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EVALUATION OF AQUACULTURE DEVELOPMENT IN TANZANIA

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ABSTRACT

Tanzania modern freshwater aquaculture started back in 1949 when the rainbow trout (*Onchorynchus mykiss*) were introduced in the Northern and Southern Highland regions by missionaries. Despite the potential and long history of aquaculture, its contribution to the economy and food security are still low. This study aims at evaluating the status of aquaculture development in Tanzania and to come with a formative tool that addresses the potential, challenges, and suggested interventions in major areas of seed, feed and management. A total of 21,300 ponds producing 3,118 tones were observed in 2015. The main freshwater species cultured are Tilapia and Catfish, and 90% of the ponds were earthen. There is potential for investing in other technology like cages due to availability of marine and freshwater which covers 64,000 km^2 and 64,300 km^2 respectively. 8,000 seaweed farmers with the production of 1,000 tonnes per year were also observed with milkfish, crab-fattening, oysters, and shrimps as other mariculture activities. Challenges were production of quality fingerlings and fish feeds where 15 hatcheries and 5 feed producers were observed in the whole country. 73% of these hatcheries have low investment and use outdated technology producing low quantity and quality fingerlings. Feed producers have challenges in power supply, uneven availability of raw materials and limited knowledge of feed quality and formulation. Feeds are sold at 3000 Tsh per kilogram, which prices out most of farmers. Low knowledge of water quality and pond management was also observed with limited availability of water quality kits. Increasing knowledge to farmers, development of technology and investment in seed and feed production, as well as investigation into alternative protein sources for fish, and more policy harmonization and control are addressed as partial solutions to the challenges.

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ACRONYMS

EAC	-	East Africa Cooperation
EIA	-	Environmental Impact Assessment
CBOs	-	Community Based Organizations
DSM	-	Dar Es Salaam
FAO	-	Food and Agriculture Organization
NADS	-	National Aquaculture Development Strategy
NBS	-	National Bureau of Statistics
NGOs	-	Non-Government Organizations
NEMC	-	National Environment Management Council
PPP	-	Public Private Partnership
TAFIRI	-	Tanzania Fisheries Research Institute
URT	-	United Republic of Tanzania

1 INTRODUCTION

1.1 Background

Tanzania modern freshwater aquaculture started back in 1949 when the rainbow trout (*Onchorynchus mykiss*) were introduced in the Northern and Southern Highland regions by missionaries. This was followed by experimental culture of Tilapia at Korogwe and Malya in Tanga and Mwanza regions respectively, during which ponds were constructed (Balarin, 1985). In this regard, the government and Non-Government Organizations (NGO´s) assisted the communities through provision of fingerlings, technical and financial assistance.

In the past five years, inland aquaculture of Tilapia and Catfish farming has been picking up substantially whereby the number of earthen fish ponds increased from 18,200 in 2010 producing 952 tonnes per year to 21,300 fishponds in 2015 producing 3118 tonnes per year. New developments have included the establishment of 10 privately owned and five public hatcheries for Tilapia, Catfish and mariculture production. Despite that seed production is still very low; reaching slightly over 7 million fingerlings (URT, 2015). About 90% of the technology used are earthen ponds of average 200 m^2 size. The main freshwater fish species cultured include Nile Tilapia (O. *niloticus*) and Catfish (C. *gariepinus*).

Mariculture, the farming of marine organisms, was pioneered by Prof. Keto Mshigeni through promoting and introducing the seaweed farming in the 1970s (Msuya *et al*., 2007). Currently there are about 8000 seaweed farmers, where 90% are women. The farmed seaweed species includes *Eucheuma denticulatum* (*E. spinosum*) and *Kappaphycus alvarezii* (*E. cottonii*). imported from the Philippines. In 2015, Tanzania exported about 1170 tonnes of dry unprocessed seaweed to Spain, United States of America, India and China. Marine finfish and shellfish farming is another popular type of mariculture which is mostly practiced along the Indian Ocean shores in the country. It comprises of pond systems of finfish (milkfish), pearl oysters, crab fattening and one commercial shrimp farm producing 300 tonnes per year.

The Fisheries and Aquaculture Policy of 2015 addresses the aim of aquaculture sub-sector in supporting the livelihood of aqua farmers through increased income and food security and thus addressing a goal in National Strategy for Growth and Reduction of Poverty. Through the National Aquaculture Development Strategy (NADS) a set of frameworks has been done for encouraging a private sector-led commercial aquaculture development in Tanzania, to develop and promote aquaculture industry in order to increase aquatic products for local consumption and export.

1.2 Rationale

Tanzania has been experiencing a decline in production of fish catches from the wild due to climatic changes, environment degradation, overfishing and illegal fishing. Meanwhile the demand of fish and fishery products is increasing where fish consumption is still low, at 8 kg/person/year (NBS, 2013) compared to 18 kg/person/year recommended by Food and Agriculture Organization (FAO). Aquaculture is a promising alternative source to cover the gap of fish demand and reduce the pressure of fishing from the wild. But evaluating its potential, the sub-sector faces several challenges including availability of quality cultured seeds and fish feeds, enough skilled personnel for providing extension services, adequate knowledge and skills for farmers to practice aquaculture commercially and reliable and adequate information (URT, 2015). Most of the ponds have average size of 200 m^2 and produce 180 kg

of fish after 6-7 months of culture. This may be due to use of low quality seeds, feeds and poor farm management. It also has been shown less interest from investors, decision and policy markers, and donors due to low availability of data, information and promotion.

This study aims at evaluating the status of aquaculture development in Tanzania and creation of a formative tool that addresses the potentials and challenges and suggests interventions in major areas of seed, feed and management. The study will be useful for the government for execution of the National Strategy for Growth and Reduction of Poverty through aquaculture.

2 RESEARCH OBJECTIVES

In Tanzania there is currently insufficient knowledge at governmental, private sector and international level about the status and potential for sustainable aquaculture development. A detailed evaluation will be done stressing in areas of seeds production, feeds production and management of farms to come up with potentials and suggestive interventions. The goal is to put together information that will be presented and discussed at the Department of Aquaculture Development in Tanzania. These can be helpful for decision making, planning and disseminated to aquaculture stakeholders. Therefore, increased knowledge and aquaculture production in Tanzania will be achieved.

2.1 General objective

- To make a detailed assessment of the aquaculture development in Tanzania

2.2 Specific objectives

- Assessing the present situation regarding aquaculture production through questionnaires.
- Point out the limitations, threats strengths and opportunities for development of aquaculture in Tanzania in seed, feed and farm management areas.
- Develop interventions to overcome the weakness and threats facing aquaculture in Tanzania.

3 LITERATURE REVIEW

3.1 World Aquaculture Production

Until 40 years ago, fish production by aquaculture was less than 5% of global fish production. Now, with the demand for fish to meet human needs, aquaculture products make up 40% (Figure 1) of global fish production (FAO, 2016). In 2014, 73.8 million tonnes of fish including crustaceans and molluscs was reported harvested from aquaculture with an estimated first-sale value of US$160.2 billion, consisting of 49.8 million tonnes of finfish (US$99.2 billion). Almost all fish produced from aquaculture are destined for human consumption, although by-products may be used for non-food purposes. Among all continents, Africa has shown slower trend of an increasing share of aquaculture production in total fish production especially in sub-Saharan countries.

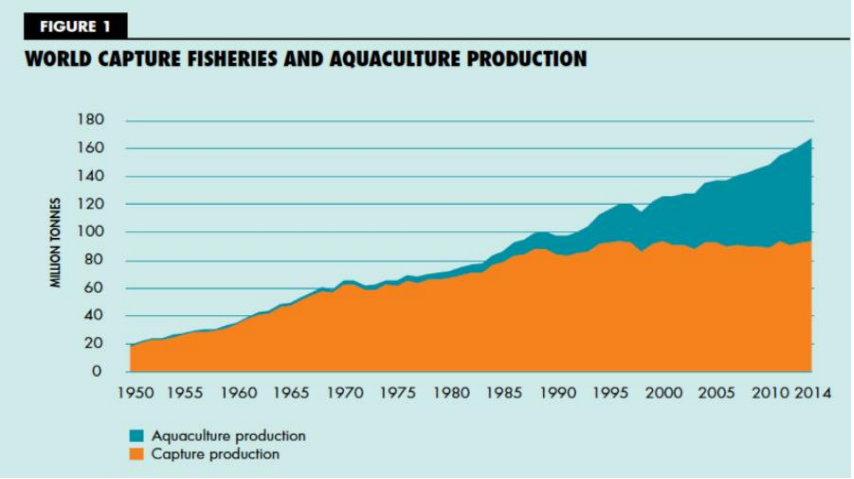

Figure 1: The development of global fish production until 2014 (source FAO, 2016)

3.2 Aquaculture Development in East Africa Countries

Due to increasing population and economic growth the demand for food (fish) in the East Africa Community (EAC) is growing. There has been a positive growth of fish farming production in all regions. Investments in aquaculture are growing in the last few years in Uganda and Kenya, in order to increase production capacity. Employment in the EAC aquaculture sector as a whole is also growing and can potentially grow further with more investments. The importance of aquaculture is rising, and this sector will be of relatively more important for EAC economy in the coming years.

In 2015, production in Tanzania was still low compared to other (EAC) countries. The growth in neighbouring countries is a positive indication that aquaculture has potential to grow in the region (Rothuis *et al.*, 2014). In Uganda and recently in Kenya, cage culture of Tilapia is getting increasing interest and attention. Studies by Boyd (2004) suggested that expansion could go to 100,000 tonnes/yr potential in all of Lake Victoria, with minor environmental consequences. The production of aquaculture in East African countries are as shown in Figure 2.

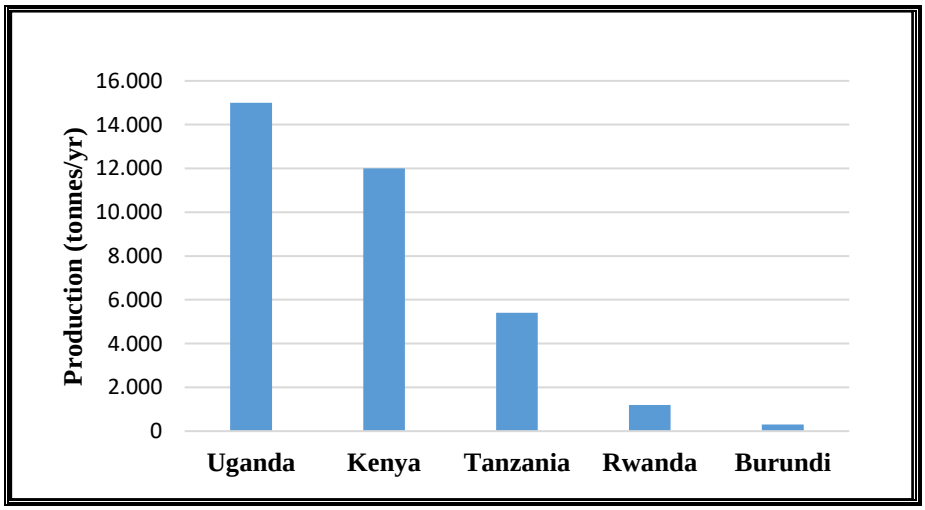

Figure 2: Aquaculture Production in East Africa in 2013 (Rothuis *et al.*, 2014)

3.3 Aquaculture in Tanzania

3.3.1 Aquaculture policy

Aquaculture development in Tanzania is implemented under the Fisheries Act of 2003 which led to the formulation of the National Fisheries and Aquaculture policy of 2015 and Fisheries and Aquaculture Regulations of 2009. Other inter sectorial Acts includes Environmental Management Act 2004 and Water Resource Management Act 2009. The competent authority of Aquaculture in Tanzania is the Director of Aquaculture Development Division which is under the Ministry of Agriculture, Livestock and Fisheries. Together with the Minister and the Permanent Secretary, they all play role in implementing aquaculture activities in a friendly and sustainable way.

The regulations have directed the procedures to take when one wants to start an aquaculture related project or a farm. The procedures for small and large scale farmers differs where the large scale farmers (having a water surface area of five hectares or more for breeding or raising fish) need to conduct Environmental Impact Assessment (EIA) through the National Environment Management Council (NEMC). The procedures are simple and easy to administer thus giving a room for local and foreign investors. There is also formulation of guidelines in progress for hatcheries, feed production, farms, aquariums and storage of aquaculture production which are intended to be used for management and control. The procedures for starting an aquaculture farm are shown in Figure 3, where the explanation is divided for small scale farm (not exceeding one hectare) and large and commercial farms (five hectares and above).

For the farms with size between one and five hectares the regulations do not state whether there should be an EIA or not, so this will depend on the pre-assessment of the project by an authorized officer.

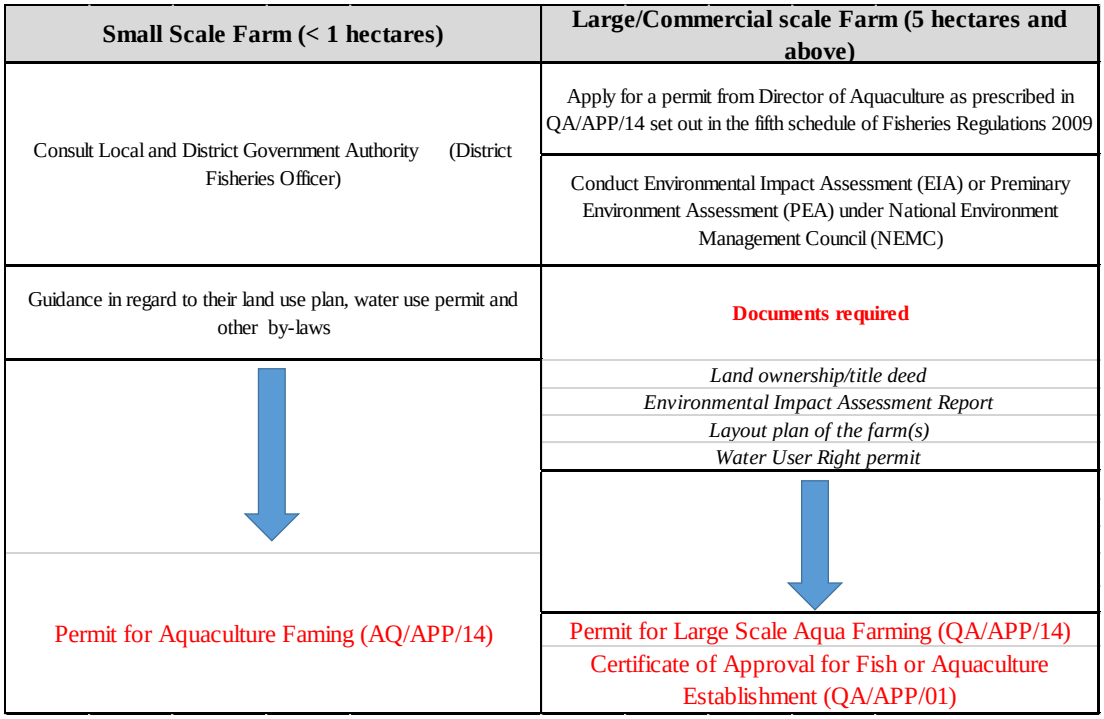

Figure 3: Procedures for starting an aquaculture farm in Tanzania.

3.3.2 Potential and trend of aquaculture production in Tanzania

Tanzania is a country with great potential in both inland and marine aquaculture. With the coastal line of 1400 km and marine water which covers 64,000 km^2 it gives opportunity to both inland based and cage mariculture practices (URT 2015). There are plentiful of fresh water resources found in the shared waters of Great Lakes namely, Lake Victoria, Lake Nyasa and Lake Tanganyika. The country is endowed with other small natural and man-made lakes, rivers systems and wetlands, all with 64,300 km^2. The country is also characterized with spatial temperature variations.

The fish market is categorized into marine fisheries and the fresh water fisheries where fish processing for exports to European Union, Asia and America is mainly done along the Indian Ocean coast and in the Lake Victoria Zone. However, there is still a large market within the country with a total population of 45 million (NBS, 2013) and within the Great Lakes Region. Tilapia which is the main *spp* cultured contribute to 16% of the total catch from Lake Victoria (Rothuis *et al.*, 2014).

Aquaculture has been identified as an area of opportunity but is yet not highly developed in Tanzania. Its contribution in the growth of GDP for the last five years is significantly less than 1% (NBS, 2014). The production (Figure 4) involves Tilapia and Catfish species from freshwater and seaweed, crabs, milkfish and prawns from mariculture. The sector is still characterized by limited number and quality of aquaculture inputs (seeds and feeds), low technology, limited knowledge and low level of investment.

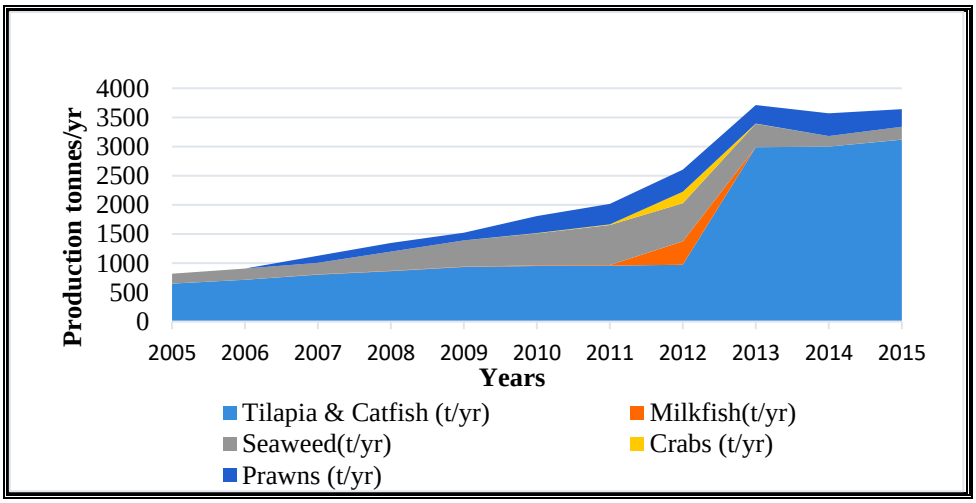

Figure 4: Trend of aquaculture production in Tanzania (URT, 2015; FAO, 2016)

3.3.3 The trend of ponds increases and extension services

Number of ponds has increased in the past 10 years from 13.011 in 2005 to 21.300 in 2015 (Figure 5). In 2009 the Aquaculture Development Division brought more service near the farmers through nine aquaculture centres established countrywide. The centres have the role of producing quality fingerlings and feeds of low price, provision of extension services and promoting aquaculture in the regions. The challenges facing these centres is lack of infrastructure, where among nine centres, only four have infrastructures for fingerlings production. They also have limited number of personnel and funds. The Local Government

Authorities also has a role of promoting aquaculture and provision of extension services through Fisheries Officers located at the Districts and Region level. Local and international NGOs and private sector have been helping the sub-sector too through Public Private Partnership (PPP).

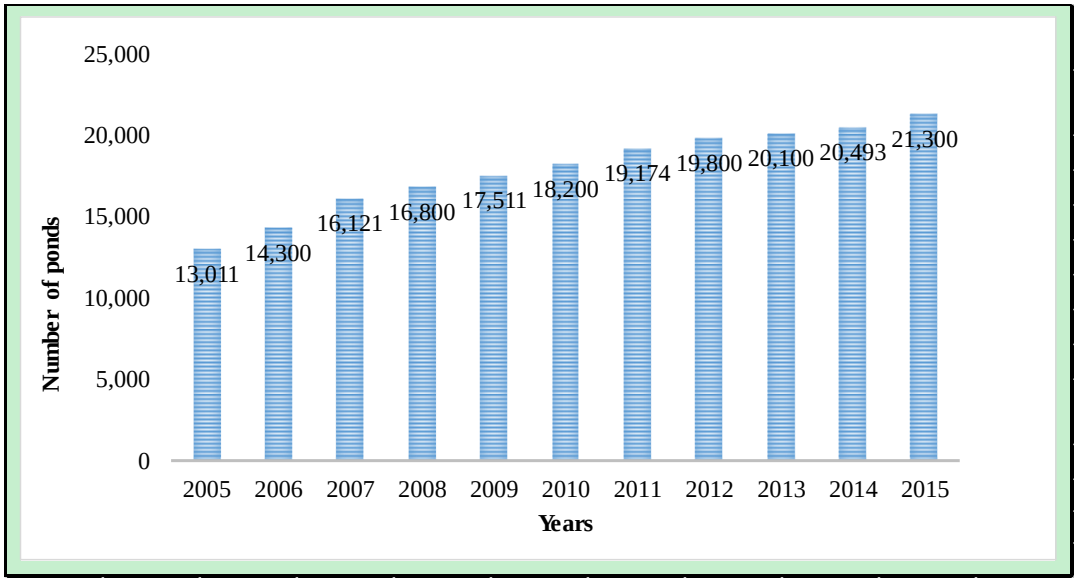

Figure 5: The trend of number of ponds in Tanzania 2005-2015

3.4 Aquaculture Development Key Issues

The "systems approach" to aquaculture development is said to recognize the diversity of influences on aquaculture development, and is a multifactorial and multidisciplinary. It shows how aquaculture systems function and study how aquaculture can be affected by different factors and develop solutions to problems that are identified (Edwards, 1998). The analytical approach has been shown to contribute in identifying issues, develop better management solutions, increase the efficiency of the business, design and testing new aquaculture systems and develop more effective extension and education approaches (Philips *et al.*, 2000).

According to Edwards (1998) and Smith (1999), in production management a systematic approach allows the farmer to control and manipulate production inputs to get better results, cost-effective production and maximized outputs and negative environmental impacts. The key components in aquaculture management for better results are:

- Quality fingerling availability and distribution; this is a major constraint to non-commercial and commercial aquaculture development in many countries.
- Feed availability and cost; if farmers have high quality feeds for reasonable price, the sector expect to have positive development.
- Good management practices; various water quality parameters need to be monitored such as temperature, dissolved oxygen, acidity (pH) and salinity.

4 METHODOLOGY

A qualitative method is used in this study where data was collected through literature and interviews. SWOT analysis was used to provide the formality for evaluation of the information.

4.1 Study design

Information for the study was created in two ways; assembly information through reviewing relevant published and unpublished literature from reports, journal articles, workshops and official government documents, and data collection in the study areas through interview. The study areas involve hatcheries, fish feeds factories and fish farms. The interview involves people working in the areas, i.e. in hatchery and farm management and feed production. A profound questionnaire (Appendix I) containing all important information regarding the management and the chain of production was administered. The aim is to see what is really going on ground zero to come with the study and develop interventions. Phone calls and visits where used.

4.2 Study tools

The specific tool used in this survey are questionnaires (Appendix I). They are used to get information from individual hatcheries, fish feeds factories and fish farms managers who give their knowledge and relevant information for the study topic. Broodstock source, types of feeds, source of raw materials, feeds and seeds prices, water quality management, level of performance and production are kinds of questions that are asked according to the premise.

4.3 Study area

The study area is Tanzania Mainland as a whole but the field survey is focused on 18 aquaculture units from three geographical and climatic zone namely; Lake zone (Mara and Kagera Regions); Southern Highlands Zone (Mbeya and Ruvuma Regions) and Eastern Zone (Dar Es Salaam, Coast and Tanga Regions) (Figure 6).

4.4 Sample size and sampling procedure

Eighteen (18) aquaculture premises from three geographical and climatic zones responded to the questionnaire (Appendix I) are shown in Table 1. The units here mean hatcheries, feed factories and fish farms were selected according to their activeness and level of production and management.

Table 1: Hatcheries, feed producers and fish farms used in the study.

Geographical Climatic zones & Regions	Aquaculture Establishments	Name of the Establishment
Lake zone (Mara & Kagera)	Hatchery	Ruhanga &JB Fish Culture Limited
	Feed producer	Ruhanga &JB Fish Culture Limited
	Fish farm	Ruhanga &JB Fish Culture Limited
	Fish farm	Baruti Fish Farm
Southern highlands (Ruvuma & Mbeya)	Hatchery	Ruhila Aquaculture Center
	Fish farm	Soffa Fish Farm
	Fish farm	Ndunguru Fish Farm
	Fish farm	Mfyule Fish Farm
	Fish farm	Gamma Fish Farm
	Feed producer	Igomela Farm Limited
Eastern zone (Dar es salaam, Coast & Tanga)	Hatchery	Eden Agric.Aqua Farm
	Hatchery	Safina Big Fish Farm
	Hatchery	Machui Aquaculture Centre
	Fish farm	Eden Agric.Aqua Farm
	Fish farm	Safina Big Fish Farm
	Fish farm	Boko Fish Farm
	Feed producer	Eden Agric.Aqua Farm
	Feed producer	Safina Big Fish Farm
Total 18 establishments		

5 RESULTS

5.1 Existing Hatcheries Ponds and Feed Producers

In recent years aquaculture development has shown positive development in Tanzania. It has included the establishment of hatcheries, feed factories and farms. By 2016 the number of hatcheries registered and producing fingerlings were 15, privately and government owned. Among these 12 are for Tilapia and Catfish and two are designated for marine *spp*. These hatcheries and five feed producers present, are not equally distributed across the country where most are found in Dar es Salaam and Coast Region (Figure 6). This makes it difficult for the farmers to transport fingerlings and feeds within long distances which brings more expenses and may cause mortalities to the seeds.

According to the URT (2015) the total number of ponds were approximately 21,300. Most of the farms are situated in Ruvuma, Mbeya, Iringa, Arusha and Kilimanjaro regions where the number of ponds exceeds 1000 in each region (Figure 6). Most of these farms are extensive culture systems. However, there is a vast need of data validation since they are based on raw data and assumptions and no inventory has been done for more than 10 years. Due to the establishment of aquaculture in new regions of Njombe, Simiyu, Geita, Songwe and Katavi, inventory is also needed to know exactly the number of ponds and aquaculture premises for management and administrative purposes. The rapid growth has been shown also in urban and neighbouring areas e.g. Dar Es Salaam and Coast, where people are investing in semi-intensive culture systems, hatcheries and feed production.

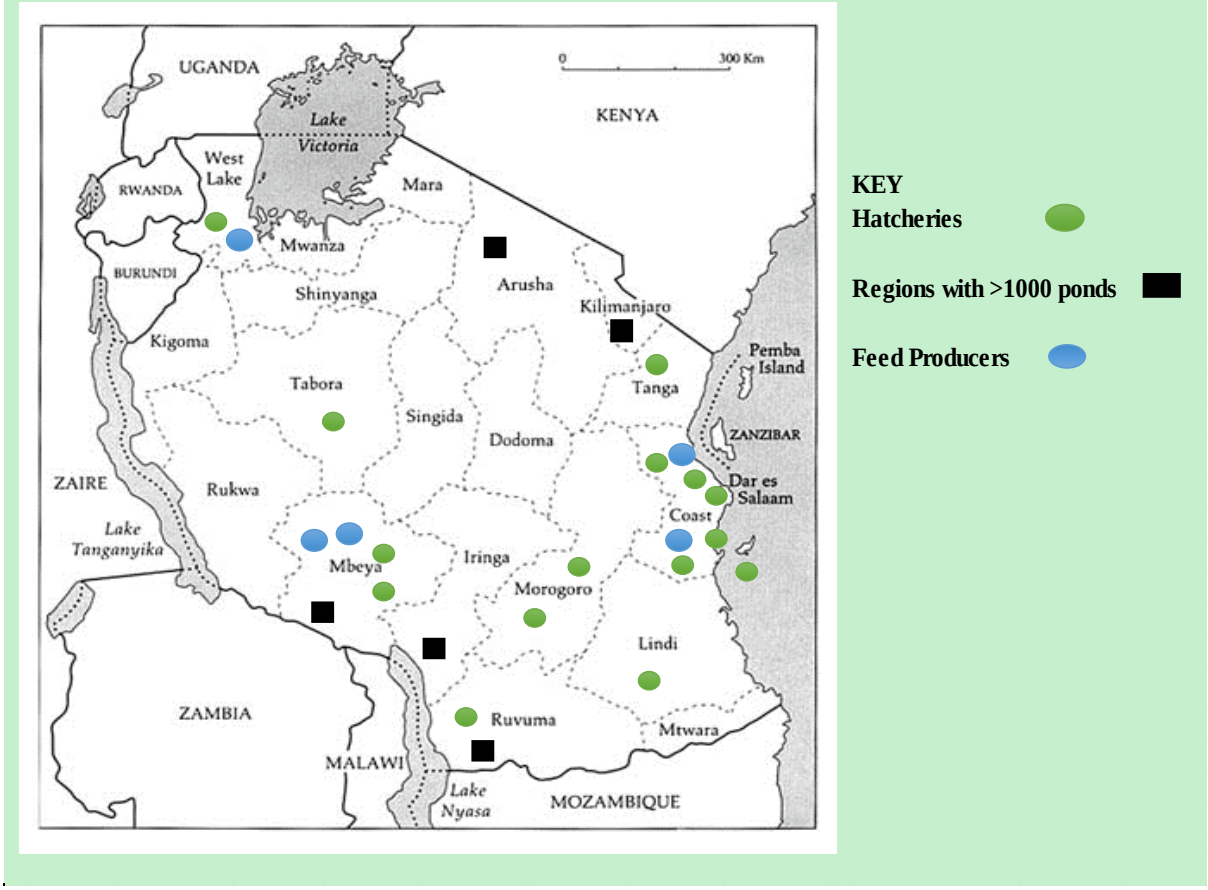

Figure 6: The map of Tanzania mainland showing regions with large number of fish ponds (>1000) and distribution of 15 hatcheries and 5 feed producers (URT, 2015)

5.2 Seeds (fingerlings) Production and Management

5.2.1 Hatchery technology

The seed production is done by government and private sector. The hatcheries are categorized into indoor and outdoor. The indoor hatcheries (most privately owned) have simple technology of tanks, glass jars and pipes for hatching. Tilapia brood stocks are cultured in ponds and egg collection is done in hapas. Eggs are collected in the mouth and taken into hatchery for hatching. After a time, they are taken to another pond where they are fed with feeds mixed with sex hormone to produce monosex fingerlings. The outdoors hatcheries containing ponds where broodstock are cultured and reproduce and collection of fingerlings is done. The stocking density of the parent fish differs from one *spp* to another from 4 m^2 for Tilapia to 7 m^2 for Catfish (Table 2). The ratio of female to male fish is 3:1 in ponds.

The indoor hatcheries are characterized by low level of investment and limited power supply. This makes them to produce under their capacity thus the total number of fingerlings produced is less than the demand.

5.2.2 Brood stock source

Broodstock source is both from the wild and from breeding stations in Uganda and Thailand for Catfish and Tilapia respectively (Table 2). This increases the expenses for the farmers to

import the fish parents from outside the country. The wild parents are obtained from Lake Victoria for Tilapia and rivers for Catfish in a size of 200-250 g and 1000 g respectively. The detailed information of the seven interviewed hatcheries are shown in Table 2

Table 2: Fingerlings production and management in interviewed hatcheries

FINGERLINGS PRODUCTION AND MANAGEMENT														
Name of hatchery	Region	Type of hatchery	Type of *spp*	Current spp produced	Broodstock source	Ratio of brood stock	Weight of broodstock (gm)		Stocking density		First feeding		Time of culture before selling	Weight during selling
							Tilapia	Catfish	Tilapia	Catfish	Tilapia	Catfish		
Eden	DSM	Indoor	Tilapia, Catfish	Tilapia, Catfish	*Tilapia* -Breeding station (Thailand), *Catfish* -wild	F: 3 M:1	F: 300 M:350	F: 1000 M:1000	4m^2	7m^2	Powdery fish meal	*Artemia*	5-6weeks	5gm
Safina	DSM	Indoor	Tilapia, Catfish	Catfish	Breeding station (Uganda)	F: 3 M:1		F: 1000 M:1000		8m^2		*Artemia*	5weeks	5gm
Machui*	TANGA	Outdoor	Tilapia, Milkfish, Mullet	Tilapia	Wild (Ocean, rivers)	F: 3 M:1	F: 300 M:250		28/tank		Powdery fish meal		3weeks	1gm
Ruhila*	RUVUMA	Outdoor /Indooor	Tilapia, Catfish	Tilapia	Wild (L.Victoria, rivers)	F: 3 M:1	F: 200 M:250		4m^2		Moina		3weeks	1gm
Ruhanga	KAGERA	Indoor	Tilapia, Catfish	Catfish	Breeding station (Uganda), wild	F: 3 M:1		F: 1000 M:1000		7m^2		*Artemia*	4-6weeks	5gm
Kingolwira*	MOROGORO	Outdoor	Tilapia, Catfish	Tilapia	Wild (L.Victoria, rivers)	F: 3 M:1	F: 200 M:250	F: 800 M:1000	4m^2	7m^2	Moina, algae		3weeks	1gm
* Government owned														

5.2.3 Hatcheries production capacity

The production of government hatcheries is less than the private owned (Figure 7) due to different level of investment and technology used. The private hatcheries have managed to produce mono sex Tilapia by 17α-methyl testosterone through start feeding. The artificial production of Catfish is still a challenge to both hatcheries and the mortality of (30-80) % has been observed. The hatcheries feeding the fry with *Artemia* (mostly private) has experienced reduction in mortality. The prices of fingerlings differ where it is more expensive in private hatcheries. Tilapia fingerlings are sold for 50 Tsh at government hatcheries and 200-300 Tsh at private and Catfish for 200 Tsh at Government and 400-500 Tsh at private.

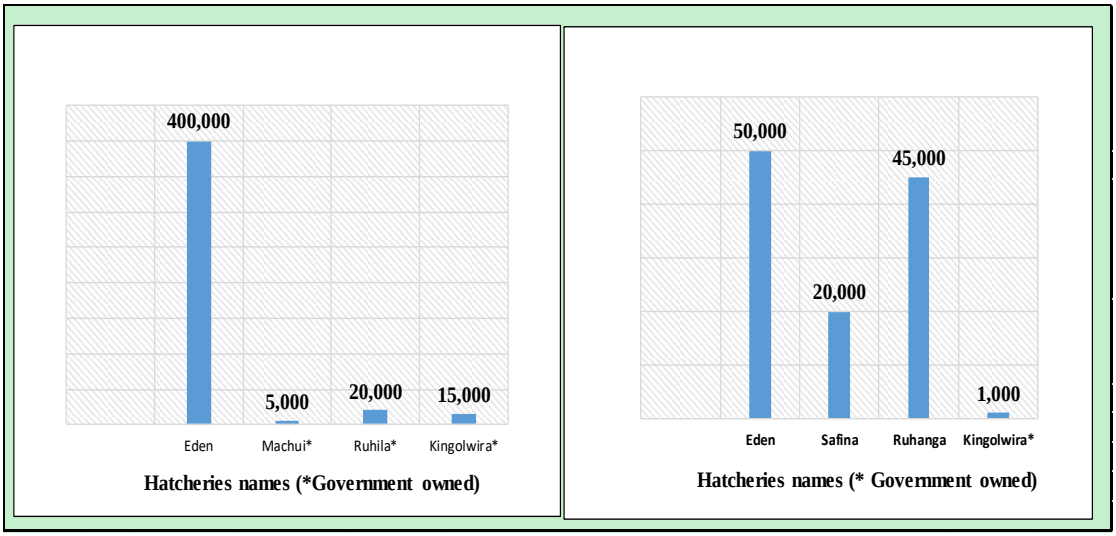

Figure 7: Number of fingerlings of Tilapia (left) and Catfish (right) from interviewed hatcheries per month

5.2.4 Brood stock and fingerlings feeding and mortality

The brood fish are fed natural and supplemented feeds obtained from feed producers and others produce their own food. The raw materials used are cassava flower, rice bran, sunflower oil, fish meal, soya bean meal, sunflower seed cake, blood meal and sea foods cuttings and offals. The feeding regime is twice per day. Provision of quality feeds is important aspect in brood stock management.

The first feeding (feed types) of Tilapia and Catfish and feed regime were different. The feeding ranges from live food of enriched *Artemia*, for Catfish and moina, algae and powdery fish meal for Tilapia. The hatcheries observed different mortality rate of 1% and 5% (Table 3). The feeding regime was up to sixth times a day and the mechanism of feeding is hand-fed.

Table 3: First feeding, mortality rate and production /month of interviewed Tilapia hatcheries

Name of hatchery	First feeding	Mortality rate (%)	Production (no/month)
Eden	Powdery fish meal	1	400,000
Machui*	Powdery fish meal	5	5,000
Ruhila*	Moina	5	20,000
Kingolwira*	Moina, algae	5	15,000
* Government owned			

5.3 Feed Production and Management

5.3.1 Feed production procedures

Feed is the most important input in aquaculture production for the high growth and quality of the fish, but it is also the input with the highest cost. The survey was done for four feed

producers among the five existing in the whole country. These are the ones which produce feed for the aim of selling to farmers. Farmers who produce their own feed locally for their fish were also interviewed.

All commercial feed producers are producing powdery and pelleted fish feed. The machines were imported from Asia. The raw materials are both locally available and imported from Kenya.

5.3.2 Feed raw materials availability and costs

Raw materials used are cassava flower, rice bran, sunflower oil, fish meal, soya bean meal, sunflower seed cake, blood meal and sea foods cuttings and offal. The availability of raw materials is not constant. For the agricultural inputs, they are highly available during harvesting time (May-July). Fish meal is available in sardine peak time during inter- monsoon winds (March-April and November-December).

Farmers who produce feeds for themselves use locally available machines to produce both powdery and un-floating pellets. They obtain raw materials from local market (animal feeds and milling centres). Cheap raw materials like cassava flower, rice bran, maize bran and cotton seed cakes from processing factory are normally used. The price of 3000 Tsh/kg for the formulated feed from the producers is high for most of extensive fish farmers who are more than 90% of total farmers. The detailed feed production and management of the interviewed producers is shown in Table 4.

Table 4: Feed production and management

FEED PRODUCERS AND PRODUCTION MANAGEMENT											
Name of feed producer	**Region**	**Type of feeds**	**Floating time (hrs)**	**Source of raw-materials**	**Regions/country coming from**	**Types of raw materials**	**Availability**	**Production (tonnes/year)**	**Distribution (regions)**	**Market demand**	**Price/kg (Tshs)**
Eden	DSM	Pellets(extruded) powdery	Unknown	Local	Zanzibar, Singida, Mwanza	Cassava flower, Rice bran, sunflower oil, fish meal and soyabean meal	Medium	1080	DSM, Coast, Kilimanjaro	High	3000
Safina	DSM	Pellets(extruded) powdery	Unknown	Local, imporeted	Mwanza, DSM, Singida, Imported-Kenya	Sunflower seed cake, fish meal and soyabean meal, bood meal and maize bran	Medium	800	DSM,Mbeya, Kilimanjaro	Medium	3000
Ruhanga	KAGERA	Pellets(extruded) powdery	Unknown	Local	Kagera, DSM	Maize bran, Rice bran, Fish meal and sea foods	Medium	1000	Kagera, Mwanza, Mara	High	3000
Igomela	MBEYA	Pellets(extruded) powdery	Unknown	Local	Mbeya, Iringa	Sunflower seed cake, fish meal and soyabean meal, bood meal and maize bran	Medium	500	Mbeya, Ruvuma, Iringa, Njombe	High	3000

The costs of raw materials differ from one source to another where the protein source and sunflower oil are the more expensive (Table 5).

Table 5: Average price s of raw materials in 2016

Prices of raw materials	
Type of raw materials	**Price (Tshs/kg)**
Cassava flower	800
Rice bran	300
Sunflower oil	4000
Fish meal	2600
Soybean meal	800

5.3.3 Feed quality and composition

The quality and floating capability of the produced feeds was not well known by surveyed respondents (Table 4). Information on feed formulation and composition was not easy to access and seems rather unclear. The chain of production from storage of raw materials to the drying of processed pellets makes the feed exposed to contamination and loss of nutrients. The raw materials and feeds are stored in polythene bags and sometimes kept direct to the floor where the moisture can cause moulds due to high temperature. The lipids in the diet might also be prone for rancidity during the drying and storage period (Figure 8).

Figure 8: The chain of fish feed production

5.4 Farm Management and Production

5.4.1 Farm technology and culture systems

Most of fish farmers use pond technology either earthen or concrete for fish grow out culture (Figure 9). Source of water are rivers, streams, wetlands and few use water from wells. Some have experienced shortage of water during dry season. The knowledge of pond construction is present and most of the ponds are well constructed with required depth of 1-1.5m, inlet, outlet

and average size of 200m^2. The decision on the size of the pond depends on the level of economy of the farmer where some have few 1 hector size pond. The problem is the management, especially for extensive system farming where ponds may contain mud, grasses and flocked inlets and outlets.

Figure 9: Earthen and concrete ponds used by most of the fish farmers

5.4.2 Fingerlings source and availability

The fingerlings sources vary from hatcheries to the wild (Table 6). Due to low availability of hatcheries across the country, some of the farmers takes long distances ranging, from between 20-650 km, to buy fingerlings. Some of the fingerlings are obtained from neighbouring countries like Kenya and Uganda. This increases expense to the farmers and might cause mortality due to stress during transportation.

The fingerlings are either mixed or monosex (all male) Tilapia. The price of fingerlings differs between government and private owned hatcheries. Catfish seeds are higher in price than Tilapia seeds. Farmers who cannot afford buying fingerlings from the hatcheries get it from the wild or among themselves.

The management of the nine farms that were interviewed is shown in Table 6.

Table 6: Farms, source of fingerlings, prices and stocking density

FARMS MANAGEMET AND PRODUCTION								
Name of farm	**Fingerlings source**	**Distance from source (km)**	**Types of fingerlings**	**Price of fingerlings (Tshs)**	**Stocking density (no. of fish/m^2)**		**Weight of fingerlings during stocking (g)**	
					Tilapia	***Catfish***	***Tilapia***	***Catfish***
Eden	Hatchery-Eden	0	Monosex	200 (*Tilapia*) 500 (C*atfish*)	2	20	5	10
Safina	Hatchery-Safina	0	Monosex	300 (*Tilapia*) 400 (C*atfish*)	8	15	5	10
Boko	Hatchery- Bigwa	165	Monosex	400		10		10
Ruhanga	Hatchery, Wild	50	Mixed sex	300	4	12	6	40
Gamma	Hatchery-Ruhila	20	Mixed sex	50	2		2	
Ndunguru	Hatchery-Ruhila	40	Mixed sex	50	4		2	
Mfyule	Hatchery-Ruhila	23	Mixed sex	50	2		2	
Soffa	Hatchery-Ruhila	0	Mixed sex	50	2		2	
Baruti	Hatchery-Kenya	650	Monosex	300	4	10	20	20

5.4.3 Fish feeding and management

The grow-out fish are fed natural and supplemental feeds obtained from feed producers and others produce their own food. The fish of 1-2 months' age are fed with powdery feeds and 3-7 months fed with pellets. Due to high cost of pellets (3000 Tsh/kg) others use powdery feed throughout the culture period.

Mixed sex fish observed a retarded growth compared to the monosex (all male Tilapia). Type of feeds and the level of management also determine the weight of the final product. The culture period ranges between 5-8 months as shown in Table 7.

Table 7: Farm management and production

FARMS MANAGEMET AND PRODUCTION										
Name of farm	**Feed type**	**Source of supplement feed**	**Water quality measuring kits**	**Weight of fish at harvesting (g)**		**Growing time (months)**	**Production (t/year)**		**Price (Tsh/kg))**	
				Tilapia	***Catfish***		***Tilapia***	***Catfish***	***Tilapia***	***Catfish***
Eden	Natural, supplements	Formulated	YES	400	800	5			7000	6000
Safina	Natural, supplements	Formulated	YES	600	1000	6	100	200	7000	6000
Boko	Natural, supplements	Locally made	NIL		1000	8		250		6000
Ruhanga	Natural, supplements	Formulated	NIL	600	1000	8	100	48	6000	6500
Gamma	Natural, supplements	Locally made	NIL	200		6	0.6		5000	
Ndunguru	Natural, supplements	Locally made	NIL	230		6	0.5		5000	
Mfyule	Natural, supplements	Locally made	NIL	250		7	1		6000	
Soffa	Natural, supplements	Locally made	NIL	250		7	2		6000	
Baruti	Natural, supplements	Formulated	NIL	500-800	1000-3000	8	100	80	8000	6000

5.4.4 Water quality management

Water quality management is done locally either by sight or hand palm by 80% of the farmers. There is no availability of water quality measuring kits. Also the knowledge of the effect water quality on the growth and wellbeing of the fish is not common. This causes the control of oxygen, pH, salinity, turbidity and ammonia not to be payed proper attention. Limited availability of water especially during dry seasons cause problems to fish and high mortality and slow growth is observed due to stress. Knowledge on disease control is still limited to most of the farmers but fortunately there hasn't been any disease breakout incident registered.

5.4.5 Harvesting storage and market

Harvesting is done either by total harvesting or partial, where nets are typical gears used. Storage facility like cold rooms, ice etc. are very limited due to power problems and level of economy of most farmers so the fish products are very prone to post harvest loss. The market point for all the farms is either on farm or neighbour fish market and the price for one kilogram of fish were between 5000-8000 Tsh for Tilapia and 5000-6000 Tsh for Catfish (Table 7).

5.5 Summary of the analysis of the aquaculture development in Tanzania

The summary is outlined in Table 8.

Table 8: The summary of the overall analysis of aquaculture development in Tanzania

Opportunities
• Abundant availability of water resources • Good environment conditions • Political will to develop aquaculture • Availability of cheap labour • Simplicity in establishing a fish farm • Good organization structure (central to local government) • Responsive policy and environment for investors • Availability of hatcheries • Open to new technology (opportunity to intensive system) e.g. cages • Market opportunity both local and within the region • Change of eating habit (preference of fish from red meat) • Decline of fish production from wild
Challenges
• Limited access of floating feeds • Lack of quality brood stock • Limited quantity and quality seed production • Low economy of the farmers hence less investment • Limited knowledge of fish pond management • Limited knowledge of health care of fish • Limited access to power (electricity) • Diseases outbreak • Market competition due to highly importation of fish • Low quality products • Environment constraints (climate change) e.g. droughts • Environment Pollution • Escapees (gene interaction and dominance to the wild) • Limited established market system • Limited storage facilities • Poor infrastructures

6 DISCUSSION

6.1 Seed production and culture technology

In fingerling production, the technology used is the limiting factor, especially for outdoor ponds, where it does not give opportunity for separation of fingerlings according to age and size. It has been shown that the hatcheries with indoor technology (privately owned) have high production of fingerlings and lower mortality compared to those with outdoor facilities. The private hatcheries e.g. Eden and Safina are doing well compared to the government hatcheries. This may be due to limited funds and low budgets directed to fisheries and aquaculture sector which makes difficulties in inverting proper technology and management in the government hatcheries. Most of the Government hatcheries needs rehabilitation and have few human resources. They are using outdated technology of mixing the parents and fry together which causes competition in feeding and space thus cause stunted growth. Interbreeding can occur also since Tilapia is said to mature at ca 60-120g, 3-4 month after release in ponds (Shoko *et al.*, 2015; Duponchelle *et al.*, 1998). All these may cause the production of low quantity and quality fingerlings.

The government has been proved failure in conducting and managing businesses. This may be due to less accountability and motivation in some civil servants. To solve this problem, the government should not engage itself in business and should remain as policy implementer, research conductor, quality controller and knowledge disseminator. There should also be more funds allocations to aquaculture subsector and aquaculture professionals should continue promoting and create awareness of importance of aquaculture to the country. This should go in hand with using the funds available as planned. That will make decision makers, donors and other stakeholders willing to support aquaculture as they will see tangible developments.

The lack of breeding programs in the country has caused some farmers to import the fish parents from outside the country which increases expenses, and may be the cause of gene interaction and dominance to the wild species if not well managed and escapee occurs (Shamsuddin *et al.*, 2012 and Thorstad *et al.*, 2008). Other hatcheries use brood stock from the wild. The use of different sized brood stock from the wild may affect the egg quality and fecundity. They are also highly characterized by inbreeding and may cause disease transfer from the wild to the hatchery. But since starting a breeding station may cost a fortune in regarding to the economy of the country, GIFT Tilapia used as brood stock which have already been imported from Thailand by a private hatchery can be managed and preserved. This can be done by multiplying their good and improved genetic materials in the farm and distribute the produced fish to other farmers. This can be done by either Tanzania Fisheries Research Institute (TAFIRI), Universities or Government Aquaculture Centres. For example, with the agreement with Thailand government, TAFIRI can get new improved fish, semen or fertilized eggs and distribute to selected hatcheries across the country which are doing well. These hatcheries will then produce brood stock and quality fingerlings and sell them to the farmers. This will also prevent the problem of interbreeding and risk of disease transfer.

Rehabilitation of already existing hatcheries in terms of developing the technology, increasing the infrastructures, access to power and adequate supply of water and farmers is needed for them to meet seeds and feeds demand in terms of quality and quantity. Also there is a need of establishing more aquaculture premises in areas where they are not existing. This can be done by collaboration between the government, private sector and NGOs.

Each can play its part and as said earlier since the government has shown un-impressive progression in terms of production it can remain as the policy implementer, quality controller and extension provider. The government should provide good environment and subsidies to the private fingerlings producers, so they can reduce the cost of production thus sell the fingerlings at reasonable prices that can be afforded by most farmers.

In terms of grow out culture technology there should be a motive to open to new technology (intensive system). There is an opportunity and potential for establishment of other aquaculture technologies like cage culture and ornamental fish. Although 90% of farmers use earthen ponds, interest in cage aquaculture in lakes and other water bodies by local and foreign investors has increased. Examples have been shown in neighbouring countries of Kenya and Uganda where investments in cage culture have been done in Lake Victoria of which is shared together with Tanzania. In Uganda cage culture started comprehensively in 2006 using cages of 4 - 9 m^3 with total production of 2,500 tonnes/yr (Boyd, 2004l; Censkowsky, 2013).

Cages can produce up to 75-300 kg m^{-3} at a stocking density of 100 to 400 fish / m^{-3} under good management practices (Ofori *et al.*, 2009). This is due to abundant availability of water which reduces the growth limiting factors that can be caused by water quality. Other advantages of cage culture are; they are not requiring re-filling of water, easily handling, breeding can not to occur in cages, - thus mixed sex fish can be cultured, fish predators are easily controlled, survival rates of fish are higher under good management and feeds are efficiently utilized.

This should go in hand with the promotion and establishment of more floating feed producers since they are very important in cage culture technology. They reduce feed loss and possibility of sedimentation if they could fall at the bottom and settle. In a study done to see the impact of Atlantic salmon (*Salmo salar*) cage culture in Mjoifjordur, Eastern Iceland on the chemistry of the sediment, revealed a significant increase of total organic matter, total organic carbon, total nitrogen and phosphorus in all analysed parameters in a station (Shakouri, 2013)

There is an opportunity to increase the production from the existing ponds by improving the seeds, feeds and management of them. This can be learnt from countries with successful pond culture history like China where Tilapia pond production is large. With the density of 30,000 Tilapia fish per acre, the yield can be 12,000 kilograms per acre (Likang, 2010). Also, Tilapia culture water need to be rich in nutrients and fertilization is very important.

6.2 Feeds production

Feed formulation and feeding management is an important aspect that should be considered sensibly. It has been shown in the study that extruded fish feed production is still low in the country and is sold at a price that cannot be afforded by many farmers. The tendency of using natural and low quality supplement feed causes low production yield and limited profit. Provision of quality feeds is important aspect in brood stock and grow out fish management, since it affects egg quality and brood stock fecundity. According to El-Sayed (2006), Tilapia brood fish require about 40-45 percent protein for optimum reproduction, spawning efficiency and for larval growth and survival. Also, El-Sayed (2013) and Hassan *et al.*, 2013 revealed that in order to ensure profitability, it is important for farmers to have access to good quality feeds at reasonable prices and optimize their feed use by applying appropriate on-farm feed management practices. Also the producers seem not to know the quality characteristics of the produced feeds and limited knowledge of the nutritional requirement of the fish. Improved

knowledge in the feed sector, quality control of the feed formulation and composition should be done to make sure the feeds produced are of high quality.

Feed cost can exceed more than 50% of the total production cost in intensive farming and protein is the most expensive ingredient (Cheng *et al*., 2010). In East Africa in general and Tanzania specifically, the best protein source is obtained from fish meal originated from the sardine (*Rastrineobola argentia*) commonly known as dagaa. The dagaa have also been consumed as food for humans and is one of the cheap source of protein to poor people. Due to increased population in the country, the demand for dagaa as food for human has increased. This makes it less available and cost effective as animal feed source. High fishmeal demand in general has increased the price of fish feed containing fishmeal and also affecting its nutritional. Quality feed has become hardly affordable to many farmers.

Research has been done to seek an alternative and cheaper protein source as ingredients in feed for tilapia. In a study by Kubiriza *et al.*, (2016) in Uganda, the freshwater shrimp (*Caridina nilotica*) and mug beans (*Vigna* radiata) were used as protein source to replace (*Rastrineobola argentia*) fish meal. The results showed the positive growth performance in fish fed with both *Caridina nilotica* and *Rastrineobola argentia.* It was also observed that when the freshwater shrimp was used as a primary source of protein in the diet the cost of the feed was reduced. This can be also applied in Tanzania by researching on the availability of *Caridina nilotica* in Tanzania waters and analyze how it can be used in fish feed production.

Also for the current available protein source fish meal and soya beans meal, it can be recommended to use the later since it is shown to be cheap. Fish meal is sold at 2600 Tshs per kilogram while soya bean is 800 Tshs per kilogram. Although the competition as the protein source for human remain the same. Other sources like cotton-seed cakes, poultry by-products, feather meal and insects can also be used. Also, knowledge increase is highly needed because mixing of ingredients of different sources needs careful formulation of the feeds and knowledge of their ingredient composition.

6.3 Farm and water quality management

More knowledge on farm management should also be given to small farmers. Water quality management, disease control, harvesting and storage and knowledge of quality assurance or preservation is important since it determines the final quality of the product. The growth of the fish in the pond depends on the level of temperature, salinity, pH, oxygen and carbon dioxide in water. So making sure the level of the said parameters is optimum is must. According to Stickney, 1997 the best protein digestibility occurs at 25°C. Also, in a study done by Chhorn *et al*., 2006 for Tilapia culture in Kenya, the optimal water temperature recommended for growth was between 29 and 31˚C and salinity of 15 ppt. Also, a pond size range of 500–2000 m^2 was recommended for easy management.

There should be a motive of increasing availability and access of water quality measuring kits to the farmers. The current tendency of using palm-hand visibility is misleading and doesn't give the actual content of water parameters. Short courses or seminars in aquaculture management in general, and water quality management and feeding in special, could improve the aquaculture productivity and profitability.

Putting increased effort on these major issues i.e. availability of quality fingerlings, fish feeds and better management of farms will increase the production of the ponds. It has been shown

that if well managed and fed, a Tilapia fingerling of 5g can reach a weight of 600-800g in six months of rearing. This can be a major progress from the current weight of 200-250g attained by most of farmers in Tanzania. This was observed in interviewed farms where Eden, Safina, Boko, Baruti and Ruhanga which obtain their fingerlings from hatcheries with breeding stations as their source of brood stock, use formulated feeds as supplement feed, and regular management of their ponds had high yields compared to Mfyule, Ndunguru and Soffa farms which use mixed sex seeds from brood stock taken from the wild and use maize and rice bran as supplement feed.

7 SUGGESTED INTERVENTIONS FOR DEVELOPMENT OF AQUACULTURE IN TANZANIA

Suggested interventions according to the needs in relative to the assessment are as shown below;

In Policy aspect the following is recommended

- Regular review and harmonization of policies, regulations, legislation to meet the current needs.
- Develop data system for easy access of information and data for planning and decisions making.
- Promote the establishment of fish farmers' associations and Community based Organisation (CBOs) so that it can be easy for the farmers to access loans and be reached in other services. They can also do businesses among themselves and it can help control of seeds and feeds prices since the farmers will have one say through their associations.
- Develop Private Public Partnership (PPP) in service delivery and investment in hatcheries, feed production and farms.
- Create linkage between stakeholders and government institutions (Government, research, university, NGOs, farmers) for easy dissemination of information and knowledge sharing.

In seed production the following is recommended

- Establishment of breeding program for assurance of affordable brood stock and eliminating dependency of brood stock from the wild.
- Promote affordable technology e.g. simple indoor hatcheries (hapas + flushing eggs from the female and take them into incubators) and promote the use of solar power to overcome electricity problem.
- Increase accessibility to quality seeds by establishing of more hatcheries that will be distributed all around the country. This decreases stressful and expensive transport of life fish.
- Develop regular extension network by involving all service providers to reach more farmers.
- Establishment of guidelines and regular inspections for control.

Feed production the following is recommended

- Develop and promote use of locally affordable machine and technology and promote the use of solar power to overcome electricity problem.
- Research on alternative cheap protein source e.g. *Caridina nilotica* to overcome the problem of competition for protein source with human and reduce the cost of production that will reduce the cost of feeds. Assess information on other domestic alternative raw materials which can be used in fish feed.
- Establishment of guidelines and inspection for control on feed quality and composition.
- Training and awareness creation to the feed providers to increase their knowledge in feed formulation and production
- Develop regular extension network by involving all service providers to reach more farmers.
- Develop well organized market system for insurance of healthy market and fair trait.

Farm management the following is recommended

- Promote the use of new technologies (e.g. cages) that can be made by using available and affordable materials.
- Increase accessibility of quality and affordable seeds and feeds by establishing more hatcheries and feed producers across the country.
- Establishment of guidelines and regular inspections to ensure that the production is done under required standards and regulations.
- Increase accessibility of water quality control kits across the country and increase knowledge on water quality importance and control.
- Develop regular extension network by involving all service providers to reach more farmers.
- Develop well organized market system for insurance of market for products and good prices.
- Increase knowledge in farm management skills, water quality, factors affecting growth, feed and feeding etc.

8 CONCLUSION

This study reveals the status of aquaculture in Tanzania, the fingerlings, feed production and farm management. It has been shown that there are potentials and good environment for both local and foreign investors due to availability of good policy, abundant water resources, both freshwater and marine, and land suitable for aquaculture practices. There is also potential for establishing of feed factories and opportunity to both local and international fish market.

Challenges that have been identified like low production of quality fingerlings, quality feeds and limited knowledge of farm management need to be worked on. Fish farmers in Tanzania should be helped in terms of extension services and given access to quality fingerlings and feeds on reasonable price. Aquaculture farmers across the country should be provided with knowledge on best practices on fish farming that will increase their production, hence increased their earnings and assured food security and highly nutritive food (fish) at family level.

From this evaluation small and large projects can be developed where operations, monitoring and evaluation can take place in various components of the projects. Various policy dialogue with other inter-sector stakeholders and public in general for harmonization of our policies for better decisions making and implementation of aquaculture in Tanzania. Aquaculture has a potential of contributing more to the country in terms of economy and food security.

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APPENDIX

QUESTIONNAIRE FOR EVALUATION OF AQUACULTURE DEVELOPMENT IN TANZANIA - 2016

DATA FROM THE GROW OUT-FARM

1. Name of the farm ……...
2. Location……...
3. Ownership
    a. Individual
    b. Group
4. As a Manager what level of aquaculture knowledge do you have?
    a. Degree and above
    b. Diploma
    c. Certificate
    d. Informal
5. Size of the farm
    a. No of ponds……
    b. Area…….
    c. Other establishments……
6. Level of management
    a. Extensive
    b. Semi-intensive
    c. Intensive
7. Types of species cultured
    a. ……
    b. ……
    c. ……....
8. Source of Fingerlings
    a. Government (Name)……
    b. Private (Name)……
    c. Wild
9. Distance of the source from the farm……
10. Price per fingerling……
11. Initial weight of fingerling at time stocked……
12. Stocking density……
13. Time period of culture (cycle)…….
14. Weight at time of harvest……
15. Production (Tones/year) …….
16. Feed type
    a. Natural
    b. Formulated
17. Source of formulated feed
    a. home made
    b. Bought from the feed shops
18. If is home-made, what is the source of raw materials
    a. ……..
    b. ……..
    c. ……..

19. Price of raw materials……
20. If is bought, Feed Price/kilogram……
21. Do you keep the records on how much you feed the fish?
    a. Yes
    b. No
22. Feeding regime……
23. Any knowledge of the quality information of the feeds
    a. Yes
    b. No
24. Water management in terms of;
    a. Oxygen
    b. Turbidity
    c. PH
    d. Salinity
    e. Effluents
25. How do you manage the parameters above?
    ……
26. Extension services
    a. Good
    b. Average
    c. Low
27. Market point
    a. On farm
    b. Local Market
    c. Major markets
    d. Others…….
28. What is the price /kilogram ……?
29. Any challenges you are facing
    a. ……
    b. ,,,,,,,,,,,,,,,,,,,,,,,,,
    c. ……....
    d. …….
30. Any suggestions
    a. ……
    b. ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
    c. …….
    d. ……

DATA FROM HATCHERY

1. Name of the hatchery ……...
2. Location…….
3. Ownership
    a. Individual
    b. Government
    c. Group
31. As a Manager what level of aquaculture knowledge do you have?
    e. Degree and above
    f. Diploma

   g. Certificate
   h. Informal
4. Size of the hatchery
   a. No of ponds/tanks/hapas…….
   b. Area…….
   c. Other establishments……
5. Type of hatchery
   a. Indoor
   b. Outdoor
6. Types of *spp* produced
   a. ……
   b. ……
   c. ……....
7. Source of Broodstock
   a. Wild……
   b. Breeding station……
   c. Other…….....
8. Average weight of broodstocks……...
9. Stocking density of brood stock in hapas/tanks…….
10. Ratio of broodstocks in hapas/tanks
    a. Male
    b. Female
11. Mortality rate of eggs…….....
12. For *Clarias* artificial propagation do you inject the fish?.....
13. What do you use as the first feeding?.....
14. Mortality rate…….
15. Initial weight of fingerling at time of selling……...
16. Time period of rearing before selling……
17. Price per fingerling……
18. Feed type
    a. Natural
    b. Formulated
19. Source of formulated feed……...
    a. home made
    b. Bought from the feed shops
20. If is home-made, what is the source of raw materials
    a. ……..
    b. ……..
    c. ……..
21. If is bought, Feed Price/kilogram…….
22. Any knowledge of the quality information of the feeds
    a. Yes
    b. No
23. Do you keep the records on how much you feed the fingerlings?
    a. Yes
    b. No
24. Feeding regime……
25. Production (number/month) ……
26. Distribution (name the regions)
    a. …….

b. …….
c. …….
d. ……..

27. How is the demand?
    a. High
    b. Low
    c. Average
28. Water management
    a. Oxygen,
    b. Turbidity
    c. PH,
    d. Effluents
29. Extension services
    a. Good
    b. Average
    c. Low
30. Any challenges you are facing
    a. ……
    b. ,,,,,,,,,,,,,,,,,,,,,,,,,,
    c. ……....
    d. …….
31. Any suggestions
    a. ……
    b. ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
    c. …….
    d. …….

DATA FROM FEED PRODUCER

1. Name of the feed factory ……
2. Location……
3. Ownership
    a. Individual
    b. Group
4. Feed type
    a. Powderly
    b. Pellets
    c. Pellets (extruded)
5. Source of raw materials…….
    a. Local
    b. Imported
6. If local, availability of raw materials
    a. High
    b. Medium
    c. Low
7. If imported, which country/s are they from?
    …….
8. Price of raw materials…….
9. Types of raw materials
    a. …….
    b. …….
    c. …….
    d. ……,,,,
    e. ……..
10. Feed Price/kilogram……
11. Quality information of the feeds (%)
    a. Protein…….
    b. Carbohydrate……
    c. Fat…….
    d. Water (dry matter) ……
    e. Minerals……
    f. Other……
12. What type of machine are using?
    a. Locally made
    b. Imported
13. Production (tonnes/year) …….
14. Distribution (name the regions)
    a. ……
    a. …….
    b. …….
15. How is the demand?
    a. High
    b. Average
    c. Low

16. Any quality assurance/accreditation
    a. Yes
    b. No
17. Do you give storage procedures and time?
    a. Yes
    b. No
18. Any challenges you are facing
    a. ……
    b. ,,,,,,,,,,,,,,,,,,,,,,,,,,
    c. ……....
    d. …….
19. Any suggestions
    a. ……
    b. ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
    c. …….
    d. …….