VALUE CHAIN ANALYSIS OF AQUACULTURE FEED IN TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2019

ABSTRACT

Tanzania is among the countries which depend on aquaculture feed for their fish farming needs. Recent decline in fish volume captured from natural waters due to, climate change, illegal fishing and increased fishing effort due to growing population has resulted into has stimulated aquaculture production. This has created an opportunity for aqua-feed manufacturers to cope with increased demand for aqua-feeds. The present study aimed to analyze the value chain of aquaculture feeds in Tanzania using cases from, regions purposively selected due to their potential in feed manufacture, fish farming and fishing activities carried out by communities in the areas. The overall objective was to analyse the aquaculture feed value chain and establish its linkage with aquaculture production systems, in particular increasing of omega-3 in farmed tilapia and subsequently enhancing availability of the same to consumers in Tanzania. The overall sample size was 85 respondents, whereby; 7 were feed manufacturers and 78 were fish farmers. The study used descriptive statistics, logit model and Return on Investment (ROI) to analyse data. Results showed that: aqua-feed value chain in Tanzania involve four main actors; aqua-feed ingredients supplier, producer, Traders and fish farmers. Furthermore, feed price has positive influence on choice of aqua-feeds whereas extension visits, experience in fish ferming and age had a negative influence. Standardized aqua-feed is most profitable compared to unstandardized feed in fish farming practice. Also, investing in aquaculture sector is viable to both feed manufacturers and fish farmers along the chain. However, as well as these benefits, there costs incured in aquaculture production. The study revealed, sustainability of aqua-feed with reference to omega-3 LC-PUFA content depends on the government intervention to strengthen the chain that will eventually benefit consumers.

DECLARATION

I, Phabian Samson Kabambara, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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ACKNOWLEDGEMENTS

This study would not have been accomplished successfully without the help and encouragement of many people. Acknowledgements are extended to the following individuals and organizations. First and foremost my sincerest gratitude goes to my academic supervisors, Dr. Adam Akyoo from the Department of Agricultural Economics and Agribusiness, Dr. Cecile Brugere and Dr. E. Msuya for their generosity, encouragement, guidance, patience, constructive comments and advice at all stages of the research and writing up of this dissertation. I am grateful to the technical expert of Aquaculture from the Department of Animal Sciences, aquaculture and Range management Dr. Nazael Madalla for his assistance and advice on aquaculture aspects. I also extend my gratitude to my fellow students, MSc. Agricultural Economics student's class 2016 for their support especially during the course work. I am indebted to lecturers and support staff at the Department of Agricultural Economics and Agribusiness. I would like to thank my sponsor SNIPH (Sustainable New Ingredients for Promoting Health) for financial support on data collection. Heartfelt thanks to my wife Jane Joseph and my son Phaseoline for their patience and understanding. I would also like to thank my extended family and friends for their encouraging words and continued support. Moreover, my special thanks go to my employer and staffs of Department of Planning, monitoring and statistics at DED Magu for granting me the study leave.

Lastly, but not least, I would like to extend my deep appreciation to the feed manufacturers and fish farmers in Morogoro, Mwanza, Mbeya, Dar es Salaam and Coast region for their cooperation during the entire period of data collection. There is no doubt that without their support this study would not have been as successful as it has been.

DEDICATION

To my grandmother Gaudencia Mhindi Mhemba, my wife Jane Joseph, my son Phaseoline, my parents and relatives who shared the pains of loneliness while I was away for studies. Your love and support are my motivation. This MSc is yours as much as it is mine.

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LIST OF ACRONYMS, ABBREVIATIONS AND SYMBOLS

%	Percentage
BRELA	Business Registrations and Licensing Agency
CSM	Cotton Seed Meal
DCs	Developed countries
DED	District Executive Director
FAO	Food and Agriculture Organization
FCR	Feed Conventional Ratio
FM	Fish meal
FO	Fish oil
GDP	Gross Domestic Product
h	Hour
Kg	Kilogram
LDCs	Less Developed Countries
M4P	Making Value Chain Working Better for the Poor
MALF	Ministry of Agriculture, Livestock and Fisheries
max	Maximum
Min	Minimum
MSc.	Master of Science
MT	Metric tons
n	Sample size
NCPF	Non-Conventional Plant Feed stuff
Qty	Quantity
SNIPH	Sustainable New Ingredients Promoting Health
SPSS	Statistical Package for Social Science

SUA	Sokoine University of Agriculture
TAFIRI	Tanzania Fisheries Research Institute
TBS	Tanzania Bureau of Standards
TFDA	Tanzania Food and Drugs Authority
TZS	Tanzania Shilling
UDSM	University of Dar es salaam

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Aquaculture Feed

Aquaculture is the fastest growing food production sector in many countries of the World. Maintaining the present growth rate, corresponding increase in availability of aqua-feed production is essential. According to FAO (2016), approximately 33% of total fish feed production is utilized for culture of carnivorous species, 30.8% for non-carnivorous species and 36.2% for culture of shrimps globally. Diets containing desired quantities of proteins are required for faster growth of most of the farmed fish species. Moreover, fish and fishery products play a vital role in food security and meeting the nutritional needs of the human population in the Least Developing Countries (LDCs) and Developed Countries (DCs) (FAO, 2014).

Fish is a good source of high value protein as well as an essential source of micronutrients including vitamins, minerals and polyunsaturated omega-3 fatty acids (FAO, 2012). Omega-3 fatty acids are one of the two along the chain of polyunsaturated fatty acids (PUFA). The main function of omega-3 fatty acids in the human body is to increase linolenic acid, *Docosahexaenoic* Acid (DHA) and *Eicosapentaenoic* Acid (EPA). DHA contributes to human brain as the main structural form omega-3 fatty acid, which comprises about 40% of the PUFAs in total content (Damitha and Suphioglu, 2014).

1.1.1 Importance of aquaculture feeds

Good diet to fish production systems is essential to economically produce a healthy and high quality of fish. In the aquaculture sector, fish feeds nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal farmed fish growth and health benefits (FAO, 2016). However, development of new species-specific diet formulations to support the aquaculture (fish farming) industry as it expands to satisfy increasing demand for affordable, safe and high-quality of standardized feed contain omenga-3 fatty acid PUFA is still low (Dunbar *et al*., 2014).

Farmed fish eat feeds that are formulated to contain all the essential nutrients needed to keep them healthy and growing to maintain the human health benefits of fish consumption (FAO, 2012). Nowadays, aquaculture provides half of all fish for human consumption and is the most-traded food commodity worldwide with more than half of fish exports by value originating in LDCs (FAO *et al.,* 2017). Global fish production rose from 32.4 MT in 2000 to 59.9 MT in 2010. In 2014, fish harvested from aquaculture amounted to 73.8 MT, with an estimated first sale value of US$160.2 billion (FAO, 2016). The world population is expected to reach about 9.7 billion by 2050 (FAO, 2016). Despite of that, local populations are currently facing malnutrition, heart disease and adult obesity due to lack of omega-3 within food supplied (FAO *et al.*, 2017).

1.1.2 Aquaculture in Africa

In Africa, Aquaculture was introduced with the main objective of improving nutrition in rural areas, generating additional income, diversifying activities to reduce risk of crop failures and creation of employment in rural areas. About 43% of the African continent is assessed as having the potential for farming Tilapia, African catfish and Carp, of which 15% is considered most suitable for fish farming (Asmah, 2008). According to Gabriel *et al*.(2007), techniques of feed formulation vary from one region to another, involving combination and blending together of feed ingredients (based on a formula) into nutritionally balanced and economically sound diets that can be used in required amount to provide the levels of manufacture desired in fish farming. The processing methods which include sourcing, mixing, pelleting, drying and storing are very crucial because they determine bioavailability of nutrients, feed choice, palatability and durability which often have profound effect on performance of fish.

African countries largely increased aquaculture feed production; however Egypt is one of the largest producers in Africa (GFS, 2018). The growth, expansion and production of aquaculture are more advanced in techniques and technicalities in Egypt compared to Sub Saharan region. Most of African use aquaculture technologies imported from Asia, Europe and North America, most of these are based on earthen pond.

1.1.3 Aquacultures in Tanzania

In the early 1950s, aquaculture started in Tanzania with experiments on Nile tilapia in ponds culture (URT, 2016). The aquaculture industry in the country is currently dominated by Nile tilapia (*Oreochromis niloticus*), rainbow trout (*Oncorhynchus mykiss*), African catfish (*Clarius gariepinus*), seaweed (*Eucheuma spinosum, Kappaphycus cottonii and E. striatum)* and milk fish *Chanoschanos*) farming. The industry is dominated by small scale farmers producing fish for household consumption and for domestic market (URT, 2015). There is also small seaweed farming and harvesting sector exploiting red algae used for carrageen production (URT, 2016).

Aquaculture in Tanzania is stagnant; about 4000 tons are produced per year, three quarters of which is tilapia (URT, 2015). The sector generates employment to an estimated 15 000 – 20 000 people engaged in the seaweed sector, 14 100 in freshwater fish farming and 3000 in the marine sector (URT, 2016). In 2014, the fisheries industry in Tanzania employed about 183 800 full time fishermen and about 4.0 million people earned their livelihoods from the fisheries sector related activities. The sector has been growing at a rate of 5.5 percent and contributing 2.4 percent to the GDP (URT, 2016). The dietary contribution of fish in terms of animal proteins is about 30-60 percent of the daily protein requirements for an adult consumption globally (FAO, 2016; URT, 2015).

Tanzania knowledge network (2014) stated, “fish farming is one of the new initiatives that has been implemented in various regions in Tanzania such as Mwanza, Arusha, Kigoma, Morogoro, Mbeya and coastal region. Fish farming was carried out through fish ponds and was mainly practiced by farmers in the rural communities as a source of food and income, the response had been positive and extremely high as evidenced by a large number of individual farmers and famers’ groups specialized in fish farming”.

There has been global decline in the annual fish production from 7.2% in 1995-2004 to 5.8% in 2014 (FAO, 2016). In Tanzania with 49% of Lake Victoria, Nile tilapia stock have declined from 402.2 thousand tonnes of fishable biomass in 1994 to 339.4 thousands in 2004 (Sanga, 2009). Climate change is threatening biodiversity (Bellard *et al*., 2012), and malnutrition due to low content of n-3 and sustainability of fish stocks, hence putting future generations at risk. Use of fishing illegal gears such as under size mesh, monofilament nets and other destructive gears has greatly contributed to fish resources depletion and environmental destruction; with resultant reduced protein supply in the world (URT, 2015; FAO, 2014). Currently, Fish farming in Tanzania is guided by National Fisheries Sector Policy of 2015 governed by the Fishery Act 2003 No. 22 and its regulations of 2009, which give direction, restriction and guidance on fishing.

1.2 Problem Statement and Justification

There are two main issues associated with the feeding of fish. One is that feed typically represents 60-80% of the total costs of fish production, owing mainly to the high cost of fish meal and fish oil as key ingredients to provide the necessary nutrients to the fish and as key sources of Omega-3 (n-3) long-chain polyunsaturated fatty acids (LC-PUFA) for human diet (Tacon and Metian, 2008). For each activity the cost drivers are recognized that determine its economic behavior (Dekker, 2003). Simply aquaculture feeds choice and feed management has a significant impact on the economic performance of fish production (Shipton and Hasan, 2013).

Hence, the type and value of feed that farmers select are dependently based on the market (either local or export/import), the value of the fish and financial resources available, the species, the culture system and intensity of production. Second is that the only alternatives to fish meal (FM) and fish oil (FO), plant proteins and vegetable oils, do not contain n-3 LC-PUFA (Harwood, 1996). Alternative plant-based ingredients are characterized by having low protein content, unbalanced essential amino acid profile, high levels of fibre and starch and presence of one or more anti-nutritional factors (NRC, 1993).

Although available at lower cost, fish feed made on the farm premises using farm by-products or locally produced small-scale commercial feeds do not fully satisfy the nutritional and physiological needs of fish (FAO *et al.*, 2017). This is compounded by the fact that many fish farmers are unaware of the nutrient requirements of their farmed species, especially dietary protein and energy levels and how it affects the production cycle. Although higher plants do not contain n-3 LC-PUFA, their precursor, linolenic acid (ALA), can be abundant in terrestrial and freshwater plants (Harwood, 1996) and many freshwater fish species including tilapia, have the metabolic capacity to convert dietary

ALA to n-3 LC-PUFA (Tocher, 2003). One potential option for increasing the amount of n-3 LC-PUFA available, particularly to poor populations, is to exploit the endogenous ability of farmed freshwater fish such as tilapia, which is widely farmed in Africa, to produce n-3 LC-PUFA from ALA from suitable and widely available local plants, which are not yet commonly used in fish feed (hence them being “non-conventional ingredients”) (SNIPH project, 2015).

There is a need, on one hand, to reduce value chain inefficiencies in the manufacture and supply of fish feed to fish farmers and on other hand to promote the use of alternative, non-conventional indigenous ingredients in fish feed to boost the contents of fish in n-3 LC-PUFA to benefit the health of eating fish for consumers (Michaelsen *et al.,* 2011; Dunbar *et al*., 2014).

Several studies such as Mwaijande and Lugendo (2015); Dixon *et al*. (2016) and El-Sayed *et al.* (2014) have been done on aquaculture value chain. The studies cover a number of topics ranging from policy imperatives for the sector’s commercialization, chain governance and employment creation and profitability analysis. However, little emphasis has been placed on feed manufacture, including the sourcing of feed ingredients and the distribution of feed, as an essential component of broader aquaculture value chains. The current study intends to take a comprehensive analysis of the aquaculture feed value chain. Increase demand of produced aquaculture feed, which will benefit small scale farmers and farmed fish healthily. This will make communities in Tanzania to shift from fishing to fish farming to improve their economic income hence poverty alleviation. Finally, the study will provide information that will help to identify policy issues that may be hindering proper functioning of the chain as well as areas that need improvement in the chain.

1.3 Objectives

1.3.1 Overall objective

The overall objective of the study is to establish the aquaculture feed sector value chain and establish its linkage with aquaculture production systems in increasing availability of omega-3 supply to consumers in Tanzania.

1.3.2 Specific objectives

i. To map and characterize the aquaculture feed sector value chain in Tanzania.
ii. To determine factors influencing the choice of aquaculture feeds by fish farmers in Tanzania.
iii. To determine the returns on investment obtained by aquaculture feed manufacturers and fish farmers in Tanzania.

1.4 Research Hypothesis and Questions

1.4.1 Research hypothes

Socio-economic characteristics do not have influence fish farmers' choice for aquaculture feed in the study area.

1.4.2 Research questions

i. What is the structure and level of coordination/organization of aquaculture feed sector value chain in the study area?
ii. How profitable are aquaculture feeds manufacturing and aquaculture farming in the study area?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Value Chain Concept

A firm is a collection of activities which are performed to design, produce, market, delivery and support its products or services (Porter, 1985). This collection of activities constitutes a value chain which shows how a product moves from the raw materials stage to final the consumers (Hitt *et al.*, 2013). Elsewhere, Porter (1985) defines the value chain specific to an individual company as the disaggregation of a firm into strategically relevant activities in order to understand the behavior of cost and the existing potential sources of differentiation. Chagomoka *et al*. (2014) define value chain processes as including the choice of market outlets and the mode of producer-buyer linkages. Value chain analysis has also been described by Macfadyen *et al*. (2012) and FAO (2014) as the primary component of assessing performance in different systems and classifying the value addition in competitive markets of production to the consumption chain activities. These activities which include designing, production, marketing, distribution and support to the final user can take place within a firm or among different firms in one or several geographical locations.

Elsewhere, various authors (Kaplinsky and Morris, 2000; Chagomoka *et al*., 2014) look at value chain as a sequence of activities which identify actors and how they interact along the chain, linkages, and quantification of earnings by various actors using data gathered from surveys and services required to bring a product or service from its conception to the final customers and to the final disposal after use. Thus, technical experts are involved to support in the production and financial service only for the sake of sustaining the chain (KIT *et al*., 2006). VCA is also a diagnostic tool which as defined by Taylor (2005) is a multi-dimensional assessment of the performance, including the analysis of product flows, information flows and the management and control of the value chain. Such analysis draws the attention of different actors to the opportunities for improvement at different stages in the value chain.

2.2 Governance in the Value Chain

Governance, according to Raikes *et al.* (2000) is vital to producers and buyer-driven along the chain in the demanded products. In addition, Humphrey and Schmitz (2002) identify governance directives under which actors in a chain must operate and establish new links of the enforced structures. However, (Gibbon, 2003) argues for one transaction connecting a pair or more links in the chain, rather than being able to characterize larger segments or the entire chain itself.

Talbot (2009) argues further that governance structure characterizes segments of the value chain and not the link between two or three nodes. Kotler and Armstrong (2014), look at these segments as associated with dividing consumers into clusters according to their observed behaviours. Producers and marketers believe behavior is superior to demographics and geographic in building market segments. Economic agents situated elsewhere in the chain may therefore benefit from strengthened coordination in the production segment and which may induce them into supporting producers' upgrading efforts (Kaplinsky and Morris, 2000).

2.3 Upgrading in Value Chains

Ernst (2004) views economic upgrading as a shift to higher value added products, services and production stages through increasing specialty and efficient domestic and international linkages. Producers through linkages among different economic agents such as input suppliers, processors and traders manage the flow of goods and services to enhance their economic welfare (Christiaensen *et al.*, 2011). Value added implies both value creation and value capture, since upgrading requires resources investment, it follows links in the chain which are expected to improve technology, knowledge and skills and increase the benefits (Barrientos *et al.*, 2011). Kaplinsky and Morris (2002) classified upgrading in four areas: process, product, functional, and chain. A process increases the efficiency of a firm's internal processes to become better than those of rival firms; a product involves improving the current one; functional add value by changing the mix of activities in a firm (such as outsourcing logistics and quality functions); and chain upgrading entails moving to a new value chain.

Moreover, functional upgrading chain goes together with the transfer of new capabilities to different value chains in relation with smaller buyers (Humphrey and Schmitz, 2004). Thus, combining whole-chain governance, individual node coordination and strategies associated to process, product and volume of both products and end-markets can be mutually strengthened for increased volume and can enable investment in processing equipment which is needed to raise the quality of produce (Riisgaard, 2010; Jespersen *et al.*, 2014).

2.4 Institutional Perspective in Value Chains

Value chains are highly complex taking into account a huge diversity of products, production practices, and actors involved and they depend on the nature and types of institutions which exist in a particular value chain (Kaplinsky, 2000; Makindara, 2012). Value chain analysis (VCA) examines the relationship between actors along the value chain and what each actor obtains from the multi-activity performed. VCA helps to keep producers and institutions from withdrawing the capital and managerial effort and putting it into other alternative investments (Kotler and Armstrong, 2014). According to North (1992), organizations are made up of formal rules, informal norms and the enforcement characteristics that determine economic performance along the chains. However, the influences are motivated by classical theories that characterize how firm's restrictions are likely to respond to output purpose (Baker *et al.,* 2002). The net gain needs quality sensitive markets that brings the rise returns to output quality, but developed high quality output typically requires high quality inputs (Halpern *et al.*, 2015). It is regularly hard for firms to measure the quality of feed and agreement ended particularly where institutions are not strong (Amodio and Martinez, 2018). The governance coordinates and control dominant actors, product, process and logistics along the chain and followed by other actors (Humphery and Schmitz, 2004).

2.5 Aquaculture Feed Value Chain

As Asiedu *et al.* (2015) suggest that, the value chain analysis has many benefits such as providing policymakers, fishing and feed companies with a systematic management tool which allows them to understand the processes in the industry. The value chain analysis also ensures that there is a long term economic performance, environmental and social sustainability of the sector and its final impact on economic growth and poverty alleviation (Brugère *et al.*, 2010).

Similarly, value addition on aquaculture promotes health improvements, trade benefits, job opportunities and product diversification against risks and uncertainty. Moreover, VCA promotes better understanding of the linkages between farmers and buyers and ensures that farmers tailor their production to the demands of consumers (FAO, 2017). In this regard, actors become more actively engaged in adding value to the products by improving quality, packaging and presence at every stage of the chain.

El-Sayed (2015) describes VCA as a useful tool of analysis in the aqua-feed sectors and aquaculture. In recent years, value chain analysis has been a useful means of assessing performance in different systems including; distributional issues and pro-poor and gender equitable growth; the relative importance of the factors influencing competitiveness, the costs, and earnings of each cycle of the value chain; identifying and analyzing gaps and weaknesses in value chain performance and identifying and suggesting appropriate upgrading, management and development strategies of improving value chain performance.

2.5.1 Mapping aqua-feed sector along the chain

El-Sayed (2014) identifies four main actors in the Egyptian aquaculture feed value chain: feed ingredients or additives and raw material suppliers, feed producers, feed marketers and traders, and fish farmers. Aqua-feed is a sector where about 90% of the Egyptian fish feeds are produced by the private sector fish feed mills that produce conventionally pelleted feeds and the public sector contributes the remaining estimated 10% of the total commercial fish feed production. However, aquaculture feed producers were reported to have obtaining positive net returns from aquaculture feed investments annually.

On other hand, farmers were found to have been producing mostly for subsistence purposes and in isolation from the commercializing value chain. Thus, the commercial sector is characterized with investments in intensive cage and pond-based aquaculture mostly for tilapia species, creating the bulk of annual production (Kaminski *et al.*, 2017). Moreover, Simpson (2012), revealed that VC in aquaculture in Ghana has become an enterprise which is acknowledged by both urban and rural communities: the sector employs 10% of the population from both urban and rural communities. The forms of aquaculture in Ghana are basically pond and cage cultures and that Catfish and tilapia were the two main fishes which were cultivated in Ghana, tilapia accounted for 80% whilst catfish account for 20% of aquaculture production.

In a value chain analysis study in the Egyptian aquaculture feed industry (El-Sayed, 2014), it was estimated that 80% of aqua-feeds which were made by public feed mills were sold through traders or retailers, as opposed to only 15-20% of aqua-feeds from private mills. Aqua-feed traders and retailers added around 3–6% to the price of fish feeds. Moreover, fish farmers specified that feed costs represented around 70–95% of the total operating costs of their farms. The study by El-Sayed (2014) used descriptive statistics and cost-effective analysis and both feed producers and fish farmers reported to have been able to obtain positive net returns from aquaculture investments annually.

2.5.2 Aquaculture feed ingredients and practice

In the aquaculture sector, fish feeds nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal farmed fish growth and health benefits (FAO, 2016). However, as Belton *et al*. (2013) revealed, despite that value chains have advanced in relationship with the growth of the formulated feed industry and the increase of the number of feed suppliers to farmers, more rural farmers are still lacking access to formulated feed. Gabriel *et al*. (2007), identify two types of aquaculture feed with their availability and practices by farmers: the first type is conventional feed, which is widely acceptable by farmed fish and farmers. These feeds are agro industrial by-products or manufactured by feed mills. The second type is non-conventional feed stuffs which are near to the area; their practice is not widely-spread worldwide and its utilization is only common in the rural area of Sub-Saharan Africa. As Hassan *et al.* (2013) observed, it is significant for farmers to have access to good quality feeds at equitable prices and optimize their feed use by applying suitable on-farm feed management practices to realize profits. Plants and animal feeds may not have sufficient nutrients to meet the needs of all cultured fish. Pond *et al.* (2005) suggested that, the values of digestible protein in each ingredient should be developed, well-balanced, and have sustainable diets. Producers and suppliers do not seem to know the quality characteristics of the produced feeds and have limited knowledge on nutritional requirements of the fish depending on the available aqua-feed at the market especially those formulated for a particular species such as catfish and tilapia (Welker *et al.*, 2016).

However, different surveys have been carried out to look for alternative and cheaper protein sources as ingredients in the feed for farmed fish. As Mzengereza (2014) noted, feed ingredients such as fish meal, animal meal or the by-products and plant material (soybean products), as primary sources of protein for fish growth, can be used in the manufacturing of affordable and quality fish feed to increase fish production in Malawi. Agbo *et al*. (2011) noted further that Cotton Seed Meal (CSM), which is a by-product of cotton after fibre and oil production, is often used as animal feeds. Kubiriza *et al.* (2017), found the fresh water shrimp (*Caridina nilotica*) and mug beans (*Vigna radiata*) being used as a protein source to replace fish meal. These results show that there has been positive growth performance in fish fed with both *Caridina nilotica* and fish meal. Thus, the cost of the feed was reduced when freshwater shrimp was used as a primary source of protein in the diet of farmed fish.

Elsewhere, Yones *et al.* (2016) found that the use of poultry waste meal costed less than the usage of fishmeal in Egypt. The replacement of fish meal with cheaper ingredients of plant origin in fish feed is necessary because of the rising cost and uncertain on the availability of fish meal (Higgs *et al.*, 1995). The inclusion of feedstuffs with relatively high levels of carbohydrate in the formulated aqua-feed is done in view of its proteinsparing action that might make the diet more cost effective (Welker *et al.,* 2016). According to Daniel (2018), the increased use of plant protein supplements in aqua-feed can reduce the cost of fish meal. For example, Mzengereza *et al.* (2016) found that salt can be used as an additive in fish diets to enhance growth, but this should vary depending on the species and geographical location. Fish farmers choose the option that benefits the cultured fish best, by comparing the nutritional supplies of the species, availability, price, storage method, hygiene and environmental effects of different feeds and see which one benefits the needs of fish farm.

White *et al*. (2018) indicate the relationship between feed management and the economic efficiency of farmers and other actors along the chain for choosing profitable feeds. The dietary formulations were chosen according to their cost, availability and suitability for use in aqua-feeds. The aqua-feed were tested at farmer-scale trials in Taal Lake for Nile tilapia and Bulacan for milkfish. The study compared the standard feed and the feeding practiced by the farmer in reducing production costs, nutrient waste output to the environment with the aim of attaining a more economical and environmentally sustainable industry. Thus, the aqua-feed made by mills performed better and were more economical than the aqua-feed made by farmers.

2.5.3 Aquaculture feed production

According to El-Sayed (2014) the commercial aquaculture feed industry in Egypt is growing at a rapid rate, with an increase of the number of fish feed mills from 5 mills producing about 20 000 tons per year in 1999, to over 60 mills with an estimate production of 800 000 – 1 000 000 tons per year in 2012. The feed sector employed 36 to 106 people per mill, with women constituting 10% of the total permanent employments in the mills. However, feed formulation is followed by processing and manufacturing. The processing method, which includes sourcing, mixing, pelleting, drying and storing, is vital in ensuring bioavailability of nutrients, feed acceptability, palatability and durability that often have a profound effect on performance of fish (Gabriel *et al.*, 2007). Feed formulation can be done by choosing a cheap source of ingredients but rich in nutrients for fish growth and optimum performance. The price of dried-pellet is higher than that of trash and vegetarian fish feed because of the differences in nutritional values (Cuvin *et al*., 2012).

Aqua-feeds are broadly classified into natural food and artificial feed. Thus, artificial feeds, both supplementary and balanced are formulated with predetermined nutritional contents and supplied to the cultured species in order to meet the essential nutritional requirements. Supplementary feeds, which are found in various forms such as powder, and pellets, alone cannot fulfill the nutritional requirements of cultured species (Tacon, 2008). The way farmed fish use protein varies by species, age, and size. However, commercial feeds contain approximately 30% protein while juvenile tilapia require up to 40% protein for proper growth and health (El-Sayed, 2013; Dabrowski and Portella, 2006).

Aqua-feed cost constitutes about 50-70% of the total production cost in the aquaculture which has made it difficult to convert the benefits of higher production related with commercial feed into economic gains when fish are fed following traditional farming principles (Borski *et al.*, 2011). The efforts of aqua-feed formulator of preparing the aqua-feed at lower cost will directly be reflected in the economy of fish farmers in terms of benefits from the development of aqua-feeds. However, in an effort of maximizing farming profits, fish farmers have established various feeding management methods, which reduce feed inputs and workers' costs (Cuvin *et al*., 2012). The use of CSM based diets replaces at least 50% of the fish meal protein in the diet of *O. niloticus* (Shipton and Hasan, 2013). These strategies include mixed feeding such as alternative commercial pellets with farm-made aqua-feed which reduce costs without reducing the nutritional quality of aqua-feed (Gabriel *et al.*, 2007).

Farmers are gradually shifting to factory-made feeds from local feed to external inputs through the application of farm-made feeds to add value of the produce. Feed cost is a major constraint to the development of aquaculture from the economic point of view, and is a key element for higher benefits as it accounts for 40-80% of the operational costs in semi-intensive and intensive systems (De Silva and Hasan, 2007). Fish feeds which are prepared with good quality feed ingredients and better feed efficiency result in higher production that cut down the feed cost and reduce waste production in fish farming. Furthermore, as FAO (2016) observes, the application of low quality feeds and inappropriate feeding methods create many problems such as fish diseases, poor fish growth and high mortality rate.

2.6 Theoretical Review

2.6.1 Theory of the firm

The theoretical underpinning that guides the aquaculture feed value chain is the theory of the firm that is the microeconomic concept founded in neoclassical economics which states that firms exist and make decisions to maximize profit. Hence, the firms interact with the market to determine pricing and demand and then allocate resources according to models that are likely to maximize net profits. The theory of the firm governs decision making in a variety of areas including resource allocation, production methods, pricing setting, and volume of production. Moreover, a producer is assumed to choose the level of output for each distribution channel in a manner that maximizes profits. As Blandon *et al*. (2007) argue, the theory of the firm tends to ignore the consumption. However, consumption is separated from production, logically, because two different economic agents are involved. In the first, the consumption is by the primary individual, and in the second a producer might make something that would not consume himself (Carroll *et al.*, 2017).

As Samuelson and Marks (2003) argue, the main motivating factor of traders in guaranteeing their capital in marketing is the level of profit received from their capital invested. Thus, the most profitable segment along aquaculture feed and fish farming value chains will attract capital relative to the lower profitable segments. Moreover, firms that are making decision on what, how and how much to produce given the available scarce resources and technology generate better outputs. A firm's production is referred to as the process of combining and coordinating raw materials and moving into the creation of some goods and services (Nicholson and Snyder, 2007). Moreover, as Harrison and Wicks (2013) argue, the notion of value has been overly simplified and narrowed to focus on economic returns of the investments. The firm owners try either to maximize profits or to minimize the costs of producing certain level of output while ensuring that they are operating on a production point.

Generally, a producer is more likely to make choices of aquaculture feed only if they would bring positive net return on the investment or the Total revenue (TR) is equal to the Total Costs (TC). Profit-maximazation is the motivator behind the establishmenbt and the existence of an investment whose profit is the function of output produced and the input prices and fixed costs at a given level of technology of production process (McFadden, 2000; Cowell, 2004; Beattie and Taylor, 1993). This is explained as:

From $\pi = TR - TC$ ....(1)

$\pi_i = py - (z_i, y) - b$ such that (x,y) T ....(2)

From the optimal combination of production factors, the maximum profit can be achieved under the condition of Equation (2) above

$$\frac{\partial \pi}{\partial y} = \frac{\partial [\, py - (z_i, y) - b]}{\partial y} = p - \frac{\partial (z_i, y)}{\partial y} = 0 \ldots\ldots (3)$$

Furthermore, in Figure 1, it is assumed that there is a perfect competition in the market for the good a firm produces and sells at any quantity at a given market price.

In this context therefore, the firm would be in equilibrium only when it achieves profit maximization. The total revenue (TR) function of a firm gives its total revenue as the function of the quantity of the output sold (q), TR = TR (q). The total cost (TC) function of the firm, on the other hand, gives total cost as a function of the quantity of the output produced (q) using different resources (TC = TC(q)). The firm's profit (π = TR – TC) would be positive at Q > QBE and negative at Q <QBE. Therefore, the firm's positive profit is maximized at q for which the slope of the TR curve is equal to the TC curve.

Whereby; π= profit, TR=Total Revenue, TC=Total Cost, MC= Marginal costs, p= price of output produced, T= Production technology used, z_i= prices of inputs used in production, y=output produced by the firm, x= level of inputs used, and b= fixed costs.

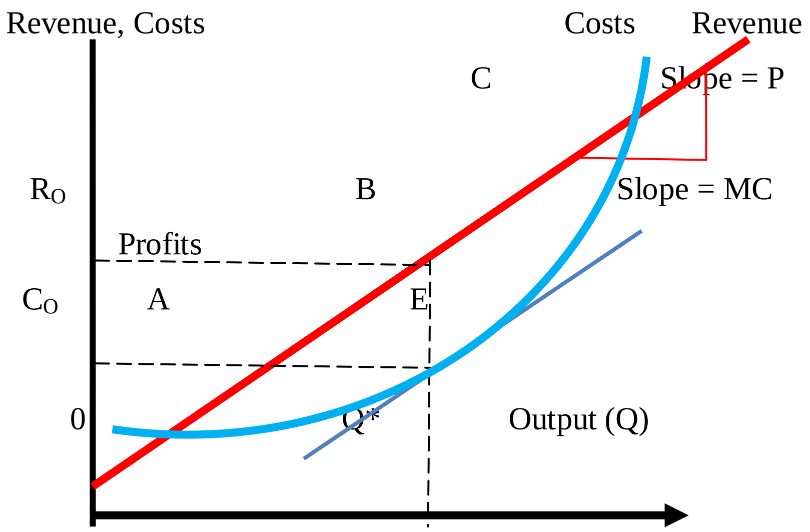


Figure 1: Firm-Profit maximization developed from (Cowell, 2004)

2.7 Empirical Approaches of Value Chain

2.7.1 Explanatory variables on aquaculture production, with emphasis on aqua-feeds

The concept of value chain was originally proposed by Porter (1985) who looked at how inputs are derived from outputs and from different actors to the final user. Value chains are highly complex taking into analysis a huge diversity of products, production practices and actors involved. Several scholars have explained the methods of evaluating each gain from the chain. For example, Debertin (1993); Kaplinsky (2000) and Raikes *et al.* (2000) reported on the differences on value chain analysis between one area of the field and another in the scale of the analysis by using different methods that refer to economic performance such as gross margin, return on investment (ROI), internal rate of return (IRR) and benefit-cost ratio (BCR).

Other players start the analysis of value chain from the initial stage of conception of the product to the final consumer commodity in-order to succeed as a value chain analysis. Others believe that every process and transaction from input to the consumer end-use product should be included in the analysis, while others choose segments and actors along the chain to analyze their value. On the other hand, Debertin (1993) found that the total costs at each stage along the value chain analysis make sense in justifying the total expenses and revenues of the investment. A high return means the investment's gains compare favorably to its cost.

However, Raikes *et al.* (2000) and FAO (2017) contend that the approach of value chain presents challenges when assessing the degree to which agro-furniture providers (i.e. fertilizers, pesticides, agricultural machineries, feed) participate in the value chain and whether they should be included in the value chain analysis (VCA). It is difficult to see anyone having an accurate description on value chain analysis. However, aqua-feed is derived along the chain where actors maximize profits from the investment. Scholars have focused much attention on estimating value chain for cost function, revenue functions and multi-inputs used in aqua feed production which are linked to fish farming. According to Schmitou *et al*. (1998), feeding fish is providing the nutritional requirements for good health of species, optimal growth, optimum yield and minimum waste within reasonable cost so as to optimize profit among actors in the chain. From the point of view of fish farming diversification (Robinson, 2006), better performance resulting from fish feed is not dependent on quality (pallet) feed alone. Better results are attained when fish are fed correctly using the right methods of feeding, which ensure all fish have access to the fish's nutritional needs.

Moreover, Madan *et al*. (2007) analyzed factors of fish production under polyculture and feed demand in Asia by using descriptive techniques to compare performance of polyculture and monoculture in terms of productivity, cost effectiveness and success. The results of the analysis revealed that further use of farm-based feed after a certain level of application cannot increase productivity as the law of diminishing marginal productivity sets in. Feed use or choice is largely determined by the income and ownership of land status of the farmer.

Economic choice is a conscious decision of using scarce resources in one way rather than another. Eriegha *et al.* (2017) identify the individual factors that affect farmer's choices along the chain and these include attitudes, values and knowledge on nutrition of aqua-feed for better management and productivity. With regards to the use of technology, FAO (2014) found that optimal pond sizes, fish feeds management and quality fingerling supply chains are vibrant technological components for sustainable fish farming system. According to Gabriel *et al*. (2007), palatability of aqua-feed is a major factor that determines feed choice by users. Feed acceptance depends on a variety of chemical, nutritional and physical characteristics, all of which can be influenced by the choice of feed ingredients and processing conditions used in the feed manufacturing (Tacon, 2008). The ability of fish to eat and detect the feed can be influenced by physical and chemical properties, pellet density (sinking rate), size, color and texture (hardness) and the chemical composition of feed which will depend on the aqua-feed ingredients used **(**Shipton and Hasan, 2013). Schmitou *et al.* (1998) observed that incorporating high level of maggot meal in the tilapia diet led to unacceptable and poor growth performances.

In addition, Ortega *et al.* (2012) assessed consumer's preferences and demand for fish, based on market analysis of the Midwest aquaculture industry. The study results revealed that consumers had awareness of the quality and safety of the aquaculture products they consume to maximize utility. However, aquaculture products are dynamic and the demand from consumers requires changes in the production and marketing, suppliers and which are met with decisions of various practices about the production and marketing of their aquaculture products. Aquaculture producers and retailers face difficulties in the supply chain management and food safety decisions partially because of significant uncertainty about consumer's protection for information on various attributes on quality of food product.

Rozana and Roslina (2015) examined the influence of socio-demographic characteristics on the level of good aquaculture practices among aquaculture farmers in the Northern part of Peninsular Malaysia. Descriptive analysis and logit model were applied to identify the socio-demographic characteristics of aquaculture farmers. The findings reveal that the level of brackish-water pond farmers is satisfactory where almost all farmers are practicing good aquaculture. Thus, age and technical knowledge related to aquaculture were the main factors that had significant influence on aquaculture production among aquaculture farmers.

Njeru (2013) found out that training and extension services offered to farmers in Embu North District in Kenya, fish stocking and availability of local market were positively correlated with fish output. Descriptive statistics was used to present percentages. Ibekwe (2007) studied the determinants of small scale fish farming in Owerri Imo state, Nigeria amongst 30 respondents. The study used regression analysis and found that education level, feed price and the size of pond were significant positively correlated with fish output.

Elsewhere, Amos (2007) studied resource use in tilapia production among 14 small scale farmers in the Savanna zone of Northern Nigeria. The study used farm business analysis, and the results showed a net income of 140.000 Naira made per hectare and that for every kilogram of feed, farmers used 5.5 kg of fish for tilapia and catfish feeding. Awoyemi (2011) analyzed profitability of fish farming among 62 women fish farmers in Osun state Nigeria. The study used budgetary method and observed a gross margin of Naira 574 314 and the net return of 419 756.17 Naira. The author concluded that fish farming was rewarding and profitable as ROI was 0.58.

2.8 Methodologies in Similar Past Studies

2.8.1 Studies in Africa and outside Africa

A study by Adanu and Mawufemor (2017) in Ghana shows that about 99% of the aquaculture farms surveyed, documented positive net returns with an average return of 72% per annum. The successes depended on feed management by the use of optimal combinations of fertilizers, aqua-feed ingredients and industrial feeds to lower feed cost and to optimize production of aquatic species during different stages of their life cycles. The aquaculture value chain was simple and this included wholesalers and traders buying at the farm-gate and reselling directly to consumers in the different markets.

Tunde *et al.*(2015) aquaculture value chain was positively related in terms of income generation and supply of animal protein to majority of people at Oyo State, Nigeria. The results revealed that the return on investment (ROI) of the aquaculture in the study area was positively related and the total revenue was higher per cycle, whereas the total cost was lower per cycle. This implies that fish farming was cost-effective and was expected to continue to operate: therefore, the higher the return on investment the more the returns from the venture.

FAO (2014), investigated key issues regarding investing in aquaculture sector: the study used descriptive statistical analysis and reported that (a) loans access to farmers, (b) extension services and training on how to prepare feed, improve associations, and farmers' access to better feeds support the growth of sustainable aquaculture, which include improving the quality and sustainability of local feed ingredients, feed manufacturing and processing, review of feed Public policy and better farm-level feed utilization.

(a) Access to loans

According to Kinda *et al.* (2008) farmers within the chain need access to loans to finance investments activities which would affect outcome through capital intensity and acquiring new and modern production equipment (boats and concrete sinker). Access to loan is important because feeding is the highest cost of production and therefore availability of developed financial system creates more investment opportunities of mobilizing and allocating resources to the most profitable ventures.

According to FAO (2016) report, farmers face uncertainties, risks in the pursuit of reproductive and growth operations. The losses affect entities of the economy namely; producers and marketers, who depend on fish farming for the supply of aqua-feed, aquaculture products and operations. The losses also affect financiers and investors who are dependent on the return of agriculture operations. Borrowed capitals protect aquaculture business operation such as equipment's, buildings and fish stock against loss.

(b) Extension services and Training, factors influencing feed choice in the study area.

As Christian (2016) pointed out, the provision of extension services and visits to rural communities improves farmers' skills and increase efficiency on their investment. The extension visit and services to farmers increases the production of outputs, information, value addition, loan access, improved feed use, and marketing of produce. The study employed descriptive statistical analysis to present results in the form of tables and figures. Fish farmers training advised farmers to embrace clusters production and marketing approach through association to benefit from the economics of scale, where it should be linked to the market (FAO, 2016).

2.8.2 Studies from Tanzania

In the Tanzanian context 58 000 and 64 300 square kilometers of fresh and marine waters respectively, which is equivalent to 30% of the total land area, are considered to be suitable for aquaculture development (URT, 1997). The main bottlenecks found were unavailability of high quality feed and high price, restrictions in accessing investment capital, knowledge for sustainable high productive fish culture systems and better fingerlings. In a study on the role and place of Women in Aquaculture in Ukerewe District, Tanzania, Luomba (2013) investigated women's critical role in the aquaculture chain from pond construction, fingerlings sorting, pond stocking, feeding, sex identification, and fish harvest. The study results show that within the two groups (gender) women make up 80% of the labor force. Women are reported to have participated extensively and actively in all phases of work performed on fish farms. The types of work done by women ranged from construction of pond, feeding the fish, cleaning of pond environment to fish harvesting. Other activities include sorting of fingerlings and pond stocking.

As noted by Chenyambuga *et al*. (2012), aquaculture in Tanzania is still a subsistence activity practiced by small-scale farmers who have low social, cultural and economic status and limited access to technology, markets and credit access. The study found that majority of farmers depended on natural food as a source of feed for their fish. The statistical analysis was used to evaluate management and value chain of Nile tilapia cultured in the ponds of small-scale farmer's in Morogoro region. On the other hand, (Rakocy *et al.,* 2004) found that fish farmers obtained fingerlings and aqua-feed from local sources such as a network of friends. Sometimes, fish farmers make their own feeds using the locally obtained materials such as maize and paddy husks, the remains of vegetables from garden and cattle dung to minimize the cost of production.

Mwaijande and Lugendo (2015) studied the value chain in terms of policy decisions which are required for the transformations of fish-farming into a viable commercial activity. The study employed descriptive statistics and content analysis method. However, VCA for policy analysis allows the investigation of multiple dimensions in the VCA framework of aqua-feed value chain in achieving specific policy objectives, such as poverty alleviation by applying different policy options and their socio-economic characteristics (Lorenzo, 2013). The value chain analysis is therefore an important step in understanding the aquaculture feed sector in Tanzania. It helps to understand the nature of the activities involved and the opportunities for the development of the sector.

2.9 Synthesis of the Literature Review

The above literature summarized researches which have been conducted worldwide, including Sub Saharan in Africa on key dynamics of aqua-feed value chain and its linkage with fish production (Dixon *et al*., 2016; El-Sayed *et al.*, 2014; Chenyambuga *et al*., 2012). These literatures however, paid little attention on aqua-feed ingredients and its linkage on production. It is evidenced that there are different models in addressing aqua-feed value chain map, factors influencing aqua-feed choice and the analysis of return on investment to both aqua-feed producers and fish farmers.

To fill the knowledge gap, this study analyzed the aquaculture feed value chain and its linkage with aquaculture production systems in increasing availability of omega-3 LC-PUFA supply to consumers and which is produced using conventional and non-conventional feed ingredients. The results from this study provide answers to questions as to “who, why” and “how” within economic agents’ categories the production of aqua-feed is low. The empirical evidence from this study are envisaged to inform policy makers on the appropriate policy interventions that promote the use of standardized aqua-feed, which would promote producers and aquaculture sector in Tanzania.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Research Conceptual Framework

Value chain analysis of aquaculture feeds depicts the way a product gains value (and costs) as it moves along the path of design, production, marketing, delivery and service to the customer (El-Sayed, 2014). However, value chain operates within an institutional context that shapes the conditions within which value chain actors exercise coordination (at particular nodes) and governance (along the chain). The rules that constitute this regulatory framework remain critically important to the high reliance on exported produce for GDP earnings (FGI *et al.,* 2013).

In order to calculate investment return along the value chain the financial data for each actor (marketplace) which includes all costs of activities involved in each actor, selling prices at each level of the chain and the consumer price were identified (Fig. 2) below shows the conceptual framework diagram for value chain of aquaculture feed. The variables such as; age, experiences of fish farming, feed price, fish stocking, government support, farming type, extension visits and land ownership, while the mentioned factors may be confounding variables to determine fish farmers choice for an aquaculture feed, because it is unclear whether such choice will have any reference to omega-3 fatty acid PUFA content that the feed is expected to produce. This study is based on the theory of firm, the theory explains the main objective of the firm/farmer to maximize profit or minimize cost through efficient allocation of resources. Profit maximization has been used to describe inter-relationship that exist between aquaculture feed manufacturers and fish farmers on minimization of cost of production and feed choice for increasing supply of omega-3 LC- PUFA content on farmed fish.

Moreover, specific factors such as age of the farm owner are expected to have positive influence on fish farming since an elders' farms have accumulated more experience than fresher farms, who might not know sources of aquaculture feed ingredients/inputs (soybean, fish meal, maize bran, corn, moringa, cotton cake and fish oil) and use of new feed technologies to reduce cost of production (Gabriel *et al*., 2007; Mwaijande and Lugendo, 2015). Ownership of the farm is expected to positively or negatively influence good return on investment (Madan *et al*. (2007). Locally farm-made feeds that are manufactured by individual farmers have impact on farmed fish practice.

Furthermore, the increased production of high value fish species and intensification of existing culture practices of freshwater finfish, has added significantly to the increased production and utilization of industrial aqua-feed in different regions (FAO, 2014; Kaminski *et al*., 2017). To sustain the expected increase in the use of aqua-feeds requires concerted advances in production technology and feeding practices. However, Papadogonas *et al.* (2013) used the longitudinal data set on manufacturing firms in Greece for the 2004-2011 periods to examine the relationship between market power, cost, and firm performance. They found that market share and cost are significant determinants of the success for the whole time period tested. Similarly, age of the firm had positive relationship with return in both periods indicating that variables such as experience gave old-timer firms edge over fresher firms in food sector. The high level of education and experience of farm owner are hypothesized to have positive impact on an aqua-feed manufacture and fish farming due to learning from past experiences (Gillespie *et al.*, 1997). Basically, regulation, institutional and firm-specific factors are identified so as to look for correct measures to register the business, improve them for development of feed industry and sustainability (URT, 2007).

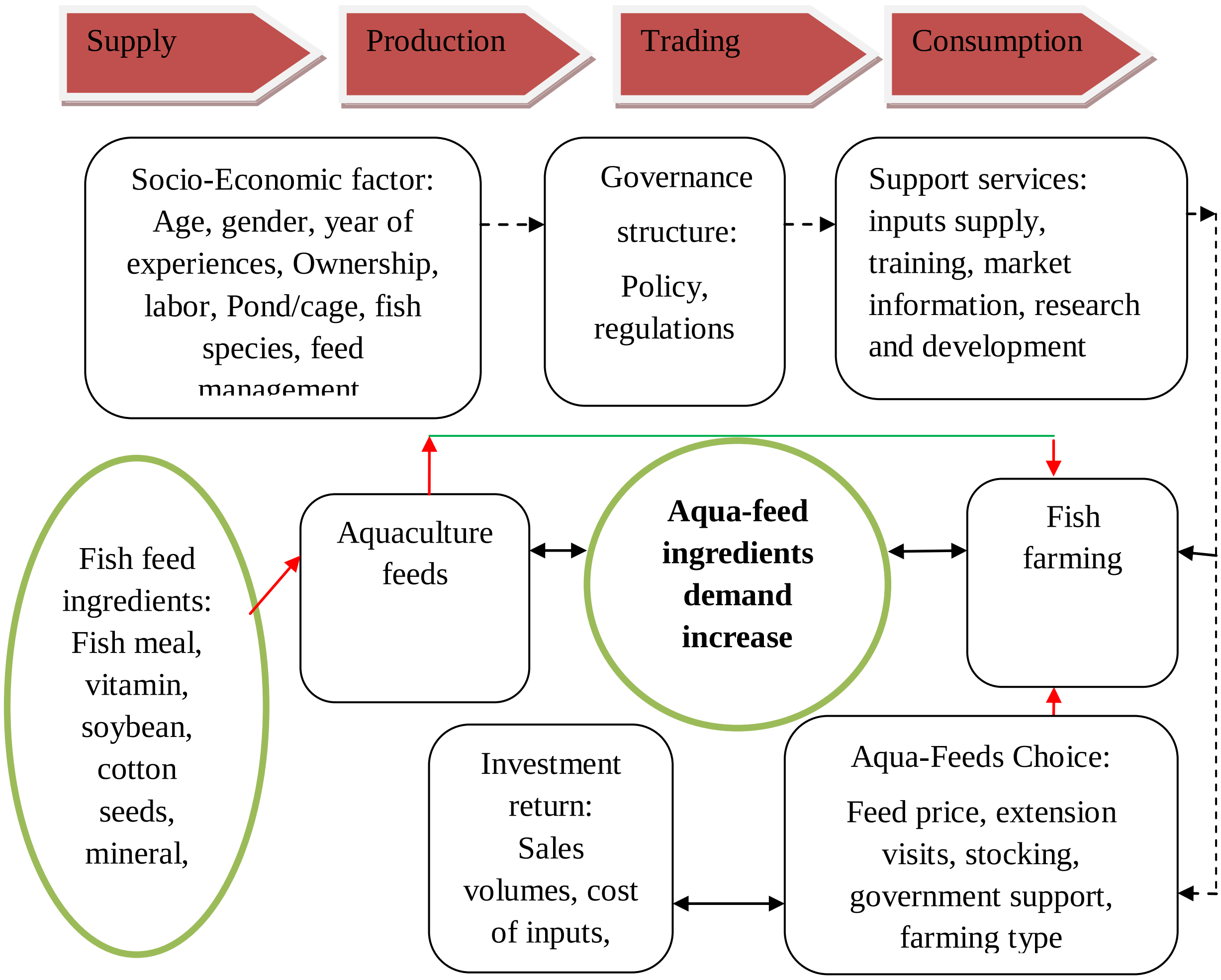


Figure 2: Conceptual framework for aquaculture feeds research (modified from Teng, 2013)

3.2 Study Area and Aquaculture Location Sites

The study was conducted in the selected areas in Tanzania namely; Morogoro, Mbeya, Dar es Salaam, Mwanza and Coast region. These areas were selected to represent a range of aquaculture feed producers, as well as capture those engaging in fish farming in contexts (rural, peri-urban, coastal) and farming systems. These areas are known to have reasonable concentrations of stakeholders, facilitating the logistics of implementation of the study. There is high production of aquaculture feeds manufacturing and farmed fish practice, which enable the area to maintain the household's access to high class animal protein to meet their nutritional needs.

3.2.1 Aquaculture location sites

Five sites were selected to represent the aqua-feed manufacturers and fish farmers in Tanzania. Mwanza region lies in the northern part of Tanzania Mainland which is dominated by Africa's largest Lake-Victoria, located between latitude 2^{o} 31' South of the Equator. Longitudinally the region is located between 32^{o} 53' East of Greenwich. Dar es Salaam is located between latitude 6° 48' South and longitude 39° 16' East. The city has a natural harbour on the eastern coast of East Africa. Moreover, Coast region is situated between latitude 7°08′ South and longitude 38° 52′ East. Morogoro region is situated between the latitude of 6°49' South and longitude of 37°40' East. Mbeya region lies on geographical location between latitude of 8° 54' South and longitude 33° 27' East.

3.3 Research Design

The study employed an exploratory sequential mixed method design. An exploratory sequential design gathers and analyzes quantitative and qualitative data in order to complement secondary data available through the literature. The design is suitable for descriptive purposes and in obtaining qualitative information as well as for determination of relationship between variables (Creswell and Plano Clark, 2011). The data collected was based on survey approach relied on in-depth interviews with stakeholders along the entire value chain; guided by a broad framework of critical issues for understanding the aquaculture feed sector in relation to fish farming. The interview schedule (Appendix 1) was designed to collect information on output of aqua-feed value chain and production inputs including their respective costs as well as socio-economic attributes of focused actors, aqua-feed producer and fish farmers.

3.4 Sample Size and Sampling Design

3.4.1 Sample size

The study interviewed a total of 85 respondents; the numbers of aqua-feed manufacturers interviewed were seven (7) and fish farmers interviewed were seventy eight (78) from sampled regions/areas and took into account rural, peri-urban and coastal value chain contexts.

3.4.2 Sampling design

Sampling was considered to reflect all the value chain links and to cover factors that might affect value chain performance of all actors along the chain. In each actor's node sample were drawn from the respondents to acknowledge contribution of each actor in the chain purposely in financial status. The regions were purposively selected for the study to represent the variety of production systems and stakeholders of value chain such as feed manufacturers. For fish farmers, random selection was employed from the list of Sustainable New Ingredients Promoting Health (SNIPH-Project). Then structured interview (questionnaire) was carried out with fish farmers in the districts level considering time and financial resource constraints of the study.

3.4.3 Selection of aquaculture feed manufacturers

The number of aquaculture feed manufacturers was very limited, purposive sampling was employed to capture 7 feed manufacturers from Morogoro, Dar es Salaam and Coast region (Table 1). Moreover, regions engaged on aqua-feeds production, sourcing, processing, marketing and linking with different aquaculture activities were logistical considered with the survey.

Table 1: Number of aquaculture feed manufacturers interviewed in the study area

Aquaculture Feed Companies				
No	**Name**	**Location**	**Type of feed**	**Plant-size[1]**
1	TANFEED	Morogoro	Fish feed	Small- scale
2	EDEN AGRI-AQAC	Dar	Fish feed	Small- scale
3	MILLER ANIMAL FEED	Dar	Fish feed	Small- scale
4	KITUNDA ANIMAL FEED	Dar	Fish feed	Small- scale
5	DAR ZOO	Dar	Fish feed	Small- scale
6	SALIBABA (HILLS GROUP)	Coast	Fish feed	Small- scale
7	RUVU FISH FARM	Coast	Fish feed	Small- scale

3.4.4 Selection of fish farmers

The sampling frame for fish farmers was drawn from Ministry of agriculture, livestock and fisheries (MALF) Annual Fisheries Statistics Report (Section 11.1, Table 48: that shows number of freshwater fish farmers and production data 2015) thus, was used to determine the proportion of farmers in these regions. A list of farmers from each selected regions was then obtained and a proportional number of farmers from each district was randomly selected from a sampling frame of 3205 fish farmers (Table 2). Sustainable New Ingredients Promoting Health (SNIPH- Project) fish farmers list. An allowance for non-completion and non-response of 29.7% (after Hox and De Leeuw, 1994) was added to each sub-sample of fish farmers (Table 2). Therefore, purposive sampling was done on selecting the district with good number of fish farmers, type of fish farming and fish species. In Mwanza region the districts selected were Ilemela (2), Nyamagana (2), Sengerema (4), Magu (4) and Ukerewe (3) and in Dares salaam were Ilala (4) and Kigamboni (5). From the Coast region were Kibaha district council (2), Kibaha Township (1) and Bagamoyo (1). In Morogoro region were Mvomero (32) and Morogoro rural district (3) and in Mbeya

[1] According to Wesley (2005) Small-scale mills operate between 100 kg to 1 t/h for village level processing or as a small commercial mills operating at 100 to 500 kg/h. Ogechukwu (2011) contened that small scale industries have small number of workers, minimal sales, small market, low capital output and capital labor ratios.

region were Mbeya city (5) and Mbeya district council (10)[2]. The detailed sample structure by region is given in (Table 2).

Table 2: Number of fish farmers interviewed from the study area

Region	Number of farmers (sample frame)	Percentage of farmers	Number of farmers to be interviewed	Adjusted Sample size	Final sample size of farmers (n)
Dar and Coast	481	15%	9	4	13
Mbeya and Morogoro	2190	68%	41	9	50
Mwanza	534	17%	10	5	15
Total	3205	100%	60	18	78

Furthermore, the criteria for aqua-feed choice by fish farmers in this study were small-scale fish farmers[3] who practice fish farming and follow the principles of aquaculture. Moreover, this current study focused on analysing the value chain analysis of aquaculture feed based on increasing demand use of standardized aqua-feed in the study area. Those who did not meet these criteria were considered as unstandardized aqua-feed users.

3.5 Method of Data Collection

3.5.1 Primary data

Data were collected by structured questionnaires[4], face to face interview were conducted from the feed manufacturers and fish farmers to get primary data, but to key informants open ended questions were used. Moreover, observation around some feed manufacturing

[2] The numbers in the brackets represent respondents from each study area where the data was collected.

[3] According to Rukanda (2018), Fish farmers practicing aquaculture on areas that do not exceed 1 hectare are called small-scale fish farmers in Tanzania.

[4] Structured questionnaire is a set of scheduled questions which specifies the exact information from respondents. One of the benefits is to capture the true complexity of societal informations by using mixed methodologies which employ both qualitative and quantitative data.

mills, ponds and cages were done to notice the volume of production as well as size and number of ponds/cages constructed. The questionnaires were designed and tested several times before being administered by the researcher using a tablet. Informaton such as social economics, farm characteristics, feeding practice, omega-3 awareness and technology adoption were included in the questionnarre. A total of eighty five (85) respondents were interviewed, which aqua-feed manufacturers were seven (7) and fish farmers were seventy eight (78) (Appendix 1 and 2).

3.5.2 Secondary data

These are data obtained from literature sources collected by other people for the some purposes such as sample frame of fish farmers. Thus, secondary data provides information and includes raw data and published ones.

3.6 Data Processing and Analysis

The data collected from aqua-feed manufacturers and fish farmers were coded to Qualtrics system and then trasfered for analysis. The data were done by using the STATA, Statistical Package for Social Science (SPSS) computer program version 16 and cleaned before transferring to Microsoft Excel for financial data analyses. Both qualitative and quantitative analyses were carried out based on specific objectives of the study as described below.

3.6.1 Qualitative data analysis

Qualitative analysis involved the computation of descriptive statistics such as frequencies, mean and range. These were used to summarize the characteristics of the feed producers and fish farmers. Descriptive statistics was used to analyze frequencies, means of variables particularly age, gender, experiences, feed price, education level and ownership.

3.6.2 Quantitative data analysis

Quantitative analysis involved scrutiny of collected financial information such cost incurred in production and returns from investment in a bid to establish the difference between aqua feed users and between regionals/districts.

3.6.3 Analytical techniques

3.6.3.1 Descriptive statistics

Descriptive statistics employed in this study were based on the specific objective one and the research question associated with it. For descriptive statistics, the use of means, percentages and ranges were employed to describe the socio-economic characteristics of the aquaculture feed manufacturers and fish farmers in the study areas. In answering the research question that states "*What is the structure and level of coordination of aquaculture feed value chain in the study area?*" the descriptive statistics were employed.

(i) Aquaculture feed manufacturers' variables

The descriptive statistics were employed to describe the characteristics of the aquaculture feed manufacturers/owners in the study area. The variables such as; age, gender, education level, Feed manufacturers ownership, government Support, governance structure and registration, fish feed ingredients, workers, investment capital and market and marketing channels.

(ii) Fish farmer's variables

The descriptive statistics was employed to describe the characteristics of fish farmers in the study area. The variables such as; farm managements, cage and pond size, fish species and stocking of fish.

3.6.3.2 Model specification

i) A Logistical model

The dependent variable in this model is binary or dichotomous, since the fish farmers has two choices, to operate in the fish farming by using either the; (0) unstandardized aqua-feed (1) standardized aqua-feed. Maddala (1992) producers are profit maximizers and choose their levels of production and decision on their inputs basis to investments. In logit model the rate change in the probability of an event happen when; $\beta_j P_i (1 - P_i)$, where j is (partial regression) coefficient of the j^{th} repressor. When a dependent variable is dichotomous, the standard ordinary least squares cannot be used because the assumptions made about the error term are violated. Maddala (1988) argued that the common models used for this type of regression analysis may include Linear Probability Models (LPM), Logit and Probit models. The linear probability model has the demerit of predicted values falling outside the permissible interval (0, 1). In this model the fish farmers either choice standardized or unstandardized aqua-feed for fish farming. Standardized aqua-feed refer to the most widely used feed conventional ratio (FCR) which are efficient in production or have nutritional quality of the final product. The aqua-feed which can be used to compare protein and calorie retention, had been calculated for most aquaculture species focusing on commercial production used in extensive or intensive farming (Tacon and Metan, 2008; Jillian *et al.,* 2018). Manufactured aqua-feeds provide the balanced nutrition needed by farmed fish, which are in the form of pellets and concentrated form.

ii) Logit model on aqua-feed choice by fish farmers

The binary logistic model was employed to evaluate fish farmer’s choice to choose among two types of aqua-feed (standardized and unstandardized aqua-feed) with reference to Omega-3 LC-PUFA for fish farming system. The fish farmer’s choice is categorical dependent variable but the factors influencing them as independent variable are multilateral. This was taken from the views of Maddala (1992) on the stated choice methods: to analysis and test hypothesis that states '*Socio-economic characteristics do not have influence on the fish farmers' aqua-feed choice in the study area'*.

Therefore, the logit model was used to analyze objective two in that it provides the advantage of predicting the probability of a fish farmer's choice between standardized feed and unstandardized feed. The dependent variable is the decision to aquaculture feed choice by fish farmers. However, criteria for fish farmers using standardized aqua-feeds are those produced with reference to Omega-3 LC-PUFA and remained produced locally or farm-made. The dependent variable is binary thus, 0= unstandardized aqua-feed and 1= Standardized aqua-feed. Therefore the logit is presented as;

$$P_t = \frac{1}{1+e^{-Zt}} = \frac{1}{1+e\text{-}(^{\alpha+\beta1X1+\beta2X2+\beta3X3+\ldots+\beta nXn)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where P_t denotes the probability that fish farmers make choice of aquaculture feed, Z^t is socio-economics characteristics.

$$P^* = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3\ldots\ldots\beta nXn+\mu \quad \ldots\ldots\ldots\ldots\ldots (6)$$

Where the X's are explanatory variables and the betas are the effects of explanatory variables.

Whereby: P* dependent variable, X_1 …. X_n= independent variables, β_0=Constant, μ = error term.

Therefore, logistic regression model employed to analyze factors influences fish famer's choice on aqua-feeds for fish farming is explained below Table 3 showing the expected sign on different variables.

Table 3: Description of the logit model variable and their prior expected signs for farmer's choice

Variables	Definitions	Hypothesized Signs
	Dependent variable	
Feed choices	Type of feed (0= unstandardized aqua-feed, 1= Standardized aqua-feed)	Logistical model
	Independent variables	
Age	Number (Continuous)	+
Fish stocking	Dummy (0=cycle, 1= Continuously)	-/+
Extension visits	Number of visit the farm (Continuous)	-/+
Government support	(0=no; 1=Yes) dummy	-/+
Experiences	Numbers (Continuous)	+
Land ownership	Dummy (0=Yes ,1=No)	-/+
Feeds price	Feeds prices in TZs (number)	+
Farming type	Dummy (0=cage,1=pond)	-/+
Fish species	Type of fishes(0=tilapia, 1=Catfishes)	+

(ii) Analysis of standardized and unstandardized aqua-feed used in the study area

A financial feasibility study on fish farming employed return on investment analysis. The formula for net return from the investment was obtained as follows:

$$\text{Return on investment (ROI)} = \frac{(TR - TC)}{TC} \quad \text{.......................................} (7)$$

Then, net return from the investment obtained by both standardized and unstandardized aqua-feed users as follows:

$$\Pi = TR - TC \text{...} (8)$$

Then, in order to compare the results of the two means between standardized and unstandardized aqua-feed users, a t-test statistical analysis was hired.

3.6.3.3 Return on investment (ROI) analysis

Financial information's were analyzed using the formulas of finding Return on Investment (ROI) to evaluate the performance of aquaculture sector. In answering the research question number that "*How profitable are aquaculture feeds manufacturing and aquaculture farming in the study area?*" The return on investment model was employed as used by (El-Sayed, 2014; Madan *et al.*, 2007). The Return on Investment (ROI) is expressed as ratio or percentage. Therefore, in this context, the present study uses ROI which is the difference between TR and TC as a proxy for profit. Furthermore, the analysis of return on investment is calculated by using the formula:

$$\text{Return on investment (ROI)} = \frac{(TR - TC)}{TC} \quad \ldots\ldots (9)$$

Whereby;

$$TR = P \times \text{Quantity produced} \quad \ldots\ldots (10)$$

$$\Pi = TR - TC \quad \ldots\ldots (11)$$

$$TC = (TVC + TFC) \quad \ldots\ldots (12)$$

TR = Total Revenue, TC =Total Cost, TVC = Total Variable Cost

TFC = Total Fixed Cost, Π= Profit, P=Price

Return on investment (ROI) is better for the investment and producers to make decision on capital and resources, when total return exceeds total costs, net returns are positive and return on investment (ROI) is positive the investment is profitable (acceptable), but when is negative the investment is operating under loss (greater than zero or less than one). Therefore, the higher the amount that ROI is, the higher the return on investment is. The criteria is good to use in the investment decision process, choose the investment that produces the higher return on investment (Puška *et al.*, 2017).

3.7 Mapping of the Aquaculture Feed Sector in Tanzania

In order to map the aqua-feed value chain in Tanzania, actors within the chain were mapped and their activities. M4P (2008), suggested eleven steps on mapping the value chain. Hence, on mapping the value chain for this study, those steps were considered (mapping core processes, identifying main actors, flow of products, knowledge of flow of information, volume of products, number of actors and jobs, geographical flow of the product or services, value of different value, relationship and linkage between value chain actors, service that feed into value chain, constraints and potential solution). The study mapped main actors involved in the core processes and mapping movement of feed from the feed manufacturers to the final consumers (fish farmers). Other steps were focused on knowledge (awareness) of feed manufacturers and fish farmers on omega-3 fatty acid PUFA, access of information to create awareness beyond stakeholders to unlock the chain from different actors, relationship and linkages between aqua-feed manufacturers and fish farmers and how they interact at the market.

3.8 Limitations of the Study

The study was undertaken in selected areas in Tanzania with a small sample. This means the information collected is subject to changes which could alter findings of similar studies in the future. Therefore, conclusions drawn from the study cannot be generalized for the whole country. Some aqua-feed producers purposely declined to give data on prices of feed selling at different market channels and revenue received fearing that data obtained might be given to the government for tax issues. However, after discussion most of them were convinced to cooperate after being assured that the information being asked was meant for this research study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The core actors in the value chain analysis of aquaculture feed were feed manufacturers and fish farmers. These will therefore be discussed in this chapter as well as considering the results from aqua-feed ingredients suppliers and aqua-feed traders to see their influence on the value chain (nodes). The socio-economic characteristics of each actor (aqua-feed producer and fish farmer), activities performed in the chain, feed choice (fish farmers), the cost incurred, revenues and the return on investment (ROI) will be discussed separately as the main core actors. Also, aqua-feeds ingredients with reference to omega-3 LC-PUFA will be focused, in terms of how easily they can be obtained. Similarly, the chapter will focus on the comparisons of standardized and unstandardized aqua-feed users and their performance.

4.1 Value Chain Analysis

4.1.1 Aqua-feed sector value chain map and characterization

The map of the aqua-feed sector value chain in the five aquaculture sites are diagrammatically shown in Figure 3. The description of and interrelationship between different actors and stakeholders categories in the chains are discussed in detail below.

4.1.1.1 Aquaculture feed ingredients suppliers

Aquaculture feed ingredients suppliers are the actors who sell aqua-feeds ingredients and supplements to either aqua-feed producers or directly to farmers for farm-made. The feed ingredients related to aqua-feed production is backward linkage. Results in Table 7 shown that the most expensive ingredients to obtain were vitamin and mineral mix, whose prices ranged from 2 750 to 7 000 TZS/Kg, the ingredient which was obtained at the lowest price was sunflower whose price ranged from 0 to 300 TZS/Kg. Aqua-feed ingredients suppliers are not vertically integrated with producers, since the majority of producers normally search aqua-feed ingredients production from recognized sources/agent.

4.1.1.2 Aqua-feed producers

These are key actors in the aqua-feed value chain; they comprise small-scale producers. According to Wesley (2005), small-scale mills operate between 100 kg to 1 t/h for village level and a small commercial mill operates at 100 to 500 kg/h. Aqua-feed production provides an important linkage between producers (mills) and feed users or farms. On the other hand, combining aqua-feed ingredients for aqua-feeds production is likely to be a suitable linkage with actors which is right and economically viable along the chain. The average total production of aqua-feed is about 60 633.33 kg per year, the average selling price of aqua-feed was 2500 TZS per kg as presented in Table 15.

4.1.1.3 Aqua-feed traders

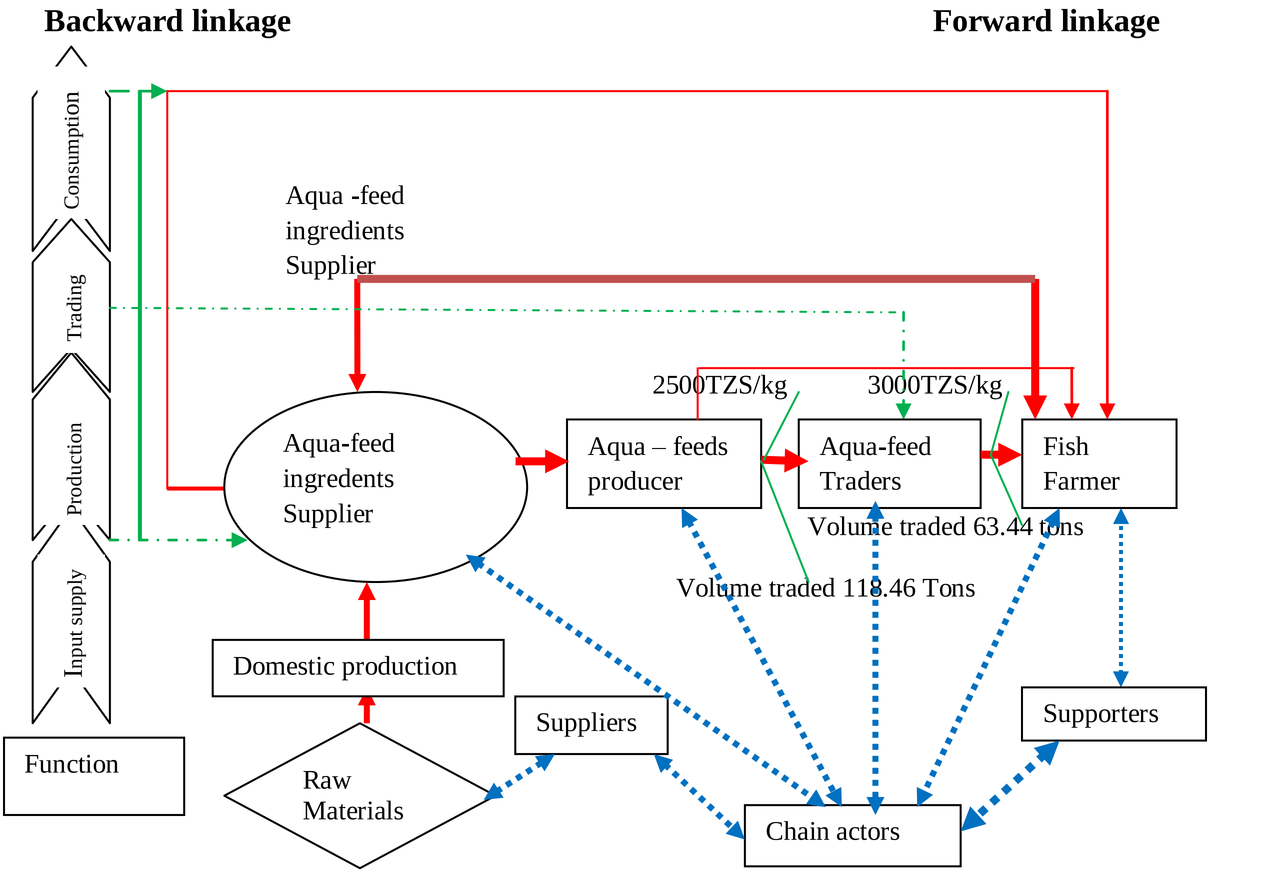
Aqua-feeds were supplied by feed traders to fish farmers after collecting from mills and repackage the bags of powder and pallets with different weights. These were sold at different markets such as wholesaler, retailer, shop points and fish farmers. Thus, aqua-feed related to distribution is forward linkage to investors. The main function for these aqua-feed traders is to buy and sell the produce at retail price to fish farmers. However, the price varies from one place to another depending on the fish farmers choice and the return on investment. Trader share infomations of aqua-feed producers and fish farmers in the market for chain development.

4.1.1.4 Fish farmers

The fish farmers were feeding their fish's aqua-feed, which contain nutritionals diets those required for better performance (standardized and unstandardized aqua-feed). However, it is important to provide support to small-scale aqua-feed producers; and engage more investors in agriculture-related investments. Farmers take advantage of availability of aqua-feed and disruptive technologies for fish farming. On the other hand, 78 fish farmers surveyed were small-scale farmers performing their activities either in the ponds or in the cages culture. The average farmed fish price per kilogram was sold at 6700 TZS per kg (Table 16). Fish farmers are direct actors performing their activities depending other octors in the issues of markets informatons, feed types and new technology of farming.

4.1.1.5 Supporters (indirect actors)

Most of the supporters (support services) assist in terms of coordination, extension services and training, financial services and policy security at the market place, input provision (fingerlings and aqua-feeds) and research through SUA, UDSM and TAFIRI (Appendix 4). Regional and District Livestock and Fisheries offices are the organizers of these services. Apart from trading actors there are non-trading service providers that support the value chain development. These involve providers of commercial and public services.



Legend:

Flow of products

Flow of information

Figure 3: Aquaculture feed value chain map in Tanzania

4.1.2 Aquaculture feed manufacturer

4.1.2.1 Socio-economic characteristics of aquaculture feed manufacturers

The study examined socio-economic characteristics of different aqua-feed Manufacturers which include: age of the aqua-feed manufacturers, gender and level of education in aqua-feed manufacturing industry and how they acquired the knowledge of aqua feed manufacturing. These factors are well illustrated in Table 4 which presents the description of each factor in terms of frequency and percentages.

Table 4: Distribution of aqua feed manufacturers by Region in the study area (n=7)

	Morogoro		Coast		Dar es salaam		
Variable	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Total %**
Age							
15-30	0	0	0	0	1	14.3	14.3
31-45	0	0	1	14.3	1	14.3	28.6
46-60	0	0	1	14.3	2	28.6	42.8
61-85+	1	14.3	0	0	0	0	14.3
Gender							
Male	1	14.3	2	28.6	3	42.8	85.7
Female	0	0	0	0	1	14.3	14.3
Education Level							
Primary school level (7 to 14 years)	0	0	0	0	1	14.3	14.3
Secondary school - O level (14-18 years)	0	0	1	14.3	0	0	14.3
University undergraduate degree	0	0	1	14.3	3	42.8	57.1
University postgraduate degree	1	14.3	0	0	0	14.3	14.3

4.1.2.2 Age and gender of the aqua feed manufacturers

The age of the interviewed feed manufacturers ranged from 15 years to 61 years, which according to Tanzania policy is the working age. As for the gender, the results show that the sub-sector in the selected regions is dominated by males who accounted for were 85.71% of the total aqua-feed manufacturers and female accounted for 14.29% of feed manufacturer (Table 4). Similar, findings are reported by Mwaijande and Lugendo (2015) in Morogoro. Also, these findings concur with the findings reported by El-Sayed (2014) in Egypt, which showed that 90% of all the sampled aqua feed mills were owned by Males and 10% were female-owned.

4.1.2.3 Education level of aqua-feed manufacturers

The distribution of education level varied from one region to another as shown in Table 4. Generally, 57.14% of the respondents had bachelor degrees, 14.29%, postgraduate degrees, 14.29% had Secondary school education and 14.29% had completed primary school education. Thus, the sector is dominated by people with bachelor degree holder as opposed to people in other levels of education; this is particularly because of the nature of feed preparation, sourcing, and production.

4.1.2.4 Actors in the aqua-feed sector value chain in Tanzania

The main key actor in aqua-feed sector value chain is aquaculture feed manufacturer, who mobilizes funds for feed manufacturing. Currently, aqua-feed sector value chain involves: aqua-feed ingredients suppliers, aqua-feed producers (manufacturers), traders, and fish farmers. This finding concurs with the findings by El-Sayed (2014) that identified four main actors of Egyptian aqua-feed value chain. However, plates 1-4 show the photos of some these actors. To look at the participation of each actor along the chain was crucial in achieving objective 1: mapping of the chain of aqua-feed in Tanzania. Plate 1 shows how the aqua-feed ingredients are collected and supplied by suppliers at mills/industries to the manufacturer of feed. Plate 2: demonstrates manufacturing process at mills where the production of aqua-feed takes place. Plate 3 demonstrates the traders of aqua-feed, the means of transport used to distribute aqua-feed to market and farms. Plate 4 demonstrates the farmers feeding pallets at farms.

Plate 1: Aqua-feed ingredients Suppliers found TANFEED mill

Plate 2: Aqua-feed Production Mill (plant) found SALIBABA in Coast Region

Plate 3: Aqua-feed supplied at the markets found in Coast Region

Plate 4: Type of fish farming found in Mwanza Region

4.1.2.5 Firm ownership in the study area

This sub-section explains the aquaculture feed manufacturer ownership of mills in their production economic units, which included; buildings, mechanizing equipment, and vehicles. Most of the mills in the study area were privately owned by individual investors who constituted 71.4% of all the mills surveyed; and the remaining 28.6% were owned jointly (jointly-venture) (Table 5).

These findings concur with the findings by El-Sayed (2014) who found that majority of the aquaculture feed manufacturers were privately owned; in other words, about 90% of the Egyptian fish feeds were produced by private sector fish feed mills, that produced conventionally pelleted feeds and the public sector producing the remaining 10% of the total commercial fish feed production. Furthermore, these aqua-feed industries (mills) were more concentrated in the urban market areas such as Morogoro, Dar es Salaam and Coast region. This was for ensuring easy access, timely and cost-effective access of the aqua-feed fish ingredients and markets of the produced aqua-feed for traders and fish farmers.

Table 5: Distribution of aqua-feed manufacturing by firm ownership in the study area

Region	Joint venture Ownership		Private Ownership	
	Frequency	%	Frequency	%
Morogoro	1	14.3	0	0
Dar es salaam	1	14.3	3	42.8
Coast	0	0	2	28.6
Mwanza	0	0	0	0
Mbeya	0	0	0	0
Total	2	28.6	5	71.4

4.1.2.6 Governance and registration in the study area

The findings in Table 6 indicate that 100% of the aquaculture feed manufactures (mills) in the study areas were registered by The Business Registrations and Licensing Agency (BRELA). This registration was for the business and company name to obtain license of aqua-feed manufacturing. Other Government agencies focused on quality of the industries were also involved to control the business and health status of people.

Table 6: Distribution of registration of aqua-feed mills by BRELA in the study area

Region	Registered	
	Frequency	%
Morogoro	1	14.29
Coast	2	28.57
Dar es salaam	4	57.14
Mbeya	0	0
Mwanza	0	0
Total	7	100

4.1.2.7 Aquaculture feed ingredients (raw materials)

This study found out that aquaculture feed ingredients which were used for aquaculture feed manufacturing were rice bran, wheat bran, maize bran, soybean meal, vitamin and mineral mix, fish meal, blood meal, coconut seed oil, cotton seed oil and others such as corn, cassava floor and salt. The inclusion levels of these ingredients contain protein, energy, vitamins and minerals when formulated as floating pallets, that form either omega-3 LC-PUFA content on aqua-feed. The study observed different prices of aqua-feed ingredients sold by aquaculture feed ingredient suppliers as shown in Table 7. These findings concur with the findings in a study by Gabriel *et al*. (2007) in sub-Saharan Africa, who found different types of aqua-feed ingredients and their availability. These local materials are mixed with vitamin and mineral (supplements) to formulate aqua-feed (pallets). Similar findings are reported by Mzengereza (2014), who noted feed ingredients such as fish meal, other animal meal or by-products and plant material (soybean products) as the primary sources of protein.

Results in Table 7 revealed that the most expensive ingredients to obtain were vitamin and mineral mix, whose prices ranged from 2750 to 7000 TZS/Kg, the ingredient which was obtained at the lowest price was sunflower seed cake whose price ranged to 300 TZS/Kg.

Although aqua-feed manufacturers use different types of aqua-feed ingredients from 7 to 14, which could form omega-3 fatty acid PUFA content on the produce for the benefits of farmed fish and human beings. The findings are consistent with the findings in a study by Welker *et al.* (2016), who found that the inclusion of aqua-feed is chosen in view of its protein that might make the diet more cost effective during feed formulation.

Table 7: Aqua-feed ingredients used for fish floating pellets production in the study area

Fish feed ingredients	Regions						
	Coast		Dar		Morogoro		Total
	Min. price/Kg	Max. price/Kg	Min. price/Kg	Max. price/Kg	Min. price/Kg	Max price/Kg	Total Max. price/Kg
Rice bran	50	100	200	400	100	100	400
Wheat bran	75	150	25	100	0	400	400
Maize bran	150	300	25	100	0	400	400
Soybean	500	1 000	600	2 000	0	1 000	2 000
Coconut oil	0	0	0	0	0	4 000	4 000
Groundnuts oil	0	0	0	0	0	4 000	4 000
Sunflower oil	0	0	0	0	0	4 000	4 000
Cotton seed cake	0	0	0	0	0	800	800
Sunflower seed cake	0	0	0	0	0	300	300
Moringa seed	0	0	0	0	0	0	0
Vitamin mineral mix	3 500	7 000	2 750	5 000	0	4 800	7 000
Shrimp paste	0	0	0	0	0	0	0
Fish meal	750	1 500	875	2 000	2 800	2 800	2 800
Blood Meal	0	0	0	0	1 000	1 000	1 000
Fish oil	0	0	0	0	4 000	4 000	4 000
Others(Cassava, corn and salt)	1 000	2 000	162.5	650	300	300	2 000

4.1.2.8 Average capital to invest in aqua-feed manufacturing per region

The findings in Figure 4 show the averages of capital investment used by firms in the study areas. These include the average number of asset owned and the cost of asset. The findings show that in order to invest in aqua-feed manufacturing one requires about 10 000 000 up to 110 000 000 TZS million as the total investment to cover basic costs.

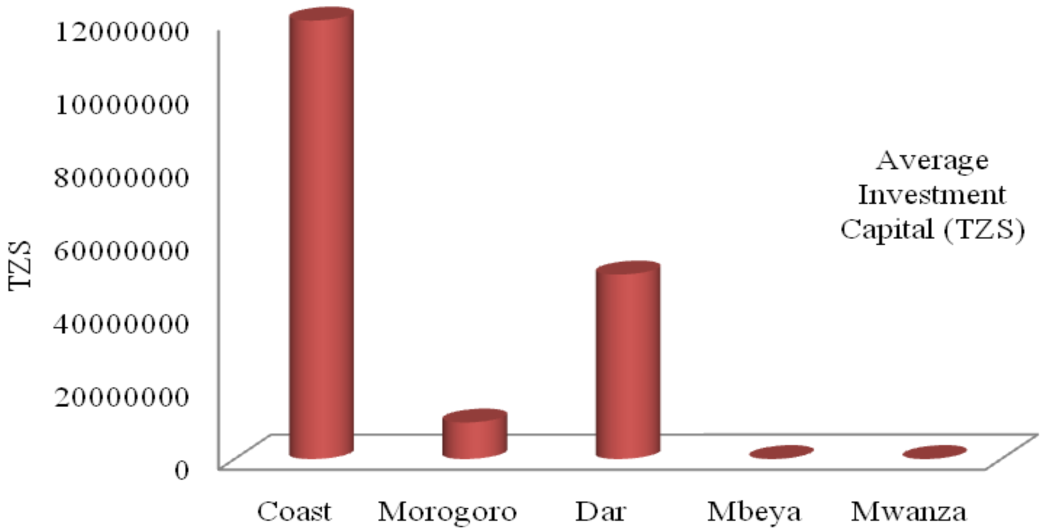


Figure 4: Average capital to start an aqua-feed manufacturing by study area

4.1.2.9 Economics and marketing of aqua-feed by study area

Marketing expenses are incurred when commodities move from the source to the final market whether by by aquaculture feed manufacturers, aqua-feed traders or fish farmers. Marketing expenses include the expenses of various services which are delivered by different actors in the marketing of aqua-feeds. The finding in Figure 5 indicate that 65.12% of aqua-feed manufacturers sold their produce directly to fish farmers, followed by 26.46% of aqua-feed manufacturers who sold their produce to retailers, 7.63% of aquaculture feed manufacturers sold their produce to wholesalers and only 0.79% aquaculture feed manufacturers sold their produce to other market (agent) of aqua-feed. Most of these aquaculture feed (pallets) manufacturers surveyed in the study sold their produce in the urban areas in Morogoro, Dar es Salaam and Coast.

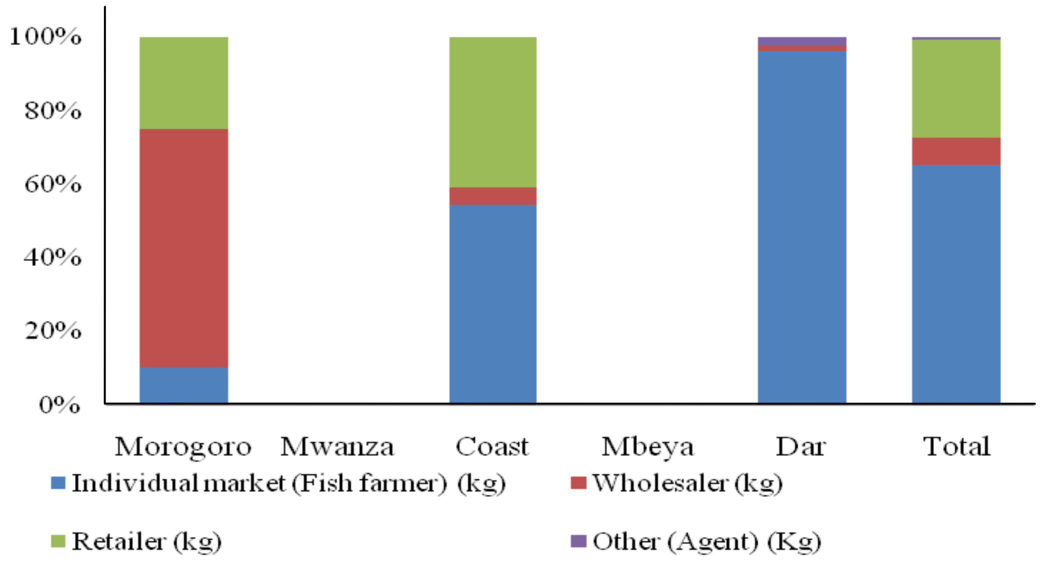


Figure 5: Marketing aquaculture feed (floating pallets) by study area

4.1.2.10 Employment creation in the study area

In this sub-section, the study looks at the contribution of aquaculture feed value chain to employment creation. Employment for aquaculture feed manufacturing varies significantly from one mill to other in the study areas. The number of full-time employment labour ranges from 5 to 23 workers per aqua-feed mill. The findings show that 65.6% of the labour force were men employed full-time, while 34.4% of the labour force were women employed full time. The distribution and contribution of aquaculture feed in job creation in the study area are shown in Table 8.

Table 8: Distribution of number of workers in aquaculture feed manufacturing by study area

Region	Number Workers					
	Full-time men	Full time-women	Part-time men	Full-time men (%)	Full-time women (%)	Part-time men (%)
Morogoro	3	0	2	7.5	0	33.3
Coast	28	5	0	70	23.81	0
Dar es salaam	9	16	4	22.5	76.19	66.7
Mwanza	0	0	0	0	0	0
Mbeya	0	0	0	0	0	0
Total	40	21	6	65.6	34.4	100

Thus, from my observation and analysis it seems that many employees depend on the demand of aquaculture feed at market.

4.1.3 Fish farmers

This sub-section describes fish farmers along the chain from five regions. The analysis was made for different regions and some variable were done in general. About 35 (44.9%) respondents were from Morogoro, 4 (5.1%) were from Coast, 9 (11.6%) were from Dar es Salaam, 15 (19.2%) were from Mbeya and 15 (19.2%) were from Mwanza region.

4.1.3.1 Linkages between aqua-feed manufacturers and fish farmers

Fish farmers practice fish farming using different production inputs such as fingerlings, aqua-feeds and hired workers. Most of the fish farmers interviewed recognized that aqua-feed is the most important component of their farming practices, comprising 53.5% of the total operating costs. However, fish farmers practice farming using local feeds ingredients which are available near their areas and standardized feed (value-added) made by the feed manufacturing companies. Feed manufacturers get their raw materials from the same source as that of fish farmers, who obtained their raw materials either from aqua-feed ingredients marketers or from feed distributors.

4.1.3.2 Aquaculture feed and fish feeding practice

Fish grown in extensive and intensive farming system[5] are given supplementary food with full nutrients needed for farmed fish. Then, stocking quality fingerlings without feeding them could have negative effects on the final product (harvest). The prepared commercial

[5]FAO (2017) Extensive fish farming refers to fish farming conducted in ponds or water bodies; while Intensive fish farming, fishes are kept, and stocked to obtain significant amounts of feed from their environment, are controlled to improve the production cycle.

feed is available in a wide range of these aqua-feeds containing diets which consist of a number of feed ingredients (standardized feed). These commercial feeds are made in various forms to address protein requirement of the culture organism, which as a rule, decreases with age. Thus, fish feeds come in different forms as starter, grower, and finisher. The finding of this study show that 35.9% of fish farmers use standardized aqua-feed and 64.1% of fish farmers use unstandardized aqua-feed. The study findings concurs with the findings in a study by Chenyambuga *et al*. (2012), who assessed the production performance and value chain of Nile tilapia grown in the ponds of small-scale farmers in Morogoro region, Tanzania. The authors revealed that aquaculture in Tanzania is still a subsistence activity practiced by small-scale farmers, majority of whom depended on farm-made aqua-feed as a source of feed for their fish.

On the other hand, during the survey most of the farmers were making farm-made aqua-feed to minimize the costs of production as shown in plate 5. Farmers were feeding aqua-feed following the recommended time and feeds for better returns as shown in Plate 6.

Plate 5: On-farm Aqua-feed production found at Mwanza Region

Plate 6: Fish feeding in the ponds found Eden farm

4.1.3.3 Socio-economics characteristics of fish farm in the study area

This sub-section presents socio-economics characteristics of fish farm in the study area which include: farm management, cages and pond statistics and size, fish species stocked, supportive services, workers and market outlets.

4.1.3.4 Fish farm management in the study area

The study findings show that 10.3% of the farm management with ownership were cage farmers and 89.7% were pond fish farmers Table 9. The ownership of the farms were 100%, by private fish farmers however some of these were part of formal groups and informal groups with each one owning his/her farm. All farmers followed the required management of pond as directed by Fisheries Officers, researchers and business partners.

4.1.3.5 Fish farming systems in the study area

The farming systems which were used by fish farmers include cages and ponds, farmers owned 1 to 17 ponds and 2 to 5 cages. Table 9 shows the the average ponds owned by each farmer in each region and the average total pond area by region the results in Table 10 show that Mwanza was leading with 12 657.87M^3 of cages, but on average the total pond area was 132.94 M^2. The total average size of pond was 198.43 M,^{2} which was easy for management. Dar es Salaam was leading among the selected areas on the average pond size of 286.59M^2. Furthermore, the results in Table 9 reveal that there was fish farmer's involvement in each of the fish farming systems. The pond was the most common practiced farming system, which was practiced by small fish farmers 89.7% of fish farmers) followed by cages, which was practiced by 10.3% of fish farmers in the study area.

Table 9: Distribution of fish farming system in the study area

Variable	Category	Region					
		Morogoro	**Coast**	**Dar**	**Mbeya**	**Mwanza**	**Total**
Farming type		**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
	Cages	0	0	0	0	53.3	10.3
	Ponds	100	100	100	100	46.7	89.7
Pond statistics							
Total volume of cage	Volume of Cages (M^3)	0	0	0	0	12 657.87	12 657.87
Total area of ponds (M^2)	Area of pond	10916	8980	11750	7582	12363.4	51591.4
Size of pond	Average Pond size (M^2)	188.2	264.18	286.59	223	132.94	198.43

4.1.3.6 Fish species stocked by fish farmers in the study area

Once the pond or cage is prepared and finished, fish fingerlings are stocked at the appropriate density depending on the culture strategy, size of the pond and the size of fingerlings. Fish farmers stocked more than one type of fish and these included; tilapia, catfish, and others such as Goldfish and perege (*Oreochromis leucostictus*). The species stocking was based on the availability of fingerlings and feed. In general, 67.9% of the fish farmers stocked tilapia, 23.1% stocked catfish and 9.0% stocked mixed fish species (fingerlings) types such as Goldfish, perege (*Oreochromis leucostictus*) and Claris. Some farmers mixed their stocks with other types of fingerlings (one pond for Tilapia and another pond for catfish). However, the findings show that Tilapia was mostly farmed species followed by catfish (Table 10). These finding concur with the findings in a study by Simpson (2012) who revealed that farmers in Ghana practiced fish farming in pond and cage cultures. Catfish and tilapia were the two main fishes cultivated in Ghana, whereby tilapia accounted for 80% whilst Catfish account for 20% of the fishes cultivated in Ghana.

Table 10: Distribution of fish stocked by farmers in the study area

Region	Fish farmers (n=78)	Tilapia (%)	Catfish (%)	Others (Goldfish etc.) %
Morogoro	(n=35)	62.9	25.7	11.4
Coast	(n=4)	100	0	0
Dar es Salaam	(n=9)	55.6	33.3	11.1
Mbeya	(n=15)	66.7	33.3	0
Mwanza	(n=15)	80.0	6.7	13.3
Total		67.9	23.1	9.0

4.1.3.7 Fish production in the study area

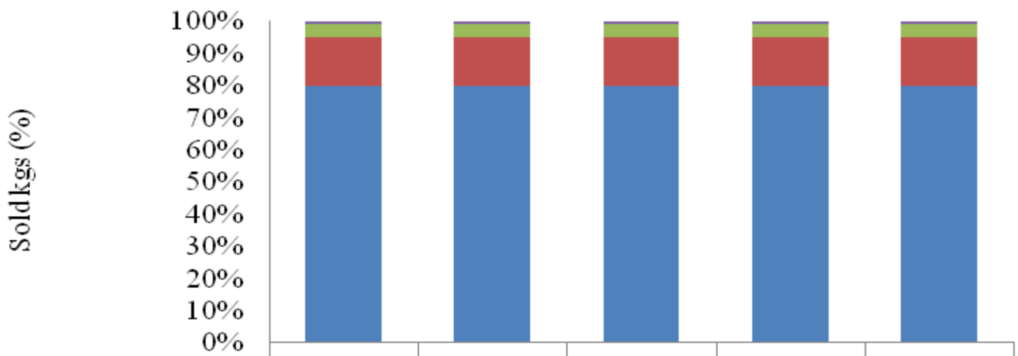
Farmers owned assets in their production economic units such as land, buildings, mechanizing equipment, vehicles and boats. In general, farmers have ponds near their homes, others far from their homes. Therefore, the results show that, there were 8 cages and 272 ponds owned by fish farmers, on a combined total area of 51 591.4 M^2. The total production of all farms was 105.776 tones, among these 99.171 tones were for tilapia and 6.605 tones were for catfish (Table 11). This means that the production of tilapia was higher than that of catfish in the study area.

Table 11: Distribution of fish production by fish type across regions

Variable Production	Category	Region Morogoro (Tons)	Coast (Tons)	Dar (Tons)	Mbeya (Tons)	Mwanza (Tons)	Total % (%)
	Tilapia	7.681	8.150	23.100	16.870	43.370	93.8%
	Catfish	1.405	2.050	2.800	0	0	6.2%

4.1.3.8 Fish markets and marketing in the study area

This sub-section explains fish sales at different markets, much of the fish produced was sold at the local market among four market channels. The average farmed fish price per kilogram was sold at 6700 TZS per Kg. The Findings show that 81.2% of fish (tilapia and catfish) was sold to individual consumers, 14.9% was sold to fish traders or wholesalers (buying fish in bulk), 3.3% was taken to sale points and 0.6% was sold to other markets (Figure 6). The findings indicate that individual consumers are a good market that ensures sustainability of fish farmers.



	Coast	Dar	Mbeya	Morogoro	Mwanza
Others	102	259	168.7	90.86	437.2
A Sale point	408	1036	674.8	363.44	1748.8
Wholesaler	1530	3885	2530.5	1362.9	6558
Individual market	8160	20720	13496	7268.8	34976

Figure 6: Distribution of fish market and marketing in the study area

4.2 Aquaculture Feed Choice by Fish Farmers

4.2.1 Test of heterogeneity, multicollinearity and endogeneity

Aquaculture feeds were a key on value chain analysis in relation to aquaculture production system. The recommended feeds are those that make fish grow faster and with good health within a short time and good management. Also, fish farming method has an effect on the production. In general, 35.9% of the respondents indicated that standardized aqua-feed is very important on their investments, thus, aqua-feeds choice is essential. However, farmers in Dar es Salaam, Mwanza and Coast were mostly using formulated high quality aqua-feeds. To determine the factors influencing aquaculture feed choice by fish farmer, the variables shown in Table 12 were analyzed by econometric model. In order to examine the heterogeneity of farmer's choice, a Logit model was use to analyze the socio economics characteristics of the respondents. The inclusion of individual-specific variables in the model makes it possible to account for some of the heterogeneity in the choice among farmers (individuals). Thus, we reject the null hypothesis of parameter equality subjected to scale heterogeneity, since the *LR* statistic (48.05) is greater than the Chi-squared critical value $\chi2$ (9) at the 1% level of significant. After rejected the null hypothesis it is concluded that the Logit model fits the data better in comparison to the base Logit model that assumes fixed choice parameters of aqua-feed by fish farmers.

Since the P-values of the Breusch-Pagan/Cook-Weisberg test was 0.2130< Chi2 = 1.55 (Appendix 3), the test was prone to rejection. The null hypothesis states that "The socio-economic and institutional characteristics have no significant influence on the fish farmer's choice on aqua-feed in the study area". The constant variance explains farmers' decision on the aqua-feed choice in the study areas. Alternatively, this indicates that aqua feed choice was responsive to variables since the Wu-Hausman F (1, 74) coefficient was 0.603351 with (p-value>0.005). This implies that the instruments in the model were separately/independently relevant in explaining fish farmers' choices towards the aqua-feed in the study area.

The results (Appendix 3) have shown that there was no multicollinearity problems in the variables on explaining fish farmers' decisions on the use of aqua-feed composition in their own fish farms; this has been proven by the mean value of the variance inflation factor of being less than ten (Mean VIF= 1.45<10). The logit regression model was used to identify factors influencing fish farmer's decision on aqua feed choices. Before employing the logit model, multicollinearity and endogeneity problem were checked and found that for all relevant variables. In this study, the choosers are fish farmers who employ the standardized aqua feed for the purpose of increasing their productivity while maintaining the availability of Omega-3 in the farmed fish.

This model was used to estimate the direction and sizes of coefficient effects of each explanatory variable. Using STATA V.13, the results of the logit model are presented in Table 12. The model prediction of fish farmers choice of standardized aqua feed was having the Log likelihood prediction of 26.89 %, while the likelihood Ratio predicted was 48.05 fold (LR chi2= 48.05). This implies that the model employed in this study is appropriate for estimating the probability of fish farmers' decisions on whether to choose the standardized aqua-feed or otherwise. The value of the χ^2 test is 48.05 (p-value=0.000 <0.05), which shows that at least one variable coefficient is non-zero in the model and that it is of statistical significance. Based on the coefficient of determination R-Square value of 0.4718 about 47.2 % of the variation in the outcome variable (aqua feed choice) is shown to influence fish farmers' decisions and this is explained by this logistic model.

4.2.2 Econometric result on factors influencing aqua-feed choice by fish farmers

Among the nine variables which are considered in the fish farmers' decision on aqua feed choice in the study areas, four (Age, experience, extension service and Feed Price) had significant effect in explaining fish farmers' choice on the aqua-feeds. The result of the logit model indicates that feed price is a positively significant factor in influencing aquaculture feed choice, while age, experiences and extension visit are negative factors which significantly influenced aqua-feed choice by fish farmers.

Meanwhile, experience in fish farming has an expected positive sign but it is statistically significant (0.208) in influencing fish farmers' aqua-feed choice. This implies that even though years of farming enable fish farmers to understand and have better knowledge in feed practices, it is not guaranteed that farmers will choose standardized aqua-feed. However, years of experience in fish farming increase the level of decision making on how to increase production through good practice; and fish farmers are better and able to assess the relevance of new fish farming technologies and inputs. This often comes from their interactions with fellow farmers and the outside world. Years of experience in farming is expected to be related to the ability of the farmer to obtain process and use information relevant to the choice of an appropriate aqua-feed among the available alternatives.

Therefore, being a fish farmer with more experience increases the chance of making choices on standardized feed containing omega-3 fatty acid PUFA, rather than fish farmers with less experience by 0.208 times, which means that, more experience increases the probability of selecting standardized feed by 0.208 times unlike the case with young fresh fish farmer.

The estimated coefficient of age for the fish farmers' decision on aqua feed choice in the study areas was negative as expected and statistically significant at 5 percent. It is commonly believed that age can serve as a proxy for farming experience: as the age increased by 1 year, the fish farmers' decision on aqua feed choice in the study area decreased by 0.076 scores keeping other factors constant (Table 12). This implies that new fish farmers in the farming practice had no alternative choice of increasing their farm production by (0.076) for using standardized feed at their activity. While the youth fish farmers are attracted to making a choice on unstandardized feed for fish farming, the old fish farmer has higher probability of making choices of standardized feed by 0.076 of field choice. The basis of these choices could be linked to experience, knowledge and skills, extension visits, customer demand of fish with reference to omega-3 LC-PUFA and the return obtained from using standardized feed. Hence, having higher life span increases the probability of making feed choice on fish farming.

The results show that as the price of feed changes by 0.001 in the market fish farmers' probability of choosing unstandardized fish feed also increases (Table 12). This means that the decrease of fish feed price per kg by 1% increases fish farmers probability of making choice of standardized fish feed (formulated feed) that contain omega-3 fatty acid PUFA. This partly indicates that fish farmers in the study areas are sensitive to market price changes. Thus, given two similar aqua-feeds which are sold at different prices, farmers will purchase the aqua-feeds offered at relatively lower prices. However, the price of standardized feed influences farmer's choice on fish farming system, helps the farm production, stimulates other sectors of production such as manufacturing industry and contributes to obtain knowledge of appropriate technologies in fish farming.

Table 12: Logit model for factors influencing aqua-feed choice by fish farmers

Feedchoice_x	Coef.	Std. Err.	Z	P>Z	[95% Conf.	Interval]
Age	-0.0763041	0.03887	-1.96	0.050***	-0.15249	-0.00012
Experiences	-0.2078852	0.120102	-1.73	0.083***	-0.44328	0.027511
ExtensionVisit	-0.7369051	0.411499	-1.79	0.073***	-1.54343	0.069618
FarmingTYPE	-1.453044	1.959806	-0.74	0.458	-5.29419	2.388105
GovtSupport	1.160179	1.008782	1.15	0.250	-0.817	3.137356
Land OWNER	-1.589218	2.035217	-0.78	0.435	-5.57817	2.399735
Feed_Price	0.0013348	0.00041	3.26	0.001**	0.000531	0.002138
Stock	-1.713021	1.239691	-1.38	0.167	-4.14277	0.716728
Species2	0.754218	0.67083	1.12	0.261	-0.56058	2.06902
_cons	7.874286	6.706788	1.17	0.240	-5.27078	21.01935

Note: ** and *** means are significance at 5% and 10% and the remain are not significance

Logistic regression	Number of obs	=	78
	LR chi2(9)	=	48.05
	Prob > chi2	=	0.000
Log likelihood = -26.897126	Pseudo R^2	=	0.4718

The frequency of extension visits to an individual (household) fish farmer increases the probability of using standardized feed (formulated) by 0.737 times per month visits at the farm, while extension visits are absent fish farmers tend to use unstandardized fish feed (Table 12). Therefore, extension visits has a significant influence on fish farmers' aqua-feed choice for fish farming, which increase the availability of omega-3 fatty acid PUFA content on farmed fishes. the results in Table 12 revealed further that access to information which is defined by the number of extension visits to farmers significantly (P<0.073) influences aqua-feed choice. The positive and significant coefficient of access to information could mainly be attributed to the fact that knowledge gained by farmers from their contacts with Extension Officers influences them into choosing standardized aqua-feed.

This study finding concurs with the findings of Christian (2016), who reported a positive relationship between extension visits to the improvement of skills and efficiency in aquaculture investment among rural communities in Ghana. Also, similar findings are reported by Njeru (2013), who found that training and extension services offered to farmers are correlated with fish farming improvement in Embu North District in Kenya.

The fish stocking has no significant influence on fish farmers' choice for feed to use. With an increase in stocking by 1.713 fishes, the desire of fish farmer to make choice on standardized feed will increase by 1.713 for cycle stocking. The possible reason is that the higher the stocking of fish the higher the farmer's ability in investing in fish farming using a standardized aqua-feed. The government support has insignificant influence on fish farmer's choice for aqua-feed by 1.160. This is may be due to the fact that farmers face other challenges regarding predators and access to information on the availability of standardized feed contained omega-3 fatty acid PUFA and markets of the produce along the chain. Receiving a government support is not a guarantee of making choices on feed for fish farming, but farmer cannot get government support and choose appropriate aqua-feed for fish farming.

Furthermore, more demand for fish by local population leads exploitation of the fish stock in natural areas such as rivers, Lake Victoria and ocean. This encourages more investors with capital, but who do not own land by 1.589 to invest on fish farming by choosing quality aqua-feed to cover the gap. This means that owning land is not a guarantee of making choices on better aqua-feed use for fish farming; there are other factors such as feed price, extension visits, the type of farming, age, experience, and fish stocking.

4.2.3 Comparing standardized and unstandardized aqua-feed use in the study area

This sub-section of aquaculture feed choice compares standardized and unstandardized feed users based on the total revenue and net returns obtained by farmers who practice farming in the study area. The revenue mean for standardized feed is 16 635 000 TZS per year, while the mean for unstandardized feed is 4 415 300 TZS per year. The net mean return of a farmer who uses standardize feed is 5 026 750 TZS, while the mean for a farmer who uses unstandardized feed is 779 900 TZS per year (Table 13). It is true that fish farmers use standardized and unstandardized aqua-feed, but both are more economical and efficient in fish farming system. Moreover, fish farmers who use standardized aqua-feed earn higher revenue and net return than fish farmers who use unstandardized aqua-feed. This finding is congruent with the finding in a study by Gabriel *et al*. (2007), who reported two types of aqua-feed with their availability and practices by farmers; one, conventional feed which is widely acceptable in farmed fish and by farmers, (formulated by feed mills) and another non-conventional feed, which is made locally.

Table 13: Comparing standardized and unstandardized aqua-feed users on fish farming systems in the study area

Item	User of standardized feed (n=28)		User of unstandardized feed (n=50)		T-Value	P-Value
	Mean (TZS: '000')	SD (TZS: '000')	Mean (TZS: '000')	SD (TZS: '000')		
Produced fish (Kg)	2559.3	5.5854	802.78	3.9755	(7.801)	.000
Sell Price (TZS)	6.5	2101	5.5	2101	(2.343)	.022
Total Revenue	16 635	11 734.9	4 415.3	8 352.66	(6.770)	.000
Fingerlings cost	173.55	273.55	46.2	169.218	(2.531)	.013
Feed cost	6 935.2	4980.5	1 357.1	3 180.47	(6.035)	.000
Labour Cost	1 036.1	1256.69	2 62.0	6 23.946	(3.639)	.004
Total Variable cost	8 144.85	6 512.71	1 665.3	3 973.634	(5.966)	.000
Total Fixed cost (Land, equips)	3 463.4	3 998.09	1 970.1	2 935.03	(2.991)	.004
Total Cost	11 608.25	10 510.80	3 635.4	6 908.664	(5.087)	.000
Net return	5 026.75	1 224.09	779.9	1 443.996	(2.262)	.027
ROI	0.433		0.2145		1.291	.096

4.2.3.1 Comparing return on investment (ROI) of standardized and unstandardized feed users in the study area

This sub-section compares the mean differences of the return on investment (**ROI)** ratio in each aquaculture feed users is 0.433 TZS per for the standardized feed and 0.21 TZS per kg for the unstandardized aqua-feed. This means that it was viable to apply both standardized and unstandardized feed on fish farming by fish farmer in a point of net returns during fish farming (ROI ratio > 1). This can be interpreted in the same way for standardized aquaculture feed users with the ratio of 0.43, which means that, for every unit of the cost of using standardized aquaculture feed in farming, farmers gained 43 units of benefits (Table 13). Also, the implication of this finding is that farmers with good returns from their production activities are more likely to afford and apply standardized aqua-feed which is aimed at increasing productivity. These findings concur with the findings in a study by Madan *et al*. (2007) who compared performance of polyculture and monoculture in terms of productivity, cost effectiveness and success. Their findings revealed that the use of farm-based feed after a certain level of application cannot increase productivity as the law of diminishing marginal productivity sets in.

4.3 Return on Investments of Aqua-Feed Manufactures and Fish Farmers

4.3.1 Overview on Return on investments

The return values are calculated depending on the availability of financial data. For both aqua-feed manufacturers and fish farmers return on investment was calculated using the total cost of production which includes the cost of aqua-feeds ingredients, fingerlings, and feeds formulated, equipment such as boat and machinery, hired labor and the revenue received.

4.3.2 Cost and return on investment to aqua-feed manufacturers

This sub-section explains the financial performance of the aquaculture feed manufacture along the value chain. The costs incurred in production and net return of aqua-feed manufacturing is varies from one to another mill in the study area. From the analysis of the results, aquaculture feed manufacturing achieve significantly higher net returns from the invested capital. The revenue from sales were very consistent ranging from 31 250 000 TZS in Morogoro, 148 500 000 TZS in Dar es Salaam to 275 000 000 TZS in the Coast region, across all 7 aqua-feed mills per year of production (Table 14). However, when the total fixed costs and the total variable costs were taken into account, the average net return ranged from 19 750 000 TZS million in Morogoro to 71 750 000 TZS in Dar es Salaam, and 92 000 000 TZS in the Coast region, with an overall average net return of 61 166 666.67 TZS million per year. This is equivalent to an average net return of 33.3% of the sales of aqua-feed (floating pallets) production from 7 mills recorded in the aqua-feed value chain.

Table 14: Return on investment of aquaculture feed manufacturers in the study area

Items	Morogoro	Regions Dar Amounts (TZS "000")	Coast
Aqua-feed sold at the market (Kg)	12 500	59 400	110 000
Market price	2500	2500	2500
A: Total Revenue	31 250 000	148 500 000	275 000 000
Fixed Cost:			
Land	500 000	16 225 000	48 500 000
Machineries	4 500 000	15 500 000	35 000 000
Buildings	4 800 000	18 625 000	26 500 000
Depreciation (2%)	200 000	0	0
B:Total Fixed Cost (TFC)	10 000 000	50 350 000	110 000 000
Variable Cost			
Labor	510 000	2 912 000	8 950 000
Fish feed ingredients (inputs)	720 000	14 120 000	31 200 000
Electricity, energy etc.	225 000	9 128 000	28 850 000
Marketing	45 000	80 000	4 000 000
Maintenance	0	80 000	0
Other (packaging)	0	80 000	0
C:Total Variable Cost (TVC)	1 500 000	26 400 000	73 000 000
Total Cost (TFC +TVC)	11 500 000	76 750 000	183 000 000
Net Profit (A-(B+C))	19 750 000	71 750 000	92 000 000
Return on investments (ROI)	1.717	0.934	0.502

Moreover, Table 14 revealed that the aquaculture feed production in the study areas in Tanzania is positively linked to the capital invested from aqua-feed manufactures (mills), since the recorded Return on Investment (ROI) shows the value of 1.717 in Morogoro, 0.934 in Dar es salaam and 0.502 in the Coast region (Table 14). Generally, the average returns on investment (ROI) was 1.051 of aquaculture feed mills in the study areas in Tanzania. The finding concurs with the finding in a study by El-Sayed (2014), who reported aquaculture feed producers obtaining a positive annual net return in the Egyptian aquaculture feed industry.

4.3.3 Return on investment (ROI) of fish farmers

This sub-section explains the financial performance of fish farmers along the value chain analysis. Moreover, the costs incurred in fish farming and the net returns from the sales of fishes vary from one farm to another in the study area. From the study findings fish farming seem to be achieving significantly higher net returns from the investment. The average revenue from the sales of fishes were very consistent across all the 5 regions practice fish farming ranging from 59 059 000 TZS in Morogoro, 66 300 000 TZS in the Coast, 194 250 000 TZS in Dar es Salaam, 126 525 000 TZS in Mbeya and 240 460 000 TZS in Mwanza region.

However, when the total fixed costs and the total variable costs were taken into account, the net return ranged from (515 650) TZS million in Morogoro, 34 494 000 TZS in Coast, 61 385 000 TZS in Dar es Salaam, 58 646 000 TZS in Mbeya and 90 036 500 TZS in Mwanza region, with an overall average net return of TZS 48 808 770 million per year. This is equivalent to an average net return of 20% of the recorded sales of fishes (Table 15). Moreover, results in Table 15 reveal that fish farming in Tanzania is most profitable in the study areas, since the recorded return on Investment (ROI) values were (0.008) in Morogoro, 1.084 in Coast, 0.462 in Dar, 0.863 in Mbeya and 0.598 in Mwanza region.

Generally, the average return on investment (ROI) in all the surveyed farms in the selected areas in Tanzania was 0.59. This finding was congruent with the finding in a study by Awoyemi (2011) who analyzed profitability of fish farming among 62 women fish farmers in Osun state in Nigeria. The study used budgetary method and observed a net return of 419 756.17 Naira and concluded that fish farming was rewarding and profitable as the return on investment (ROI) was 0.58.

Table 15: Return on investment of fish farmers by region

Items	Coast	Dar	Mbeya	Morogoro	Mwanza
	Regions				
	Amounts (TZS "000")				
Fish sold at the Market (Kg)	10 200	25 900	16 870	9 086	43 720
Selling price at market (TZS)	6.5	7.5	7.5	6.5	5.5
1:Total Revenue	66 300	194 250	126 525	59 059	240 460
Fixed Cost:					
Land	5 487	33 100	11 800	35 370	29 475
Machineries	0	5 000	2 300	0	10 500
Buildings	1 800	5 000	5 000	1 100	7 500
Total Fixed Cost (TFC)	7 287	43 100	19 100	36 470	47 475
Variable Cost					
Labor	11 200	11 750	300	242.65	16 410
Fish feed ingredients (inputs)	11 697	71 300	48 250	22 242	83 475
Fingerlings (Tilapia and Catfish)	1 622	3 565	212.5	620	2 650
Electricity, energy etc.	0	0	0	0	363.5
Net for protection	0	150	16.5	0	50
Total Variable Cost (TVC)	24 519	89 765	48 779	23 104.65	102 948.5
2:Total Cost (TFC +TVC)	31 806	132 865	67 879	59 574.65	150 423.5
Net Profit (1-2)	34 494	61 385	58 646	(515.65)	90 036.5
Return on investments (ROI)	1.084	0.462	0.863	(0.008)	0.598

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Overview of Aqua-Feed Value Chain

The study was about to promote fish farming by increasing the demand of aqua-feeds with reference to omega-3 LC-PUFA, in-order to improve health status of consumers, especially taking into account that there is a decline of wild captured fish from freshwater. Moreover, aqua-feed producers in Tanzania will improve aqua-feed by increasing availability of omega-3 LC-PUFA, so as to improve health status and reduce poverty among economic agents. The specific objectives of the study were: to map and characterize aquaculture feed sector value chain, to determine the factors influencing feed choice by fish farmers, and to determine the returns on investment obtained by feed manufacturers and fish farmers.

5.2 Conclusions

5.2.1 Mapping and characterization of aqua-feed sector value chain

The study revealed that aqua-feed sector value chain in Tanzania involves four actors that are directly engaged in production namely; aqua-feed ingredient supplier, feed producer, feed traders and fish farmers. All aquaculture feed mills are officially registered by BRELA and produce feeds by following rules and regulations governing the sector. The economic significance of aqua-feed ingredients is highly important when upgraded to aqua-feed with reference to omega-3 LC-PUFA content. Their availability and purchasing price vary from one area to another, but the most expensive aqua-feed ingredient was vitamin and mineral mix whose price ranged from 2750 to 7 000 TZS/Kg, the cheapest ingredient was sunflower seed cake whose price ranged from 0 to 300 TZS/Kg. Feed industries are mostly located in Morogoro, the Coast and Dar es Salaam Regions.

Moreover, findings revealed that most aqua-feed manufacturers and fish farmers block the aqua-feed (value chains inefficiencies) among the economic agents in the study area. Because the market structure for both feed manufactured and fish produced are the same as about 65.1% of the manufactured aquaculture feed are sold directly to fish farmers, the remaining 34.9% are sold to aqua-feed traders (wholesaler and retailer) and the agents. About 81.2% of the harvested fish (tilapia and catfish) are sold to individual consumers who buy live fish. Therefore, it can be concluded that these two marketing channels are better-off to consumers when compared to the rest.

5.2.2 Factors influencing aqua-feed choice by fish farmers in the study area

Fish farmers use both standardized and unstandardized aqua-feed for fish farming in Tanzania. Thus, feed price was found to have a positive influence on aqua-feed choice whereas extension visits, experiences, and age had negative influence on aqua-feed choice for fish farming. The comparison of these aquaculture feed values indicate that standardized aqua-feed which is used by fish farmers is the more profitable than the unstandardized aqua-feed in the study area. The study revealed further that using standardized aqua-feed is better for aquaculture sector and for investors because, with reference to n-3 LC-PUFA, it makes farmed fish grow faster and healthier. The results also showed that the standardized aqua-feed had higher mean on the total revenue of 16 635 000 and the net return of 5 026 750 TZS per year, while the unstandardized aqua-feed user had the mean total revenue of 4 415 300 and net return of 779 900 in TZS per year. There was no significant difference between use of standardized and use of unstandardized aqua-feed by fish farmers at 5% level of significant. Therefore, it can be concluded that feed price, extension visits, experiences, and age influence on aqua-feed choice for fish farming.

The relationship between aquaculture feed sector and farming production systems shows that aqua-feed was the most expensive and crucial for farmed fish, representing about 53.5% of the total aqua-feed costs. The finding of this study showed that 35.9% of fish farmers use standardized and 64.1% use unstandardized aqua-feed. The standardized aqua-feed users had the highest production cost mean of 6 935 200 TZS per unit cost and unstandardized aqua-feed users had the lowest cost of 1 357 100 TZS per year in fish farming. In general, choices have a cost to incur, the producers see the real costs and opportunity cost in-terms of the choice of what to forego: if one aqua-feed type has higher values in-terms of return from investment than the other type.

5.2.3 Return on investment obtained by aqua-feed manufacturers and fish farmers

The financial analysis of aqua-feed manufacturers and fish farmers, through return on Investment (ROI) values indicate that both feed manufacturers and fish farmers are performing well. The average returns on investment (ROI) is viable to both aqua-feed manufacturers and fish farmers, since the average return on investment (ROI) recorded was 1.051 to feed manufacturers and 0.59 to fish farmers. Therefore, it can be concluded that investing in aquaculture feed in Tanzania is economical and efficient along the chain.

5.3 Recommendations

The main objective of the study is to promote the demand for the use of improved aqua-feed with reference to omega-3 LC-PUFA content, for farmed catfish and tilapia in Tanzania for the benefit of local populations using aqua-feed (standardized and unstandardized aqua-feed). Therefore, aqua-feed VC will be a more productive sector in increasing the production on aqua-feed and improving health status and per capita. In order to make the investment of aqua-feed and fish production productive, the following recommendations are made.

5.3.1 Intervention to increase demand of aqua-feed

Feed manufacturers and fish farmers should be given training on the role and functining of value chains to reduce value chain inefficiencies in the supply of aqua-feed to fish farmers (proper marketing channels). The government should encourage private sector to establish aqua-feed industries in the area such as Mbeya and Mwanza region to make aqua-feed with reference to omega-3 LC-PUFA easily available. This will lower aqua-feed price and attract more investors in the aquaculture sector.

5.3.2 Sustainability of aquaculture feed value chain

The feed manufacturers and fish farmers should be equipped with new knowledge of aqua-feed formulation and preparation, which will bring direct impact on fish farming practice. Improved knowledge should be done to make sure the aqua-feeds produced have high quality and best to use for more profits.

The economic agents (government, researchers) should support in training only, rather than in inputs and financial aid to fish farmers; this will make farmer more committed to the expected returns from the capital invested and to the sustainability of the sector. This will increase the market for standardized aquaculture feed produced by feed manufacturers and hence increases job creation in the country. The government should provide subsides to aqua-feed producers, which will lower the price of standardized aqua-feed, because small scale farmers cannot afford it. Fish farmers should be encouraged to form groups and become members of cooperatives. This will help fish farmers in getting soft loans from the government and financial institutions, because aquaculture sector incurs costs in production and distributions. The loan can be used to hedge (insurance) against price fluctuation at the market and insure access to equipment. The government should restructure the law and regulations of the fisheries Act, 2003 (No.22 of 2003) and The

Fisheries Regulations 2005) (Regulation 34(1) of aquaculture development, that address restrictions of farming at open areas such as Lake Victoria and rivers (cages) for people who need to invest but do not own land. Farming permits should be provided near their administrative area (District). This will increase investors in aquaculture sector (extensive farming), and thus increase the availability of supply of fish with reference to omega-3 LC-PUFA.

The quality and standards of produced and supplied aqua-feed should be improved by selecting the type of feed which can make farmed fish grow faster and farmers to acquire returns from the investments rather than betting with the types of aqua-feed available at the market or farm-made.

5.3.3 Strengthening of the aquaculture feed value chain

There should be a strong relationship between aqua-feed producers and the nodes to boost investment along the chain. The use of researchers on research and development of types of feed and farming systems according to geographical and market will make aqua-feed sector more profitable. Furthermore, research will increase the use of standardized feed with affordable price to fish farmers.

5.4 Areas for Further Studies

According to the findings of the study of value chain analysis of aquaculture feed in Tanzania, further studies can be conducted in the following areas.

i. To examine risk perceptions and risk management strategies among feed manufacturers and fish farmers in aquaculture sector.
ii. Establishments of aquaculture insurance as a way to secure fish farmers from risks and uncertainties.

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APPENDICES

Appendix 1: Feed Manufacturers Questionnaire

Qn 1: Please enter location of main office and/or main production location (Region, District, town) ……………………..

Qn 2: Where is the feed production unit located? (Only 1 answer)

(a) Rural area ( ) (b) Peri-urban area ( ) (c) Urban area ( )

Feed producer characteristics:

Qn 3: What type of feed producer are you? Select the description that matches most closely:

(a) An importer of commercial feed formulated outside Tanzania (agent or actual feed company ( ) (b) An in-country national feed producer ( ) (c) A local or small-scale feed producer with extruder ( ) (d) Other (please describe) ( )

Qn 4: Here, in Tanzania, what is your main product?

(a) Terrestrial animal (livestock + poultry) feed mainly ( ) (b) Fish feed mainly ( )

(c)Terrestrial animal and fish feed in equal proportions ( ) (d) other (describe) ( )

Qn 5: How many fish feed products are you commercializing? (Enter the number of products)

(a) Bulk fish feed (enter number of different types of fish feed sold bulk) (b) Packaged fish feed (enter number of different types of packaged fish feed) (c) Fish feed supplements (enter number of different types of supplements)

(d) Other types of fish feed product (please describe.

Qn6: For how many years have you been producing fish feed? (Enter number of years)

Qn8: Is the manager/owner of the production facility a man or a woman?

(a) a man ( ) (b) a woman ( )

Qn9: What is the age of the manager/owner of the feed production facility?

(a) 15-30 ( ) (b) 31-45 ( ) (c) 46-60 ( ) (d) 61-85+ ( )

(e) Does not know / prefers not to say ( )

Qn10: What is his/her educational level? (Manager/owner) (1 answer possible)

(a) Informal (no schooling) ( ) (b) Primary school level (7 to 14 years) ( )

(c) Vocational diploma level ( ) (d) Secondary school O'level (14-18 years)

(e) Secondary school A 'level (18-20 years) (f) University undergraduate degree

(g) University postgraduate degree ( )

Qn11: Are you a member of an association or cooperative of feed producers?

(a) Yes ( ) (b) No ( )

Qn12: Are you a member of a Facebook or WhatsApp group on fish feed manufacturing?

(a) No ( ) (b) Yes ( )

Feed additives and premixes:

Qn13: Do you have a production line for feed premixes or additives in your production facility?

(a) Yes ( ) (b) No ( )

Qn14: Are these for FISH or for other animal?

(a) For fish ( ) (b) For other animals ( )

(c) For both fish and terrestrial animals ( ) (d) other (please indicate) ( )

Qn15: What is the % of additives/premixes produced for fish compared to that produced for other animal (enter the number only) ____________________

Qn16: What is the average sale price of additives/premixes for FISH in 2017 (enter the number only in TSH) ____________________

Qn17: What is the average sale price of additives/premixes for other TERRESTRIAL ANIMALS in 2017 (enter the number only in TSH) _________________

Qn18: How has the average sale price of additives/premixes changed compared to previous years?

(a) Increased ( ) (b) Decreased ( ) (c) Stable ( )

Economic and marketing information:

Q19: Are you a recipient of any government support or subsidies for feed production? (Incl. subsidized equipment or inputs)

(a) Yes ( ) (b) No ( )

Qn20: If yes, please describe the type of support or subsidy you receive (enter text)._____________

Qn21: Are you part of a public-private partnership?

(a) Yes ( ) (b) No ( )

Qn22: If yes, please describe the type of public-private partnership you are part of (e.g. with whom, how long for, to do what) ____________________

Qn23: Are you (or your business) officially registered with a Government agency (e.g. TRA, BRELA)?

(a) Yes ( ) (b) No ( )

Qn24: What quantity of feed and additives/premixes for TERRESTRIAL ANIMAL did you produce (Enter figure, in TONNES/YEAR). Enter zero if not producing terrestrial animal feed.

(a) In 2017 (b) In 2016

Qn25: What quantity of FISH feed did you produce... (Enter figure, in TONNES/YEAR). Enter zero if not producing fish feed.

(a) In 2017 (b) In 2016

Qn26: What are the average sale price of the fish feed you sell bulk? (Enter figure in TZS/kg). _____________

Qn27: What are the average sale price of the packaged fish feed you sell? (Enter figure in TZS/kg). _____________

Qn28: What was your total annual gross income? (Enter figure in TZS)

(a) In 2017 (b) In 2016

Qn29: What were your total operating costs? (Enter figure in TZS)

(a) In 2017 (b) In 2016

Qn30: For 2017, please provide a breakdown of your total operating costs (enter figure in %. Estimates can be provided)

(1) Inputs (2) Labor (3) Electricity, energy etc. (4) Marketing (5) Other (describe)

Qn31: What percentage of your total operating costs is for FISH feed production? (Enter figure in %. If they do not produce fish feed, enter 0) _________

Qn32: What were your total investment/fixed costs? (Enter figure in TZS)

(1) In 2017 (2) In 2016

Qn33: For 2017, please provide a breakdown of your total investment/fixed costs (enter figure in %. Estimates can be provided)

(1) Land (2) Machinery (3) Buildings (4) Depreciation (5) Other (describe)

Qn34: How many people are employing on a regular basis? EXCLUDING family members (Enter number only)

(1) Number of full-time men (2) Number of full-time women (3) Number of part-time men (4) Number of part-time women

Qn 35: How do you sell your fish feed? (Tick: multiple answers are possible)

(a) Farmers (customers) come to the production site to buy fish feed directly (1)

(b) Traders or wholesalers purchase the feed bulk for resale (2)

(c) We have agents (sellers) going to the fish farms to sell the feed to farmers (3)

(d) We distribute to specific retailers (8)

(e) We have a shop/retail outlet (4)

(f) I transport feed to farm directly (6)

(g) Other (please describe) (5) ____

Qn36: What percent of the total volume of your fish feed sales do you sell to? (Indicate % each time)

(a) Individual farmers (indicate %) (1)____

(b) Fish farmers' cooperatives (indicate %) (8) ___

(c) Traders or wholesalers (indicate %) (2) ____

(d) Retailers (indicate %) (3)_____

(e) Other (please describe) (5)_____

Raw ingredients:

Qn37: What ingredients are you using for FISH feed, and what is their availability? Drag and drop the ingredients you use in relevant boxes, according to their availability. Drop ingredients not used in the "Not used" box.

Always available and relatively cheap	**Variable availability and/or price**	**Most difficult to obtain and/or expensive**	**Not used**
Rice bran	Rice bran	Rice bran	Rice bran
Wheat bran	Wheat bran	Wheat bran	Wheat bran
Maize bran	Maize bran	Maize bran	Maize bran
Soybean	Soybean	Soybean	Soybean
Coconut oil	Coconut oil	Coconut oil	Coconut oil

Groundnut oil	Groundnut oil	Groundnut oil	Groundnut oil
Sunflower oil	Sunflower oil	Sunflower oil	Sunflower oil
Cotton seed cake	Cotton seed cake	Cotton seed cake	Cotton seed cake
Sunflower seed cake	Sunflower seed cake	Sunflower seed cake	Sunflower seed cake
Moringa seeds	Moringa seeds	Moringa seeds	Moringa seeds
Mineral and vitamin mix	Mineral and vitamin mix	Mineral and vitamin mix	Mineral and vitamin mix
Shrimp paste	Shrimp paste	Shrimp paste	Shrimp paste
Fish meal	Fish meal	Fish meal	Fish meal
Blood meal	Blood meal	Blood meal	Blood meal
Fish oil	Fish oil	Fish oil	Fish oil
Other (please specify)	Other (please specify)	Other (please specify)	Other (please specify)

Qn38: What is the purchase price of these ingredients? (Enter figure in TZS/kg. If not used, leave blank)

(1) Rice bran (2) Wheat bran (3) Maize bran (4) Soybean

(5) Coconut oil (6) Groundnut oil (7) Sunflower oil (8) Cotton seed cake

(9) Sunflower seed (10) Moringa seeds (11) Mineral and vitamin mix (12) Shrimp paste

(13) Fish meal (14) Blood meal (15) Fish oil (16) other (please specify)

Qn39: What are the processing costs of these ingredients for inclusion in the feed? (Enter figure in TZS/kg. Enter 0 if there are no processing costs, leave blank if not used).

(1) Rice bran (2) Wheat bran (3) Maize bran (4) Soybean

(5) Coconut oil (6) Groundnut oil (7) Sunflower oil (8) Cotton seed cake

(9) Sunflower seed (10) Moringa seeds (11) Shrimp paste (12) Mineral and vitamin mix

(13) Fish meal (14) Blood meal (15) Fish oil (16) other (please specify)

Qn42: Do you think your current knowledge on feed manufacturing would be sufficient to manufacture this feed?

(a) Yes ( ) (b) No ( ) (c) May be ( ) (d) Doesn't know ( )

Qn43: Do you intend to adopt non-conventional ingredients as standard for inclusion in feed manufacturing in the long term?

(a) Yes, in conditionally ( ) (b) Yes, but at the condition ( ) (c)No ( )

Qn44: The survey is now finished. Thank you for cooperation. If there is anything you would like to advice (e.g. personal observations, additional information about the enterprise, feed producing facilities etc.) …………………….

Appendix 2: Fish Farmers Questionnaire

Qn 1: Please enter location name (Region and District) __________

Qn 2: Is the farm located?

(a) In a rural area ( ) (b) In a Peri-urban area ( ) (c) In an urban area ( )

Farmer's characteristics:

Qn3: Is the manager/owner of the farm:

(a) a man (1) (b) a woman (2)

Qn4: What is your age? (Enter number of years only) __________

Qn5: What is your education level?

(a) Informal (no schooling) ( ) (b) Primary school level (7 to 14 years)

(c) Vocational diploma level ( ) (d) Secondary school - O level (14-18 years

(e) Secondary school - A level (18-20 years) ( ) (f) University undergraduate degree

(g) University postgraduate degree ( )

Qn6: How many years' experience in fish farming do you have? (Enter number of years)

Qn7: Have you received formal training on fish farming?

(a) Yes ( ) (b) No ( )

Qn8: How many times did you receive training on fish farming since you started fish farming? (Enter number of times) _____________

Qn9: Are you a member of an association, club or cooperative of fish farmers?

(a) Yes ( ) (b) No ( )

Qn10: Are you a member of a Facebook or WhatsApp group on fish farming?

(a) No ( ) (b) Yes ( )

Qn11: How many times PER MONTH does an extension officer visit your farm? (Work out the frequency if needed, e.g. 1/week = 4 times/month, once per term = 0.33/month). Enter a figure only. _______________

Qn12: How frequently do you consume your own fish? (1 answer only)

(a) Never ( ) (b) Once per year ( ) (c) At harvest time only ( ) (d) Once per month ( ) (e) Once per week ( ) (f) More than once per week ( )

Farm characteristics

Qn13: Are you a recipient of any government support for fish farming? (Any support, incl. financial)

(a) Yes ( ) (b) No ( )

Qn14: If yes, please describe the support you are receiving.

Qn15: Are you doing cage farming?

Yes ( ) (b) No ( )

Qn16: How cages do you have (enter number)

Qn17: What is the volume of 1 cage (enter figure in m3)

Qn18: How many ponds do you have? (Enter number only)

Qn19: What is the pond area? (Enter area in m^2)

Qn20: Which species do you farm? (Multiple answers are possible)

(a) Nile tilapia (Sato/Gege) ( ) (b) African catfish (Kambale) ( ) (c) Other 1 (please specify) ___________

Qn21: How do you stock and grow your fish?

(a) In cycles (= stocking at the same time, harvest all together) ( )

(b) Continuously (= continuous stocking and partial harvest when needed)

Qn 22: How much fish do you produce in total (all species together) per cycle? (Enter TOTAL kg/cycle) ________________

Qn 23: How do you sell all your fish? (Multiple answers are possible)

(a) Consumers come to the pond/farm to buy the fish live (1)

(b) A fish trader or wholesaler comes to my farm to buy the fish bulk (2)

(c) I take my fish to a sale point to sell it myself (3)

(d) I have a shop (4) (e) Other (please specify) (5) ____

Qn 24: At what price do you sell your fish to LOCAL CONSUMERS during the RELIGIOUS SEASON (e.g. Easter)? (Enter price in TZS/kg) _______________

Qn25: At what price do you sell your fish to LOCAL CONSUMERS outside the religious season? (Enter price in TZS/kg) ______________________

Qn26: At what price do you sell your fish BULK during the RELIGIOUS SEASON (e.g. Easter)? (Enter price in TZS/kg) _______________________

Qn27: At what price do you sell your fish BULK outside the religious season? (Enter price in TZS/kg) ___________________________

Qn28: How many family members regularly work on the farm? (Enter number only) ___

Qn29: How many regular employees do you have on your fish farm, EXCLUDING family members? (Enter number only)

(a) Full-time men ( )

(b) Full-time women ( )

(c) Part-time men ( )

(d) Part-time women ( )

Qn30: How many EXTRA people do you hire at harvest time, EXCLUDING family members? (Enter number)

(a) Men ( ) (b)Women ( )

Qn31: Do you hire a consultant for specific purposes?

(a) Yes ( ) (b) No ( )

Qn32: If yes, please describe for what purpose. ___________________

Qn33: Do you own the land where the ponds are built? If NO describe

(a) Yes ( ) (b) No ( )

Qn34: Are you keeping a register book of your expenses and revenues?

(a) Yes ( ) (b) No ( )

Qn35: Are you willing to communicate your overall costs of production per cycle (or per year)?

(a) Does not want to say ( ) (b) Yes ( )

Qn36: If yes, what are the total costs of production? (Enter price in TZS. Specify if it is per cycle or per year) ____________________

Qn37: How does it compare with the total costs of production of the previous cycle (or year)?

(a) Lower than the COP of the previous cycle (or year) ( )(b) Higher than the COP of the previous cycle (or year)( ) (c)Same as the COP of the previous cycle (or year) ( )

Qn 38: Are you following the pond management recommendations of the Fisheries Department?

(a) Yes, very closely( ) (b) Somewhat closely ( ) (c) No, not closely or not at all ( )

Qn 39: Are you subscribing to an insurance policy for fish farming?

(a) Yes ( ) (b) No ( )

Qn 40: Do you currently have (or have you had in the past) a loan from the bank for fish farming? (a) Yes ( ) (b) No ( )

Feeding practices

Qn 41: Which of the following statements best describes your feed use? (Select only the most important one)

(a) Regular use of commercially formulated feed from foreign company (imported) ( )

(b) Regular use of commercially formulated feed from Tanzanian company ( )

(c) Regular use of feed made on farm with locally available ingredients (on-farm & local agricultural by-products)( ) (d) Irregular, infrequent or no feeding ( )

Qn42: What is the name of the feed company you are getting your feed from? (Enter name) ______________________

Qn43: Where do you buy the feed from?

(a) A local shop ( ) (b) A fish feed retailer (can be local or in the next town) ( )

(c) The company sends a seller to my farm to deliver the feed ( )

(d) Other (please specify) ( ) _____________________

Qn44: If you make your own feed, which ingredients are you using? (Multiple answers are possible)

(a) Rice bran ( ) (b) Wheat bran ( ) (c) Maize bran ( )

(d) Soybean ( ) (e) Coconut oil ( ) (f) Groundnut oil ( )

(g) Sunflower oil ( ) (h) Cotton seed cake ( ) (i) Sunflower seed cake ( ) (j) Moringa leaves ( ) (k) Mineral and vitamin mix (l) Shrimp paste ( ) (m) Fish meal ( ) (n) Blood meal ( ) (o) Fish oil ( ) (p) Aquatic macrophytes or seaweed( )

(q) Other (please specify) _________________

Qn45: What is the price of your feed? (Calculate and enter the price in TZS/kg if commercial feed is used, or try and estimate the cost per kg if feed is home-made)

Qn46: How much feed do you use in total per cycle (enter number of kg. If he/she doesn't know: enter "not sure", if they are not feeding: enter 0) __________________

Qn47: Feed costs represent what percentage of total costs of fish farming?

(a) Less than 50%( ) (b) Between 51 and 80% ( ) (c) More than 81% ( )

Qn48: Do you weigh fish to calculate feed usage? (= calculate the Feed Conversion Ratio - FCR) (a) Yes ( ) (b) No ( )

Omega-3 awareness:

Qn49: Have you ever taken a spoonful of fish oil?

(a) Yes ( ) (b) No ( )

Qn50: This spoonful of fish oil is a good source of Omega-3 oils. How much do you know about Omega-3s in general, their sources and their health benefits?

(a) A lot ( )(b) A bit( ) (c) Nothing/never heard about it ( )

Qn51: Do you know any commonly used products that are enriched with Omega-3 oils?

(a)Yes ( ) (b) No ( )

Technology adoption scenarios:

Qn52: Do you think your current knowledge on feeding would be sufficient to use this feed? (a)Yes ( ) (b) No( ) (c) Maybe( ) (d) doesn't know ( )

Qn53: Do you intend to adopt feed containing non-conventional ingredients as your MAIN FEED in the LONG RUN?

(a)Yes, in conditionally ( ) (b) Yes, but at the condition (explain)... (c) No ( )

Qn54: The survey is now finished. Thank you for cooperation and time. If there is anything you would like to add and advice from the interview (e.g. personal observations, additional information about the farmer, his farm etc.)___________

Appendix 3: Econometrics results of aqua-feed choice by fish farmer

(a) TESTS HETEROSCEDASTCTY

```
estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity
        Ho: Constant variance
        Variables: fitted values of Feedchoice_ndex

        chi2(1)      =     1.55
        Prob > chi2  =   0.2130
```

(b) TESTS OF ENDOGENEITY

```
Instrumented:  Feed choice_ndex
Instruments:   Extension Vist Age            Govt Support Farming
Experiences                                  type
Species2 Stock Land owner

. estat endog

Tests of endogeneity
Ho: variables are exogenous

Durbin (score) chi2(1)      = .630821    (p = 0.4271)
Wu-Hausman F(1,74)          = .603351    (p = 0.4398)
```

(c) MULTICOLINEARITY TEST ON THE SELECTED VARIABLES

Variable	VIF	1/VIF
Farming type	2.49	0.401822
Land owner	2.44	0.409631
Experiences	1.24	0.808363
Feed Price	1.24	0.808379
Govt Support	1.22	0.817816
Age	1.16	0.859818
Stock	1.13	0.88603
Extension Visit	1.09	0.918698
Species2	1.09	0.920509
Mean VIF	1.45	

Appendix 4: List of feed manufacturing company

AQUACULTURE FEED COMPANIES			
No	Name	Location	Type of feed
1	TANFEED	Morogoro	Animal +fish feed
2	EDEN AGRI-AQAC	Dar es salaam	Animal +fish feed
3	RUVU FISH FARM	Coast	Fish feed
4	SALIBABA	Coast	Animal +fish feed
5	DAR ZOO	Dar es salaam	Animal +fish feed
6	KITUNDA ANIMAL FEED	Dar es salaam	Animal +fish feed
7	MILLER	Dar es salaam	Animal +fish feed

List of Institution (supportive services

No	Name	Location	Main Activity
1	TROUW NUTRITION, EVONIK AND CARGIL	Uganda	Feed manufacturing
2	EAGC		Feed manufacturing
3	CRS	Kenya	Feed manufacturing
4	SOGECO	Morogoro	Agri-Research, training and Practice
5	MBEGANI FISHERIES		Training and research
6	SUA	Morogoro	Training, consultancy and research
7	UDSM	Dar es salaam	Training, consultancy and research
8	TAFIRI	Dar es salaam	Training, consultancy and research
9	BRELA	Dar es salaam	Registration of business entity such as feed industries and licence provider
10	TBS	Dar es salaam	Quality and Standards assurance
11	TFDA	Dar es salaam	Protect and Promote Public Health

Appendix 5: Summary of Market channel of aquaculture feed

LOCATION	Coast				Dar es salaam				Morogoro				Total				
	N	Minimum	Maximum	Mean	N	Minimum	Maximum	Mean	N	Minimum	Maximum	Mean	N	Minimum	Maximum	Mean	Std. Deviatio
Feed_prod_kg	2	50000	60000	55000	4	2000	28000	14850	1	12500	12500	12500	7	2000	60000	25985.71	21407.9
Prce_kg_sold	2	2000	3500	2750	4	1500	3000	2125	1	2500	2500	2500	7	1500	3500	2357.143	690.065
QTY_MKT_A	2	0	60000	30000	4	2000	28000	14302.5	1	1250	1250	1250	7	0	60000	16922.86	21431.6
QTY_MKT_B	2	0	5000	2500	4	0	750	187.5	1	8125	8125	8125	7	0	8125	1982.143	3267.92
QTY_MKT_C	2	0	45000	22500	4	0	0	0	1	3125	3125	3125	7	0	45000	6875	16851.8
QTY_MKT_D	2	0	0	0	4	0	1440	360	1	0	0	0	7	0	1440	205.7143	544.268
MKT_A_TZS	2	0	2.1E+08	1.05E+08	4	4000000	42000000	28345000	1	3125000	3125000	3125000	7	0	2.1E+08	46643571	7414435
MKT_B_TZS	2	0	10000000	5000000	4	0	1500000	375000	1	20312500	20312500	20312500	7	0	20312500	4544643	785569
MKT_C_TZS	2	0	90000000	45000000	4	0	0	0	1	7812500	7812500	7812500	7	0	90000000	13973214	3365085

Appendix 6: Feed production and marketing

Location	Coast				Dar es salaam				Mbeya				Morogoro				Mwanza				Total			
	N	Mini mum	Maxi mum	Mean	N	Mini mum	Maxi mum	Mean	N	Mini mum	Maxi mum	Mean	N	Mini mum	Maxi mum	Mean	N	Mini mum	Maxi mum	Mean	N	Mini mum	Maximum	Mean
Tilapia_KG	4	1700	2400	2037.5	9	1100	5200	2566.667	15	30	3700	1124.667	35	12	700	219.4571	15	150	7000	2891.333	78	12	7000	1271.423
AfricanCatfsh_KG	4	0	1400	512.5	9	0	1500	311.1111	15	0	0	0	35	0	500	40.14286	15	0	250	23.33333	78	0	1500	84.67949
Total_PROD_KG	4	1700	3450	2550	9	1100	5200	2877.778	15	30	3700	1124.667	35	12	750	259.6	15	150	7000	2914.667	78	12	7000	1356.103
QTY_Farmgate_KG	4	1360	2760	2040	9	880	4160	2302.222	15	24	2960	899.7333	35	9.6	600	207.68	15	120	5600	2331.733	78	9.6	5600	1084.882
Consumer_FARM_PR	4	7000	8000	7750	9	7500	8000	7888.889	15	0	10000	6666.667	35	0	6000	4742.857	15	0	7500	5300	78	0	10000	5737.179
QTY_Wholesaler	4	255	517.5	382.5	9	165	780	431.6667	15	4.5	555	168.7	35	1.8	112.5	38.94	15	22.5	1050	437.2	78	1.8	1050	203.4154
Wholesaler_PR	4	7000	8000	7500	9	5000	8000	7444.444	15	0	9000	6233.333	35	0	7000	4268.571	15	0	8000	5466.667	78	0	9000	5408.974
QTY_SalePont	4	68	138	102	9	44	208	115.1111	15	1.2	148	44.98667	35	0.48	30	10.384	15	6	280	116.5867	78	0.48	280	54.2441
SalePONT_PRC	4	5000	5000	5000	9	4500	7000	6111.111	15	0	8000	5666.667	35	0	7000	2528.571	15	0	9000	5900	78	0	9000	4320.513
QTY_Other_KG	4	17	34.5	25.5	9	11	52	28.77778	15	0.3	37	11.24667	35	0.12	7.5	2.596	15	1.5	70	29.14667	78	0.12	70	13.56103
Other_PRC	4	4500	4500	4500	9	4000	4500	4444.444	15	0	6000	1966.667	35	0	6000	928.5714	15	0	5500	3033.333	78	0	6000	2121.795
Farmgate_TR	4	10880000	22080000	15790000	9	7040000	33280000	18062222	15	0	26640000	7667733	35	0	3600000	1040709	15	0	30000000	12002933	78	0	33280000	7143651
Wholesaler_TR	4	1785000	4140000	2896875	9	1320000	5460000	3100000	15	0	4440000	1264700	35	0	675000	180115.7	15	0	7875000	2511550	78	0	7875000	1313273
SalePONT_TR	4	340000	690000	510000	9	308000	1248000	677111.1	15	0	740000	269760	35	0	140000	29402.86	15	0	1960000	646946.7	78	0	1960000	293765.4
Other_TR	4	76500	155250	114750	9	49500	234000	127277.8	15	0	185000	51266.67	35	0	30000	2524.286	15	0	315000	102566.7	78	0	315000	51286.54
TOTALFSH_FARM_TR	4	13081500	27065250	19311625	9	8717500	40222000	21966611	15	8400	32005000	9253460	35	3000	4425000	1252751	15	302500	36900000	15263997	78	3000	40222000	8801976
FINGERLINGS_COST	4	17000	145000	53125	9	75000	1000000	396111.1	15	0	370000	41466.67	35	0	50000	3428.571	15	0	1000000	176666.7	78	0	1000000	91916.67
LABOUR_COST	4	50000	100000	75000	9	50000	3500000	1305556	15	0	5000000	746666.7	35	0	1200000	69328.57	15	0	2500000	1094000	78	0	5000000	539570.5
FEED_PRICE	4	3500	3500	3500	9	2000	3500	2611.111	15	500	5000	1543.333	35	0	3000	880	15	500	3500	2186.667	78	0	5000	1592.949
TOTAL_FEED_used_KG	4	3000	3500	3375	9	0	4000	2944.444	15	0	5000	1322	35	0	600	150.5143	15	70	6000	2548	78	0	6000	1324.59
TOTAL_feedCOST_TC	4	10500000	12250000	11812500	9	0	10800000	7922222	15	0	10500000	2446467	35	0	750000	149771.4	15	35000	15750000	6765000	78	0	15750000	3358513
TVC	4	10617000	12445000	11940625	9	610000	15000000	9623889	15	0	15550000	3234600	35	0	1520000	222528.6	15	45000	18850000	8035667	78	0	18850000	3990000
TFC_land_net_Water	4	1300000	4000000	2950000	9	100000	15000000	3677778	15	10000	15000000	2358000	35	0	1500000	153857.1	15	100000	15000000	4398333	78	0	15000000	1943974
PROFIT	4	1164500	11620250	4421000	9	1775000	12757500	8664944	15	-41600	9217000	3660860	35	-13750	3865000	876365.7	15	157500	9300000	2829997	78	-41600	12757500	2868002
TC_TVC_TFC	4	11917000	16376500	14890625	9	710000	30000000	13301667	15	17000	23870000	5592600	35	0	1620000	376385.7	15	145000	28850000	12434000	78	0	30000000	5933974