
			Adopters	Non adopters	
Gross margins	Positive	Observed	26	12	38
		% within GMs	68.2	31.6	100
		% within adoption	41.3	14.5	26
		% of the total	17.8	8.2	26
	Negative	Observed	37	71	108
		% within GMs	68.7	65.7	100
		% within adoption	58.7	85.5	74
		% of the total	25.3	48.6	74
	Total	Observed	63	83	146
		% within GMs	43.2	56.8	100
		% within adoption	100	100	100
		% of the total	43.2	56.8	100

Source: Field survey, 2015

Farmers' yield was 0.5-1.8 Kg/m^2 for tilapia production and 1.5- 8 Kg/m^2 for catfish production. These yields are within 0.5-1.5Kg/m^2 found by Neira *et al*. (2009). Also farmers who operated four (4) or more ponds had a better gross margin than those who had one pond due to the economies of scale. This finding concurs with Okechi *et al.* (2004) in the Lake Victoria Basin where he noted economies of scale in operating twelve ponds instead of one pond.

4.3.5 Fixed Costs of Fish Ponds

The profitability of fish farming is dependent on the medium of production by Ross *et al.* (1995) as it will determine the fixed costs incurred to construct a pond. In this study, the mediums of production systems were concrete, earthen and liner ponds. The construction fixed costs per square metre was lowest with earth at KES84.00, compared to KES 4,000.00 for concrete and KES 500.00 for liner ponds. Cleaning and repair cost after harvest had the earth ponds lowest at KES 10.00 per square metre. Fish pond construction costs are fully depreciated during the first year. These cost elements had a significant effect on net fish income and caused 58 percent of the farmers to incur losses.

4.3.6 Net Fish Income

The average net fish income for a Makueni fish farmer was KES 17,180.86 per $300m^2$, which was the equivalent of KES 572,695.33 per hectare. This average net fish income is below the potential of KES 73,221per $300m^2$, which is the equivalent of KES 2,607,467.33per hectare (Mbugua *et al*. 2007).

Profitability of fish farming in Makueni County has been very elusive due to "inefficiency and obstructionism by some key stakeholders. In Kibwezi, farmers were not selected on merit and pond site suitability was done poorly due to political influence. These have been the contributing factors to the low mean net fish income and higher dropout rate of ESP members. Howard et al (2008) found similar factors as the causes of many abandoned ponds in Kisii County.

4.3.7 Profit Analysis and Benefit-Cost Analysis

A profit cost (PCR) and benefit cost ratio (BCR) was done using data of the 39 farmers with positive gross margins. It was found 30.8 percent of them had a profit cost ratio of less than 0.65. While 35.9 percent of them had benefit cost ratio of greater than 1.A farmer with a BCR of greater than 1 implies that farmers met their costs and was left with some income. These profit indicators are good because it means that the enterprise is sustainable. In studies done in Nigeria by Olasunkami (2012) and in Egypt by El-Naggar *et al*. (2010) found that BCR must be greater than 1 and PCR should be less or equal to 0.65 for an enterprise to be sustainable.

4.3.8 Fish Farming Profitability

Fish farming is profitable as indicated by 52.4 percent of adopters who had a positive gross margins and yields of 0.5-1.8Kg/m^2. This is supported by Mbugua (2002) study that indicates a yield of .05-1.5 Kg/m^2 is what can sustain a profitable fish production that is reliant on cereal bran as primary feeds. The cost and returns of the adopters averaged as follows: feed cost 56 percent, fingerling cost 24.5 percent, labor 19.1 percent and gross margin (60.9 percent) These results differ from Boateng *et al*., (2013) on fingerling cost (12 percent), labor cost (13percent), and gross margin (72percent); however, there is corroboration on feed cost at 56 percent.

4.4 The best alternative crop to fish system to use water resources (A comparison of tomato and fish culture and their integration)

Table 4.16a shows that a gross margin of KES 1000,050.28 and a net cash income of KES 52,250.28 from plot 1.

Table 4.16a: Plot 1-Fish farmer gross margin and net tomatoes income from 0.05ha in Kibwezi, Kenya

Variable	Description	Kenya shilling (KES.*)
Total Revenue (TR)	25cases @120 kgs @KES 50.00	150,000.00
Land preparation	35 @200	7,000.00
Seedlings	2000 @KES 5.00	10,000.00
Pesticides		7,499.72
Labor	72mdy@KES200	14,400.00
Fertilizer(manure+ Dap)		3,550.00
Harvesting	25cases @KES100	2,500.00
Transport	25cases @KES200	5,000.00
Total Variable Cost (TVC)		49,949.72
Gross Margin (GM=TR-TVC)		100,050.28
Land lease	500M^2 @K10.00	5,000.00
Equipment (water pump)		20,000.00
Commissions (workers)		15,000.00
Fuel (for pumping water)	78litres@100	7,800.00
Total fixed costs (TFC)		47,800.00
Total Costs (TC= TVC+TFC)		97,749.72
Net Cash Income (TR-TC)		52,250.28

Source: Field survey 2015 * 100 KES=1 U.S $; +

Table 4.16b shows the results of plot 2 that had a net cash income of KES.77, 750.21 at the end of a six month cycle. Total fixed costs were less than those used in plot 1 due to lower commissions paid and zero cost assigned to water pump.

Table 4.16b: Plot 2-Fish farmer gross margin and net tomatoes income from 0.05ha in Kibwezi, Kenya

Variable	**Description**	**Kenya shilling (KES*)**
Total Revenue (TR)	25cases @120kg@KES50	150,000.00
Land preparation	35 @KES200	7,000.00
Seedlings	2000 @ KES 5.00	10,000.00
Pesticides		7,499.79
Labor	72mdys@KES200	14,400.00
Fertilizer(manure+ Dap)		3,550.00
Harvesting	25cases @KES100	2,500.00
Transport	25cases @KES200	5,000.00
Total Variable Cost (TVC)		49,949.79
Gross Margi (GM=TR-TVC)		100,050.21
Land lease	500M^2 @KES10.00	5,000.00
Commissions (workers)		10,000.00
Fuel (for pumping water)	78litres@KES100	7,800.00
Total fixed costs (TFC)		22,300.00
Total Costs(TC=TVC+TFC)		72,249.79
Net Cash Income (TR-TC)		77,750.21

Source: Field survey 2015 * 100 KES=1 U.S $;

The total sold tomato output (Q_f) was 3,000Kgs per 0.05 hectares fish pond area (FPA) The computed per hectare (H=1) production (Q_h) is 60 Metric tons using the formula:

$Q_h = H/FPA \times Q_f/1000$

Where

Q_h is the computed average production per one hectare.

H is a hectare (10,000m^2)

FPA is fish pond area ($500m^2$)

Q_f is the total tomato output per fish pond area (FPA)

The per hectare computed tomato output corroborates with other global studies (Tschirley et al, 2004; and Makunite, 2007) but is inconsistent with Kenya small scale farmer national average yield of 12 Metric tons and 30.7 Metric tons for a progressive farmer(Atheron and Rudich, 1986). The results of tomato production in Table 4.16a found gross margin of KES.200.10 per square metre and net profit of KES.104.50 per square metre in returns. These returns are higher than in Wachira et al, (2014) study that found a gross margin of KES.14.92per square metre and a net profit of KES.12.99 per square metre in open field production system in Nakuru County, Kenya. This differential might be attributed to the fact that trial plots were used in Kibwezi as opposed to small- scale farmers in Nakuru who were randomly selected.

Table 4.17a: Pond 1- Fish farmer gross margin and net cash income from 0.03ha earth pond in Kibwezi, Kenya

Variable	Description	Kenya Shilling (KES*)
Total Revenue (TR)	1800kg@KES360	648,000.00
Fingerlings	3000@KES15	45,000.00
Feeds (homemade)	2635kg@KES54	142,290.00
Feed	171.43@KES105	18,000.00
Office supplies		899.83
Labor	896mhrs@KES60	54,760.00
Fertilizer(cattle manure)	300kgs@KES7	2,100.00
Transport		13,600.00
Total Variable Cost		276,649.83
Gross Margin		371,350.17
Earth pond construction	1 @ KES 60,000.00	60,000.00
Land lease	$500M^2$ @KES10.00	5,000.00
Equipment-Water pump		19,460.00
Commissions(workers)		60,551.00
Fuel (pumping water)	90 litres@ KES89.99	8,099.10
Total fixed costs		153,110.00
Total Costs		429,759.83
Net Cash Income (catfish)		218,240.17

Source: Field survey 2015*100 KES=1 U.S $;

Table 4.17a shows the income statement for pond 1.The gross margin and profit were KES. 371,350.17and KES.218, 240.17 respectively from pond 1 catfish production output of 1,800 kilogrammes at the end of a nine month cycle. Pond 1 had an average catfish production of 6 Kilogrammes per square metre which did not corroborate with 1.11Kgper square metre found in Okechi study (2004).

Table 4.17b (below) shows the gross margin and net cash income for pond 2, where 2,520 kilogrammes of harvested catfish was sold and a net income of KES 298,471.69 attained at the end of a nine month cycle.

Table 4.17b: Pond 2- Fish farmer gross margin and net cash income (in KES) from 0.03ha earth pond in Kibwezi, Makueni County, Kenya

Variable	Description	Kenya Shilling (KES*)
Total Revenue (TR)	2520kgs@KES360	907,200.00
Fingerlings	3000@KES15	45,000.00
Feeds (homemade)	2635kg@KES54	142,290.00
Feeds	514 kg@KES105	53,970.00
Office supplies		1,528.21
Labor	896mhrs@KES60	54,760.00
Fertilizer(cattle manure)	300kgs@KES7	2,100.00
Transport		13,600.00
Fuel (pumping water)	90litres@ 89.99	8,099.10
Total Variable Cost (TVC)		321,347.31
Gross Margin (GM=TR-TVC)		585,852.69
Earth pond construction	1 @ KES 60,000.00	60,000.00
Land lease		5,000.00
Equipment-Water pump		19,460.00
Commissions(workers)		102,921.00
Total fixed costs (TFC)		187,381.00
Total Costs (TC=TVC+TFC)		508,728.31
Net Cash Income (TR-TC)		398,471.69

Source: Field survey 2015 * 100 KES=1 U.S $;

Table 4.18a and Table 4.18b show the gross margins and net cash income for pond 1 and pond.2 stocked with tilapia

Table 4.18a: Fish farmer gross margin and net cash income from 0.03ha earth pond in Kibwezi, Makueni County, Kenya

Variable	**Description**	**Kenya shilling (KES*)**
Total Revenue (TR)	416Kg@360	148,760.00
Fingerlings	2,000 @ KES 10	20,000.00
Feeds (homemade)	1035kg@KES54	55,890.00
Labor	400mhrs@KES60	24000.00
Office supplies		250.28
Fertilizer(cattle manure)	78.6Kgs @ KES 7.00	550.00
Transport		2,000.00
Total Variable Cost (TVC)		102,690.28
Gross margin(GM=TR-TVC)		46,069.72
Equipment-water pump		19,460.00
Land lease	500M^2 @KES10.00	5,000.00
Fishing gears		14,800.00
Fuel-pumping water	68.9litres@KES 89.99	6,200.00.
Total fixed costs (TFC)		45,460.00
Total Costs (TC=TVC+TFC)		148,150.28
Net Cash Income (TR-TC)		609.72

Source: Field survey 2015 * 100 KES=1 U.S $;

Tabl4.18bb: Pond 2 -Fish farmer gross margin and net cash income from 0.03ha earth pond in Kibwezi, Makueni County Kenya

Variable	Description	Kenya shilling (KES*)
Total Revenue (TR)	416Kgs@360	148,760.00
Fingerlings	1,800 @ KES 10	18,000.00
Office supplies		259.66
Feeds (homemade)	785Kgs@KES54	42,390.00
Labor	325mhrs@KES60	19,500.00
Fertilizer(cattle manure)	78.6Kgs @ KES 7.00	550.00
Transport		2,500.00
Total Variable Cost (TVC)		83,199.66
Gross Margin (GM=TR-TVC)		65,560.34
Land lease	500M^2 @KES10.00	5,000.00
Equipment- wheel barrow		5,690.00
Fuel-pumping water	101.6litres@KES 93.99	9,550.00
Total fixed costs (TFC)		20,240.00
Total Costs (TC=TVC+TFC)		103,439.66
Net Cash Income (TR-TC)		45,320.34

Source: Field survey 2015 * 100 KES=1 U.S $;

The rate of return was for one Kenyan shilling invested in catfish and tilapia production returned KES 1.51 (pond-catfish) and KES 1.00 pond 1 -tilapia) respectively. The comparable returns for tomato enterprises were KES 1.52 (plot 1- tomatoes) and details are shown in Table 419

Table 4.19: Comparison of tomato and fish (catfish and tilapia) costs and returns for fish farmers in Kibwezi, Makueni County Kenya

Variable	Catfish		Tilapia		Tomatoes	
	Pond 1	Pond 2	Pond1	Pond 2	Plot 1	Plot 2
Total revenue	648,000.00	907,200.00	148,760.00	148,760.00	150,00.00	150,000.00
Total variable cost	276,649.83	321,347.31	102,690.28	83,199.66	49,949.72	49,941.79
Gross margin	371,350.17	585,852.69	46,069.72	65,560.34	100,050.28	100,050.21
Total fixed cost	153,110.00	187,381.00	45,460.00	20240.00	47,800.00	22,300.00
Total cost	429,759.83	508,728.31	148,150.28	103,439.66	97749.72	72249.79
Profit (Loss)	218,240.17	398,471.69	609.72	45,320.34	52,250.28	77,750.21
Gross margin ratio GM/TR	0.57	0.65	0.31	0.44	0.67	0.67
Profit cost ratio TC/TR	0.6630	0.561	0.996	0.695	O.652	0.486
Benefit cost ratio TR/TC	1.508	1.783	1.004	1.438	1.534	2.076

Source: Field survey 2015. * 100 KES=1 U.S $

The Profit cost ratio of catfish was 0.561 and 0.486 for tomatoes during the second season. The results of benefit cost ratio for all three enterprises were greater than 1 as indicated in Table 4.19. A farmer with a BCR of greater than 1 implies that farmers met their costs and was left with net cash income to invest or consume. These profit indicators are good because it means that the enterprise is sustainable. In studies done in Nigeria by Olasunkami (2012) and in Egypt by El-Naggar *et al*., (2010) found that BCR must be greater than 1 and PCR must be less or equal to 0.65 for an enterprise to be sustainable.

Based on the results of table 4.16a, 4.16b, 4.17a, 4.17a, 4.18a and 4.18b the costs of pond construction and fuel costs were lower than the average of KES 75,000 (pond construction) and KES 20,000.00(water costs) (MCALF, 2014). This is because the trial fish ponds and plots for tomato were located on good sites within 300 meters of a permanent source of water (river

Kiboko). Secondly, the black clay soils have better water retention for the earth ponds. Close proximity to water source minimized the cost outlay for pipes and fuel used.

Catfish culture was more profitable than tilapia as shown in Tables 4.17a, 4.17a, 4.18a, 4.18b and 4.19. The average weight of harvested tilapia and catfish is 290grams and 850grams respectively after six months. At the ninth month the average catfish weight had increased to 1.2 kilogrammes with no significant change in the tilapia average weight. The wholesale price for catfish and tilapia was KES360 per kilogramme.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Fish farming in Makueni County is mainly practiced by farmers who were engaged in other enterprises like tomatoes, cattle, goats, sheep, fruits etc. Only 43.2 percent of the sampled farmers were still practicing fish farming in 2015. The main strengths were water waste discharged from fishponds could be used for irrigation to increase crop production and the availability of black clay soils near permanent rivers are ideal sites for aquaculture development. Weaknesses identified were poor selection of fishpond sites, a majority of selected fish farmers were resource poor to undertake a successful fish farming operation and used inappropriate technologies. Opportunities were excellent extension-farmer contact links, and private hatchery development. Key threats were farmers non- involvement in designing fish farming programmes with other stakeholders (governments or donors and research institutions), inadequate fishery budgets, and overreliance on government. Fish farming has a high potential especially for earth pond development along the permanent rivers of Kiboko, Makindu and Athi.

Five variables fish markets (0.001), education (0.004), distance to input markets (0.004), membership to a farmers' society or group (0.012), and age (0.020) were found to significantly influenced adoption of fish farming. Two value chains were observed: one for the local market and the other for regional markets. In the local markets harvested fish was always sold with limited processing and had a short value chain. In the regional markets, more actors were involved who dealt with the few large scale farmers.

Fish farmers with the highest gross margins and net cash income engaged regular employees or committed themselves to pond management activities.

The study findings established that fish farming was a viable enterprise in Kibwezi as shown by the benefit cost ratio analysis. Tomatoes had better returns on the three measures (gross margin ratio, profit cost ratio and benefit cost ratio) when compared with catfish and tilapia. It can be concluded that proximity to water sources and black clay soil sites were the best enablers of fish farming integration with agricultural production.

5.2 Recommendations

It is recommended that the county government selectively promote fish farming in areas that have most potential. In pond site selection, fisheries extension officers can assist farmers identify sites. The County Ministry of Agriculture, Livestock and Fisheries can earmark fish production zones based on water source and soil types. The County should partner up with private hatchery owners to produce high quality fingerlings. Self-initiative among farmers is important if fish farming has to be a viable joint partnership with public and donor agencies. The National and County governments should provide tax break to business men willing to invest in establishment of local input supply operations and processing plants for fish, which will eventually minimize input supplies costs to farmers and promote nationall fish markets

5.3 Contribution To Knowledge and Suggestions for Further Research

The study shows that fish farming can be profitably farmed Kibwezi, Makueni County, Kenya given its developed road network and educational levels of farmers. There is need for further studies on tomato production in comparison to fish production over a period of time to document their profitability in the study area. The result of such studies could strengthen public efforts to promote fish farming in the ASALs.

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APPENDICES

APPENDIX 1: RESPONDENT CONSENT FORM

I am Paul Wesonga, PhD Candidature and Lecturer at the Department of Land Resource Management and Agricultural Technology, University of Nairobi.

This Fish Farmers' Survey and Focus Group Discussion is organized by Paul Wesonga a PhD Candidature as part of the Peer Science Research Project investigating: **An analysis of fish value chain under Economic Stimulus programme (ESP) inKibwezi, Makueni County, Kenya**

The research will assist me to complete my PhD studies in Dryland Resource Management by writing this thesis on the above topic.

Peer Science Research is applied research and the findings will be made available to Makueni fish farmers/stakeholders and Makueni Decision Makers. I hope that the study will come up with recommendations on

a. What are the most critical variables affecting fish farming in Makueni County?
b. What do the most profitable fish farmers have in common
c. How has fish farming sustained livelihoods in Kibwezi (ASAL).

Participation is Voluntary and feels free to withdraw at any given time of the interview OR call and/or SMS me at 0733-640031 if you need to withdraw you discussion within two weeks time frame of the interview date.

Confidentiality of the information given will be maintained. If you consent we would like to take notes, record and take pictures where appropriate during the interview/ Focus Group Discussion to enable Paul to review the information again at the college.

Respondent Consent Questions

Thanks for your time and Cooperation.Name…………………………………………………Date…………………………
…………

1. Do you consent to participate in the research? I) Yes ii) No
2. Could you grant us permission to take notes, pictures and tape the discussion? I) Yes ii) No
3. The research findings will be disseminated at a central location in Kibwezi. Would you like to attend? i) Yes ii) No
4. Are you willing to share with us copies of your records to preserve accuracy of data given? (i) Yes (ii) No
5. Do you have any questions or observation that you would like to share with us before we begin the interview/discussion
6. The interview/FGD will take about 60/120 minutes.

APPENDIX 2: KEY INFORMANTS GUIDE

Name of interviewer………………………………………………………………………………

Name of the respondent……………………………………………………………………………..

Title…………………………………………………..Gender…………………………………

Socio economic characteristics of the respondent

Gender	Age in years	Education	Experience	Aquaculture training	Extension /livestock training

Overview of Fish Farming

1. How many registered fishponds under Economic stimulus programme (ESP) are in the county? Give breakdown by ward or sub-county if possible.
2. Are there farmers who were recruited by the ESP program, but have abandoned their ponds?
3. If the answer to 2above is yes, approximately what percentage of farmers have abandoned their fishponds?
4. What species of fish are grown?
5. How many registered /practicing fish farmers are there in this county
6. Are farmers organized into groups?
7. From where do farmers purchase fish fingerlings?
8. Approximately how many farmer groups do fish farming?

County Infrastructure Support for Fish Farming

9. Has ministry built a cold storage facilities or processing plant for fish in the county?.....
10. How much money does the county plan or spend in promoting fish farming in the County.
11. Does the County have a fish hatchery? .... If yes where……….
12. If no to question 7, does the County plan to establish a fish hatchery?

Management Practices

13. How are the fishponds constructed? Concrete……. Earth…… Liner…….
14. Fish farming practices: Monoculture……… Polyculture
15. What species of fish are grown?

Marketing

16. Where do farmers sell their fish and average price per kilogram?

Challenges

17. What are the main challenges faced by fish farmers?
18. Are there challenges in obtaining the fingerlings?

APPENDIX 3: FOCUS GROUP DISCUSSION GUIDE

Name of Facilitator……………………………………………………………………………………

Venue…………………………………………Date……………………………………………

Overview of Fish Farming

1. Are there farmers who were recruited by the ESP program, but have abandoned their ponds?
2. If the answer to 2above is yes, approximately what percentage of farmers have abandoned their fishponds?
3. What species of fish are grown?
4. Are farmers organized into groups?
5. From where do farmers purchase fish fingerlings?
6. Approximately how many farmer groups do fish farming?

County Infrastructure Support for Fish Farming

7. Does the County have a fish hatchery? .... If yes where……….
8. If no to question 7, does the County plan to establish a fish hatchery?

   MANAGEMENT PRACTICES

9. How are the fishponds constructed? Concrete……. Earth…… Liner…….
10. Fish farming practices: Monoculture……… Polyculture
11. What species of fish are grown?

Marketing & Extension

12. Where do farmers sell their fish and average price per kilogram?

Challenges

13. What are the main challenges faced by fish farmers/fisheries officials?

14. Are there challenges in obtaining the fingerlings?

APPENDIX 4: QUESTIONNAIRES FOR INPUT SUPPLIERS

1.Name of Business……………………………………...…Date………….…………...

2. Name of respondent ………… ……………..………….. Sex …………….……………

3. Role of respondent ………………………………………………………….…….

4. Location of business…………………..……..District/Region ……………………

5. Type of Business: Hatchery   Fish Feeds   Hardware   Liner Supplier Other(specify)

6. What year was the business started? ……...…………………………………

7. Where do you get your broods of tilapia/catfish from? ……………………………

8. Please give the name and location of fish farmers that buy fingerlings/inputs from you

Name	Stock bought	Unit Cost	Farmer site	Extension service

9. What other inputs do farmers buy from you? .

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

10. How often do farmers buy those inputs?

11. How do farmers transport bought fingerlings to their fish ponds?

12. Do you have delivery services to the farmers of input supplies bought or ordered?

13. If yes to Q12, what are your charges?

14. What is the average unit weight of fingerling sold?

15. Do current stocks/production meet the farmers' need? Yes No

16 What factors determine the price at which you sell your stocks?

17. What is the annual total cost of operating this business?

18. What is your annual total revenue of this fish enterprise?

18b. What rank is fish farming among your other enterprises?

19. In your opinion what is the future of fish farming in this country?

20. Could provide any suggestions that could improve fish farming.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

21.Fish bought and consumed in your household.

Type of fish	Qty bought	Unit cost Kg	Price	Frequency fish consumed per week

APPENDIX 5: FISH FARMER QUESTIONNAIRE

Date___/____/____ (Day/Month/Year) Questionnaire Code.|___|___|___|

Name of Interviewer…………………………………………………………………..

GENERAL INFORMATION

COUNTY………………………………………………………………………………………

SUB-COUNTY……………………………………………………………………………..

LOCATION……………………………………………………………………………………

SUB-LOCATION……………………………………………………………………………

VILLAGE………………………………………………………………………………………

SECTION 1: FISH FARMER DEMOGRAPHICS

1. Information about the fish farmer

Name	Age	Sex (1)	Literacy (2)	Education Level (3)	Marital Status (4)	Occupation (5)	Language (6)	Religion (7)

CODES FOR FISH FARMER DEMOGRAPHICS			
(1) Sex: 1- Male 2 – Female			
(2) Literacy: 1. Can read and write	**(4) Marital status:** 1. Married 2. Single	3. Employed (formal) 4. Employed	3.Kamba 4.Other (Specify)…………………

2. Cannot read and write **(3) Education Level:** 1. Nursery, kindergarten 2. Primary 3. Post-primary, vocational 4. Secondary, A-level 5. College (middle level) 6. University 7. Adult education *(Gumbaru)* 8. None	3. Divorced 4. Separated 5. Widowed 6. N/A 7. Don't Know 8. Other (specify)……………………… **(5) Occupation:** 1. Subsistence/mixed farmer 2. Pastoralist	(informal) 5. Business (include: commercial, livestock and crop production) 6. Domestic worker 7. Home maker/House wife 8. Student 9. N/A 9. Others (Specify)……… **(6) Language** 1. English 2. Swahili	**(7) Religion:** 1. Catholic 2. Protestant 3. Other Christian 4. Hindu 5. Traditional 6. No religion 7. Muslim 8. Others (Specify)……………....

2. Are you a member of any of the following **(Tick one)**

ESP YES [ ] NO [ ] Fish Farmer Society YES [ ] NO [ ] Fish Community based Organizations? YES [ ] NO [ ] others specify --------------------------

i. **If ESP member, answer the following questions:**

No. Of ponds	Year	Size	Fingerlings per pond		Type (liner or earth)	ESP	Not ESP
			Tilapia	Catfish			

ii. **How many of the ESP ponds are not active?**

a. **If so, why are inactive?**

(1) **---**

(2) **---**

(3) **---**

(4) **---**

(5) Others Specify --

3. If YES in No. 2 above, how often do you hold your meetings? **(Tick one)** (A)Weekly [ ] (B) Every Month [ ] (C) Every 3 Months [ ] (D) Twice a Year [ ] (E) Once a Year [ ] (F) others (specify)……..............

4. How would you score/rank your frequency of attendance to the meetings? **(Tick one)**

(A)Very Good [ ] (B) Good [ ] (C) Fair [ ] (D) Poor [ ]

5. In your own opinion how would you score the management of the Farmer Groups/Society/ Community based Organizations? **(Tick one)**

S/No	**Management Practice**	**Tick appropriate Box**			
		Good	**Fair**	**Poor**	**Don't Know**

1.	ESP				
2.	Democratic management				
3.	Information sharing				
4.	Farmer education/training				
5.	Internal savings and lending				
6.	Gender inclusion/equity				
7.	Experimenting and innovation				
8.	Others (specify)				

SECTION 2: FISH PRODUCTION INFORMATION

1. What is the size of your farm? **(Tick one)**

(A) <2 acres [ ] (B) 2-5 acres [ ] (C) 6-10 acres [ ] (D) 11-15 acres [ ]

i) Do you own or rent the farm?

ii) How much owned or rented?

iii) How many acres of land do you currently cultivate? ------------- Acres

iv) How much your land is under fish production? **(Tick one)**

(A) <2 acres [ ] (B) 2-5 acres [ ] (C) 5-10 acres [ ]

v) What other major enterprises do you have?

Enterprise (major crops)	Acreage/ livestock unit	Yield/ year	Price/ unit	Annual income (KES)	Annual costs (KES)

Ranking of All Enterprises

Enterprise	Rank (1- 5)
Fish farming	

1- Very good 2- Good 3- Average 4- Fair 5- Poor

vi) What are the sources of water for your ponds? ---

vii) What is the recommended level of water for your pond? ---

-

viii) How do you manage your water levels? ---

ix) What do you feed your fish on?

(1) -----------------------------

(2) -----------------------------

(3) -----------------------------

Section 3: Types and Sources of Fish Feeds

Type of fish feed	Source of feed	Distance from farm (km)	Amount (kg/ tin)	Price/ unit (KES)	Frequency of feeding

1. If own feed, what is the type and composition of feed? --------------------------------------
2. How much labour do you use per cycle? --
3. How much does it (labour) cost? --
4. At what age and weight do you harvest your fish? ------------------------------------
5. Do you harvest gradually or completely? --
6. Give a reason for the response above---
7. What is the farm- gate price/ kg (or per unit) and amount: Tilapia ----------------

   Catfish ----------------
8. Market price/ kg (or per unit) and amount of

Type of fish	Amount of fish (kg)	Farm- gate price/ unit (KES)	Market price/ unit (KES)
Tilapia			
Catfish			

9. How many times in a year do you restock each fishpond? (Tick one)

   (A) Once [ ]   (B) Twice [ ]   (C) Thrice [ ]   (D) None [ ]

10. How many times do you harvest per year/ per pond? --------------------------------

11. What is the total yield/ year? Tilapia ------------------------ (kg/ year) or units

Catfish ------------------------ (kg/ year) or units

12. How much fish did you harvest in 2014?

Tilapia ------------------ (kg) Catfish ------------------------ (kg)

13. Where do you sell your fish? ------------------- Distance from farm -------- km

14. How do you preserve your fish? --

15. How much fish do you and your family consume? ---------------------------------

16. Mention 5 key problems you encounter as a fish farmer

(1) ---

(2) --

(3) --

(4) --

(5) --

17. Suggest solutions to the above problems

(1) --

(2) --

(3) --

(4) --

(5) --

SECTION 4: FISH FARMING REVENUES AND EXPENSES

Item	Kilograms (kg)	Value (KES)
Revenue		
Selling Price		
Harvested output		
Tilapia sales		
Catfish sales		
Other fish related sales		
Total income		
Variable costs		
Fingerlings		
Feeds		
Fertilizer		
Lime		
Field labour:		
Stock		
Feed		
Fertilizer		
Harvest		
Dyke/levee repairs, after draining		
Security personnel		
Total variable costs		

Fixed costs		
Construction costs		
Management costs		
Interests paid on loan		
Ponds (Lease)		
Total fixed costs		
Total costs		
Net cash fish income		
Non-cash adjustments to income		
Cash inventory adjustments		
Depreciation equipment		
Depreciation ponds		
Net farm income		
Gain/loss on sale of capital assets		
Machinery		
Motor Vehicles		
Land		
Other		
Net fish income		

SECTION 5: MARKET ACCESS

1. What is the distance to the nearest main market centre from the fish farm? ---------- Kilometres

2. What is the type of road from the fish farm to that market? Codes 1= Tarmac, 2= All season murram road, 3= Seasonal murram road, 4= Other (Specify) -------------------

3. What is the distance to the nearest collection or postharvest storage facility? ------------- kilometres

4. What is the distance from your fish farm to the most important town? ---------kilometres

5. What is the cost of transport to the most important town? KES……………

6. What is the distance of your fishpond from the nearest fish input shop in kilometres? .....

SECTION 6: EXTENSION

Provide the following information on extension access and suitability

General information

Did you receive extension contact for any of the fish farming for the last one year? **1= Yes 2= No** **(**If No, go to next section. If Yes, who was the provider? (See ranked codes below)	What types of services were provided? (See ranked codes below)
Extension services provider	Types of services provided

1= Government 5= Input dealers 2= NGO/ donor 6= Farmer group 3= Exporter 7= Cooperative society 4= Local traders 8= Other Specify ---------------	1= Fish management 5= Record keeping 2= Pond management 6= Value addition 3= Water management 7= Fish marketing 4= Hygienic practices 8= Other Specify ------------

Fish farming information

Type of fish farming product for which you received extension contact	Provider of the service (See codes above)	What types of services were provided? (See codes above)

SECTION 7: CREDIT AND FINANCING

1. Information on access to credit

Have you ever looked for credit for use in fish farming? (1= Yes, 2= No (If No, go to Question 2, If Yes, who was the source of credit?)	Major form of credit	Amount (KES)	Interest charged (KES)
Major source of credit 1= Government agency 2= Exporters/ buyers 6= Farmer groups	1= Money 2= Materials and/ or		

3= Commercial bank 7= Relatives/ friends 4= Shylocks 8= Input dealers 5= Donor/ NGO 9= Other Specify ----------------	inputs 3= Other		

2. If No, why haven't you obtained credit?

Reasons for not getting credit	
1= Not needing any loan	4. High cost to obtain the credit/ loan
2= No collateral as required	5. Other
3= Not a member of the institution	Specify -------------------------------

APPENDIX 6: PROCESSOR QUESTIONNAIRE

1. General Information

1.1 Name of Town/trading Centre____

1.2 Date of interview ____

1.3 Name of enumerator ____

2. Description of the Respondent

2.1 Group 1=Retail Trader, 2= Middleman/broker 3= Distributor/wholesaler 4= Supermarket 5=Processor

2.3 Name of respondent: ____

2. 4 Gender of respondent 1=Male 2= Female

2.5 Age of the respondent (Years) ____

2.6 Education Level _________________________________ [1=No formal education, 2=Primary, 3=Secondary (ordinary level), 4=Secondary (advanced level) 5=Tertiary]

2.7 What is your responsibility in this business? 1= Owner 2= Hired manager 3 = others (specify)

3. What fish products have you processed from 2010 to date?

Fish products **(see code 1)**	Source of raw material **(see code 2)**	Unit of purchase **(see code 3)**	Purchase price of raw material	To whom do you sell to the finished	Unit of sell **(see**	Selling price per unit

				products **(see code 4)**	**code 3)**	

Codes

1. **Products:1=** fish pillets**2**= tilapia **3**= catfish , **4**= fish fillets**5**= fish animal feed, **6**=smoked fish, **7**= Others (specify)
2. **Source: 1=** Open market **2=** Shop/supermarket **3=** Farmer **4=** Others (specify)
3. **Unit of purchase/sell: 1** = heap **2**= Kilogram **3**=bags **4**= others (specify)
4. To whom did you sell: 1= **Retailer** 2= **Final consumer** 3= **Both consumer and retailer** 4= **processors** 5= **others (specify)**

4.0 Scale of operation, frequency of processing and quantity/quality criteria for fish

4.1 How frequently do you buy fish raw materials for processing?

1= daily [ ] 2= 2-3 time a week [] 3= Weekly [ ] 4= fortnight [ ] **5**= monthly [ ] 6= others (specify) ________________

4.2 List the fish raw materials you buy and the respective products you make from them?

Codes for Products b: 1=tilapia fillets; 2=smoked catfish; 3=fishmeal; 4=smoked tilapia;

5=catfish fillet; canned fillets

Raw material bought	**Variety bought**	**Quantity bought**	**Product(s)use codes from above**	**Reason for using variety to produce product**	How long (hours/days) after buying do you process?

4.3 In your own view, how would you rate the demand for fish processed products? 1= high demand [ ] 2= average demand [ ] 3= low demand [ ]

4.4 Is the supply of fish processed products adequate to meet the customer demand throughout the year? 1= Yes [ ] 2= No [ ]

4.5 Using the scores below, Score for the characteristics that your customers consider as important when buying fish processed products

Products	Fish processed products							
Characteristics	Canned tilapia	Tilapia fillet	Flours	Catfish fillet	Canned catfish	Animal feeds	Salted	Fermented
Size								
Colour								

Storability								
Taste								
Nutritive value								
Cookability								
Foreign matter								
Texture								
Maturity								
Disease/pest damage								
Packaging								

Codes:1= Not important 2= somewhat important 3= fairly important 4= very important

4.6Do you make any contractual agreement with your suppliers in advance? 1=Yes 2= No

4.7 If yes what was the nature of agreement made? 1= Formal,   2= Informal

4.8 Do you process your fish products on order? 1=Yes, 2=No

4.9 In which months are the sales? Lowest _____________ Highest ________________

4.10 Do you do marketing promotion for your products 1=Yes   2= No

4.11 What other services do you offer to attract more customers?

1. = Credit services, 2= Product delivery, 3= Free samples 4=others (specify)

4.12 Do you face any problems while transacting your business associated with fish processed products? 1=Yes   2=No

4.13 If yes, what are the problems? ___________

1= irregular supply of raw, 2=quality of raw material, 3= irregular demand, 4= inadequate supply 5=price 6=other (specify)

4.14 In your view what can be done to improve your fish processing business?

1.____

2.____

4.15 Would you be willing to work with other chain actors to improve the fish processing & fish trade?

1=Yes, 2=No

4.16 If no why? ____

4.17 Do you belong to any association of businesses dealing in fish products? 1=yes 2=No

4.18 If yes what is the name of the Association ___________________________________

4.19 What are the main activities of the Association?

____

5.0 Processing equipment

	Responses (if more than one, list codes)	
5.1.3 What are the commonly used processing equipment/tools 1=chippers, 2= graters, 3= solar dryers, 4= Pounding mortar, 5= Pangas, 6= Knives, 7= Grinding mill, 8=other (name)_		
5.1.4 What treatments do you do on fish during processing drying? 1=washing 2=canning 3=smoking 4=salting 5=fermenting 6=Others (specify)______		
5.1.5 Reason for treatment above		

1=Cleaning 2=Detoxify 3=Reduce bulkiness 4=Others (specify)		
5.1.6Where does the processing take place? (1= Designated room, 2=other		

5.1.7 What constraints do you face with the processing equipment / tools you use and what are your coping mechanisms?

Product	**Equipment(s) used**	**Constraints**	**Coping mechanism**

5.2 Storage

5.2.1. Do you store fish processed products? 1=Yes, 2=No

5.2.2 If yes, why do you store? 1= sell in a distant market 2= to built up stock 3= other specify___

5.2.3 If no, why don't you store fish products? 1=quality 2= price change 3= lack of appropriate storage facilities 4=competition from other alternative products 5= other specify ____________________

5.2.4. Do you store fish processed products in the same store with other commodities?

1. Yes 2.No

5.2.5. If yes, name the other commodities stored alongside fish products? ________________________________

5.2.6 How do you package your processed products for storage? 1= Poly propylene bags 2. Baskets

3. Gunny bags, 4= Jute Bags 5= Drums, 6= plastic containers, 7=Brown paper, 8=Others (specify)______

5.2.7. Where do you store your packaged fish processed product?

Product	**Where is the product stored (Use codes below)**	**Reason for use**

Codes: 1= On shelves in a store 2= On a racks 3= Boxes 4=refrigerators 5=Others (specify)

5.2.8. How long do you normally store each of the products before sale?

Product	**Length (in days, weeks, months) of storage**	**Main causes of loss** 1= Pests 2= rotten 3= Thieves 4=. Weather, 5= Others (specify)

5.2.9. What do you do with the damaged or spoilt fish processed products?

Product	Damaged or broken	spoilt (molded or caked)

6.0 Waste management

6.1 How do you manage wastes from fish processing operation?

Processing operation	Type of waste	How waste is managed
Internal waste		
Scales		
Washing		
Dewatering /pressing		
Canning		
Others (specify)		

APPENDIX 7: TRADERS QUESTIONNAIRE

1. General Information

1.1 Name of Town/trading Centre____

Name of the business ____

Date business was established____

1.2 Date of interview ____

1.3 Name of enumerator ____

2. Description of the Respondent

2.1 Group 1=Retail Trader, 2= Middleman/broker 3= Distributor/wholesaler 4= Supermarket

2.3 Name of respondent: ____

2. 4 Gender of respondent 1=Male 2= Female

2.5 Age of the respondent (Years) ____

2.6 Education Level ______________________________ [1=No formal education, 2=Primary, 3=Secondary (ordinary level), 4=Secondary (advanced level) 5=Tertiary]

2.7 What is your responsibility in this business? 1= Owner 2= Hired manager 3 = others (specify)

3. Traders and distributors information

3.1 What are the fish and fish products you handled from 2012 to date?

Fish product**(se**	Product	Unit of purchase(**Se**	Purchase price/unit	Transport mode	To who	Selling price/unit

e code 1)	source (see code2)	e Code 3)				(See code 4	m did you Sell (See code)			
			Low	Mode	High			Low	Mode	High

Codes

1. **Products:1** = Tilapia fish **2**= catfish **3**= salted fish 4= f smoked fish , 5= canned fish 6= fermented fish 7= fish animal feed, 8= Others (specify)
2. **Source: 1=** Open market **2=** Shop/supermarket **3=** Farmer **4=**Farm gate 5+Others (specify)
3. **Unit of purchase: 1** = Heap/pile **2**= Sachet **3**= wheel barrow **4**= Kilogram **5**= bags, 6= Gorogoro, 7= others (specify)
4. Transport mode 1=**Bicycle** 2= **Public vehicle/matatus** 3= ox-cart 4= **back/head** 5= **pick up** 6= **others (specify)**
5. To whom did you sell: 1= **Retailer** 2= **Final consumer** 3= **Both consumer and retailer** 4= **processors** 5= **others (specify)**

4.0 Scale of operation, frequency of trade and quantity criteria for fish

4.1 What types of fish traders operate in this town or market?

1= Retailers [ ] 2= Wholesalers [ ] 3= Others (specify)____________________

4.2 How frequently do you buy fish and/or fish product for sale?

1= daily [ ] 2= 2-3 time a week [] 3= Weekly [ ] 4= fortnight [ ] **5**= monthly [ ] 6= others (specify) ________________________________

4.3 What quantities of fish products do you usually buy per month? ____________________________

What size/weight of fish do your customers want?

a) Tilapia b) Catfish------------------

Are you able to supply the size or weight of fish demanded by your clients?

If the answer to the question above is no, state the reasons why

4.4 In your own view, how would you rate the demand for fish products in this market? 1= high demand [ ] 2= average demand [ ] 3= low demand [ ]

4.5 Is there demand for fish and fish products in this market? 1= seasonal [ ] 2= all year [ ] ?

4.6 Is the supply of fish products adequate to meet the customer demand throughout the year? 1= Yes [ ] 2= No [ ]

4.7 Using the scores below, Score for the characteristics that your customers consider as important when buying fish products

Products	Fish and fish products							
Characteristics	Fresh tilapia	Fresh catfish	smoked	Salted	Dried	Canned tilapia /catfish	Other Canned fish	Animal Feeds

Size								
Colour								
Storability								
Taste								
Nutritive value								
Cook ability								
Foreign matter								
Texture								
Maturity								
Disease/pest damage								

Codes 1= Not important 2= somewhat important 3= fairly important 4= Very important

4.8Do you make any contractual agreement with your suppliers in advance? 1=Yes 2= No

4.9 If yes what was the nature of agreement made? 1= Formal, 2= Informal

4.10 In which months are yoursales lowest-------------Highest

4.11 Do you do marketing promotion for your products 1=Yes 2= No

4.12 What other services do you offer to attract more customers?

1.= Credit services, 2= supplies product delivery, 3=Other (specify)

4.13 Do you face any problems while transacting your business associated with fish and fish products 1=yes 2= No

4.14 If yes, what are the problems?

1= Irregular supply, 2=quality variability, 3= irregular demand, 4= other (specify)

4.15 What percentage of your household income is derived from the fish business? ………….

4.16 In your view what can be done to improve your fish business?

1.____

2.____

4.16 Would you be willing to work with other chain actors to improve the fish trade? 1= Yes, 2= No

4.17 If no why? ____

4.18 Do you belong to any association of businesses dealing in fish products? 1=yes 2=No

4.19 If yes what is the name of the Association _______________________________________

4.20What are the main activities of the Association?

5.2 Storage

5.2.1. Do you store fish products? 1=Yes, 2=No

How do you store fish or fish products a) store b) fridge c) other (specify)

5.2.2 If yes, why do you store? 1= sell later at a higher price 2= to built up stock 3= other specify___

52.3 If no, why don't you store fish products? _____________________________________

5.2.3. Do you store fish in the same store with other commodities? 1. Yes 2.No

5.2.4. If yes, name the other commodities stored alongside fish products? 1= Cereals, 2= legumes 3= other specify__________________

5.2.5 How do you package your products for storage? 1= Poly propylene bags 2. Baskets

3. Gunny bags, 4= Jute Bags 5= Drums, 6= plastic containers 7=Others (specify)______

5.2.6. Where do you store your packaged fish product ?

Product	**Where is the product stored (Use codes below)**	**Reason for use**

Codes: 1= on floor in store 2= On a raised platform in store. 3. Others (specify)…………

5.2.7. How long do you normally store each of the products before sale?

Product	**Storage(in days, weeks, months)**	**Main causes of loss** 1. Pests 2. Molds 3. Thieves 4. Weather, 5. Others (specify)

5.2.8. What do you do with the damaged/spoilt fish products?

Product	**Damaged/broken**	**spoilt (molded)**

5.2.9 Any comments on fish you would wish to share?

APPENDIX 8: QUESTIONNAIRE FOR HOTELS, TILAPIA/CATFISH KIOSKS AND CAFES

1. Name of Business……………………………...…Date……………………...

2. Name of respondent ………………………….. Sex ………….…………

3. Role of respondent ……………………………………………………….

4. Location of business……………..District/Region ……………………...…

5. Type of Business: Restaurant Tilapia/Catfish Cafes and Kiosks

6. What year was the business started? ……..…………………………

7. Where do you get your adult tilapia/catfish for?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

8. How often do you buy it?

Daily More than once a week, weekly or bi-weekly

Monthly Less than once a month

9. In what form(s) do you buy it? Live, fresh or frozen

Smoked Salted Others (specify)…………………

10. In what form(s) do you sell it? Grilled Boiled (as in soup) fried

Salted Frozen Smoked

11. Please indicate the size of Tilapia you normally prefer to buy per kg)? <2   2- 3,   >3

12. What quantity do you buy each week? .... in kilograms

13. How much does it cost? KES …………………………………………………

14. How many kilograms do you sell per day or per week? …………………

15. How much do you sell per day or per week? KES………………….

16. Does your current supply of Tilapia meet your requirement? Yes No

17. What factors do you look out for before buying the fish?

Uniformity Size Price Freshness

18. In your opinion which fish species do you consider the closest substitute to tilapia? Specify…………………………..…….……………

Table2. For daily operational fish activities

Qty ordered/day	Qty sold/day	Usable Qty left/day	Waste/day

APPENDIX 9: CONSUMER QUESTIONNAIRE: MAKUENI COUNTY

The aim of this study is to measure the current levels of fish performance at the consumer levels as part of the Researcher PhD thesis work and also form a basis for future monitoring and evaluation in future projects. Your honest responses will be used to inform Researcher of the current situation, and will therefore be treated with utmost confidentiality; and will not be used to purposes other than research only. Your cooperation and participation is highly appreciated. Thank you for accepting to take part in this study.

Enumerator's name __________________ Start time___________ End time _________

Background information

1: General information

1. Classifying information	
Date of interview	
District	
Division	
Location	
Village	
GPS coordinates of residence	
Agro-ecological zone (AEZ)	
Date checked	

Date of data entry	

2: Respondent and General Household Information

2.1. Name of respondent	
2.2. Respondent gender	1= Male [ ], 2 = Female [ ]
2.3. Is respondent head of household	1= Yes [ ], 2 = No [ ]
2.4. If no, relationship to household head	1= Spouse [ ], 2 = Son/daughter [ ], 3 = Parent [ ], 4 = Son/daughter in-law [ ], 5 = Sibling [ ], 6=Other relative [ ]
2.5. Educational level	Respondent [ ] Household head [ ] (use code list below) 1=No formal education, 2=Primary), 3=Junior , 4=Secondary (ordinary level), 5=Secondary(advanced level) 6=Tertiary
2.6. Age (years)	Respondent [ ] Household head [ ]
2.7. Marital status	Respondent [ ] Household head [ ](use code list below) 1=Married living with spouse, 2=Married but spouse away, 3=Divorced/separated, 4=Widow/widower, 5=Not married, 6=Other (specify)………..
2.8. Household size	No. of females [ ] No. of males [ ] No. below 15 [ ] No. above 65years [ ]

2.9. Main occupation	Respondent [ ] Household head [ ](use code list below) 1=None, 2=Farming, 3=Salaried employment,4=Self-employed off-farm, 5 =Farm worker, 6= Off-farm worker, 7=Other (Specify)_______
3.0 Household food security status	
3.1 Whatare your main sources of proteins?	
3.2 Which crops are the most important for food security?	List 5 in order of importance
3.3 What is the households sources of food security	1= Farming 2= Salaried employment 3= Self employment off-farm 4= others specify _______________
3.4 Which months of the year don't you have sufficient food	

4. Consumer

4.1 Do you consume fish or any products from fish? 1=Yes 2= No

4.2 If the answer to 4.1 above is no, give the reasons why?

4.3 If yes how often do you consume fish in your household?

4.4__List type of fish you normally buy and consumed; their sources and buying price last year?

____

Type of Fish	Source (see code 1)	Frequency of	Unit of purchase	Amount consumed	Buying price/unit		
					Low	**Moderate**	**High**

		purchase (See code 2)	**(see code 3)**	**per week by household**			
Tilapia							
Catfish							
Others(specify)							

Code 1: **Source: 1=** Open market **2=** Shop/supermarket **3=** Farm-gate **4=** Others (specify)

Code 2:Frequency of purchase:1= once a week **2**= 2-3 time a week **3**= Weekly **4**= fortnight **5**= monthly **6**= others (specify)

1. **Code 3:Unit of purchase:** 1 = Heap/pile 2= Kilogram 3= Gorogoro, 4=others (specify)
2. **Code 4:Amounts** 1= Heap/pile 2=Kgs 3=gorogoro 4=others (specify)

4.5 What criteria do you use when buying fish from the market?

NB = Please rank criteria used by codes indicated below

Fish characteristics	**Type of fish**					
	Tilapia	Omena	Trout	Nile Perch	Catfish	Shrimp
Fresh fish						
Smoked						
Storability						
Taste						
Nutritive value						
Others (specify)						

Codes: 1= yes 2=no 3= other

4.3 Where do you eat the fish 1- home; 2-restaurant; 3- Other

4.4 What is the buying price, for the various categories fry, baked smoked, etc

4.5 Type of fish fry boiled, baked smoked

Tilapia………………………………………………………………………………

Catfish……………………………………………………………………………..

4.6Do you face any challenges obtaining (purchasing) fish and fish products? 1=yes, 2= No

4. 7. If yes indicate the problems below (Use codes indicated below)

Product	**Problem**
Tilapia	
Catfish	
Other specify	

Code: 1=Appearance 2=Taste 3=Foreign matter 4=Availability 5=other specify

____

4.8 Any comments on fish you would wish to share?

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………

APPENDIX 10: TEST OF MODEL COEFFICIENTS

Test of Model Coefficients

	Chi-square	Df	P-value
Step	51.010	10	.000
Block	51.010	10	.000
Model	51.010	10	.000

Source: Field survey 2015

APPENDIX 11: Model Summary n=146 cross- sectional data of fish farmers in Kibwezi

Appendix 11: Model Summary n=146 cross- sectional data of fish farmers in Kibwezi

Model	R	R^2	Adj R^2	Std Err
1	.557[a]	.310	0.258	0.428

Predicator[a] AGE, GENDER, MSTATUS, EDUC, MLIHOOD, MEMSP, CREDIT. EXTVT, FISHMKT, INPUTMKT

APPENDIX 12: ANOVA; n=146 Cross-sectional data of fish farmers in Kibwezi

Appendix 12: ANOVA; n=146 Cross-sectional data of fish farmers in Kibwezi

Model	Sum of squares	Df	Mean square	F-value	Sig.
Regression	10.835	10	1.083	5.891	.000[a]
Residual	24.095	131	0.184		
Total	34.930	141			

Source: Field survey 2015 Predicator[a]Constant, AGE, GENDER, MSTATUS, EDUC, MLIHOOD, MEMSP, CREDIT, EXTVT, FISHMKT, and INPUTMKT

APPENDIX 13: COEFFICIENT CORRELATIONS[a]

Model			INPUTMKT	MEMSP	MSTATUS	GENDER	FISHMKT	EDUC	AGE	MLIHOOD	CREDIT	EXTVT
1	Correlations	INPUTMKT	1.000	-.093	.144	.018	.062	-.021	.122	.055	-.071	-.243
		MEMSP	-.093	1.000	-.106	.113	.153	.144	.208	.114	-.051	.286
		MSTATUS	.144	-.106	1.000	.028	-.001	-.134	.230	-.340	.047	-.158
		GENDER	.018	.113	.028	1.000	.025	.079	.102	-.004	-.116	-.160
		FISHMKT	.062	.153	-.001	.025	1.000	.103	.089	-.029	-.261	.272
		EDUC	-.021	.144	-.134	.079	.103	1.000	-.098	.162	.091	-.023
		AGE	.122	.208	.230	.102	.089	-.098	1.000	-.006	-.104	.099
		MLIHOOD	.055	.114	-.340	-.004	-.029	.162	-.006	1.000	-.111	-.017
		CREDIT	-.071	-.051	.047	-.116	-.261	.091	-.104	-.111	1.000	.425
		EXTVT	-.243	.286	-.158	-.160	.272	-.023	.099	-.017	.425	1.000
	Covariances	INPUTMKT	5.346E-7	-1.032E-5	8.186E-6	1.017E-6	1.793E-6	-4.237E-7	2.704E-6	4.076E-6	-5.123E-6	-1.162E-5
		MEMSP	-1.032E-5	.023	-.001	.001	.001	.001	.001	.002	-.001	.003
		MSTATUS	8.186E-6	-.001	.006	.000	-2.129E-6	.000	.001	-.003	.000	-.001
		GENDER	1.017E-6	.001	.000	.006	7.433E-5	.000	.000	-2.722E-5	-.001	-.001
		FISHMKT	1.793E-6	.001	-2.129E-6	7.433E-5	.002	.000	.000	.000	-.001	.001
		EDUC	-4.237E-7	.001	.000	.000	.000	.001	-8.234E-5	.000	.000	-4.112E-5
		AGE	2.704E-6	.001	.001	.000	.000	-8.234E-5	.001	-1.715E-5	.000	.000
		MLIHOOD	4.076E-6	.002	-.003	-2.722E-5	.000	.000	-1.715E-5	.010	-.001	.000
		CREDIT	-5.123E-6	-.001	.000	-.001	-.001	.000	.000	-.001	.010	.003
		EXTVT	-1.162E-5	.003	-.001	-.001	.001	-4.112E-5	.000	.000	.003	.004

a. Dependent Variable: adoption

APPENDIX 14: COEFFICIENTS

Model		Unstandardized Coefficients		Standardized Coefficients			99.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.589	.511		1.152	.251	-.746	1.923					
	AGE	.042	.030	.109	1.375	.171	-.038	.121	.106	.118	.100	.827	1.209
	GENDER	-.090	.076	-.089	-1.187	.237	-.287	.108	-.116	-.102	-.086	.931	1.074
	MSTATUS	-.034	.078	-.036	-.431	.667	-.237	.170	-.076	-.037	-.031	.760	1.316
	EDUC	-.083	.028	-.233	-2.998	.003	-.155	-.011	-.310	-.250	-.217	.867	1.154
	MLIHOOD	-.040	.101	-.032	-.400	.690	-.305	.224	.023	-.034	-.029	.834	1.199
	MEMSP	.423	.152	.226	2.792	.006	.027	.820	.223	.234	.202	.803	1.246
	CREDIT	.045	.099	.044	.456	.649	-.214	.304	.234	.039	.033	.566	1.768
	EXTVT	.092	.065	.146	1.400	.164	-.079	.263	-.237	.120	.101	.480	2.081
	FISHMKT	.123	.040	.273	3.120	.002	.020	.227	.338	.259	.226	.683	1.464
	INPUTMKT	-.002	.001	-.264	-3.401	.001	-.004	-.001	-.296	-.281	-.246	.872	1.147

a. Dependent Variable: adoption

APPENDIX 15: COLLINEARITY DIAGNOSTIC

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	AGE	GENDER	MSTATUS	EDUC	MLIHOOD	MEMSP	CREDIT	EXTVT	FISHMKT	INPUTMKT
1	1	9.382	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.754	3.528	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.78
	3	.269	5.904	.00	.01	.00	.06	.02	.00	.00	.03	.11	.06	.09
	4	.163	7.579	.00	.13	.00	.23	.15	.07	.00	.00	.01	.01	.02
	5	.124	8.699	.00	.00	.43	.12	.22	.00	.00	.00	.05	.00	.02
	6	.092	10.110	.00	.29	.17	.01	.25	.18	.00	.00	.04	.05	.00
dimension0	dimension1 7	.072	11.404	.00	.05	.23	.07	.02	.03	.00	.01	.32	.46	.02
	8	.063	12.160	.00	.17	.00	.40	.21	.65	.00	.00	.00	.00	.00
	9	.048	14.003	.00	.20	.12	.07	.01	.03	.07	.27	.04	.31	.06
	10	.029	18.002	.01	.00	.00	.04	.02	.00	.23	.64	.16	.00	.00
	11	.004	49.003	.98	.15	.05	.00	.10	.04	.69	.05	.26	.10	.00

a. Dependent Variable: adoption