Assessment of Productivity and Supply Chain of Aquaculture Projects in Gauteng Province for Sustainable Operation

by

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Abbreviations

DAFF:	Department of Agriculture, Forestry and Fisheries
DTI:	Department of Trade and Industry
FAO:	Food and Agricultural Organization
NASF:	National Aquaculture Strategic Framework
GDARD:	Gauteng Department of Agriculture and Rural Development
PUA:	Public Understanding of Aquaculture

Acknowledgement

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Dedication

This work is dedicated to my wife Adetutu, to our ever inspiring children Sharon, Rachael, Daniel, Grace and Michael. Your prayers and motivation despite my absence from home made this a reality. Finally, I give the work to the one who gave me life and inspiration; God, the ever-present help in time of need. To Him be all the glory.

Declaration

Name : Babawale Oyeleke Sowemimo

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Degree : Master of Science (Agriculture)

Title of the dissertation: **Assessment of Productivity and Supply Chain of Aquaculture Projects in Gauteng Province for Sustainable Operation.**

I declare that the above dissertation is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

……. ……

Student signature Date

Abstract

The main aim of the study is to assess the productivity and supply chain of aquaculture projects in Gauteng Province, South Africa. The research adopted the use of quantitative method; and collected data and information from the five regions that make up the province. Both primary and secondary data were collected. The study used correlation analyses to determine the perfect fit or negative fit of some variables to supply chain as well as the consumers' reactions to the questionnaires. Gross margin analysis as well as gross profit margin ratio was used to determine the profitability of aquaculture production in the province.

Findings of the study revealed underutilization of production capacities of the established fish farms. The fish farmers in the study are currently using 36% of the capacities of the established aquaculture projects in the study area. The profit margin was in excess of 40% in all the projects surveyed. The study further revealed lack of proper, effective and efficient supply chain for aquaculture projects which adversely affect aquaculture growth and sustainability in Gauteng Province.

KEY WORDS

Productivity; Profitability; Supply chain; Sustainability; Aquaculture projects; Freshwater fish species; Marine fish species.

CHAPTER 1

1. INTRODUCTION

1.1 Background

Aquaculture is one of the fastest growing food production sectors in the world. Africa is an aquaculture destination of choice owing to favourable environmental condition with about 43% potential area for farming tilapia, African catfish and carp (Ridler & Hishamunda, 2001). Several African countries are making good contributions to world aquaculture. Countries like Egypt, Ghana, and Nigeria are some of the leading aquaculture destinations on the continent. However, South Africa's contribution to the global aquaculture production is insignificant (FAO, 2012a).

The fishing industry in South Africa is divided into two broad categories in term of production tonnage. The well developed and matured marine capture subsector and less developed aquaculture subsector (Britz, 2014). According to FAO (2012b), out of South Africa's total fish production of 721000 tonnes in 2012, the aquaculture sector contributed only 6000 tonnes.

Between 2000 and 2012, the contribution of the aquaculture sector to the South Africa fisheries witnessed an increase of 0.4%. The sector contributed about 1% of Africa's aquaculture production and 0.00003% of the global production in 2012 (DTI, 2013; FAO, 2014a). In Africa, as at 2010, South Africa ranked 10 behind several African nations in aquaculture production (FAO, 2012a).

The marine aquaculture sector is concentrated mainly in Western Cape (FAO, 2012a). Marine fish production started in 1673 and 1676 with the attempt to culture the indigenous oyster species. Commercial operation of oyster farming was however successful only in 1948 (FAO, 2012a).

The total marine aquaculture production in 2011 excluding seaweed was 1883 tonnes. The abalone subsector contributed up to 55% of the total production followed by mussels, oysters and finfish with 35.1%, 14.3% and 0.4% respectively (FAO, 2012a). Western Cape was the leading marine aquaculture province followed by

Eastern Cape and Northern Cape respectively. Out of the total marine fish production in 2011, Western Cape produced 1624 tonnes followed by 252 tonnes from Eastern Cape and 6 tonnes from Northern Cape (DAFF, 2012).

The freshwater aquaculture industry is the oldest aquaculture sector in the country with the production of Rainbow trout whose seed was first imported into South Africa in 1896 (Hecht & Britz, 1990). It has a higher number of producers and cultured species in South Africa than the marine sector. The major farmed species are rainbow trout, ornamental species, tilapia and catfish (DAFF, 2012).

The sector witnessed an improvement of 12.7% in total production from 2006 to 2011. The sector produced 2921 tonnes of fish in 2011 (FAO, 2012a). Trout was the most cultured freshwater species in 2011 followed by ornamental species. The overall total freshwater species production in 2011 shows the trout subsector contributed 1428 tonnes followed by the ornamental and koi carp with respective productions of 660 and 572 tonnes. The other cultured species sharing the remaining production tonnage are tilapia, catfish (Aquaculture annual report, 2012). The dominant freshwater aquaculture producing provinces are Western Cape, Eastern Cape, Mpumalanga, KwaZulu-Natal and Gauteng. Free State, North West, Northern Cape and Limpopo are still developing (DAFF, 2012).

Gauteng province is one of the warmest provinces of South Africa. While the temperature over winter can range between 5º and 19º Celsius bringing frost and chilly mornings, the summertime has temperature range between 17º and 28º Celsius is warm and in some part lasts about 8 out of the 12 months of the year (Moja Media, 2015). The province is suitable for warm water fishes especially tilapia and catfish which have temperature range of between 20-30º Celsius for catfish (Hecht *et al*. 1988 and FAO, 2011) and 26-30º Celsius for tilapia (Farmers weekly, 2012; El-Sayed, 2005). However, despite the suitable weather condition, aquaculture development has been slower than expected in Gauteng province (Dekker, 2014).

There are currently no commercial aquaculture farms in Gauteng province (Dekker, 2014; GDARD, 2015). Aquaculture is regarded to be practiced in small scale in the province with maximum production output of less than 100 tonnes of fish in a year per existing farms (DAFF, 2014; GDARD, 2015).

There are about 24 farms (both food fish and ornamental) that are operational in Gauteng province with twenty-nine other aspiring farmers willing to enter the industry (GDARD, 2015). However, despite the number of farms, the industry analysis by GDARD reported a proposed combined production of 276 tonnes of fish by all the interviewed producers for the 2016/17 production year (GDARD, 2015).

1.2 Rationale and motivation

Several studies were conducted to find out why freshwater aquaculture development in Gauteng province has been slower in growth than expected despite the great infrastructural facilities, government commitments to boosting aquaculture and suitable environmental conditions (FAO, 2012a; GDARD, 2015; SOPA, 2015).

The current study was conducted to assess the productivity, supply chain and profitability of aquaculture projects in Gauteng province. The outcome and recommendations from this current work about productivity, supply chain and profitability of existing aquaculture projects in Gauteng province is important for the future of the sector. As it may help many aspiring farmers and interested investors make bold decisions and be fully committed to the sector. The factors that affect market value and the supply chain were determined. These factors should be considered for policy and strategy development to enhance production, growth and sustainability. According to Okechi (2004), entrepreneurs will be willing to invest in aquaculture and promote it to commercial level if it can be demonstrated to be profitable, because farmers make production decisions on yield that will give the most returns (Hawley, 1975; Ahmed, 2004).

1.3 Problem statement

The productivity of aquaculture projects in Gauteng province is not known and the supply chain of aquaculture is underdeveloped (Britz *et al*. 2009; Britz, 2014; GDARD, 2015). Productivity was defined by Fried *et al*. (1993) as the ratio of outputs to inputs in which case a production system is said to be productive and efficient when it achieves higher outputs for a set of inputs and inefficient and unproductive if

the output is lesser for a set of inputs. Measuring the productivity of a system provides information that can help in strategic planning and decision making. If the growth of a farm is impeded due to technological inefficiency, more research could be done into finding new technology. However, if growth is due to allocative inefficiency, then the management's ability comes into focus (Martinez-Cordero, 2004).

Supply chain is a network of manufacturer and service providers that work together to convert and move goods from the raw materials stage through to the end user. It exists to support the market that it serves (Cecil & Robert, 2006; El-Sayed, 2013). According to the studies by Britz *et al.* (2009), Britz (2014) and GDARD (2015) on freshwater aquaculture in Southern Africa, many aspects of the supply chain cannot support commercial scale aquaculture. The value chain that will pay for the supply of goods and services is not well established, even though fry and fingerling supplies are available. They come from small hatcheries and cannot support industrial scale aquaculture. Distribution and sales are not well developed to be able to place large volumes of products in the market due to very low cold chain capacity (Longvastol, 2012). The focus of this study is to assess the supply chain for aquaculture in Gauteng province to determine its existence and support towards growth and sustainability for productive and profitable aquaculture sector in the province.

Studies by DAFF (2014) and GDARD (2015) have shown that there are currently a number of aquaculture projects and several aspiring farmers in the province. However, failed investments and closed-down aquaculture projects in the past (DAFF, 2014; Dekker, 2014; GDARD, 2015) will raise a serious concern and be a source of caution to aspiring farmers, hence the need for a study of this nature.

1.4 Research questions

Based on the problem statement of this study, the research will attempt to answer the following questions:

1. What is the actual production capacity compared to the current production of all existing aquaculture projects in Gauteng province?

2. Do the existing aquaculture projects in Gauteng province operate productively for sustainability?
3. How does the supply chain contribute to aquaculture projects in Gauteng province?
4. Can the freshwater fish consumption pattern in the province lead to growth and sustainable operation of aquaculture projects in Gauteng province?

1.5 Study aims and objectives

The aim of this study is to assess the productivity and the supply chain of aquaculture projects in Gauteng province in order to determine the profitability of the sector as well as possible constraints to its growth and sustainability.

1.5.1 The specific objectives are to:

1. Assess the productivity of existing aquaculture projects in Gauteng province.
2. Determine the existence and efficiency of the supply chain for aquaculture towards growth and sustainable operation of aquaculture projects in Gauteng province.

1.6 Research hypotheses

It is hypothesized that:

1. The existing aquaculture projects in Gauteng province are not productive.
2. The supply chain for aquaculture in Gauteng province is not efficient and does not contribute to the growth and sustainable operation of aquaculture projects in the province.

1.7 Research ethics considerations

The ethical clearance letter for this study was sought from and given by the Gauteng Department of Agriculture and Rural Development (GDARD). This permission was submitted to the University of South Africa (UNISA) for the final clearance by the college's ethics committee for the evaluation of the proposal. The final clearance was given to carry out the study. Promise was given to farmers and all stakeholders that all information, ratings and assessments of any of the research instruments will be treated with strict confidentiality. Data generated were analysed and processed as

group information with no discrimination on grounds of colour, tribe, nationality, religion, race or background.

1.8 Chapter arrangements

This dissertation consists of five chapters which are summarized as follows: The first chapter provides the general background to the study, rationale and motivation, the problem statement, the study aims and objectives, research hypothesis and questions, ethics considerations, structural chapter arrangements and a brief summary of the chapter. The second chapter presents the literature review of aquaculture, starting with its global and regional importance as well as production and growth. It describes the fish farming sector in South Africa and Gauteng Province. Further, the chapter expresses the productivity, growth, role of supply chain and profitability of the sector in Gauteng Province. The third chapter presents the methodology and design employed for the study. It describes the study location, research design, sampling and analytical methods. The results and interpretations were presented in chapter 4 while the fifth chapter shows the discussion, conclusion and recommendations of the study.

1.9 Summary for chapter one

The fisheries industry in South Africa is divided into the wild capture fishery and aquaculture. Aquaculture in South Africa is still in a developmental stage and currently practiced on small scale. The sector is divided into marine and freshwater and it is geographically distributed across all the nine provinces. The impacts of the South African aquaculture at global and continental levels are minimal contributing 0.00003% to the global production and 1% of the total production in Africa in 2012.

Gauteng Province is one of the warmest provinces in South Africa and suitable for the production of warm water fishes. The province however cannot currently boast of any commercial aquaculture farms. According to GDARD (2015), production output of existing farms is less than 100 tonnes per year. The productivity of the existing aquaculture farms as well as the supply chain is not known. Therefore the focus of the current study is to assess the productivity and supply chain of aquaculture for sustainable operation.

CHAPTER 2

2 LITERATURE REVIEW

2.1 Introduction

It was shown in the last chapter that the South African aquaculture industry is making little impact to both the global and continental annual aquaculture total productions. The low performance of the sector is due to its underdevelopment and the small scales of production across the nine provinces. Exception is the coastal province of Western Cape which is the economic hub for aquaculture production in the country and the most significant contributor to the GDP (DAFF, 2014).

In this chapter, I will assess the productivity and the supply chain of aquaculture projects in Gauteng Province in order to determine the profitability of the sector as well as possible constraints to its growth and sustainability. This is crucial as the results may help aspiring farmers and investors make bold decisions and be fully committed to the sector. I will begin the chapter by presenting the global importance of aquaculture, and then move on to examine the global, African and South African aquaculture production and growth. Furthermore, a report on the aquaculture industry in Gauteng Province detailing its current states will be made before examining the need for measuring profitability and growth, the role of supply chain in aquaculture growth and development as well as profitability in aquaculture business (DAFF, 2014; GDARD, 2015).

2.2 Importance of fish farming

More than half of the world population depends on fish as their main source of animal protein (WBG, 2011; FAO, 2014a). Fish is an essentially nutritious and often irreplaceable, high quality source of animal protein which is crucial to a balanced diet, especially in marginally food secure communities (Barg *et al*. 1999). Fish and the fisheries sector are of great social and economic importance globally. The sector plays a very significant role as a key source of protein and essential micronutrients. More than 50% of the population from many countries gets their daily animal protein requirement from fish and fish products (FAO, 2012b). Fish contributes about 17

percent to the world's animal protein intake, and is the main source of animal protein along with essential micro nutrients and fatty acids for three billion people (Ayinla, 2009). The per capita fish consumption has risen from 10 kg in the 1960s to more than 19 kg in 2012 (FAO, 2012c).

The sector is a source of income and employment (FAO, 2012a). Employment in the fisheries and aquaculture sectors has grown at a rate faster than the world's population since 1990. Globally, around 56 million people are directly employed in fisheries and aquaculture. Some 200 million others are employed along the value chain, from harvesting to distribution. The livelihoods of some 660 to 820 million people, representative of 9 to 12 percent of the global population, are dependent on the sector. In 2012, direct employment in the sector increased to about 60 million with people engaging in both capture fisheries and aquaculture (FAO, 2013).

Globally, about 60% of the total fish supply is obtained from marine and inland capture fisheries; the remainder is derived from aquaculture. However, the capture fisheries has plateau due to unsustainable practices such as overfishing, illegal, unreported and unregulated fishing (IUU fishing), destructive fishing, as well as unsustainable aquaculture practices. The major prospects for increasing fish supplies lie in aquaculture (FAO, 2003 and FAO, 2012c). However, there are also concerns about aquaculture production sustainability because of its dependence on marine stock as feed for farming carnivorous fish, the difficulty of farming certain species, waste generation and the transmission of diseases among different stocks (FAO, 2010; Khan *et al.* 2011). FAO (2008) posited that aquaculture remains the largest user of fishmeal - 46.1% of world farmed fish and crustaceans were feed-dependent. Research revealed that about 15 million tonnes of the 148 million tonnes of fish supplied from both the capture fisheries and aquaculture was reduced to fishmeal and oil.

2.3 Global fish farming production and growth

Although the global fisheries has plateau and many aquatic organisms fully exploited, aquaculture production tends to have witnessed major increased production in recent years. Figure 2.1 shows the trend in global fisheries and

aquaculture production and the positive effect of aquaculture at keeping up with the challenge of growing fish demands in the face of dwindling capture production.

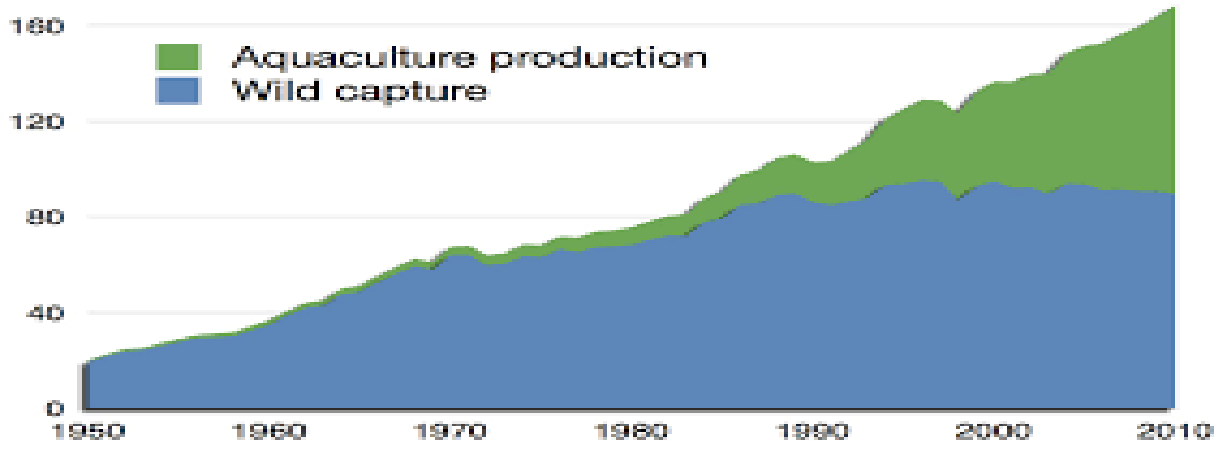

Figure 2.1: World capture fisheries and aquaculture production as of 2012

(Source: FAO, 2014)

Aquaculture is defined as the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants (FAO, 1990; Mancini *et al.* 2010). It was believed to have started in China in the fifth century (Pillay & Kutty, 2005). Aquaculture has contributed immensely to livelihoods, poverty alleviation, income generation, employment and trade globally (Shakouri & Yazdi, 2012). Though its full potential has not yet been fully realized across all continents especially the continent of Africa (WBG, 2009; FAO, 2009).

The number of fish farmer was estimated to have grown from 3.9 million in 1990 to 16.6 million in 2010. The massive growth in aquaculture has given rise to the production of fish species originally known with capture fisheries but whose supply from the capture fisheries is limited because of over exploitation (FAO, 2012c). Though aquaculture is an agricultural activity competing with livestock and other crops for the same basic inputs such as land, water, labour, nutrients, management etc. yet, it is currently one of the fastest growing food production systems in the world (Albert, 1996; FAO, 2009).

The growth of aquaculture has taken place in the last three decades and has expanded at an average annual rate of more than 8 percent from 5.2 million tonnes in 1981 to 62.7 million tonnes in 2011 (FAO, 2012c). The growth was attributed to

the increase in the demand for fish in the face of diminishing supply from the capture fisheries. Globalization, trade liberalization, urgent need for sustainable food supply, increasing scientific and technological innovations and entrepreneurial skills also contributed to the growth. The growth is also due to the recognition of the need by many countries to achieve greater self-reliance in food production and greater balance of international trade (Barg, 1992; Pillay *et al*. 2005; FAO, 2012).

2.4 Aquaculture production and growth in Africa

Aquaculture came to Sub-Saharan Africa in the 1950s (Ridler & Hishamunda, 2001; Hecht, 2006). The major objectives were improving nutrition in rural areas, generation of additional income, diversification of activities, reduced risk of crop failures and the creation of employment in rural areas (Hecht, 2006). Africa has great potential for aquaculture. About 43% of the African continent is assessed as having the potential for farming tilapia, African catfish and carp (Kaptesky, 1994). Fifteen percent of land in Africa is considered most suitable for aquaculture, with the potential to produce an average of 2 crops per year of Nile tilapia and African catfish. However, though aquaculture has grown in most continents of the world, it has not done so in Africa (Ridler & Hishamunda, 2001). Despite various efforts since the 1950s, returns on government and international aquaculture investments are insignificant (FAO, 2004). Kapetsky (1994) reported that less than 5% of the suitable aquaculture land area is being used (Kapetsky, 1994).

The fish consumption per capita in Sub-Saharan Africa is relatively low at 9.1kg/year in 2009. Indeed it is roughly half of the global average (FAO, 2012b). The contribution of Africa to world aquaculture production in 2012 was 1,485,367 tonnes measuring just 2.23%. The highest African contributors to aquaculture production are Egypt, Nigeria, Malawi, Ghana etc. (Muir, 2005; FAO, 2011a).

A number of reasons have been suggested for the poor rate of growth in aquaculture development in the region. These include fish consumption preferences, level of economic development in rural areas, the policy and governance environment, and limiting social factors together with a lack of access to available information (FAO, 2006; Moehl, 1999). However, in spite of the poor growth rate of aquaculture in the

Sub-Saharan Africa the market for fishery products is expected to increase due to rapid population growth, urbanization and increasing affluence (WBG, 2013).

The report of WBG (2013) submitted that developing regions, like Sub-Saharan Africa would consume a much greater share of the world's fish in the future and trade in fish commodities would also increase. The increase in fish consumption in the developing countries would be up to 57%. This will be an increment from 62.7 million tonnes in 1997 to 98.6 million tonnes in 2020 (WBG, 2013).

FAO (2010) projected that the total imports of fish in Sub-Saharan Africa will increase from 54 million tonnes in 1997 to 429 million tonnes by 2020. The region will continue to import low value finfish and export high value finfish, crustaceans and fishmeal. The report also projected that the export of high value finfish will reduce to 40% of its current value due to reduction in capture fisheries while the importation of low value finfish would double its current value by 2020. The report concluded with the submission that the only way by which more fish could be produced in Africa is through increased participation in aquaculture production (FAO, 2010).

2.5 The fish-farming sector in South Africa

Fish farming in South Africa is nascent, still in a developmental stage and currently practiced on small scale (DTI, 2013; DAFF, 2014). Available fish production statistics indicate that the total marine and freshwater aquaculture production by subsectors in 2013 excluding seaweed, carp, ornamentals and koi carp productions was 4802.11 tonnes with marine and freshwater aquaculture accounting for 2985.70 and 1816.41 tonnes respectively. This shows an increase of 18.22% from 2012's total production figure and a growth rate of 8.7% from 2005 to 2013 (DAFF, 2014).

2.5.1 South Africa's marine aquaculture

The marine sector of South African aquaculture is fast developing with focus on mussels, oysters, abalone, seaweeds and dusky kob (DAFF, 2014). Table 2.1 shows South Africa's major marine aquaculture species and the scale of operation for 2013.

Table 2.1: South African marine aquaculture species and scale of operation in 2013

Common name	Scientific name	Scale of operation
Abalone	*Haliotis midae*	Commercial
Pacific oyster	*Crassostrea gigas*	Commercial
Mussels	*Mytilus galloprovincialis,* *Choromytilus meridionalis*	Commercial
Seaweed	*Ulva spp., Gracilaria spp.*	Commercial
Dusky kob	*Argyrosomus japonicus*	Commercial

Source: DAFF, (2014)

Other marine species kept for research purposes include yellowtail, mangrove snapper, yellow belly rockcod, bloodworm, white stumpnose, south coast urchin and the South African scallop (DAFF, 2014).

According to DAFF (2014), there are 36 marine aquaculture farms in South Africa. They are mostly located in the Western Cape. The sector witnessed an increase of 30.04% in production compared with 2012. The Mussel aquaculture is the best of all the marine cultured species followed by Abalone culture. However, by subsector production increase in 2013, abalone subsector witnessed an increase of 32.25% followed by mussels, oysters and finfish subsectors with increases of 29.82%, 14.75% and 15.29% respectively (DAFF, 2014). Table 2.2 shows the marine aquaculture subsector production in South Africa and the growth rate of the industry from 2001 to 2013.

Sub sector	Year and production (tonnes)													Total (tonnes) 2000-2013
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Abalone	372.88	429.42	462.02	509.2	670.8	833.36	783.25	1037.11	913.58	1015.44	1036.01	1111.41	1469.78	10825.29
Finfish	0.3	2.38	14	1.81	1.68	0	0	2.71	22.75	0	7.99	48.46	122.54	225.66
Mussels	600	429.11	623	640	472	542	466	736.74	682.4	700.14	570.16	859.77	1116.13	9227.07
Oysters	187.53	272.1	255.24	147.66	174.91	279.87	157.86	226.62	223.53	276.57	269.34	241.58	277.23	3237.05
Prawns	120.19	157.7	124.88	0	0	0	0	11.44	17.92	0	0	0	0	558.97
Seaweed	0	0	0	0	0	664	0	1833.49	1900.18	2015.01	2884.61	2000	*	14297.29
Totals**	1280.9	1290.71	1479.14	1298.67	1319.39	1655.23	1407.11	2014.62	1860.18	1992.15	1883.50	2985.69	2985.69	24074.05

*Seaweed culture data not confirmed for the year 2013
**Total production excludes seaweed cultured

Table 2.2: South Africa's marine aquaculture production 2001-2013

(Source: DAFF, 2014)

2.5.2 Freshwater aquaculture production and growth

The development in South Africa's freshwater aquaculture in terms of production tonnage and contribution to the national economy is still minimal. According to DAFF (2014), lacks of awareness of the sector by the general population, as well as lack of developmental and transformational skills are some of the reasons for the slow growth of freshwater aquaculture in South Africa (DAFF, 2014).

The most important areas for the production of freshwater species are the Mpumalanga Lowveld, Western Cape, Eastern Cape Limpopo and Northern Kwazulu–Natal. Major cultured freshwater fish species produced in 2013 are shown in Table 2.3 below. They include trout which is mostly farmed in the Western and Eastern Capes, Mpumalanga and Kwazulu-Natal. Tilapia, which was the second largest farmed freshwater species, is farmed nationwide. Other freshwater species cultivated are catfish, carp, marron crayfish and some ornamental species (DAFF, 2014).

Table 2.3: Freshwater aquaculture species culture in South Africa, 2013

Common Name	**Scientific name**	**Operational scale**
Rainbow trout	*Oncorhynchus mykiss*	Commercial scale
Brown trout	*Salmo trutta*	Commercial scale
Mozambique tilapia	*Oreochromis mossambicus*	Commercial scale
Nile Tilapia	*Oreochromis niloticus*	Commercial scale
African Sharptooth catfish	*Clarias gariepinus*	Pilot scale
Common carp	*Cyprinus carpio*	Commercial scale

Koi carp	*Cyprinus carpio*	Commercial scale
Marron (Freshwater crayfish)	*Cherax tenuimanus*	Commercial scale

Source: DAFF, 2014

There are 193 farms which engage in freshwater aquaculture in 2013. This is an increase of 32 farms compared to the number of farms in 2012 (DAFF, 2014). Mpumalanga has 42 freshwater fish farms, which is the highest for all the provinces. Other provinces with established freshwater aquaculture farms are Gauteng with 36 farms, Western Cape with 27 farms, Limpopo with 25 farms, North-West with 23 farms and Kwazulu-Natal with 16 farms (DAFF, 2014). The reported freshwater aquaculture production by subsector from 2006 to 2013 is shown in Table 2.4.

Table 2.4: South Africa's freshwater aquaculture production 2006-2013

Subsector	**Year and production (tonnes)**								**Total production (tonnes) 2006-2013**
	2006	2007	2008	2009	2010	2011	2012	2013	
Tilapia	0	0	0	10	10	100	234.17	289.71	643.71
Trout	807	658	943	948.62	950	1199*	1428	1521.70	8455.32
Catfish	180	180	180	180	180	160	0	0	1060
Marron	0.2	0.4	0.4	0.4	0.8	0.8	3.5	5	11.5
Totals	**987.2**	**838.4**	**1123.4**	**1139.02**	**1140.**	**1459.8**	**1665.67**	**1816.41**	**10170.53**

Source: DAFF, 2014

2.6 South Africa aquaculture growth and economic performance 2013

South African aquaculture witnessed a growth of 18.22% in production volume from 2012. The marine sector of the aquaculture industry grew by 30.04% while the freshwater subsector grew by 8.29%. The growth in the freshwater sector was attributable to the increase in the production volumes of the trout and tilapia subsectors.

As it can be seen in Table 2.5, the abalone subsector accounted for 76.01% of the total Rand value for the whole aquaculture sector as well as having the largest number of employee which was approximately 500 (DAFF, 2014). The value of aquaculture sector in 2013 grew to R696 million which was 38.1% increment compared to 2012. The employment generation increased by 604. This makes a total of 2831 direct employment in the sector in 2013 compared with 2227 in 2012. The subsector production and value for 2013 is shown in Table 2.5.

Table 2.5: Production and value in South African aquaculture sector 2013

Aquaculture subsector	Production (tonnes)	Value R million	Percentage increase
Marine			
Abalone	1469.78	529	76.01
Mussels	1116.14	20	2.89
Oysters	277.23	16.6	2.39
Finfish	122.55	6	0.88
Total	**2985.7**	**571.6**	
Freshwater			
Trout	1521.70	113	16.2
Catfish	0	0	0
Tilapia	289.71	9.9	1.42
Marron	5	1	0.14
Total	**1816.41**	**123.9**	

Source: DAFF, 2014

2.7 Fish farming in Gauteng Province

Gauteng aquaculture industry is underdeveloped compared to provinces like Western and Eastern Capes or Mpumalanga. The province was ranked fourth by DAFF (2014) in

terms of the total freshwater fish production and number of fish farms operating in the province in 2013 (GDARD, 2015). Aquaculture production is limited by several factors which include the weather condition, shortage of fresh water and poor species for production. The high summer, low winter temperature common in the province disallows all year round production of warm water species like catfish, tilapia etc. Production technologies like tunnels and insulated building that could be used are too expensive in view of cheaper production systems in other nations. Using such technologies will make aquaculture products uncompetitive both at the local and global markets (DAFF, 2012a).

The non-availability of adequate fresh water is also a great geographical restriction for freshwater aquaculture in South African provinces. Cold water species are restricted only to areas with permanent cold streams and warm water species to where temperature is high for several months of the year (Britz *et al*. 1990 and DAFF, 2012). Gauteng province is only suitable for the production of tilapia and other fish species with similar climatic requirements and tolerance for water temperature (GDARD, 2015). Therefore, pond fish production especially for Mozambique tilapia is limited to areas such as the central, northern, eastern and south-western parts of the province according to the study done by Agricultural Research Council while Nile tilapia could be farmed anywhere but within a closed system for those who can provide the required technology (GDARD, 2015). In 2011, Gauteng province was in distant third in the export of fish and aquatic invertebrates. As shown in Table 2.6, the province exported 105312 tonnes which made 2.99% of total national export, trailing behind Western and Eastern Capes respectively (DAFF, 2012). These export products were not only the products of the province but also products brought into the province from other areas of the country (GDARD, 2015)

Table 2.6: Values of fish and aquatic invertebrates exported by provinces

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Western Cape	2 332 640	2 123 608	2 157 577	1 971 535	2 679 059	3 069 999	2 686 785	2 799 263	2 799 263
Eastern Cape	367015	356231	323849	350683	385676	474601	376415	387192	339755
Northern Cape	250	10947	21963	19991	1053	4814	2838	138	28
Kwazulu Natal	4946	1752	14201	16987	26643	137321	77310	12839	39265
North West	0.00	0.00	0.00	78	0.00	0.00	2903	39	1963
Gauteng	26195	28732	33185	73406	128026	92095	94799	104969	105312
Mpumalanga	5740	1050	192	001	107	650	382	1288	6851
Limpopo	0.00	0.00	0.00	0.00	0.00	0.00	87	605	869

(Source: DAFF, 2012)

The highest export value of R77.5 million for the province came in 2007 from City of Johannesburg (DAFF, 2012a) while the total percentage share of fish and aquatic invertebrates exported by the districts of the province between 2003 and 2011 are shown in Table 2.7.

Table 2.7: Values of fish and aquatic invertebrates exported by Gauteng Province

Year / **Districts**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Sedibeng	0	0	0	0.00	0.28	0.01	0.65	0.21	0.01
Metsweding	1.45	2.90	0.00	0.00	0.00	0.00	0.22	0.01	0.00
West Rand	0.25	0	0.02	0.00	0.03	36.44	39.52	38.82	35.56
Ekurhuleni	31.21	37.82	13.53	57.41	38.59	16.37	14.48	18.33	30.95
City of Johannesburg	65.88	57.32	85.93	42.57	60.57	45.57	43.95	42.02	32.86
City of Tshwane	1.22	1.96	0.51	0.02	0.54	1.61	1.19	0.61	0.61
Total	100	100	100	100	100	100	100	100	100

Source: DAFF, 2012

However, from the Gauteng aquaculture feasibility study carried out by GDARD (2015), as shown in Table 2.8 below, Gauteng province has a total of twenty four operational aquaculture farms, nine non-operational farms and twenty nine aspiring new farmers. Only fourteen of the operational farms deal with food fish while the rest are into ornamental fish productions (GDARD, 2015).

Table 2.8: Species and status of aquaculture facilities in Gauteng province

Primary species(excluding trout)	Number of operational farms	Estimated future production from operational farms (2016) tons/yr.	Number of aspiring new entrants	Number of closed farms/facilities
Tilapia species	14	276	5	7
Koi and Ornamental fishes	9	-	1	5
Prawns	1	1500	-	-
Carp as food fish	0	0	0	1
Grass carp	0	0	0	1
Catfish	0	0	0	1
Unknown	0	0	23	8
Total	**24**	**-**	**29**	**23**

Source: GDARD, 2015

Figure 2.2 shows the municipal and district areas of Gauteng province. The metropolitan municipality and districts of the province – City of Johannesburg, West Rand, Ekurhuleni, City of Tshwane, Sedibeng and Metsweding - have big potential for fish farming with adequate consumption.

Figure 2.2: Municipal and district areas of Gauteng Province

Tilapia is the most common farmed species in Gauteng province. *Oreochromis mossambicus* was the predominant farmed species in the past because it is indigenous to South Africa. Most farms have however replaced *O. mossambicus* with the fast growing *Oreochromis niloticus* which is listed as an alien invasive species (GDARD, 2015). However, due to the fast growth nature of *O.niloticus*, the South African government has resolved issues surrounding permitting in support of its production. Many farmers have therefore been awarded permits in line with the National Environmental Management Biodiversity Act: Alien and Invasive Species Regulations to farm the species (GDARD, 2015). The production of tilapia species has been widely acclaimed and the species has enjoyed commercial production status in the last 20 years in many countries of Europe, Africa and America (Elsenburg, 2012; Lake harvest, 2013).

The species is embraced in Gauteng province because of its white flesh for which has been dubbed the 'aquatic chicken'. The interest in tilapia production in the province is due to the presence of foreign African nationals who are from countries where fish consumption is valued and the South Africans who are imbibing the art of healthy eating

The African sharptooth catfish is another food fish which are being farmed in the province but whose production has stopped because they are difficult to sell due to their red colour, meaty texture and distinct flavour (Stander, 2007). Local buyers found its appearance unappealing and the cost too high. Whereas it's a sought after by some immigrants from some African regions where it is regarded as a delicacy, local buyers regarded it as an inferior species to fish like tilapia (Britz, 2014). Other fish species produced in the province include carp, prawn and ornamental fishes (GDARD, 2015).

Production figures for the aquaculture sector are not available in the province's aquaculture industry owing to the fact of non-commercial nature of the industry. However, many producers have started perfecting strategies and completing facilities in order to become commercial farms (GDARD, 2015).

2.8 Aquaculture productivity and growth

Measuring the productivity efficiency of a production system entails taking into consideration the constituent parts of economic efficiency which includes technical efficiency (TE) and allocative efficiency (AE) (Martinez-Cordero, 2004). The technical efficiency ensures that waste is avoided in production through producing as much as technology will allow using minimum inputs as the technology allows. Allocative efficiency refers to the ability to combine inputs in optimal proportions taking into consideration the prevailing prices (Farrell, 1957; Wautabouna, 2012; Economic online, 2016).

Aquaculture has primarily been a developing world activity, especially in the Asian countries (Agboola, 2011). Asian countries are reported to produce 90% of global aquaculture production, with about 62 out of the 90% coming from China (FAO, 2009; WBG, 2014). The number of fish farmers was estimated to have grown from 3.9 million in 1990 to 16.6 million in 2010 and to 19 million in 2012 with about 96 percent of it in Asia (FAO, 2014a). Much of the increase in Asian aquaculture is attributable to expanded area for fish production, advancement in technology and improved productivity (WBG, 2013). African countries have no significant contribution to the boom in aquaculture production. Production from the continent is negligible when compared to other continents; hence the need for in-depth studies into an aquaculture economic analysis in the continent in order to position the continent as a major player in the global aquaculture production (Agboola, 2011).

In market economies, if aquaculture business is to become profitable, products must be actively and effectively marketed (Tisdell, 2003). However, profitability is not only influenced by the market or marketing strategies but also by the costs of production.

The term production in economy is associated with the conversion of physical inputs to physical outputs. It is basically an activity of transformation, which connects inputs and outputs. Production depends among other things on the types of techniques available and the costs of inputs used in the production process. Doll and Orazem (1984), defined production as the use of tangible and intangible resources (inputs) to produce goods

and services to satisfy human wants. Production is a process. The process of production can be in the form of raw material (inputs) transformation to finished products (output) or change in place through the supply chain (storing, packaging, transporting etc.

In production, the inputs (production factors) needed to produce a product can be either fixed or variable inputs/ factors depending on how readily their usage can be changed. Fixed production factors are those that remain fixed and do not change with the level of farming activity or level of output while variable factors are those that change or vary with the level of production or output. In aquaculture, fixed inputs include tax, depreciation in assets, staff salaries, land, insurance premium etc. while variable inputs include fingerlings, feeds, fertilizers, labour, drugs, fuel, electricity and water.

The production function serves as a tool to analyse the relationship between input and output in production (Akpan *et al.* 2011). It is a catalogue of output possibilities which shows the quantitative relationship between inputs and outputs. According to Constantin *et al.* (2009), production function is defined for a given state of technology and it shows the relationship between the maximum amount of output that can be produced and the inputs required to make that output. The main objective of every producer/farmer is to use inputs in such a way as to optimize the number of output produced (Kibirige, 2013). Therefore, the knowledge of production function by a farmer helps to:

- identify the inputs which influence the production process and the efficiency with which these inputs were used.
- identify those inputs which could cause increase in the output more than per unit of each input so that they could be used in higher quantities.
- identify the level of use of inputs which contributed less to the production and therefore able to reduced them to required levels.

It can also provide some of the information needed by policymakers to improve productivity of freshwater aquaculture in the province.

2.8.1 The role of supply chain in aquaculture

The supply chain demonstrates the full range of activities which are required to bring a product or service from conception, through the different phases of production and delivery to final consumers (Kaplinsky & Morris, 2000; ACCA, 2010). It was defined by Lambert *et al.* (2006) as the integration of key business processes from end-user through original suppliers that provide products, services, and information that add value for customers and other stakeholders. It has an important focus of competitive advantage for organizations and businesses. Supply chain occurs among two or more parties linked by a flow of resources. However, the parties involved in a supply chain do not need to be different firms; they can be different departments, divisions or even key people within an organization (Njoku & Kalu, 2015).

The major goal of supply chain is to deliver maximum value for the least possible total cost, therefore assessing the supply chain of any enterprise entails looking at every step the business goes through from raw materials procurement to the end user (Investopedia, 2011). Managing the supply chain is therefore paramount to any organization or enterprise for the sake of effectiveness and profit making.

Supply chain management has been defined differently by different authors as shown in Table 2.9 below. However, though the definitions are slightly different from each other's, they all tend to speak to the importance of integration, communication and coordination between functions and organizations in order to create value for the customer (Gillyard, 2003). Supply chain management is a way of improving competitiveness of an enterprise by reducing uncertainty of material handling and enhancing customer service. It is a cross-functional approach that includes managing the movement of raw materials into an organization, certain aspects of the internal processing of materials into finished goods, and the movement of finished goods out of the organization and toward the end consumer (Njoku & Kalu 2015).

Table 2.9: Supply chain management definitions

Authors	Definitions
Tan *et al.* (1998)	SCM encompasses materials/supply management from the supply for basic raw materials to final product (and possible recycling and re-use). SCM focuses on how firms utilize their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimization and efficiency.
Berry *et al.* (1994)	SCM aims at building trust, exchanging information and market needs, developing new products, and reducing the supplier base to a particular OEM so as to release management resources for developing meaningful, long term relationships.
Jones and Riley (1985)	An integrative approach to dealing with the planning and control of the materials flow from suppliers to end-users
Saunders (1995)	External chain is the total chain of exchange from original source of raw material, through the various firms involved in extracting and processing raw materials, manufacturing, assembling, distributing and retailing to ultimate end customers.
Ellram (1991)	A network of firms interacting to deliver product or service to the end customer, linking flows from raw material supply to final delivery.
Christopher (1992)	Network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.
Lee & Billington (1992)	Network of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products and distribute the finished products to customers.
Kopczak (1997)	The set of entities, including suppliers, logistics services providers,

	manufacturers, distributors and resellers, through which materials, products and information flow.
Lee & Ng (1997)	A network of entities that starts with the suppliers' supplier and ends with the customers' custom production and delivery of goods and services.

Source: (Croom, Romano & Giannakis, 2000)

The key success factor for players in any enterprise is the ability to gain market share and this can be achieved by increased capacity and aggressive marketing of products in addition to good distribution network (Njoku & Kalu, 2015). The aquaculture industry and its market in Gauteng province is underdeveloped in comparison to provinces like Western and Eastern Capes as well as those of some African countries like Nigeria, Zambia, Malawi and Uganda (GDARD, 2015). However, the aquaculture industry in Gauteng province has great future potential. The province boasts of a large population including expatriates from fish eating nations of the world, therefore a large potential market for aquaculture products exists in the province. The assessment of supply chain is therefore necessary in order to provide information on profitability for the various agents along the chain. Assessment of profitability of a business enterprise is very important. It helps the business owner to find out if the business is making profit or not.

2.8.2 Profitability in aquaculture enterprises

Profit and profitability are two words that are used interchangeably in business environment; however the difference between the two words is that while profit is an absolute term, profitability is a relative concept. According to Njoku and Kalu (2015), profit and profitability are closely related and mutually interdependent, with distinct roles in business. While profit refers to the total income earned by the enterprise during the specified period of time, profitability refers to the operating efficiency of the enterprise. It is the ability of the enterprise to make profit on sales and it is the ability of enterprise to get sufficient return on the capital and employees used in the business operation.

According to Weston and Brigham (2006) as cited by Njoku and Kalu (2015), “to the financial managers, profit is the test of efficiency and a measure of control, to the owners, it is a measure of the worth of their investment, to the creditors, it is the margin of safety, to the government, it is a measure of taxable capacity and a basis of legislative action and to the country, profit is an index of economic progress, national income generated and the rise in the standard of living”.

A variety of management techniques have been developed for the assessment of profitability in farm and other types of businesses. Each technique is dependent on factors such as investment size, period of investment and the objectives of investing in the particular type of business (Kamangira *et al.* 2014).

According to Jolly and Clonts (1993), as reported by Kamangira *et al.* (2014), the management techniques which are used to determine profitability or viability of different technologies in aquaculture can be classified as:

- Static indicators which include gross margin, net revenue
- Capital budgeting indicators which include Cost benefit analysis (CBA), Net present value (NPV) and Internal rate of return (IRR).

Static indicators do not require discounting while capital budgeting methods require discounting of future cash flows. Each of these indicators has limitations; however most researchers agreed that gross margin is a better tool of profitability measurement (Adeyeye *et al.* 1982; Ahmad, 2004).

2.8.3 Gross margin analysis (GMA)

Gross margin is a simple indication of the financial performance of individual farming enterprises. It is a reliable way of gauging how well an enterprise is working in financial terms. Acting as a single-figure indicator of the technical performance of an enterprise, the economic environment in which it is operating and the relative financial success of the management choices being made (AA International, 2013). Therefore, gross margin may be used to:

- Assess the performance of a single enterprise, in the same project or on the same farm, in different seasons or years.
- Compare the performance of different enterprises in the same project or on the same farm, in different seasons or years.
- Compare the performance of similar enterprises in different projects or on different farms, in different seasons or years.

Gross margin analysis has been used in many studies and it appears to be the method of choice in profitability calculation because of its accuracy in profit estimation (Ahmad, 2004). Fapohunda (2005) used the gross profit margin to analyse the profitability of homestead fish farm in Ondo State of Nigeria with a conclusion that homestead fish farming is profitable both in terms of protein availability and cash at hand from sale of excess cropped fish. Recommending that fish farmers should source fingerlings from reputable hatcheries and use recirculation aquaculture system (RAS) as opposed to pond system in use. Adeogun *et al.* (2012) using the same method in status, cost and profitability of aquaculture enterprises in Nigeria: implications for food security found that the different methods of fish farming in the study area achieved healthy levels of profitability that guarantee its economic viability. In another study, 'An Examination of Income Generation Potential of Aquaculture Farms in Alleviating Household Poverty: Estimation and Policy Implications from Nigeria' conducted by Ogundari and Ojo (2008), the results, considering the size and positive gross margin obtained showed that aquaculture production is a profitable investment. He concluded that investment in aquaculture farms will ensure sustainable income generation, capable of helping household to break out of vicious cycle of income poverty.

Others who have used the gross margin analysis to determine profitability include (Kareem *et al.* 2008a; Erbaugh, 2008). Ahmad (2004) in his study of the factors affecting the profitability and yield of carrot production in two districts of Punjab submitted that the gross margin was used to determine profitability because of its accuracy in profit estimation.

2.9 Summary for chapter two

As discovered from this chapter, the global impacts of aquaculture can be seen from its contribution to human livelihood in terms of income and employment as well as been a source of protein which is crucial to a balanced diet. This chapter also revealed the under developed nature of aquaculture in South Africa as a whole and Gauteng Province in particular. The province is far behind many provinces in the country in terms of fish farming. Some of the constraints responsible for underdevelopment of the sector include shortage of freshwater as well as varied weather condition.

CHAPTER 3

3 RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter shows the state of underdevelopment in the aquaculture industry of Gauteng Province. The productivity and supply chain of aquaculture in the province is not known therefore the focus of this study is to find answers to a number of questions as stated in chapter 1 from existing farms in order to find the way forward for the growth of the sector

In this chapter an outline of research methods that were followed in the study is presented. The chapter provides information on the study location, as well as participants and how they were sampled. It describes the research design that was chosen; the instrument that was used for data collection and the procedures that were followed to carry out the study. The methods used to analyse the data were also discussed.

3.2 Study location

The research study was conducted in Gauteng province of South Africa. The layout of Gauteng Province is shown in Figure 3.1 below. It was initially called Pretoria-Witwatersrand-Vereeniging before given the name Gauteng in 1994 (Makiti Guides and Tours, 2008). The province is situated in the Highveld and located between latitude 27^0 to 29^0 east and 24^0 to 26^0 south in the north-eastern part of South Africa. Gauteng province is the smallest province in South Africa covering an area of 16 548 km^2 which is 1.4% of the total land area of South Africa (South Africa info, 2012). However, it is the most populous province of the country having a population of nearly 12.3 million, which is almost 25% of the total South African population as of 2011 (Stats, 2006; Stats, 2011).

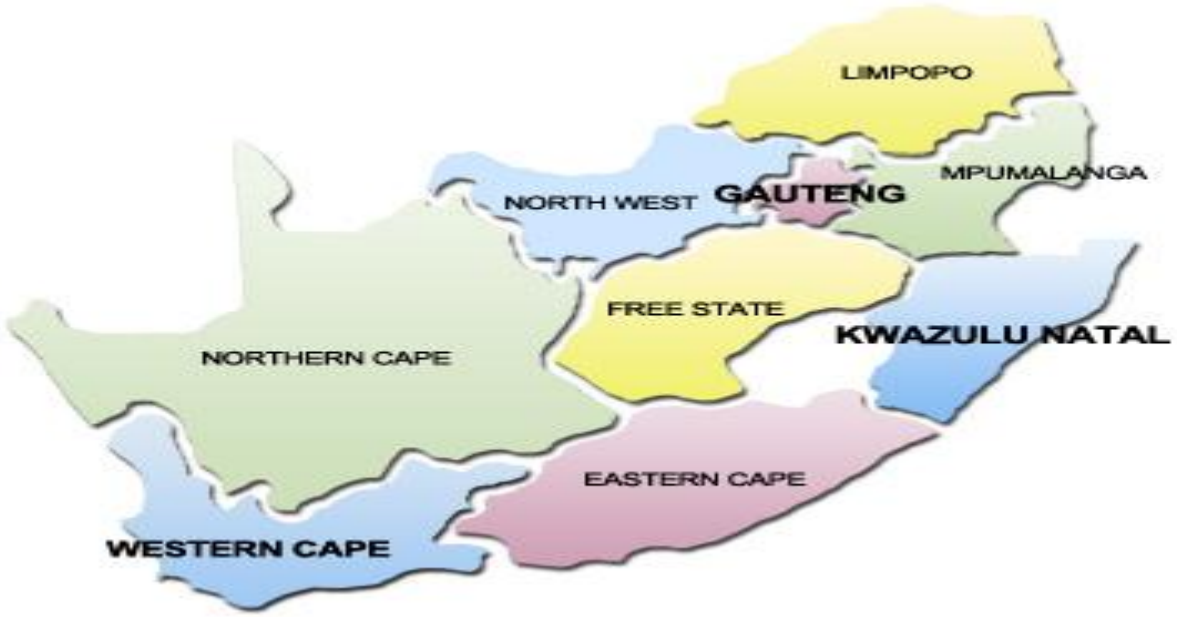

Figure 3.1: Map of Gauteng province showing it location on the map of South Africa

Gauteng province is divided into three metropolitan municipalities and two district municipalities as indicated in Figure 3.2. The metropolitan municipalities are City of Tshwane (Pretoria), City of Johannesburg and City of Ekurhuleni/East Rand while West Rand and Sedibeng formed the district municipalities (Makiti Guides and Tours, 2008). Economically, the province forms the economic hub of South Africa. It is home to many companies ranging from manufacturing, technology, financial to telecommunications. It generates one third of the South African GDP, 10% of the Sub-Saharan Africa GDP and 7% of the total African GDP (Stats, 2011).

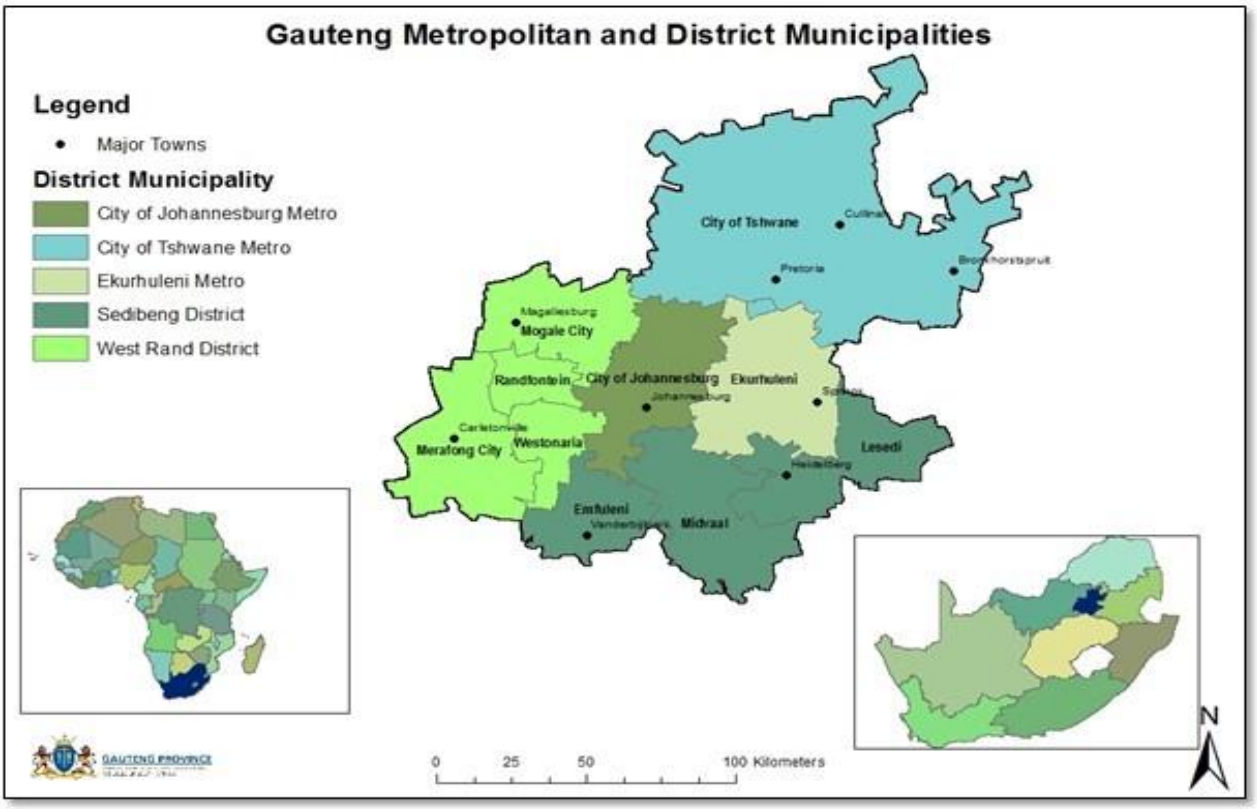

Figure 3.2: Map of Gauteng province of South Africa showing the metropolitan and district municipalities

Gauteng province is mainly an urban province. However, its agricultural sector makes up a small share of the economy providing the cities and towns with daily fresh produce (GCIS, 2004; Makiti Guide and Tours, 2008). In terms of climatic conditions the province falls within the areas with hot summer and cold winter making it generally too cold for warm water fish and too hot for cold water fish (without the use of equipment for water heating or cooling) (Dekker, 2014).

3.3 Research design

In order to achieve the main aim of the study which is to assess the productivity and supply chain of aquaculture projects in Gauteng Province, the research adopted the use

of quantitative method and collected data and information from the five regions that make up the province. Both primary and secondary data were collected. Primary data were collected from the main stakeholders in the supply chain: the farmers, suppliers, wholesalers/ retailers and the consumers through the use of structured questionnaires. Structured questionnaire is an efficient research instrument because it requires less effort, time and budget. Prior to the formal survey, each respondent was contacted via phone call. The reason for the study was explained and a formal appointment was set up after the respondent has agreed to the survey. The questionnaires were distributed to the respondents on contact and the data were captured manually.

The structured questionnaire addressed different topics and has different sections for farmers and all stakeholders in the supply chain of aquaculture in the province as well as investors (Appendix 3). The sections addressing fish consumers took note of preferences from respondents who are South Africans and South African immigrants.

Secondary data was collected through a desk review of on-line data base which was predominantly a collection of documented data like reports, research articles, statistics etc. as well as from direct contact with development and research institutions like ARC, Aquaculture Association of Southern Africa, Aquaculture Institute of South Africa, Department of Agriculture and Rural Development, DAFF, etc.

At the secondary data collection stage, data/ information was gathered to:

- describe aquaculture projects as well as the supply chain in Gauteng province.
- identify the districts and municipalities where the survey was carried out.

From the reviews of studies done on aquaculture projects in Gauteng province, it was discovered that there are approximately fourteen known Tilapia fish farmers, nine Koi and ornamental fish farmers and one Prawn producer (GDARD, 2015).

3.4 Sample and sampling methods

Snowball and convenience sampling methods were used to collect primary data for the study. Snowball sampling method is a non-probability sampling method that depends on referral. This method has been proven as an authentic sampling technique both for formal and informal researches (Handcock & Gile, 2011). The approach is to identify a person suitable for the study. The same person in turn recommends others (StatPac, 2011).

There are fourteen operational food-fish aquaculture projects in Gauteng province according to reports from GDARD (2015) and Aquaculture Research Council (2015). Therefore, acquainting with one project will lead to the other projects by recommendation and referral. Twenty retailers were sampled through the same method while convenience sampling was used for the sampling of 110 consumers. Convenience sampling is a non-probability sampling method where unit selection is based on accessibility or convenience (StatPac, 2011). Its advantage is that it is direct, easy and a relatively less expensive method (Trochim, 2006).

Data collection was done between April and July, 2016. Contact was made with a known farmer who introduced the researcher to another farmer etc. However, out of fourteen fish farmers contacted through telephone, only five agreed to be interviewed. The others indicated they were either not in the country at the time or were no longer engaged in aquaculture business. Those who asked that the questionnaire be forwarded to them to complete and return never returned them. In all, five fish farmers were interviewed for this study.

3.5 Data analysis

All the data collected were coded and entered into Microsoft excel 2007 spreadsheet and transferred into Statistical Package for Social Sciences version 24 (SPSS 24). The study used Microsoft excel and SPSS 24 to analyse the descriptive characteristics of the respondents such as frequencies, percentages, mean and standard deviation.

SPSS was also used for correlation analysis. Correlation serves to measure how well one variable can predict the other (given the context of the data), and determines the precision that can be assigned to a relationship. The regression between two or more associated variables in the supply chain of aquaculture projects was tested. The study used correlation coefficient to determine the perfect fit or negative fit of some variables to supply chain as well as the consumers' reactions to the questionnaires.

The *linear correlation coefficient, r*, measures the strength and the direction of a linear relationship between two variables. The mathematical formula for computing ***r*** is:

$$r = \frac{n\sum xy - \left(\sum x\right)\left(\sum y\right)}{\sqrt{n\left(\sum x^2\right) - \left(\sum x\right)^2}\sqrt{n\left(\sum y^2\right) - \left(\sum y\right)^2}}$$

(Where n is the number of pairs of data, x and y are the sample standard deviations, xy is the sample covariance)

The final results of the study is reported by indicating any correlation greater than 0.8 as *strong* positive correlation, 0.6 to less than 0.8 as positive correlation while any correlation less than 0.5 as *weak* and negative among test variables.

3.5.1 Profit analysis

Gross margin analysis as well as gross margin ratio was used as proxy to determine the profitability of aquaculture production in the province. The gross margin refers to the total income derived from an enterprise less the variable costs incurred in the enterprise while the gross margin ratio refers to the ratio of gross margin expressed as a percentage of sales.

The gross margin was represented by

G.M = TR – TVC

Where

G.M = Gross margin

TR = Total revenue

TVC = Total variable cost

While the gross margin ratio (GMR) was represented by

GMR = (GM ÷ TR) %

3.6 Summary for chapter three

This chapter focused on the methodology that was used in the study. An explanation of quantitative research as a method for data collection and analysis was given. Measures followed during the data collection were discussed and the information about the sample and data analysis was provided.

CHAPTER 4

4 RESULTS AND INTERPRETATIONS

4.1 Introduction

This chapter consists of the results from the survey conducted among aquaculture farmers, wholesalers/ retailers and the consumers in Gauteng province. The succeeding sections present the results of production and profitability of the aquaculture projects. Furthermore, the results of the supply chain and consumers' fish consumption dynamics in Gauteng province were presented.

The following section revealed the actual production capacity as well as the current usage of aquaculture projects in Gauteng province. The section also determined the profitability of the sector. Profitability was calculated by finding the gross margin of each respondent's aquaculture project. The findings provided answers to the actual production capacity versus current capacity utilization. Whether aquaculture projects in the province are making profit or not was also answered.

4.1.1 Demographic characteristics of fish farmers in this study

About 15 farmers were contacted for the study. However only five agreed to grant the interview and responded to the survey questionnaire. The others either were not in the country or because of the 'no production' status of their farms did not participate in the survey. As shown in Table 4.1, all the farmers who responded to the interview were males and are all married. One of the farmers was above 65 years while two each were within the age ranges of 30 to 49 and 50 to 64 respectively. The results of the correlation analysis are attached as appendix 1. There was a positive correlation between the age of farmers and the number of fish harvested per cycle at 0.768. This

means that increase in age increases fish harvest per cycle. This implies that old age affects fish production positively which may be a result of more years of experience in aquaculture business. There was a strong positive correlation between the age of farmers and the difficulty at getting production inputs at 0.802. This means that increase in the age of farmers increases the difficulty of getting inputs for fish production. This implies that as the age of farmer increases it leads to the difficulty of getting production inputs in Gauteng province. This may be so because most of the production inputs have to be sourced outside the province. There was a positive correlation between the age of farmers and farm revenue at 0.772. This means increase in the age of farmers increases fish farming revenue. This implies that age has positive effect in revenue generation in fish farming.

Aquaculture in Gauteng province is young and still developing (GDARD, 2015). This can be confirmed in the years of experience of the five respondents (farms). Only one of them falls within the five to ten years of experience in aquaculture. The remaining respondents have the experience that falls within one to five years. In actual fish farming experience, apart from the farmer who has 4 years of experience, the others are just between one and two years. There was a strong correlation between number of years in aquaculture and the production inputs used at 0.802. This means that increase in years in aquaculture increases the ease of getting production inputs. This implies that the ease at which production inputs is got is influenced by the number of years one has spent in fish farming.

Table 4.1: Demographic characteristics of participated fish farmers (n = 5)

Characteristics		**Percent**
Gender	Male	100
	Female	0
Marital status	Single	0
	Married	100
	Divorced	0
	Widowed	0
Age (years)	18-29	0
	30-49	40
	50-64	40
	65 0r above	20
Years of experience in aquaculture	1-5 years	80
	6-10 years	20
	11-15 years	0
	16-20 years	0
	20 years or more	0

Source: Data from this study was used

4.1.2 Types of Operation

Plastic and concrete tanks are mostly used for fish production in the province (Table 4.2). Three of the fish farmers interviewed use plastic tanks for fish rearing while two use concrete tanks. As presented in Table 4.2, all the farmers practice intensive farming

using Recirculation Aquaculture System (RAS). The fish are fed three or more times daily depending on how active and hungry they are when observed.

The farm management system includes the owners with farm assistants performing all daily routines needed to grow the fish. Tilapia is the most popular fish produced by the farmers (Table 4.2). Its popularity is demand driven by consumers who prefer tilapia species to any other freshwater fish species.

Table 4.2: Management inputs and production systems for studied farms in Gauteng

Management system/production	**(n = 5)**	**Percentage (%)**
Type of production system		
Concrete tanks	2	40
Plastic tanks	3	60
Earthen pond		
RAS		
Other		
Management inputs		
Extensive	-	
Semi-intensive	-	
Intensive (RAS)	5	100
Type of fish produce		
Catfish	-	
Tilapia	5	100
Trout	-	
Carp	-	
Other	-	
Farm's daily routine		
Owner	-	
Family members	-	
Owner and assistants	5	100
Farm assistants	-	

Source: data from this study was used

4.1.3 Farm production capacity vs current production

The production capacities of each participated project and the current capacity utilization are presented in Figures 4.1 and 4.2. Figure 4.1 shows the farm capacity versus the actual usage of each farm that participated in the study. The outcome shows that none of the farms are operating to full capacity.

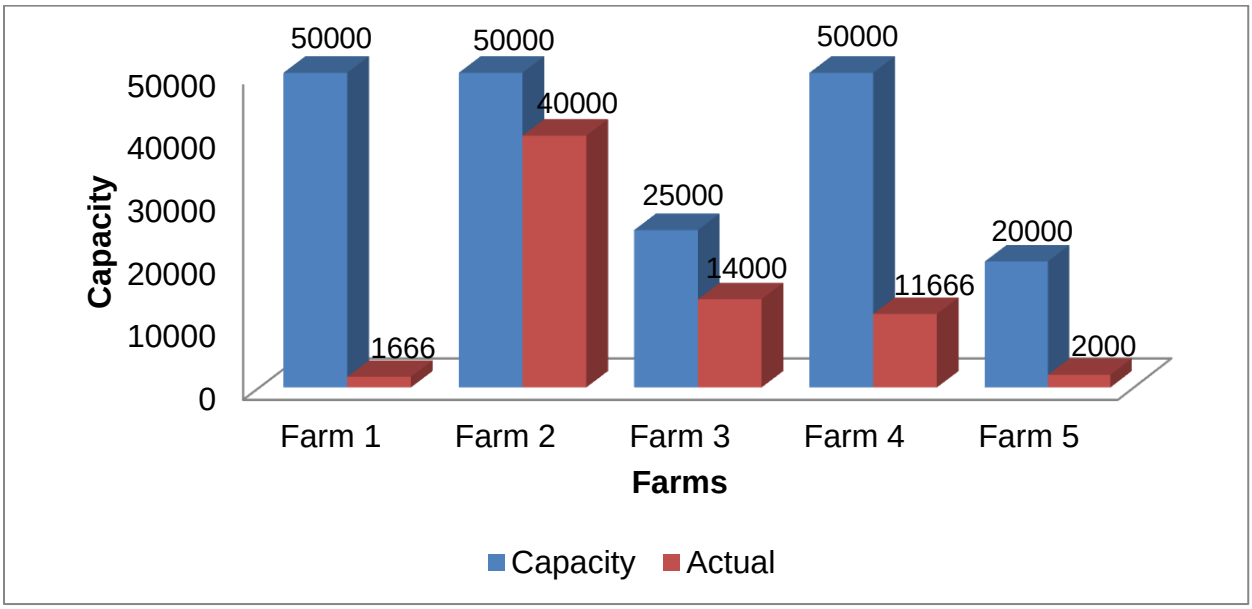

Figure 4.1: Cross tabulation of aquaculture farm capacity and actual usage

Source: Data from this study was used

Figure 4.2 indicates that only farms 2 and 3 are being utilized at above 50% of their total capacities, all the other farms are greatly underutilized. The reasons given for the underutilization by the farmers concerned include lack of fund, increased cost of inputs and insufficient man-power. There was a strong positive correlation between number of fish harvested per production cycle and the number of workers at 0.885. This means that increase in the number of workers increases the number of fish harvested per production cycle. This implies that more skilled or experience workers will lead to more harvest. There was a strong positive correlation between number of fish harvested per production cycle and business profitability at 0.859. This means that increase in number of fish harvested per cycle of production increases business profitability. This implies

the more the number of fish harvested per production cycle the more profitable the aquaculture business.

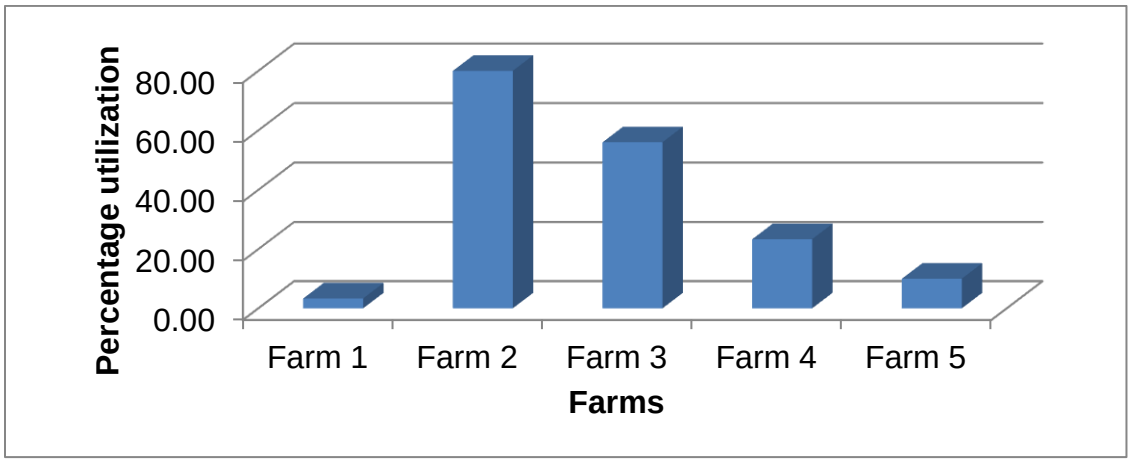

Figure 4.2: Actual percentage utilization of aquaculture farms' production capacities.

Source: Data from this study was used

4.1.4 Productivity and profitability of the aquaculture projects in this study

Various inputs are needed for the production of fish either in the table-size, juvenile or fingerling forms. Such inputs include both fixed and variable inputs. Fish farming is one of the agricultural enterprises being practiced in the same location by participated farmers. Therefore no fixed input could be apportioned to the aquaculture enterprise because of the intertwined usage of the inputs. Productivity by definition could not be determined but inferred from production and utilization. The profitability of aquaculture projects that participated in the study was determined using the gross margin analysis.

4.1.5 Gross margin analysis and gross margin ratio analysis

The variable factors used in aquaculture production include human capital, electricity in the case of Recirculation Aquaculture System (RAS) which is the type of aquaculture production system used in the province. Other variable inputs are water, feed, and

oxygen. All the participated fish farmers could not put costs on the various inputs used in the farm for fish production. However, they have a system of evaluation which is the production of a kilogram of fish at a particular cost. Therefore, the farmers were only able to give the price of producing one kilogram of fish per cycle of production. This production cost was used to calculate the gross margin of each farm surveyed.

Out of the 5 farms on which the gross margin was done, the minimum gross profit was found to be R33,334, while the maximum was R840,000 for the production cycle assessed. All the 5 farms had positive gross margin as shown in Table 4.3. There was a strong positive correlation between number of workers in the farm and farm revenue at 0.883. This means that increase in the number of workers in the farm increases the farm revenue. This implies that more revenue will be generated for the farm as the number of workers (skilled) increases. There was a strong positive correlation between number of workers in the farm and farm profit at 0.847. This means that increase in the number of farm workers increases farm profit. This implies that more profit will accrue to the farm as more skilled workers are employed.

Table 4.3: Gross margin output of fish production

Variables	**Farmer 1**	**Farmer 2**	**Farmer 3**	**Farmer 4**	**Farmer 5**
Total production per cycle (Units)	5 000	120 000	42 000	35 000	6 000
Unit production cost (Rand/Kg)*	25	25	26	26	22
Total production cost (Rand)**	41 666	1 000 000	364 000	303 333	44 000
Selling price per kg (Rand)	45	46	46	45	45

Total revenue per cycle (Rand)	75 000	1 840 000	644 000	525 000	90 000
Gross margin (Rand)***	33 334	840 000	280 000	221 667	46 000

* Unit production cost includes the cost of fingerlings, labour, feed, electricity etc.
** Total production cost = Unit production cost multiplied by number of fish produced in kilogramme
*** Gross margin = Total revenue – Total production cost
Source: Data from this study was used

The results of the gross margin ratio are presented in Table 4.4. The outcome revealed that farm 5 made a gross margin ratio of above 50% while the other four farms were from 42 to 46%. There was a strong positive correlation between the age of farmers and business profitability at 0.842. This means that as age increases profitability in aquaculture business increases. This implies that increase in age increases fish farming profitability. This may be due to more experience in aquaculture. There was a strong positive correlation between number of fish harvested per production cycle and farm profit at 0.996. This means that increase in profit is brought about by increase in number of fish harvested per production cycle. This implies that increase in the number of harvested fish will lead to more profit in fish farming.

Table 4.4: Gross margin ratio

Farm	**Production cost (R)**	**Total revenue (R)**	**Gross margin (R)**	**Gross margin ratio (%)**
Farm 1	41 666	75 000	33 334	44
Farm 2	1 000 000	1 840 000	840 000	46
Farm 3	364 000	644 000	280 000	43
Farm 4	303 333	525 000	221 667	42
Farm 5	44 000	90 000	46 000	51

Source: Data from this study was used

4.1.6 Conclusion on productivity and profitability

The findings from the section have shown that the aquaculture projects in Gauteng province are producing under capacity. This is seen from the production capacity of each project and the actual current utilization. Whereas the combined total production should have been 195 tonnes of fish at full capacity utilization. Only about 70 tonnes of combined total fish production were recorded for this survey. The current utilization represents 36% of the total farms capacity. This revealed that fish farms in Gauteng Province are not productive. However, in spite of the under production, fish farming in the province seemed to be profitable. The findings indicated that while one of the farms had more than 50% gross margin ratio, all other farms had gross margin ratios that are above 40%.

4.2 Supply chain and marketing of aquaculture products by the farms in this study.

Supply chain is the term used for all the elements involved in the sourcing, production and marketing of products and services. According to Chopra *et al.* (2007), the principle of supply chain activity is receiving input from firm's suppliers, add value to the input and deliver end products to customers. It encompasses all the parties that were involved, directly or indirectly, in fulfilling a customer request. The current study was conducted to determine the existence and efficiency of supply chain of aquaculture projects in Gauteng Province. It further assessed the nature of the market as well as the freshwater fish consumption pattern in the province.

4.2.1 Aquaculture supply chain and value adding among the farms used in this study

All the farmers interviewed were involved in some form of fish farming primary production and grow-out. Primary production entails fish fry, fingerling and juvenile production. The secondary (grow-out) production involves growing fish to table size for the market, packaging and distribution. Two of the five producers interviewed were

involved with fish fingerling and juvenile production. The remaining three farmers preferred to buy fingerlings from sources within and outside Gauteng province. All the farmers were involved with grow-out table size fish production. They perform some forms of processing, grading, packing and distribution. The fish are sold both at the farm gate as well as to the community where the products are demanded.

4.2.2 Supply chain and aquaculture production inputs in Gauteng Province

Key inputs needed in aquaculture production include fish fingerlings, feed, water, electricity and various production systems. Apart from fingerling production, some of the farmers interviewed produced and designed the equipment they use on their farms. Two of the farmers aim at selling the technology to up and coming fish farmers in the future. They also intend to enter the field of aquaculture training as the industry establishes. There is currently no fish feed producer or supplier in Gauteng province according to the finding from this study. Feeds are sourced from Kwazulu-Natal for fish production in the province. Food fish fingerlings, especially tilapia species are produced by one farmer out of the 5 participated farmers. Other farmers buy fingerlings from him or from other sources within and outside South Africa. All the farmers use borehole water as major source of water supply for production activities.

4.2.3 Supply chain and fish sales in Gauteng Province

The study found that distribution of fish is done by the producers from the farm gate to consumers and retailers. Only one of the participating farmers indicated that his farm sells to a wholesaler. The other farmers sell directly to individuals in the informal fish retail business due to the small quantity of fish currently produced.

Twenty informal fish retailers were interviewed during the data collection period. The sellers were from the cities of Johannesburg and Tshwane. Although much effort was expended to engage fish wholesalers for the survey, all the participated sellers were fish retailers.

Figure 4.3 shows the breakdown of where the retailers sourced fish from in the province. As revealed in Figure 4.3 below, 50% of the respondent fish retailers buy the fish they sell from the City of Johannesburg while the remaining 50% buy from different locations in the City of Tshwane. While 35% of Pretoria sellers buy from undisclosed areas of the city, 10% buy from a dam called Damdorin at Hartebeespoort and the remaining 5% buy from Soshanguve.

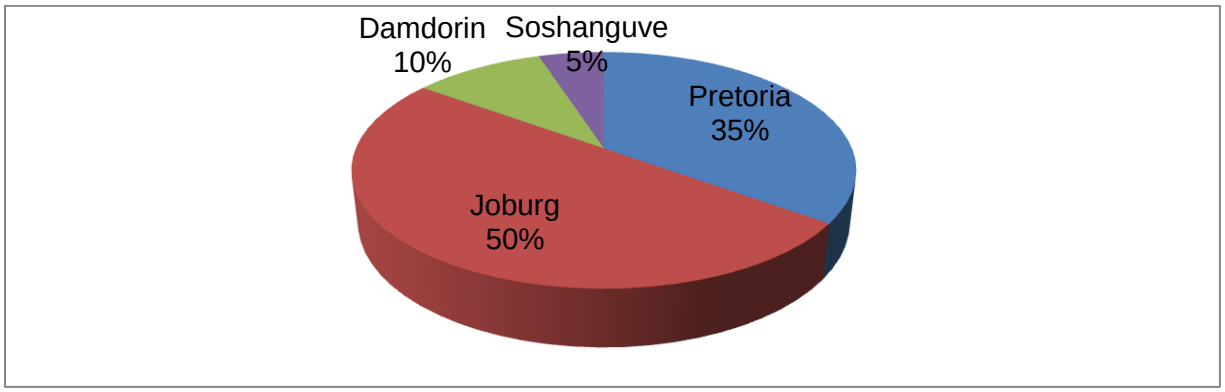

Figure 4.3: Places and location of fish sources by retailers from Gauteng province

Source: Data from this study was used

4.2.4 Purchasing outlets for fish retailers in Gauteng Province

Figure 4.4 shows that majority of the fish retailers (60%) buy fish for sale from designated fish markets in their localities. While 25% of the retailers buy fish from various dams, 5% each source fish from wholesalers and landing sites.

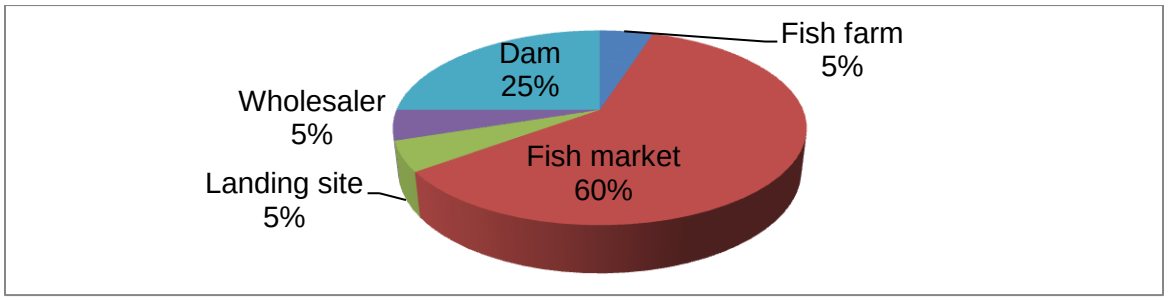

Figure 4.4: Locations where retailers purchase fish within Gauteng Province

Source: Data from this study was used

4.2.5 Type of fish frequently purchased by retailers

Tilapia and catfish are the fishes of choice greatly in demand by the retailers. As shown in Figure 4.5, 60% of the buyers indicated that buyers demand for tilapia more than any other fish species. 27% submitted that they always purchase more catfish to sell because people demand for them. Out of the remaining respondents, 8% buy more of trout species while 5% buy carp. All respondents indicated that they buy combinations of different fish species. There was a positive correlation between type of fish people buy and how much the seller bought the fish in kilogram at 0.702. This means increase in how much the seller bought a fish species in kilogramme increases the type of fish people are willing to buy. This implies that increase in the kilogramme cost of a fish species leads to people buying more of other fish species. However, some buy more tilapia and catfish species because demand for them are much more in the areas where they are located. There was a positive correlation between type of fish bought by sellers and name of the area where fish is bought at 0.723. This means that increase in awareness of the name of the area where fish is bought increases the purchase of the fish type. This implies that a particular fish type will receive more patronage from the sellers as they are aware of where to buy it.

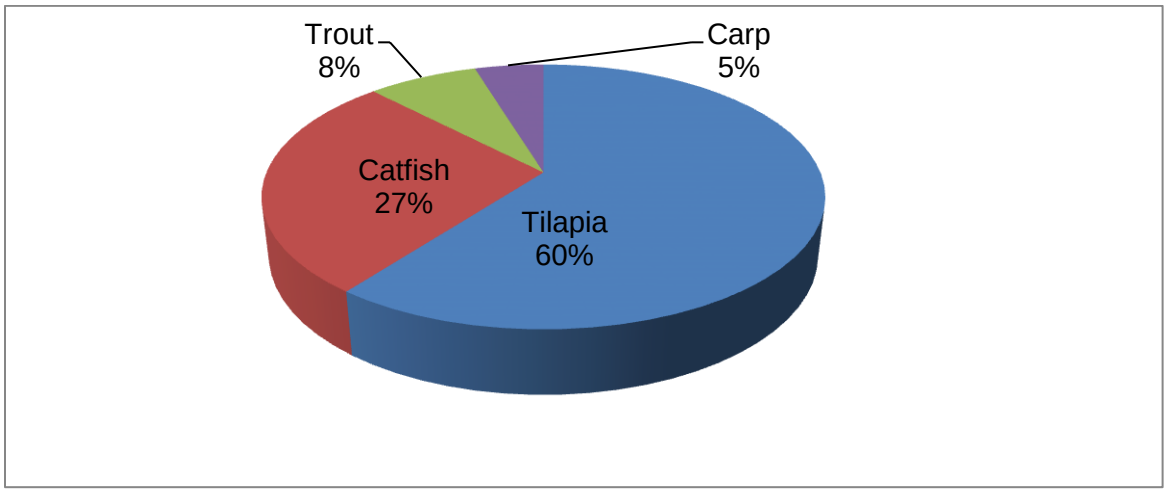

Figure 4.5: Types of fish purchased by retailers in Gauteng Province

Source: Data from this study was used

Figure 4.6 shows the frequency at which retailers purchase fish from the different sources. While 85% of the retailers buy fish on a weekly basis, 15% buy fish more than once a week.

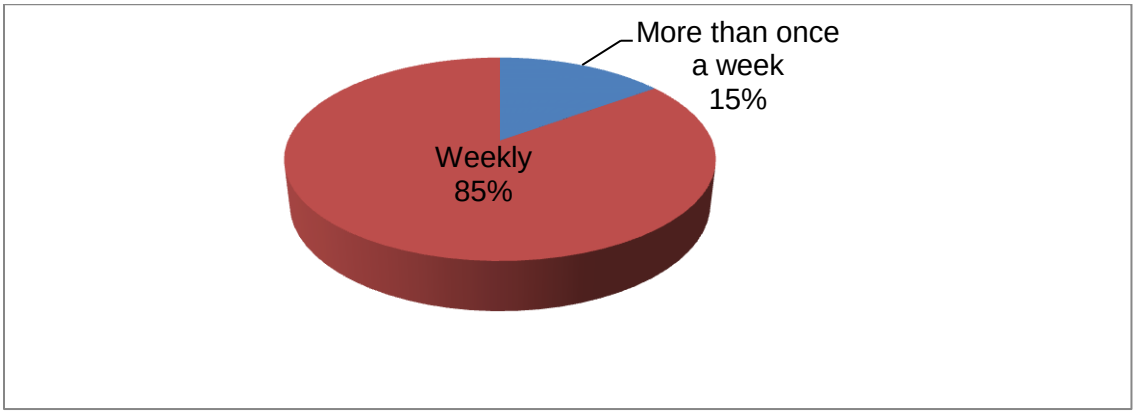

Figure 4.6: Fish purchasing intervals by retailers in Gauteng Province

Source: Data from this study was used

4.2.6 Fish sales by the retailers and profitability

Table 4.5 shows that majority of the fish retailers (45%) sell fish to the consumers in pieces and not in kilogramme. However, while 20% sell at between R71-80 per kilogramme another 20% sell theirs between R30-40 per kilogramme. The remaining respondents who also sell in kilogramme sell at between R51-60 (2%) and R61-70 (5%) per kilogramme respectively. There was a positive correlation between how much a fish species is bought in kilogram and competition in buying freshwater fish at 0.638. This means that how much a fish is bought in kilogramme increases the competition in buying freshwater fish. This implies that increase in the price of a fish species will lead to the purchase of other freshwater fish species.

Table 4.5: Selling prices of fishes by retailers

Price(/kg)	Frequency (n = 20)	Percent
R30-40	4	20
R51-60	2	10
R61-70	1	5
R71-80	4	20
Total	**20**	

Source: Data from this study was used

Figure 4.7 presents the verbal confirmation of the profitability by informal fish retailers in Gauteng province. Fish retailing is profitable according to 76% of retailers while 15% indicated that fish retailing is not profitable. The remaining 9% could neither say Yes nor No.

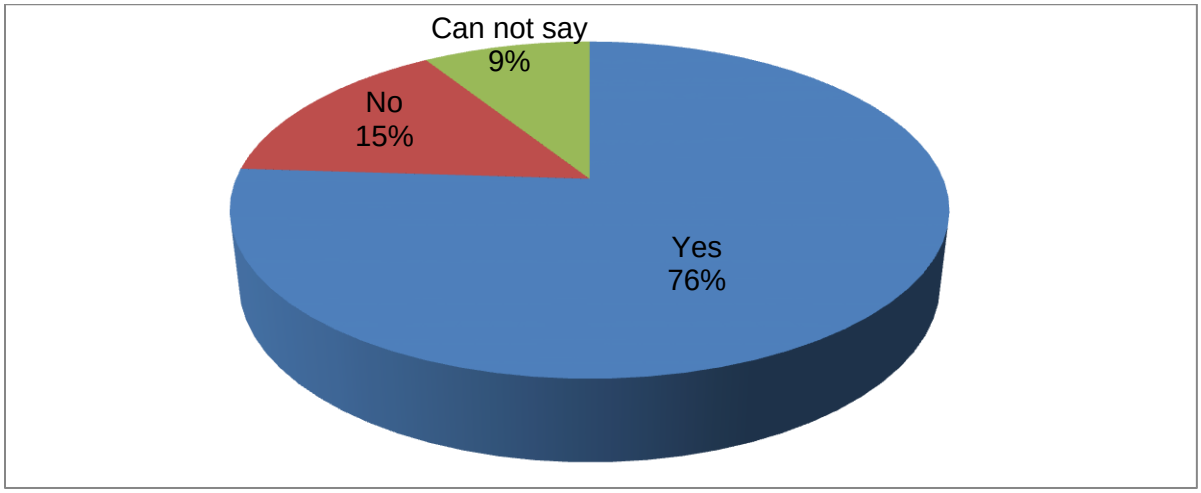

Figure 4.7: Profitability of fish retailing according to responses from retailers

Source: Data from this study was used

4.2.7 Open-end question remarks by informal fish retailers in Gauteng Province

Figure 4.8 gives the breakdown of suggestions by fish retailers in Gauteng province that can lead to the growth of aquaculture market. Several of the fish sellers (65%) gave no remark for the growth of the market. However, 15% advised that consumers need to be encouraged to buy fish. From the other respondents, 5% indicated that consumers need more education on the benefits of fish consumption. Establishment of more farms and lowering of prices were advocated by 5% each. The remaining 5% of the respondents recommended that fish should be kept fresh by the sellers to attract more customers.

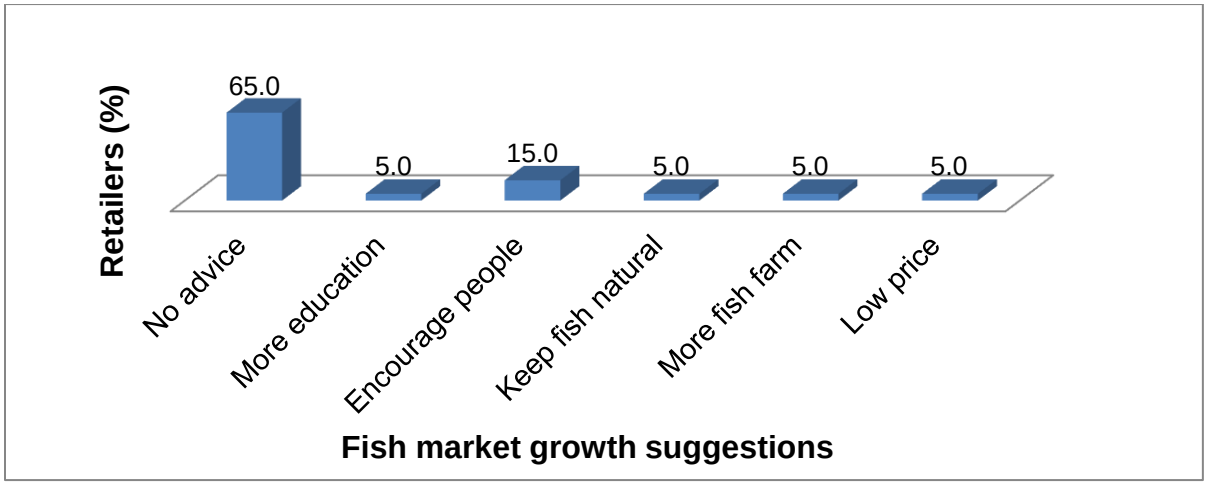

Figure 4.8: Suggestions that can lead to the growth of freshwater fish market in Gauteng Province

Source: Data from this study was used

4.2.8 Summary on supply chain and marketing of aquaculture products

The finding shows that there is no established supply chain of aquaculture in Gauteng province. Almost all the value adding activities are performed by the producers themselves. Apart from fish production equipment suppliers, every other aspect of production, processing and marketing are carried out by the fish producers. Fish feeds

are not available in the province. Fish producers travelled to other provinces especially Kwazulu-Natal to source feed.

The small size of the aquaculture sector in Gauteng province resulted in fish producers selling their fish mostly to retailers and directly to consumers. There are very few wholesalers according to the findings of this study. Only one of the fish producers interviewed sells to a wholesaler. The other producers sell to informal retailers who themselves sell in smaller amounts to fish stalls and consumers. However, the quantity of fish produced by the farmers is not enough to meet the consumers' demand. Therefore, some of the informal retailers go to nearby dams to buy fish for retail from fish anglers. The market for freshwater fish is large in Gauteng province owing to increasing public health awareness and the presence of foreign nationals in the province.

4.3 Consumers fish consumption dynamics and preferences

4.3.1 Demographic characteristics and preferences of respondents

Table 4.6 presents the gender of consumer respondents who were chosen randomly from the province for the survey. While 51.8% of them were males, the remaining 48.2% were females.

Table 4.6: Gender of fish consumer respondents

Characteristics	**Frequency (n = 110)**	**Percent**
Female	53	48.2
Male	57	51.8
Total	110	100.0

Source: Data from this study was used

The age ranges of the randomly selected consumer respondents are shown in Figure 4.9. About 48% of them fell into the age range of 26-35 years while 28% were in the range of 36-45 years. The remaining respondents, 21% and 3% fell into the age ranges of 18-25 years and 46-55 years old respectively.

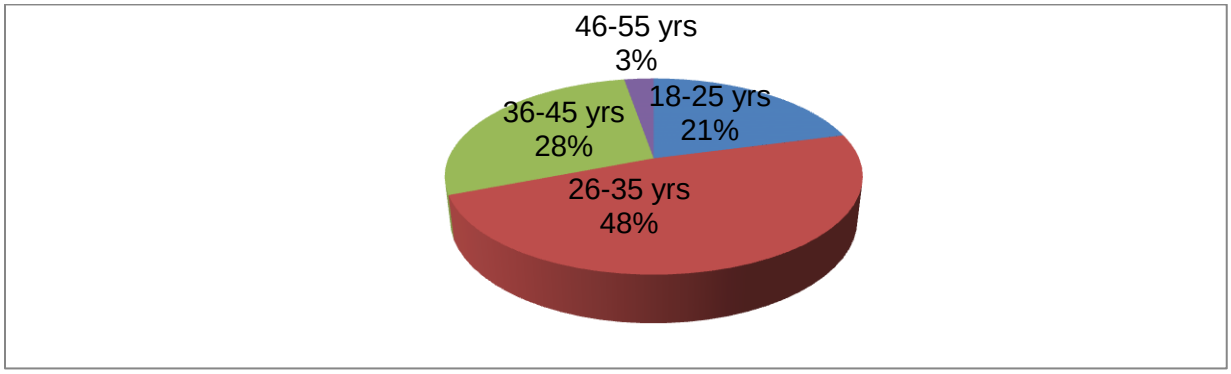

Figure 4.9: Age range of fish consumer respondents in Gauteng Province

Source: Data from this study was used

Academic background of fish consumers who participated in the study is shown in Figure 4.10. The largest number of the respondents (36%) was university graduates while 31% were college graduates. Out of the other consumers, 19% were post graduate and 14% had grade 12 certificates.

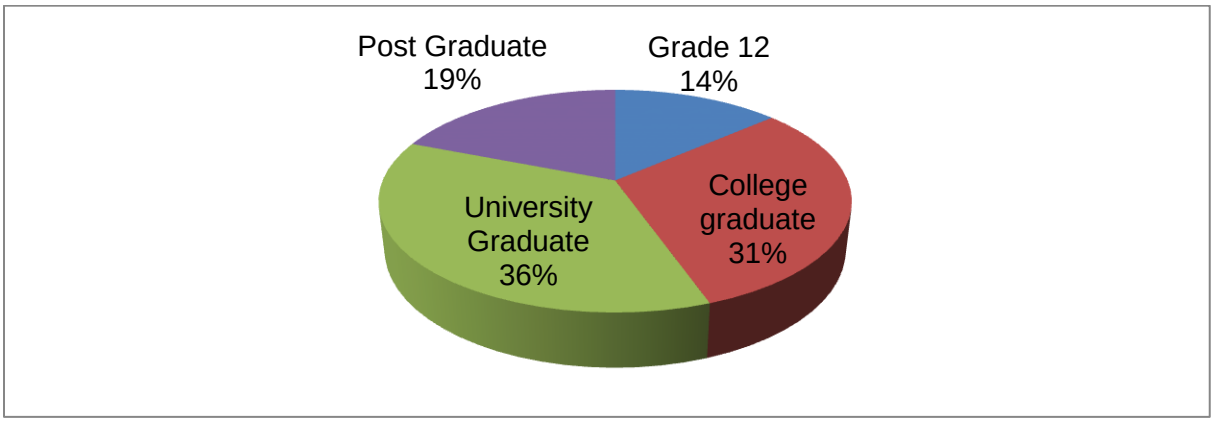

Figure 4.10: Academic qualifications of respondent fish consumers in Gauteng Province

Source: Data from this study was used

Figure 4.11 presents the result of the outlets where consumer source fish. A higher proportion of the respondents (72%) buy fish from the supermarket. There was a weak correlation between type of fish eaten by consumers and the places where fish are bought at 0.467 with significant of <0.001. Fish outlets like road side, market and spasa shops made up of 13%, 10% and 5% of respondents respectively. Other respondents buy fish from a combination of outlets depending on where they found their preferred fish. The percentage score for supermarket (72%) is not surprising because majority of the respondents eat hakes. Hake is sold in frozen form and could be found majorly at the supermarkets.

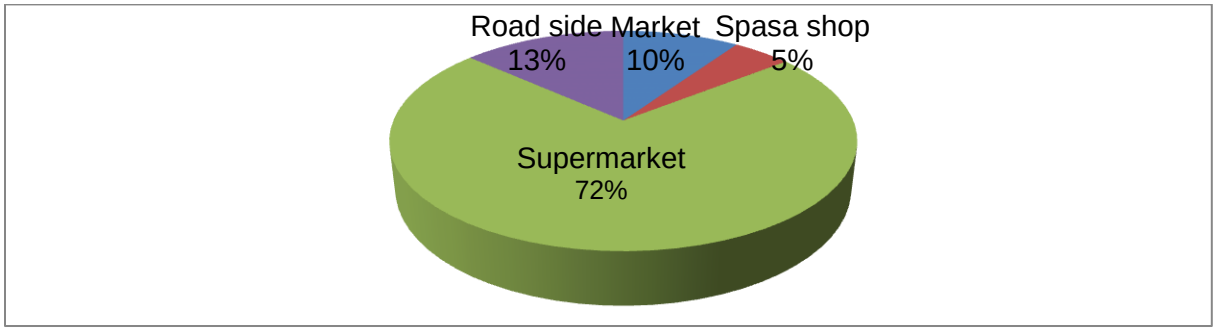

Figure 4.11: Fish sales outlets where consumers prefer to purchase fish

Source: Data from this study was used

The breakdown of the forms in which consumers preferred to buy fish is presented in Figure 4.12. Out of the different forms in which fish is sold in the market, frozen fish is the choice of 60% of the respondents. There was a weak correlation between the choice of fish eaten by consumers and the form of fish bought at 0.368 with significant of <0.001. Fried fish is the choice of 21% while 11% of the respondents buy theirs in fresh form. Live fish is chosen by 3% while the remaining number of respondents (15%) does not have a specific form in which fish is bought.

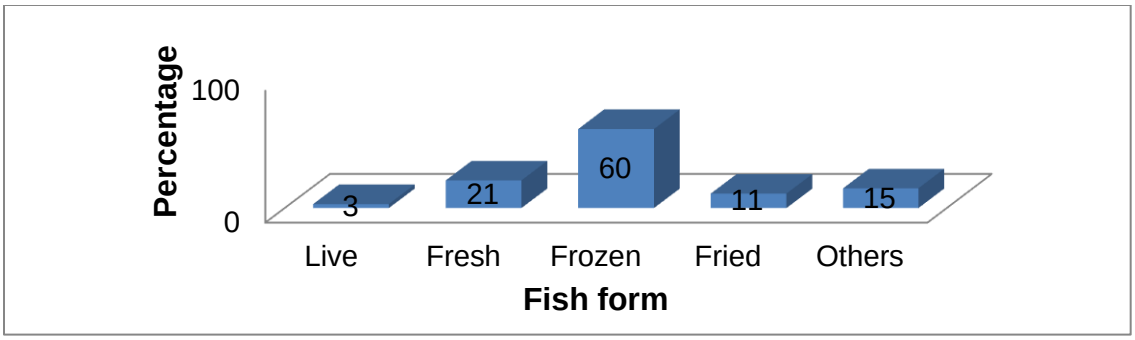

Figure 4.12: Fish forms preferred by respondent consumers in Gauteng Province

Source: Data from this study was used

The result of the frequency of consuming fish by the respondents is presented in Figure 4.13. Majority of the respondents (58%) eat fish every week while 26% eat it more than once a week. Whereas 10% eat fish once in a while, 6% reported they don't eat fish at all. There was a positive correlation between frequency of fish consumption and place of fish purchase at 0.61. This means increase in places of purchases increases the frequency of fish consumption by the people. This implies that more fish marketing outlets influence more fish consumption.

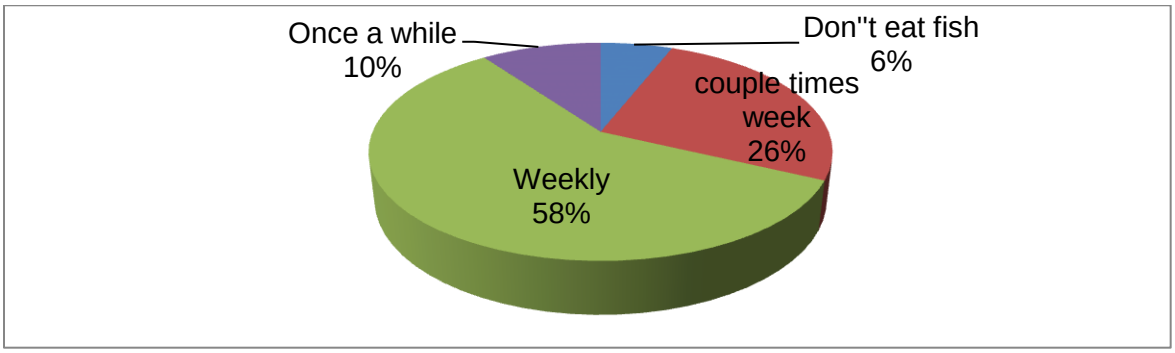

Figure 4.13: Frequency at which consumer respondents eat fish in Gauteng Province

Source: Data from this study was used

4.3.2 Distribution of respondents according to nationalities and municipal areas

The result of the nationalities of consumers who participated in the survey is presented in Figure 4.14. They are from seven different nations. South Africans took more than half of the respondents (64%) followed by Zimbabweans and Nigerians with 13% and 12% respectively. The other nationals represented in the survey were Congolese, Malawian, Mozambicans and Cameroonians with 4%, 4%, 2% and 1% respectively.

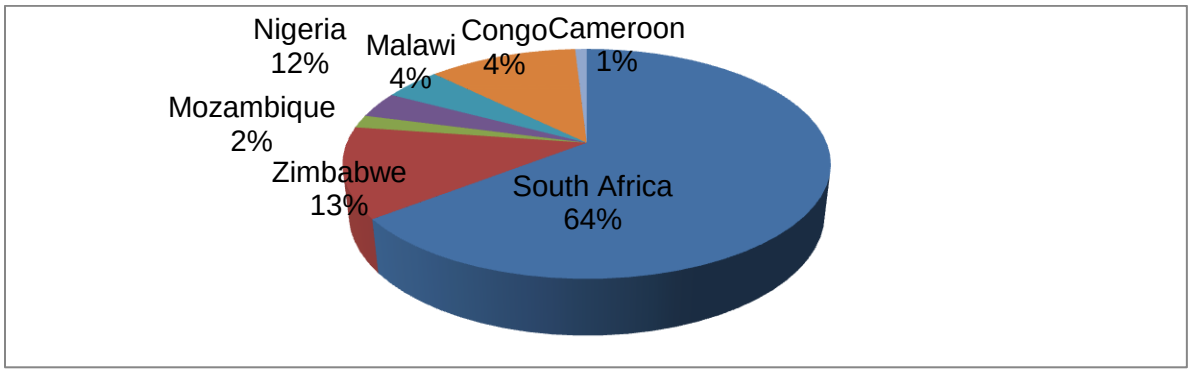

Figure 4.14: Nationalities of participants in the current study

Source: Data from this study was used

Four of the six major districts of the province were covered during the data collection as presented in Table 4.7. Majority of the respondents (83.6%) reside within the City of Tshwane and 8.2% reside in the district areas of Johannesburg. Ekurhuleni metropolitan areas and West Rand had 4.5% and 3.6% of respondents dwelling there respectively.

Table 4.7: Districts of Gauteng Province where consumer participants in the study reside

Districts	Frequency (n=110)	Percent
Tshwane	92	83.6
City of Johannesburg	9	
West Rand	4	3.6
Ekurhuleni	5	4.5

Source: Data from this study was used

4.3.3 Type of fish species consumed by respondents and factors influencing it

This study revealed that hake is the fish of choice commonly eaten in Gauteng province. Figure 4.15 shows that 70% of the respondents indicated hake as the major fish they are accustomed to and eat. Respondents that showed preference for tilapia and sardine were 10% and 8% respectively. Preferences for catfish, trout and carp were shown respectively by 5%, 1% and 1% of respondents. Only 2% of the total respondents indicated that they don't eat fish at all.

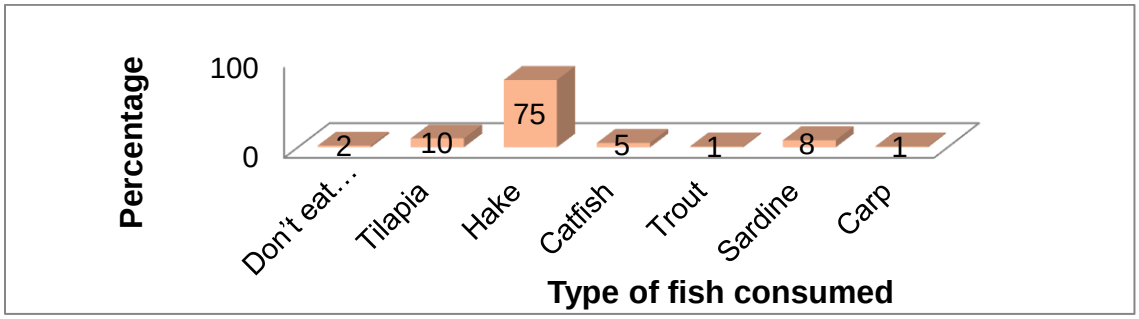

Figure 4.15: Type of fish species consumed by respondents

Source: Data from this study was used

According to Figure 4.16 below, the greater percentage of respondents who eat hake fish are South African (58%). Coming in a distance second is sardine with 7.3%. Freshwater fish species tilapia and catfish followed with 5.5 and 4.5% respectively.

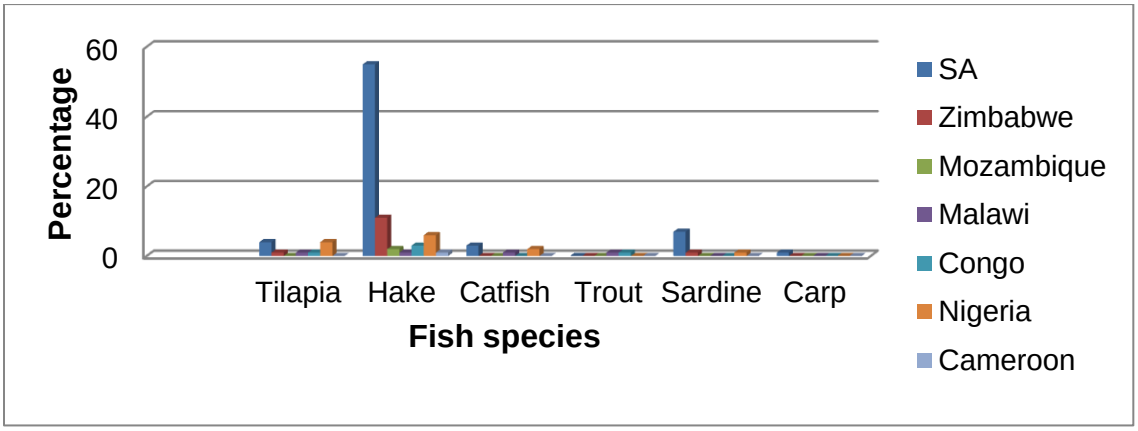

Figure 4.16: Preferred fish species consumed by different sampled nationalities

Source: Data from this study was used

The choice of fish is greatly influenced by taste according to what the survey report revealed. Figure 4.17 shows that 54.5% of the respondents considered taste above all other factors while 20% indicated that cost determines their willingness to buy any type of fish. Availability is a factor considered by 10% of the respondents. Ease of processing and a combination of the factors serve as influence for some of the respondents.

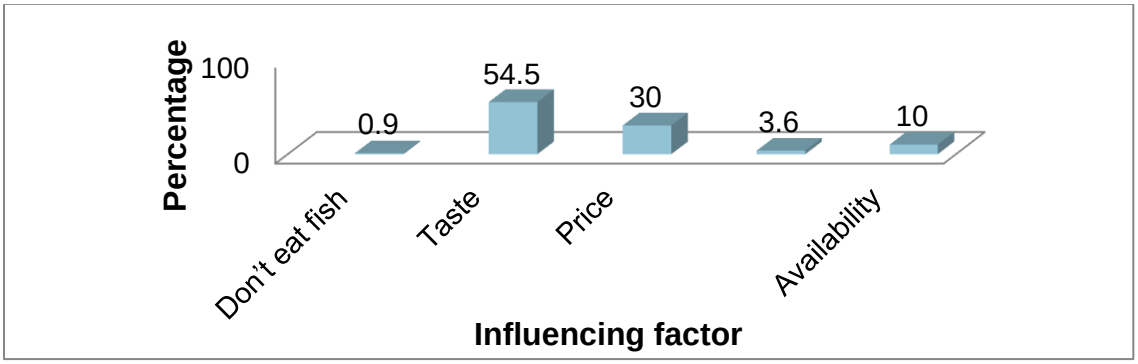

Figure 4.17: Factors influencing respondents' fish consumption

Source: Data from this study was used

4.3.4 General animal protein preferred by sampled consumers in Gauteng Province

Figure 4.18 reveals that the animal protein preferred by the consumers is chicken. The result shows that 52% of the respondents chose chicken as the animal protein of choice in the province. This was followed by beef (23%), fish (21%) and pork (4%) respectively.

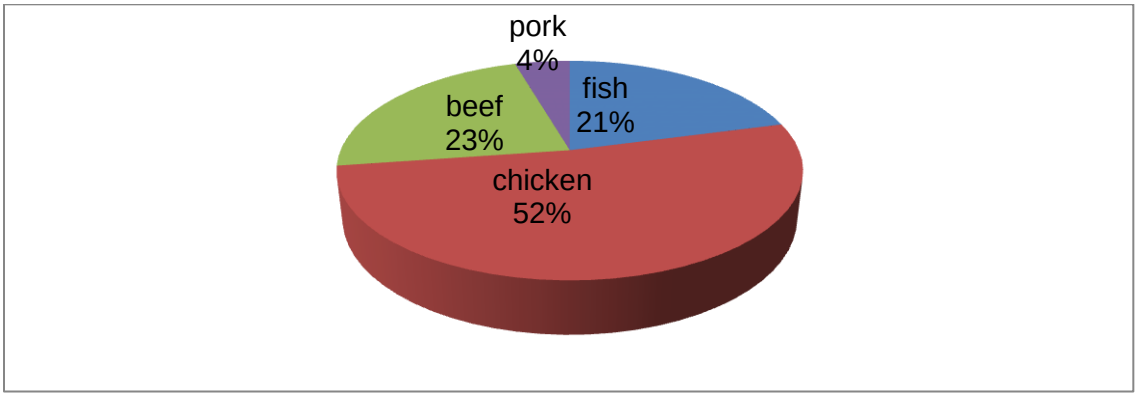

Figure 4.18: General animal protein preference by respondents in Gauteng Province

Source: Data from this study was used

4.4 Constraints to the growth and profitability of fish farming in Gauteng Province

The survey results showed that there are many constraints hindering the growth of aquaculture in the province. Table 4.8 shows the list of problems encountered by farmers. However, lack of skilled labour in aquaculture seemed to be a problem that cut across all the farmers where responses were got for the survey. The results of the correlation analysis are attached as appendix 1. There was a positive correlation between the farm producing all seasons and the availability of skilled manpower at 0.791. This means large number of unskilled manpower increases the inability of the farm to produce all seasons of the year. This implies that more skilled manpower will lead to all year round fish production. There was a positive correlation between the current operational status of the farm and problem of skilled manpower at 0.791. This

means that the increase in the problem of skilled manpower increases the current operational status of the fish farm. This implies that the lack of skilled manpower will lead to whether the farm is currently in operation or not. There was a positive correlation between the biggest problem of fish farming (skilled manpower) and how often fish is fed at 0.707. This means that increase in the problem of skilled manpower increases the problem of how often fish is fed. This implies that the problem of skilled manpower leads to a less frequent feeding of cultured fish. There was a positive correlation between the biggest problem of fish farming and reasons why fish demands are not met at 0.746. This means increase in the problem of skilled manpower increases the reasons why fish demands are not met. This implies that the more the problem of skilled manpower persists, the less the fish that will be supplied to the market.

Government policies as well as the regulation of the subsector are the other constraints that were pointed out by the farmers. Regarding financing, all the farmers complained about not having access to funding either from the government or banks. Lack of funding makes farm expansion impossible to achieve. There was a strong positive correlation between farm revenue and number of workers at 0.883. This means that increase in the number of workers increases the farm revenue. This implies that the more the number of people who work in the farm, the more the revenue that will come into the farm. There was a strong positive correlation between farm revenue and business profitability at 0.859. This means that the increase in farm revenue increases business profitability. This implies that more revenue to the farm will lead to more profitability to the fish farming business.

On personal level, some other problems encountered on regular basis by farmers include outage of electricity. Alternative sources of power supply had to be turned to at such times. This cause production costs as well as the cost of fish products to increase. The problem of broodstock (matured fish used for breeding purposes) is another constraint experienced by farmers especially those with intention to enter the business of fish fingerlings and juvenile productions. The lack of sources for the purchase of broodstock in the country is a major constraint. Government regulation concerning importation of fish is a big hindrance to the growth of the subsector. Out of the

respondent farmers, only one is able to produce fingerlings for table-size fish production. The other farmers buy fingerlings and juvenile fish from him or from other provinces.

Table 4.8: Constraints to the growth of aquaculture as indicated by fish producers in Gauteng province

FARMERS	Constraints experience by farmers				
Farm 1	Lack of skilled worker	Limiting government policies	Lack of labour knowledge on fish		
Farm 2	Poor legislation	Erratic power supply	Poor extension	Underdeveloped market	
Farm 3	Lack of knowledge of system design	Oxygen control	High cost of heat generation	Unavailability of fish seed	Unavailability of fish feed
Farm 4	Poor funding	Lack of skilled worker	Limiting policies		
Farm 5	Unavailability of broodstock	Lack of passionate workers	Lack of skilled worker	Erratic electricity supply	

Source: Data from this study was used

4.5 Summary for chapter four

According to the results presented in this chapter, aquaculture projects in Gauteng Province are under producing with 36% of the current production capacity. However, fish farming is profitable in the province as revealed by the gross margin analysis which was used to determine the profitability of the sector. The supply chain of aquaculture in

the province is not established and cannot support the growth and development of the sector in its current form. Freshwater fish species are mainly sold in the informal market. Marine fish species are the most commonly sold in the formal market due to low production from the freshwater fish farming sector. Aquaculture is bedevilled by several constraints in Gauteng Province. However, the presence of increasing number of immigrants from fish eating African nations assures that fish farming will be a more lucrative business if the constraints are removed.

CHAPTER 5

5 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The current study was conducted to assess the productivity and the supply chain of aquaculture projects in Gauteng province in order to determine the profitability of the sector as well as possible constraints to its growth and sustainability. The results of the study are discussed in the sections that follow starting with aquaculture productivity and profitability in Gauteng Province.

5.1.1 Demographic characteristics of fish farmers and farm management system in Gauteng Province

There are about 14 existing freshwater food-fish aquaculture projects with about five aspiring farmers in Gauteng Province (GDARD, 2015). However, only five of the existing fish producers participated in the current study. The descriptive results for the fish producers showed that the farmers were all white males. There were no female fish producers as far as this study can confirm. However GDARD (2015) reported the presence of female fish producers as well as aspiring ones in the province. None of those contacted responded to the survey. The reasons for the women non-participation in the current study are unknown. They did not fill the questionnaire given out nor gave the researcher any opportunity to interview them. Women participation in aquaculture is a need that must be encouraged in Gauteng Province aquaculture sector if the enterprise will witness the kind of growth and development that the government desires. Boto and Philip (2013) reported the active roles of women in aquaculture in Southeast Asian countries, submitting that their efforts have resulted in the growth and development of the sector in their respective countries. Women have more motivation than men in the adoption of new technologies that can provide nutritional benefits such

as fish farming (Olasunkanmi, 2012). Studies have revealed that in Africa's agricultural sector, women play key roles by participating critically in achieving food security and economic well-being of the continent (Werby, 2001; Moehi, 2003; Olasunkanmi, 2012). The findings from this study further revealed that there were no black male fish farmers in Gauteng Province. All the aspiring black male fish farmers according to previous report (Britz *et al.* 2009; GDARD, 2015) have not begun production owing to logistics of land acquisition, funding etc.

The average age range of fish producers in the province was 54 years. This age range seems to be negative for aquaculture growth and sustainable development in the province. Ike and Chuks-Okonta, (2014) reported the age range of 31 to 50 years as the productive age for fish farming. Studies have suggested that the age bracket of 31-50 years is the best suited age for agricultural activities because the individuals at such age are able bodied, active, progressive and eager to implement new production methods (Yunusa, 1999; Onumah & Acquah, 2010). El-Naggar *et al.* (2010) reported the average age of fish farmers in Egypt as 43 years. Olasunkanmi (2012) found that the average age of fish farmers in Osun State, Nigeria was 40 years. He concluded that with the age, the state has great potential to sustain fish farming for many more years. Onumah and Acquah (2010) revealed that while younger farmers are very adaptive to change, older farmers are technically less efficient. Therefore, for aquaculture in Gauteng province to grow and become sustainable, it must be made to hold great attraction to the youths.

The study further revealed that none of the fish producers in Gauteng Province who participated in this study has any aquaculture training degree. Though they are aware of institutions offering trainings in aquaculture, they claimed to have derived their knowledge of aquaculture through self-learning and hands-on knowledge. The findings agrees to GDARD (2015) where report indicates that farmers` knowledge had been attained from on the job experience or other farmers as opposed to formal training. However, this situation is not good for aquaculture growth and sustainable development. Most aquaculture collapse and poor fish growth have been attributed to

illiteracy and lack of technical know-how on the part of the practitioners especially in Africa (Boto & Philip, 2013). New innovations are welcomed and adopted where there are formal education and training. Education builds up the desire to acquire and utilize information on improved technology. The results usually have positive impact on productivity (Olarinde & Kuponiyi, 2004; Osondu *et al.* 2014).

From management point of view, this study revealed that both white and black males are in upper management. This is a departure from the report by GDARD (2015) where only white males and females were found to be in the upper management while those in lower management were black males and females. There seemed to have been an upgrade in the style of management of the farms. Black males were found to be farm managers working alongside white male owners to run the farms in most of the projects surveyed. This is a good indication that the aquaculture sector in Gauteng Province is headed in the right direction for growth. The practice is one of the best practices in provinces of South Africa such as Western and Eastern Capes where aquaculture is well developed (Bote *et al.* 2006; Britz *et al.* 2009).

5.1.2 Aquaculture production and productivity in Gauteng Province

The capacity of each aquaculture projects and the actual current capacity utilization were studied. The results showed underutilization of the facilities (36%) leading to lower tonnage of fish per cycle of production in all the farms. This finding supports studies by Botes *et al.* (2006) that reported aquaculture farms in Gauteng Province to be among those that were operating below 20% in South Africa. The reasons for the underutilization include lack of skilled manpower, poor access to credit facilities and poor information on current trend and technology. Other reasons are over regulation, poor government policies implementation, under developed supply chain as well as inadequate power supply. All these problems are major constraints associated with fish production in Africa and some other parts of the world (Iniobong & Emem, 2006; Boto & Philip, 2013; Osondu & Ijioma, 2014). They are constraints that must be taken care of in order to harness the benefits inherent in the sector (UNEP, 2013).

The Cobb-Douglass and regression analyses could not be carried out for the farms surveyed. There was a lack of reliable records of inputs and the number of participating producers was small. Okechi (2004) pointed out a similar problem of record keeping while studying the profitability of African catfish farming in the Lake Victoria Basin, Kenya. The researcher submitted that analysis without proper records defeats the objective of any study. Therefore, fish farmers must be encouraged to inculcate the act of proper record keeping for fish farming to compete favourably with other agribusiness.

5.1.3 Aquaculture profitability in Gauteng Province

Aquaculture is profitable in Gauteng Province as shown by the findings from the current study. According to Hofstrand (2006), profitability is the principal goal of all business ventures, without profit, no business will survive in the long-run. Consequently, measuring current and past profitability and projecting future profitability is very important. A gross margin analysis was done on each farm to determine the profitability of aquaculture business in the province. The findings revealed that the scale of production was not the same in the aquaculture projects surveyed. Therefore, the gross margin analysis and the gross profit margin ratio were done on individual farms and for one production cycle. The results showed a positive response of high gross profit margin for all the aquaculture projects. With the high gross profit margin, aquaculture enterprise in Gauteng Province is making a reasonable profit on sales and the overhead costs are kept in control. Judging from the gross profit margin ratio from the aquaculture projects, it is concluded that fish farming in Gauteng Province is profitable. The profit is also expected to rise as the farms age and more hands-on experience are gained by the producers.

The profitability result agrees to the conclusion of Olasunkanmi (2012) who worked on the economic analysis of fish farming in Osun State, South-Western Nigeria. The outcome of the current study further agrees with Matlala (2014), who studied the economic performance of tilapia farming in Southern China. Other studies which reported the feasibility and profitability of fish farming include those by Okechi (2004);

Fapounda (2005) and Nguyen (2012). Fish production is economically rewarding and profitable. It is capable of creating employment, augmenting income, reducing malnutrition and improving the living standards of fish farmers (Boateng *et al.* 2013). However, Martinez-Cordero and Leung (2004), emphasised the need for good planning and operation by aquaculture farmer for sustainable grow and profitability.

5.1.4 Aquaculture production and constraints encountered in Gauteng Province

The five producers interviewed for this study were tilapia farmers. The farms had a combine total production capacity of 195 tonnes. However, their combine total production for the 2016 production year was about 69.5 tonnes. This was way too low compared with the 276 tonnes estimate for 2016/17 production year in the study conducted by GDARD in 2015.

Challenges associated with poor performance include funding and absence of passionate skilled labour. Other challenge was permit for farming particular fish species especially *Oreochromis niloticus.* Regarding funding, all the farmers were aware of the government commitment to fund aquaculture. However, the processes involved in getting the fund are tasking. All except one farmer claimed to have been able to access the funding. All the other farmers claimed to run the farms out of their personal funds. Inaccessibility to funding is a major constraint. Therefore, fish farming in Gauteng Province has remained small scale because intensive commercial aquaculture is expensive to establish and manage. This submission agreed to the studies carried out by (Botes *et al.* 2006, Britz *et al*. 2009; GDARD, 2015). The studies concluded that majority of fish farmers were unable to access funding and could not grow has they had envisioned.

Another constraint was the ban on the production of other species of tilapia except Mozambique tilapia. However, the slow growth of Mozambique tilapia made farmers preferred Nile tilapia which is fast growing and economically viable. Getting permit to farm Nile tilapia was a daunting task according to the farmers. Britz *et al.* (2009)

reported this constraint as a very important deterrent to the development of aquaculture enterprise in South Africa. The responses regarding constraints to the growth of aquaculture in the province are peculiar to the whole country (Hecht *et al.* 1988; GDARD, 2015).

5.1.5 Supply chain of aquaculture in Gauteng Province

Supply chain from the stand point of ACCA (2010) demonstrates the full range of activities which are required to bring a product or service from conception, through the different phases of production and delivery to final consumers. The study revealed that there is no established supply chain of aquaculture in Gauteng province. The findings are in agreement to studies by Britz *et al.* (2014) and GDARD (2015) that suppliers of materials and equipment such as pumps, filters and filter media are readily available in the province. However, major production inputs such as fish fingerlings, broodstock and feeds are largely missing. The current study revealed that only one fingerlings producer exists for fish farmers in the province. Many aquaculture farmers source fingerlings from other provinces especially Eastern Cape, while other farmers import fingerlings and broodstocks from other countries. Many fish producers have begun to prepare for fingerlings production for their farms due to the scarcity of the suppliers of the essential input (AISA, 2009; GDARD, 2015). Agboola (2011) reported that availability of seeds is of economic importance in agriculture especially in fish farming business. Some participants in the current study have purchased production equipment for the commencement of fingerlings production.

Aquafeed is not available in Gauteng province as the findings of this study show. Farmers purchase fish feed from other provinces, the closest of which the study revealed is about 650 kilometres from the province. The current study agrees to Dekker (2014) and GDARD (2015) who reported that fish producers from Gauteng Province go as far as Kwazulu-natal and Cape Town to buy aquafeed from feed suppliers called AVI Plus and Montego. Aquafeed is major in fish production and its cost takes up about 60% of the production costs in aquaculture (Falayi, 1992; Sogbesan *et al.* 2006; Munguti *et*

al. 2012). Adding transport cost to an already expensive input is a negative for the growth of aquaculture in the province. It increases production costs and therefore the selling price of the fish produced.

This current study showed that there are no processing facilities for freshwater fish in the province. Farmers carry out fish processing such as sorting, gutting, filleting, packaging and storage by themselves. The findings also revealed that there is no formal market for freshwater fish in the province. Freshwater fish are mainly sold at the informal markets which could be designated fish stalls or road sides to fish traders. The results agreed to McCaffety *et al*. (2012) who revealed that locally cultured trout, freshwater fish has never been sold in formal markets, and consumption is largely limited to informal sales from subsistence fishing. GDARD (2015) also concluded that the formal market for fish in Gauteng Province is centred mainly on marine fish species. Freshwater fish species are sold at the informal market. The fish producers in the province indicated that they sell a great percentage of their fish at the farm gate. The buyers sell to other retailers and consumers in local communities especially among foreign nationals.

Though records by DAFF (2012) showed fish exportation from Gauteng Province, this study however agrees to GDARD (2015) to confirm that fish species exported from the province are fish brought in from other provinces and those imported from other countries. The current study revealed that the volume of fish currently produced in the province is not large enough to satisfy the local market. This shows that there is room for growth and expansion of the sector both for the local and international markets.

5.1.6 Freshwater fish and consumption pattern in Gauteng Province

Findings from this study revealed that freshwater fish is in great demand in Gauteng Province. This great demand is due to the large population associated with the province and the health consciousness/awareness campaigns which is compelling people to eat healthy (GDARD, 2015). The findings confirm the submission of Shipton and Britz

(2007) that there is increasing number of immigrants from traditional fish eating African nations in South Africa. This therefore could make freshwater fish farming a lucrative business and South Africa a fish farming investment destination. Welcomme *et al*. (2010) stated that fish consumption increases with urbanization. Wherever there is the occurrence of population growth, globalization, economic development, income development and environmental awareness, the demand for fish increases. There is therefore a higher probability of freshwater fish gaining a sizable market in Gauteng Province. This is due to the large presence of foreign nationals in the province and the health conscious South Africans.

Previous studies on the protein preferences by South African consumers showed that meat, rather than fish is the prefer choice by most people (Britz, 2014; McCarthy, 2014). Findings from studies have discovered that while consumers spend an average of 31% of their food budget on animal protein products only 4% of it is spent on fish products and only 6.2 kg is the per capita consumption of fish compared with 38.5 kg, 18.51 kg and 4.5 kg for chicken, beef and pork respectively (Britz, 2014; McCarthy, 2014; GDARD, 2015). Results from this current study agreed to these findings. The consumers interviewed for the study showed their animal protein preference for chicken, beef, fish and pork in that order. However, as more awareness is created around the benefits of fish consumption, the market for fish will expand in the province.

5.2 Conclusion

The objectives of this study were to assess the productivity of aquaculture projects in Gauteng Province and the efficiency of supply chain for growth and sustainable operation. The results from the study showed that existing aquaculture projects in the province are under producing. Whereas the surveyed projects have combined production capacity of 195 tonnes, only 69.5 tonnes of fish were produced for the year in review making just 36% utilization of existing facilities. Several constraints which corroborate previous studies (Botes *et al.* 2006; Britz *et al.* 2009; GDARD 2015) were discovered for the under production. Some of the constraints include poor access to

funding, inadequate skilled work force as well as lack of established input suppliers within the province. It can be concluded judging from the above submissions that aquaculture projects are not productive in Gauteng Province. However, despite the production constraints and under production, fish farming in Gauteng Province is profitable. Fish farming venture is be able to meet the socio-economic goals of the government in terms of job creation and poverty alleviation.

Supply chain of aquaculture in Gauteng Province is under developed according to the findings of this study. The study discovered that all fish producers from the province have nowhere within the province to buy inputs such as feeds. There are also no processing facilities for value adding to fish produced before they are moved to the market for sale. Fish market in the province is divided into formal and informal. The formal market outlets include restaurants and retail stores while the informal markets are the spasa shops, fish markets and roadside markets. The market for freshwater fish in Gauteng Province is mainly informal. Formal market deals mainly with the sale of marine fish species. One of the reasons why formal market do not trade in freshwater fish species is the low volume of fish production in the province. Deduction from the findings of this study showed that fish species produced in the province is sold in the local market. In conclusion, the study revealed that the supply chain of aquaculture in Gauteng Province is not efficient.

The general conclusions from this study are: Aquaculture projects in Gauteng Province are currently not productive. This leads to the acceptance of hypothesis 1. The supply chain of aquaculture is not available to contribute to a significant growth of the sector as well as its sustainability. This leads to the acceptance of hypothesis 2.

5.3 Recommendations

Judging from the facts as revealed by this study that aquaculture projects are not productive and that the supply chain of aquaculture is not significantly contributing to its growth in Gauteng Province owing to several constraints, this study recommends:

- The promotion of fish-farming by the government as a viable and profitable industry to encourage investors for greater investments in all fish production ancillary services such as aquafeed production, provision of processing/storage facilities etc. that will enhance aquaculture productivity in the province.
- Development of new legislations for aquaculture practices to overcome existing regulations especially those that are not promoting the growth of the sector in the province.
- Development of a marketing campaign strategy for the creation of awareness about the value, profitability and health benefits of fish and fish farming in order to encourage more participation at the various levels of the value chain.

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Appendix 1: Correlation Analysis from this study

		Nationality	Age	Education level	Type fish eat	Choice fish u eat	How often fish eat	Last time eat fish	Form fish U buy	Where U buy fish	Preference rate
Nationality	Pearson Correlation	1	.245**	-.051	.103	.172	-.030	-.150	.143	.230*	.279**
	Sig. (2-tailed)		.010	.595	.283	.073	.756	.118	.135	.016	.003
	Sum of Squares and Cross-products	365.900	37.600	-9.700	59.500	53.400	-6.500	-30.800	68.900	107.100	237.500
	Covariance	3.357	.345	-.089	.546	.490	-.060	-.283	.632	.983	2.179
	N	110	110	110	110	110	110	110	110	110	110
Age	Pearson Correlation	.245**	1	-.057	.177	.232*	-.183	-.211*	.019	.140	.041
	Sig. (2-tailed)	.010		.554	.064	.015	.056	.027	.842	.146	.672
	Sum of Squares and Cross-products	37.600	64.218	-4.527	42.818	30.236	-16.636	-18.200	3.873	27.218	14.545
	Covariance	.345	.589	-.042	.393	.277	-.153	-.167	.036	.250	.133
	N	110	110	110	110	110	110	110	110	110	110
Educatio	Pearson Correlation	-.051	-.057	1	-.051	-.060	.035	-.015	.110	-.071	.058

n level	Sig. (2-tailed)	.595	.554		.597	.533	.715	.876	.252	.463	.545
	Sum of Squares and Cross-products	-9.700	-4.527	98.191	-15.227	-9.655	3.955	-1.600	27.391	-17.027	25.682
	Covariance	-.089	-.042	.901	-.140	-.089	.036	-.015	.251	-.156	.236
	N	110	110	110	110	110	110	110	110	110	110
Type fish eat	Pearson Correlation	.103	.177	-.051	1	.285**	.122	-.105	.366**	.467**	.102
	Sig. (2-tailed)	.283	.064	.597		.003	.202	.275	.000	.000	.287
	Sum of Squares and Cross-products	59.500	42.818	-15.227	907.318	139.636	41.864	-34.000	276.773	342.318	137.045
	Covariance	.546	.393	-.140	8.324	1.281	.384	-.312	2.539	3.141	1.257
	N	110	110	110	110	110	110	110	110	110	110
Choice fish u eat	Pearson Correlation	.172	.232*	-.060	.285**	1	-.067	-.239*	.368**	.423**	-.071
	Sig. (2-tailed)	.073	.015	.533	.003		.489	.012	.000	.000	.464
	Sum of Squares and Cross-products	53.400	30.236	-9.655	139.636	263.673	-12.273	-41.800	149.945	167.236	-50.909
	Covariance	.490	.277	-.089	1.281	2.419	-.113	-.383	1.376	1.534	-.467
	N	110	110	110	110	110	110	110	110	110	110
How	Pearson Correlation	-.030	-.183	.035	.122	-.067	1	.303**	.123	.061	-.138

often fish eat	Sig. (2-tailed)	.756	.056	.715	.202	.489		.001	.202	.526	.151
	Sum of Squares and Cross-products	-6.500	-16.636	3.955	41.864	-12.273	128.773	37.000	34.955	16.864	-69.591
	Covariance	-.060	-.153	.036	.384	-.113	1.181	.339	.321	.155	-.638
	N	110	110	110	110	110	110	110	110	110	110
Last time eat fish	Pearson Correlation	-.150	-.211*	-.015	-.105	-.239*	.303**	1	-.147	-.104	-.274**
	Sig. (2-tailed)	.118	.027	.876	.275	.012	.001		.124	.280	.004
	Sum of Squares and Cross-products	-30.800	-18.200	-1.600	-34.000	-41.800	37.000	115.600	-39.800	-27.200	-131.000
	Covariance	-.283	-.167	-.015	-.312	-.383	.339	1.061	-.365	-.250	-1.202
	N	110	110	110	110	110	110	110	110	110	110
Form fish U buy	Pearson Correlation	.143	.019	.110	.366**	.368**	.123	-.147	1	.410**	-.091
	Sig. (2-tailed)	.135	.842	.252	.000	.000	.202	.124		.000	.346
	Sum of Squares and Cross-products	68.900	3.873	27.391	276.773	149.945	34.955	-39.800	630.991	250.373	-101.318
	Covariance	.632	.036	.251	2.539	1.376	.321	-.365	5.789	2.297	-.930
	N	110	110	110	110	110	110	110	110	110	110

Where U buy fish	Pearson Correlation	.230*	.140	-.071	.467**	.423**	.061	-.104	.410**	1	.018
	Sig. (2-tailed)	.016	.146	.463	.000	.000	.526	.280	.000		.855
	Sum of Squares and Cross-products	107.100	27.218	-17.027	342.318	167.236	16.864	-27.200	250.373	591.718	19.045
	Covariance	.983	.250	-.156	3.141	1.534	.155	-.250	2.297	5.429	.175
	N	110	110	110	110	110	110	110	110	110	110
Preference rate	Pearson Correlation	.279**	.041	.058	.102	-.071	-.138	-.274**	-.091	.018	1
	Sig. (2-tailed)	.003	.672	.545	.287	.464	.151	.004	.346	.855	
	Sum of Squares and Cross-products	237.500	14.545	25.682	137.045	-50.909	-69.591	-131.000	-101.318	19.045	1975.864
	Covariance	2.179	.133	.236	1.257	-.467	-.638	-1.202	-.930	.175	18.127
	N	110	110	110	110	110	110	110	110	110	110

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

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 2: Consent form and questionnaire

Consent form

Title of research project: Assessment of productivity and supply chain of aquaculture projects in Gauteng province for sustainable operation.

Dear Mr/Mrs/Miss/Ms/DR_____ Date _____2016

Nature and purpose of the study

This is to seek your assistance in the completion of the above named research project. The main purpose of the study is to analyze the supply chain of aquaculture in Gauteng province in other to see its impact on the growth and sustainability of the sector since aquaculture is one of the investment destinations of the government. At the end of the research, a recommendation will be drawn and presented to stakeholders for approval.

Research process: the study requires your participation in the following manner:

- All aquaculture farms/farmers/wholesalers/retailers in the province will be requested to participate in the study.
- Respondent may be representative of any ethnic group, age or gender.
- Basic demographic information will be required from you such as age, cell number, occupation, Language, educational background.
- The duration of this research project is a maximum of two hours.
- Each farmer will be provided with a questionnaire to read, after reading the interviewer will start asking questions.
- Pictures of the farm and business areas will be taken only if the farmer agrees.

Confidentiality

This is to promise that your ratings and assessments of any of the research instruments as well as your opinions on any of the issues will be kept strictly confidential. Only the members of the research team will have access to the information. No data published in dissertations and journals will contain any information by means of which you may be identified. Your anonymity is therefore ensured

Withdrawal clause

I understand that I may withdraw from the study at any time. I therefore participate voluntarily until such time as I request otherwise.

Potential benefits of the study

The outcome of the study will be published in journals. This will allow many more researchers as well as policy makers to know about the constraints militating against aquaculture sustainability in the province. However, your anonymity is assured.

For more information

In case of any further information or clarification, you may contact Mr Barileng Mogoje or Dr Mary-Jane Thaela-Chimuka.

Consent

I, the undersigned, …… (Full name) have read the above information relating to the project and have also heard the verbal version, and declare that I understand it. I have been afforded the opportunity to discuss relevant aspects of the project with the project leaders, and hereby declare that I agree voluntarily to participate in the project.

I indemnify UNISA and any employee or student of UNISA against any liability that I may incur during the course of the project. I further undertake to make no claim against UNISA in respect of damages to my person or reputation that may be incurred as a

result of the project/trial or through the fault of other participants, unless resulting from negligence on the part of UNISA, its employees or students.

A copy of this consent form can be obtained from the researchers.

Signature of participant: .....

Signed at …… on ……

Witnesses

1.....

2.....

Appendix 3: Questionnaire

Questionnaire no:	Farm number:

PART A: DEMOGRAPHIC

1 Gender	a) Male	b) Female			
2 Age	a) 18-29	b)30-49	c)50-64	d)65-more	

3 Marital status

a) Married	b) single	c) divorced	d) widowed		

4 Principal occupation

a) Project owner	b)Project member	c) Farm worker	d) Others

5 Location of farm

Sedibeng	Metsweding	West Rand	Ekurhuleni	City of Joburg	City of Tshwane

6 Name of town or village

a)	b)	c)	d)

7 How long have you been involved with aquaculture?

a) 1-5 yrs.	b) 6-10 years	c)11-15 years	d) 16-20 years	e) 21 years and more

8 Reasons for fish farming

a) Income generation	b) Entertainment	c) Home consumption	d)	

PART B: DESCRIPTION OF FARM/ PROJECT

1 Type of production system

a) Extensive	b) Semi-intensive	c) Intensive	d) RAS	
2 Production activity				
a) Fingerlings production	b) Juveniles Production	c) Table size production	d) Others	
3 Size of farm				
a) <1 hectare	b) between1-2 hectares	c) >2 hectares	d)> 5 hectares	
4 Land ownership				
a) Own land	b) Lease from private owner	c) Lease from government		
5. What is the production capacity of the farm if all the facilities are duly used?				
a)	b)	c)		
6. Is the farm regularly stocked to capacity?				
a) Yes	b) No			
7. If NO, what are the reasons?				
a)	b)	c)		

PART C: FINANCING							
1 Source of funding for start up							
a) Government	b) NGO	c)Self contribution	d) Loan/grant				
2 Name of funder							
a) DAFF	b)Social dev.	c) Eskom	d) Self contribution	e) DTI			
3 Interest payable on loan							

a) 2-4%	b) 5-7.5%	c) 7.5-10%	d) 11-15%		

4 Repayment of loan

a) Once a year	b) Every harvest	c) Every month	d) Every 6 months	

5 Breed of fish

5 Breed of fish	b) Catfish	c) Trout	d)

PART D: OPERATIONAL MANAGEMENT ASPECTS

1 Current status

a) Operating	b) Not operating	c) Intervals

2 If not operating, give reason

a) No fund	b)Disagreement	c) No profit	d) Shortage of resources	

3 Daily routine

a) Owner	b) Family member	c) Owner and assistants	d) Assistants	

4 Record keeping

a) Daily	b) Monthly	c) Only on deliveries	d) Only sales	e) no records		

5 Business and financial plans

a) Available	b) Not available	c) Partly available	d)		

PART E: SKILL THROUGH TRAINING AND EXPERIENCE

1 Do you have any training in aquaculture?

a) Yes	b No	c) fish farming experience

2 Experience

a) Commercial fish production	b) Artisanal fishing	c) No experience

3 Extension service

a) Regularly	b) Seldom	c) N/A

4 How many man power do you have?			
a)	b)	c)	d)
5 What are the main man power problems of the farm if any?			
a)	b)	c)	d)
PART F: FEEDING OF FISH			
1, Do you feed your fish?			
a) Yes	b) No	c) Sometime	d)

2. How often do you feed the fish?				
a) Once daily	b) Twice daily	c) Thrice daily	d) no feeding	
3. What types of feeds do you give your fish?				
a) Imported feed	b) Self mix feed	c) Commercial feed	d) Left overs	
4. How many kg do you feed to fish a day?				
a) <1 kg	b) 1-2 kg	c) 2-3 kg	d)	
5. How much does it cost you to feed your fish per month?				
a)	b)	c)	d)	

6.How expensive is feed compared to other production cost?		
a) Very expensive	b) Not expensive	c) Moderately expensive
7. Is feed readily available?		
a) Yes	b) No	c)
8. Where do you buy the feed?		

a) Local market	b) Another district	c) Another province	d) Others

PART G: MARKETING		
1 are there informal fish market to sell fish to in the province?		
a) Yes	b) No	c)
2. How established are these markets?		

a) well established	b) moderately established	c) struggling	d) not established	

3 What freshwater fish species are commonly demanded?

a) catfish	b) tilapia	c) trout	d) carp	

4. Do you sell to wholesalers or retailers?

a) wholesalers	b) retailers	c) both

5. How often do they buy?

a) always	b) not always	c)

6. Are you able to meet the sellers demand?

a) yes	b) no	c)

7. If no, why?

a)	b)	c)	d)

8. In what forms are the fish sold?

a) live	b) fresh	c) frozen	d)smoked		

What are challenges you have with fish distribution?

a)	b)	c)	d)

PART H: PRODUCT SUPPLY

1. What are the inputs needed for fish production?

a)	b)	c)	d)			

2. Are the inputs available as and when needed?

a) yes	b) no	c)	d)

3. Are the inputs available in adequate quality and quantity?

a) yes	b) No	c)

4. Which of the inputs pose trouble to get?

a)	b)	c)	d)	

5. Where do you source the inputs?

a) other town	b) other province	c) nearby	d)

PART I: INFRASTRUCTURE DEVELOPMENT			
Infrastructure	**Available**	**Not available**	**Others**
Tarred road in the village or near farm			
Electricity			
Water in the farm			
DAFF offices			
Central market			
Internet facility			
Cell phone network			
Others			
Cell phone network			

PART J: EXPENDITURE					
1. How much generally in Rands do you spend on stocking per month?					
a)1000-3000	b)2001-5000	c) 5001-10000	d)10001-20000	e) >20000	
2. Is the business profitable?					
a) Yes	b) No				
3. What is your average profit?					
a)	b)	c)	d)		

4. How profitable?			
a) very profitable	b)barely profitable	c)not profitable	d)
5. Do you get credit from suppliers?			
a) Yes	b) No		
6. What are the biggest problem you are facing as a fish farmer			

a)	b)	c)	d)	

Appendix 4: Questionnaire for market Survey (wholesalers and retailers)

PART A: DEMOGRAPHIC AND GENERAL INFORMATION					
1. Gender	a) Male		b) Female		
2. Age (years)	a) 18-29	b) 30-49	c)50-64	d) Above 65	
3. Name of business/location :					
4. Role of respondent					
a) Owner	b) Sales person		c) Assistant	d) Others	
5. Location of business					
a)City	b)Town		c)District	d)Other	
6. Type of business					
a) Wholesale	b) Retail		c) Intermediate	d) Others	

PART B: PURCHASING AND MARKETING					
1. Where do you get your fish from?					
a) Fish farm	b) Fish market	c) Landing site	d)Wholesalers		
2. Locations where you buy your fish from					
a)	b)	c)	d)		
3. How often do you buy fish?					
a) Daily	b) More than once a week	c) Weekly	d) Monthly	d) Others	
4. In what form do you buy your fish?					
a)Live	b) Fresh	c) Frozen	d) Smoked		

5. In what form do you sell your fish?					
a) Live	b) Fresh	c) Frozen	c) Smoked	d) Salted	
6 Which market do you sell in?					
a)	b)	c)	d)		
7Are there informal freshwater fish market					
a) Yes	b) No	c)			
8 How established are these markets?					
a) well established	b) moderately established	c) struggling	d) not established		
9 Are there competition in freshwater fish buying and other fish species?					
a) Yes	b) No	**c)**			
10 Are there constraints to the growth of freshwater fish market in the province					
a) Yes	b) No	c)			
11. What are the constraints					
a)	b)	c)	d)		
12. What can be done to grow the informal freshwater fish market in the province?					
a)	b)	c)	d)		
13. What species of fish do you buy?					
a) Trout	b) Tilapia	c) Catfish	d) Carp		
14. Which group of people do you sell to?					
a) Literate	b) Semi-literate	c) Illiterate			
15. Any general complaints from buyers?					
a) Yes	b) No	c)			
16 What are the major complaints of customers?					
a) high cost	b)fish flavour	c) unavailability of fish	d)		
17. Do current fish supply satisfy your demand?					
a) Yes	b) No	c)			
18. Which fish species do people buy more?					

a) Trout	b) Tilapia	c) Catfish	d) Carp	
19. Is the business profitable?				
a) Yes	b) No	c) I can't say		
20. What advice will you give for the growth of freshwater fish market?				

Appendix 5: Questionnaire for consumer survey.

1. Nationality of respondent:			**Date:**			
2. Sex:	a) Female			b) Male		
3. Where do you live?						
3b. District/Region:						
4. Please indicate your level of education?						
a) No formal education	b) Middle School	c) Grade 12	d)First degree	e)		
5. Religion	**a) Christian**	**b) Moslem**	**c)**			
6. When did you last eat fish?						
a) Today	b) Within the week	c) More than a week ago	d) About a month			
7. How often do you eat fish?						
a) Daily	b) More than once a week	c) Weekly	d) Once in a while			
8. Which fish species do you prefer or buy most?						
9. Why that fish (Please tick as many as are applicable)?						
a)Taste	b) Price is reasonable	c)Ease of processing	d)availability			
10. Do you know the difference between freshwater fish and marine fish?						
a) Yes	b) No	c)				
11. Examples of freshwater fish are: Tilapia, Catfish, Trout, Carp etc. Which one are you familiar with?						
a) Tilapia	b) catfish	c) trout	d) carp			
12. Do you eat any of the above fish?						
a) Yes	b) No	c)				
13. Why don't you eat any of them?						

a) I don't know them	b) The taste is not good	c) I don't know where to buy them	d) Expensive		

14. Why do you eat them?

a) Nice taste	b) they are cheaper	c) It is a tradition	d) They are cheaper	

15. How much do you spend on fish per month?

a)	b)	c)

16. In what form(s) do you normally buy fish?

a) live	b) Fresh	c) Frozen	d) Smoked	e) fried			

17. Where do you normally buy it from?

a) Market	b) Cold store	c) Supermarket	d) Fish market	e) Fish farm		

18. Please indicate your regular sources of protein in order of preference (1 most preferred, 4 least preferred)

a) Meat ( )	b) Poultry ( )	c) Fish ( )	d) Bush meat ( )	