Review and analysis of small-scale aquaculture production in East Africa

Part 3. TANZANIA

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WAGENINGEN UNIVERSITY & RESEARCH

BoP INNOVATION CENTER

Fair & Sustainable Consulting

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This report describes the findings of a literature study and of interviews with fish farmers and key informants familiar with the Tanzanian freshwater aquaculture sector. The study was part of an assignment commissioned by Msingi East Africa. The report was developed in collaboration with Stichting BoP Innovation Centre.

Msingi is an East African industry development organisation. It aims to support the growth of competitive industries in the region. Aquaculture has been selected as the first East African industry to support among strategic industries in which East Africa has a comparative advantage. Msingi supports their growth through investment and technical assistance to pioneer businesses; this is complemented by wider support to the sector, such as on policy, technology transfer, research and development, human capacity building or support to key sector organisations.

The Tanzanian freshwater aquaculture sector consists of roughly 19,000 small-scale farmers operating one or a few small ponds stocked with tilapia and/or catfish. Fish are fed in most cases with agricultural by-products and residues that are available on the farm. For most producers, fish farming is a part-time activity besides other sources of income. A small but growing number of farmers have specialised and are applying commercial fish feeds and are reaching higher levels of production. Total annual freshwater fish production of Tanzania is estimated to be 5000 metric tonnes. In the last years a growth of production is reported to take place as result of existing farms expanding and new farms being established. Part of the new farms use floating cages placed in Lake Victoria and Lake Kumba. All farmed fish is sold on the Tanzanian market, mostly as fresh, whole fish.

Lack of capital and finance opportunities, a shortage of affordable commercial fish feeds, a shortage of fingerlings (fish seeds) of good quality and a lack of knowledge among farmers about improved aquaculture practices, farm management and a business–like approach to fish farming have been identified as major bottlenecks for growth of production of the small-scale producers. Recommendations for action that would address these bottlenecks are given in this report.

Key words: small-scale aquaculture; commercial aquaculture, small-holders; aquaculture value chain; Tanzania; East Africa

This report can be downloaded for free at www.wur.eu/cdi (under publications).

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Photo cover: Cage culture at Lake Kumba, Tanga Region, Tanzania. Photo: Conrad Cosmas, BigFish Farm

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List of abbreviations and acronyms

AAT	-	Aquaculture Association of Tanzania
ANEA	-	Aquaculture Network of East Africa
BMP	-	Best Management Practices
BSc	-	Bachelor of Sciences
CoAF	-	College of Agricultural Sciences and Fisheries Technology
CBO	-	Community-Based Organisation
DAARS	-	Department of Animal, Aquaculture and Range Sciences (under Sokoine University of Agriculture)
DAD	-	Department of Aquaculture Development
DAFS	-	Department of Aquatic Sciences and Fisheries (under University of Dar es Salam)
EAC	-	East African Community
EIA	-	Environmental Impact Assessment
FETA	-	Fisheries Education and Training Agency
GMO	-	Genetically Modified Organism
HVLD	-	High Volume Low Density
IAA	-	Integrated Aquaculture Agriculture
LVFO	-	Lake Victoria Fisheries Organisation
LVHD	-	Low Volume High Density
MLF	-	Ministry of Livestock and Fisheries
MALF	-	Ministry of Agriculture, Livestock and Fisheries
MSc	-	Master of Science
NACTE	-	National Council for Technical Education
NADC	-	National Aquaculture Development Centre (proposed)
NADS	-	National Aquaculture Development Strategy
NGO	-	Non-Government Organisation
SUA	-	Sokoine University of Agriculture
TAFIRI	-	Tanzania Fisheries Research Institute
UDOM	-	University of Dodoma
UDSM	-	University of Dar es Salaam
URT	-	The United Republic of Tanzania
USD	-	United States dollars
WCDI	-	Wageningen Centre for Development Innovation, Wageningen University & Research
WUR	-	Wageningen University & Research

1 Introduction

East Africa is endowed with excellent natural freshwater resources and climate. Currently freshwater aquaculture in the region is practised by thousands of small-scale fish farmers producing Tilapia and Catfish, mainly in ponds but also in artisanal cages in lakes. Smallholder fish farming has been promoted by Governments and by various development partners. Nevertheless, the scale and productivity of smallholder aquaculture in East Africa remains below the level needed to support significant sector growth. International evidence suggests that small-scale aquaculture can play a significant role in parallel to the development of larger commercial production that will catalyse the sector. Development of a viable smallholder sector has the potential to greatly improve livelihoods in the industry.

Msingi (www.msingi.com), is a pioneering East African industry development organisation. It aims to support the growth of competitive industries in the region. Aquaculture has been selected as the first East African industry to support among strategic industries in which East Africa has a comparative advantage. Msingi supports their growth through investment and technical assistance to pioneer businesses; this is complemented by wider support to the sector, such as on policy, technology transfer, research and development, human capacity building or support to key sector organisations.

Currently available data on the small-scale producer segment in East Africa is inadequate to inform a clear strategy at this level. Msingi in combination with BoP Innovation contracted Fair and Sustainable Consultancy who teamed up with Wageningen University and Research to carry out an independent assessment of current small-scale freshwater aquaculture production. This assessment will enable Msingi to develop a robust strategy to engage producers at this level. The study is conducted in the context of the current sector with emergent commercial industry players and will also enable Msingi to determine existence of opportunities to link small-scale and commercial producers.

2 Methods

The objective of the small-scale producer study is to demystify this segment and provide Msingi, regional aquaculture industry and interested stakeholders with objective data on the status of small-scale aquaculture and its potential for growth. The detailed study objectives and subjects to be covered are found in Appendix 1.

2.1 Definition of aquaculture smallholders

The small-scale producer or smallholder farmer is defined as farmers producing less than 50 tonnes per annum either through cage or pond culture, either individually or as a group (for example cooperatives) and managing his farm from a business perspective. The study only covers semi- to intensive fresh water fish farming and excludes subsistence fish farming, coastal, salt water fish and other aquatic organisms farming.

2.2 Literature and field studies

The study comprised of two parts: a desk study and a field study. The desk study was undertaken by Peter G.M. van der Heijden and analysed literature and data available in the WUR current databases and updates from published reports, grey literature, peer-reviewed scientific articles, national statistics and reports. These were supplemented by documentation and data not available online but accessible locally to national consultants.

Visits and interviews of fish farmers, service providers and other key informants served as additional validation methods. The methodology for field data collection was semi-structured interviews by a category of actors guided by the content and scope of the research questions. Data gathering was based on interviews (mainly face to face but through telephone in some cases) of key informants and fish farmers that include both open-ended and closed questions.

The field work of this study was undertaken by Dr Amon P. Shoko. During field visits, semi-structured interviews focused on production systems and management, the fingerling and fish feed production and distribution systems, finance and market linkages available to the small-scale fish farmers. The semi-structured interview method was used to collect information from both key informants individually or in focus group discussions. From the objectives and subjects to be covered in this study, lists of questions were derived that were tailored to the various categories of key informants. These lists are found in Appendix 2.

Photo 1 *Members of the study team conducting an interview*

Key informants in this study included sample groups of fish farmers, managers of fish hatcheries and fingerlings producers, fish feed producers, finance providers; national industry associations and umbrella organisations, sector associations, officials at the Ministry in charge of Aquaculture, East African Community (EAC) institutions in charge of aquaculture, research and academic institutions and others. The list of persons interviewed is found in Appendix 3.

The desk study was completed before the study in the field took place. The findings of the interviews and observations in the field work were added and integrated in the draft desk study report, resulting the final version of the report.

3 Findings

3.1 Overview of the Tanzanian aquaculture sector

The fisheries sector as a whole is of significance to Tanzania. The total production of fishery products was around 370,900 tonnes in 2013. In the same year 39,000 tonnes of seafood products were exported and an additional 6642 tonnes of seafood products were imported (MALF, 2014). Fisheries contribute around 10% of the National GDP and fish is the main source of protein to nearly one third of the country's population. Fish consumption in Tanzania is currently about 7.8 kg per capita. This figure is close to the African apparent fish consumption per capita (8.3 kg/year), but less than half of the World's average per capita consumption of approx. 17 kg/year. In Tanzania fish are mostly sold fresh, fried, sun-dried, salted or smoked (ASARECA, 2013).

Aquaculture in Tanzania started in the early 1950s with experiments with tilapia in pond culture. During this period fingerlings obtained from Lake Victoria, Congo and Pangani rivers were distributed by the government to public and private farms including public water reservoirs. Estimates showed that by 1960s Tanzania had about 10,000 ponds, with a surface area of around 1,000 ha. Today the sector includes tilapia, trout (one farm) and African sharptooth catfish (in fresh water) and marine aquaculture (mariculture) sector producing seaweed, milkfish and prawns. The last species is grown in one commercial farm on Mafia Island. According to Shoko (2017), Tanzania has at least three endemic tilapia species that have also aquaculture potential namely: Wami tilapia (*O. urolepis hornorum*), Shire tilapia (*O. shiranus shiranus*) and Tanganyikan tilapia (*O. tanganicae*).

Until recently aquaculture production has been more or less static at about 4,000 tonnes per year, three quarters of which is Nile tilapia (MALF, 2016). Estimates by the MALF of the total annual farmed fish / aquaculture production of Tanzania developed as follows (Figure 1):

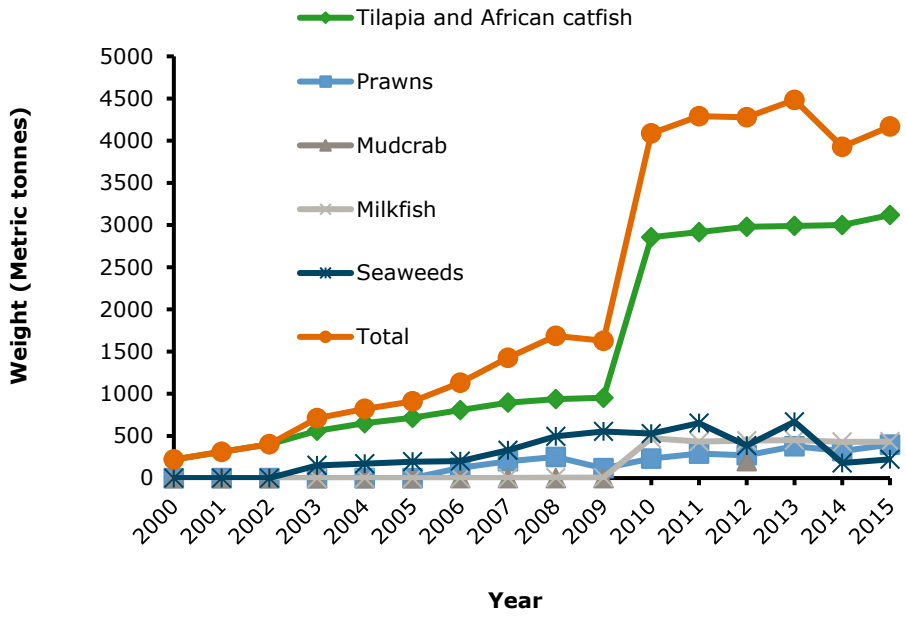

Figure 1 *Estimated total annual aquaculture production of Tanzania*
Data Source: MALF, figure from Shoko & Basiita, 2018, with slight modification by A. Shoko

An accelerated growth seems to have taken place in the past 2 years: the total aquaculture production for 2017 is estimated by the Ministry of Livestock and Fisheries (MLF) at over 10,000 tons (Mahika, pers. comm., 2018). Aside from improved statistics collection, this growth of Tanzanian aquaculture production is associated with improved awareness creation done by the MLF to practice aquaculture for improving people's livelihoods. Newly established pond and cage aqua-farms are the result of improved coordination of aquaculture activities by Department of Aquaculture Development (DAD) under MLF.

Tanzania's aquaculture production equates to about 3% of total fish supplies for human consumption in the country. This contribution to national food security and economic development can be qualified as small. However, the aquaculture sector generates considerable employment, with an estimated 15,000 – 20,000 people (mostly women) engaged in the seaweed sector (for carrageenan production), 14,100 engaged in freshwater fish farming and 3,000 in the marine sector (mainly milkfish and shrimps, seaweeds excluded), see Table 1.

Table 1 *Estimates of number of ponds and people involved in Tanzanian aquaculture*

Species/type	Number of farmers	Number of ponds	Year	Source
Farmed fish	17,511	19,930	2012/13	Rothuis et al, 2014
Nile tilapia	17,725	20,235	2013	MALF (2014)
Aquaculture production minus seaweeds	19,233	22,700	2017	WorldFish, 2017

Aquaculture in Tanzania is still primarily a small-scale activity, with most owners operating one or a few small ponds, little formal management and low productivity, reflecting its *largely subsistence nature*.

However, a few farms in Dar es Salaam and the Coast (Pwani) regions operate on a medium-scale level: they have two to four dozen grow-out ponds each, in size ranging from 450 to almost 2000 m^2. Some of these medium-scale producers have developed their own feed supply and hatchery facilities (MALF, 2016; this study finding). There are some larger vertically integrated production units such as the company operating larger ponds for shrimp production on Mafia Island.

Cage culture has started in the Tanzanian part of Lake Victoria, albeit later and still at a smaller level than in Uganda and Kenya. The reported complexity of multiple licensing requirements with several agencies, namely the National Environment Management Council, Ministry of Environment and the then Ministry of Agriculture, Livestock and Fisheries (now, Ministry of Livestock and Fisheries, MLF) may have affected the speed of development (MALF 2016). At present approx. 106 square cages, in size varying between 2 x 2 meters, 2 x 6 m and 6 x 6 m, are operational (Shoko pers. observation.)

Experiments with fish cages have also started in Lake Tanganyika and Nyasa by TAFIRI. There is one major joint fish pond venture between a Danish and a Tanzanian company (Ruvu Fish Farm) and several of the training and research institutions, such as Fisheries Education & Training Agency (FETA) and TAFIRI, also operate farms. University of Dar es Salaam (UDSM) and Sokoine University of Agriculture (SUA) located in Dar es Salaam and Morogoro region respectively also operate fish farms for training and research purposes.

The Government of Tanzania has invested in aquaculture training, with degree programmes at UDSM and SUA, and skills training at the FETA Campuses located in Mwanza, Bagamoyo, Kigoma and other locations.

Tanzania has considerable physical potential for increasing the contribution of aquaculture, given the extensive coast line, lake and river water resources, ideal temperatures and availability of raw materials for feed. Consumers are familiar with fish; demand for fish is high and growing, as is the

population of approx. 55 million people. One report concluded that "Nevertheless, the environmental and market conditions in Tanzania bode well for sustained large scale commercial aquaculture development in the medium to long term, provided the necessary policy, investment and regulatory support measures are put in place by government." (Britz et al, 2015, p. 4)

3.2 General description of the small-scale commercial fish farming sector

3.2.1 Species farmed

Nile tilapia (*Oreochromis niloticus*) is by far the main freshwater species farmed. In addition, and when available, African sharptooth catfish (*Clarias gariepinus*) is stocked either alone or together with tilapia to control the excessive reproduction of tilapia. Catfish fingerlings are also in demand as bait for long line fishery for Nile perch on Lake Victoria and other lakes.

3.2.2 Geographic distribution

Aquaculture is practised almost everywhere in Tanzania, but mostly in the regions of Arusha, Mbeya, Iringa, Morogoro, Kilimanjaro, Ruvuma, Tanga, Coast, Dar es Salaam, Lindi and Mtwara (MALF, 2015). The main areas where the fresh water tilapia is farmed are in the South, especially the Ruvuma (more than 43%), Njombe (almost 14%) and the Iringa (more than 11%) region (Rothuis et al, 2014). Fish pond farming is also conducted in the regions of Kagera, Mwanza and Mara in the Lake Victoria basin (see Shoko et al., 2011a). Cage culture has started in Lake Victoria and in Lake Kumba (Tanga region).

Figure 2 *Map of the United Republic of Tanzania, showing the regions*
Source: https://sw.m.wikipedia.org/wiki/Mikoa_ya_Tanzania

3.2.3 Production systems

Farming in small ponds of 150-300 m^2 is the dominant freshwater fish farming system. Most farmers own only 1 -3 ponds and are farming in an extensive way (3 fish/m^2 or less). Shah et al. (2012, p. 8673) report that 'Integrated fish farming practices are common, especially in the eastern region, and polyculture of fish and duck is popular". Most farmers harvest 6 to 12 months after stocking (Wetengere, 2010a).

In recent years, some medium and larger scale farms were started. One is Ruvu fish Farm (Miswe village in Kibaha district, Coast Region), a joint venture between a Danish and a Tanzanian company. Both partners are equal shareholders with an initial investment of USD 1.4 million. They presently have 40 ponds of 450 m^2 and plans are in place to increase to over 100 ponds. Their planned production is 500 tons per year but at present the owners focus more on fingerling production than table-size fish due to the high demand for fingerlings. There are also going to invest in a feed mill and presently import high quality feeds (Lee & Namisi, 2016; this study).

J&B Ruhanga Fish Culture Company Ltd is located in Kagera region. The farm has 19 grow-out ponds of 30 x 50 m^2 each and three nursery ponds of 30 x 40 m^2 and produces 3 tonnes of tilapia and 1 tonne of catfish monthly. They have also invested in three feed mills with a production capacity of 500 Kg per hour and sell feed to other farmers at 1700 TZS (= US $ 0.76)/Kg. The farm also sells 40,000 fingerlings per month (Lee & Namisi, 2016; this study).

In addition, and according to reports, cage farming in Lake Victoria has taken off at modest levels when compared with the neighbouring countries. There are about 106 square cages in the Tanzanian part of Lake Victoria with varying sizes. The size of 60 cages were reported as 2 x 2 m (10 cages), 2 x 6 m (16 cages), 6 x 6 m (24 cages) and 5 x 5 m (10 cages) (G. Rucho, AAT, pers. comm., June 2018). There is also one cage in Lake Tanganyika of 4 x 6 m and one in Lake Nyasa (4 x 4 m) set for experimental purposes by TAFIRI. In Kumba Lake located in Korogwe, Tanga region, there are 36 cages of 6 x 6 m. Further study of the performance of cage culture in Tanzania is recommended.

Photo 2 *Cage culture in Lake Victoria (Photo: Charles Mashafi, TAFIRI, Mwanza)*

3.2.4 Pond productivity

Reliable data on production and productivity of small-scale fish farms are hard to come by because the owners seldom keep detailed records of purchase of inputs or harvest results. Pond productivity data provided by various authors is summarised in Table 2.

Table 2 *Productivity data of Tanzanian fish ponds as reported by various authors*

Average pond productivity	District (Region)	Additional comments	Source
1,823 kg/ha	Mara & Kagera regions		Shoko et al (2011a)
5,312 kg/ha	Mbarali (Mbeya region)	Average of 86 farmers	Chenyambuga et al. (2014)
4.2 tonnes/ha	Kilombero (Morogoro Region	Average of 4 farmers	Limbu et al (2017)

The pond productivity data reported by Limbu et al. (2017) refer to ponds stocked with tilapia and catfish (to control tilapia reproduction) in a density of 3 fish/m^2. The ponds were owned by farmers who were intensively trained and supervised by researchers during a farm-based research, comparing yields from 200 m^2 fish ponds and vegetable plots that were managed separately or in an integrated fashion (with pond water used to irrigate the vegetables).

3.2.5 Management systems

Fish farming is for most small-scale rural farmers a part-time activity besides crop farming and other income-generating activities. Records of purchase of inputs and harvest results are seldom kept. Details about pond management by small-scale fish farmers are reported in Paragraph 3.3.

In the survey among 38 farms and aquaculture companies in the regions of Dar es Salaam and Coast that was undertaken as part of this study it was found that daily fish farm management is mostly done by hired labour (76.5%). About 23.5% of farm owners in the surveyed region use family labour for daily fish farm management. Most (74%) fish farm owners use hired labour during the peak season of fish farming activities. Majority of farmers (58%) spend less than two hours/day, and 21% spends 2 to 4 hours for daily fish farm management. About 21% spend 6 to 12 hours for daily farm management. It is important to note that the present study was conducted in the peri-urban areas which justify the use of hired labour. This situation should be very different from rural small-scale farms where family labour is mostly used in daily aqua farm management.

3.2.6 Disease and health management

Shah et al. (2011) report that "No antimicrobials are used in aquaculture, although different types or antimicrobials and growth promotors are used in poultry and animal husbandry" (p. 8673)

The articles and reports reviewed do not mention specific disease problems. Based on the extensive experience of one the authors, there have been no serious reports associated with fish diseases in aqua farms in Tanzania except for some cases of "crack head disease" in African catfish. "Crack head disease" which was also reported in the present survey, is mostly associated with lack of certain nutrients and catfish not being able to utilize major nutrients in the feed rich in Vitamin C. There have also been rarely reported cases of bacterial and fungal infections in the farmed Tilapia. The general view is that fish diseases have not been a major issue in Tanzanian aquaculture. During the present study, about 44% of the interviewees reported to practice disease management through quality feeding, restricting unauthorized person from visiting the farm site, monitoring of water quality and regular pond checks.

3.2.7 Supporting systems

3.2.7.1 Advise and training

The Fisheries Education and Training Agency (FETA) was established in accordance with the Executive Agency Act No 13 of 2009 of the United Republic of Tanzania to provide non-university tertiary education and training in fisheries, aquaculture and related disciplines. It is fully registered and accredited by the National Council for Technical Education (NACTE) to offer qualifications up to National Technical Award (NTA) level VI. The high standard that has been established has made it possible for the agency to conduct national and regional fisheries training programmes and enrol students from Tanzania and other countries in the region. The major role of FETA is to implement capture fisheries and aquaculture development objectives as expressed in the National Fisheries Sector Policy and Strategy Statement (1997) and National Aquaculture Development Strategy, 2009 (NADS 2009), including education and training, consultancy, applied research, provision of fingerlings and feeds, business promotion, and to produce boats, gear and aquaculture equipment.

The FETA, Mbegani and the Nyegezi campuses in Bagamoyo and Mwanza offer technical training courses in fishing technology, aquaculture, fish processing and quality control, coastal resources management, and other subjects relevant to the development needs of the fishery sector.

Kingolwira (Morogoro district, Mrorgoro region), Mwamapuli (Igunga district, Tabora region) and Ruhila (Songea district, Ruvuma region) are fingerling production centres owned by the government that make seeds available to fish farmers.

There are nearly 8000 government agricultural extension workers employed in Tanzania who have among their tasks to give technical advice to (subsistence fish) farmers. In addition, Non-Governmental Organisations (NGOs) and Community-based organisations (CBOs) also are active with training and other forms of support to fish farmers.

3.2.7.2 Research

Tanzania Fisheries Research Institute (TAFIRI) was established by the Act of Parliament No. 6 of 1980 as repealed by the Act No. 11 of 2016. It is the only fisheries research organ mandated by the government to carry out and coordinate different research on fisheries and aquaculture. The institute has a mission to become a strong centre of excellence in fisheries research and consultancy in the Eastern and Southern Africa. Its vision is to promote, conduct and manage fisheries research and consultancy for sustainable development of fisheries in Tanzania. The research areas covered include: Stock assessment and fisheries statistics, Fish biology, Hydrobiology and water pollution, Gear technology, Aquatic ecosystems and biodiversity, Climate change and environment, Capture fisheries, Aquaculture, Socio economics and marketing.

TAFIRI has its headquarters located in Kunduchi, Dar es Salaam. The institute has four research centres and one Substation namely Mwanza Centre and Sota Substation on Lake Victoria, Kigoma Centre on Lake Tanganyika, Kyela Centre on Lake Nyasa (Malawi) and Dar es Salaam Centre on the Indian Ocean.

During the "Stakeholders' Workshop on Tilapia Aquaculture in Tanzania and the Way Forward" (Mazsons Hotel, Zanzibar, 5-7 October 2016) a set of resolutions was drafted and signed by the directors of the Department of Aquatic Sciences and Fisheries (University of Dar es Salaam); Institute of Marine Sciences (University of Dar es Salaam); Department of Animal, Aquaculture & Range Sciences (Sokoine University of Agriculture) and Tanzania Fisheries Research Institute. In this so-called *Zanzibar Aquaculture Declaration*, the directors called upon the Government of Tanzania to establish a semi-autonomous *National Aquaculture Development Centre* (NADC) at Kingolwira, in the premise of the Kingolwira Aquaculture Centre. The mandate of the proposed NADC would be to spearhead the development of the entire aquaculture value chain in collaboration with the private sector. The NADC roles and objectives shall be to generate science-based aquaculture technologies and information appropriate for overcoming challenges across the aquaculture value chain; verify, demonstrate, and transfer viable technologies and best aquaculture management practices; develop and strengthen capacities of the aquaculture sector; promote interaction between scientific community

including students and farmers at field level; accommodate the TAQ-Network activities with the view to promote collaborations with national, regional and international institutions; accommodate the Tanzania fish germplasm bank; provide a national quarantine facility for infected and or imported fish and fish health facilities. (Zanzibar Aquaculture Resolution, 2016)

So far, the establishment of the NADC has not yet taken place.

3.2.7.3 Education

Fisheries and Aquaculture related subjects are offered at the Department of Aquatic Sciences and Fisheries (DASF) and the Department of Animal, Aquaculture and Range Sciences (DAARS) of the University of Dar es Salaam (UDSM) and Sokoine University of Agriculture (SUA) respectively. In addition, the School of Biological Sciences in the College of Natural and Mathematical Sciences of the University of Dodoma (UDOM) offers BSc in Aquaculture and Aquatic Sciences.

DASF is under the College of Agricultural Sciences and Fisheries Technology (CoAF) of the UDSM. CoAF is a newly established college at UDSM. The breadth and scope of DASF encompasses programs for undergraduate and postgraduate teaching, research and public services in basic and applied aquatic sciences with an emphasis on fisheries management and aquatic resource conservation. The department offers diploma in Fisheries, B.Sc. in Aquatic Sciences and Fisheries Technology. The Department also offers postgraduate programs leading to M.Sc. and Ph.D. in Aquatic Sciences including aquaculture.

The Department of Animal, Aquaculture and Range Sciences (DAARS) was established in 1970 as Department of Animal Science and Production (DASP) under the then Faculty of Agriculture of University of Dar es Salaam and retained its name with establishment of Sokoine University of Agriculture in 1984. It was renamed DAARS following a University wide restructuring in 2015. The mission of the department is to promote development in animal science, aquaculture, range management and allied sciences through training, research and delivery of services. The Department is actively involved in teaching, research, outreach and production in fields of animal husbandry, aquaculture and range management.

3.2.7.4 Credit

The great majority of investors in aquaculture are self-sponsored. The high interest on loans from banks (which can reach 19%) is one factor that prevents use of credit for aquaculture investments. The banks visited as part of this study promised to reduce interest rates with time. During the consultation with financial institutions, the bank representatives pointed out that they are ready to provide loans in any agricultural activities including aquaculture on the condition that the business demonstrates its viability. The representatives said viability is important to enable clients to recover the loans.

Some organizations such as Land O'Lakes Development International (https://www.landolakes.org) are supporting various innovation projects such as aquaculture through a competitive fund. This organization is promoting household food security programmes for women.

3.2.8 Marketing and distribution of fish

In Mbarali and Mvomero districts 42.3% of the fish harvested was eaten at home (Chenyambuga, 2014). The average sale price was Tsh 2345 / kg. Customers in the direct neighbourhood were the most popular market outlet (83.3%) followed by local market (14.6%), see Table 3. On average 81% of the fish was sold un-processed. Fish that was processed was either fried (71%) or smoked (29%).

Table 3 *Marketing and processing practices for pond cultured Nile tilapia in Mbarali and Mvomero districts*

Variable	Mbarali	Mvomero	Overall	Prob.
Proportion of fish consumed at home (%)	38.0	46.6	42.3	0.20
Proportion of fish sold (%)	62.0	53.4	57.7	0.10
Price/kg (mean ± s.e.)	2,317 ± 350	2,358 ± 111	2,345 ± 131	0.91
Marketing channels				0.19
Neighbours (%)	73.7	86.2	83.3	
Local markets (%)	15.8	13.8	14.6	
Secondary markets (%)	10.5	0.0	2.1	
Fish Processing				0.70
Yes (%)	15.8	20.7	18.8	
No (%)	84.2	79.3	81.3	
Processing methods				0.44
Smoking (%)	0.0	41.4	29.2	
Frying (%)	100	58.6	70.8	

Source: Chenyambuga et al (2014).

Mwaijande & Lugendo (2015) report that 71.3% of the farmers they surveyed sold their product to their neighbours, the others sold their products in the village markets. Some traders and retailers collected fish from the farm site - this was the case for 23% of the farmers surveyed. None of the farmers sold their fish to processing plants. Producers received only 35% of the price received by traders for tilapia with a weight of 1 kg or more (TSh 2,470.00 vs 7,670.00). However, the capacity of fish farmers to produce tilapia of this size is limited.

In the past years retail prices of tilapia have been increasing steadily, ranging at present from Tshs 3,000 per kg (USD 1.30) in rural areas to Tshs 10,000.00 per kg (USD 4.50) in urban areas. Normally the market prices of fish follow that of wild-caught fish (Shoko, 2017, p. 14).

3.2.9 Sector Coordination

Aquaculture activities in Tanzania are coordinated by Ministry of Livestock and Fisheries (MLF) through the Department of Aquaculture Development (DAD). At national level MLF through DAD works with other government research and training institutions such as TAFIRI, UDSM and SUA. It will soon start working with University of Dodoma (UDOM) since it also offers training in fisheries and aquaculture. It also works with non- governmental organisations (NGOs) and institutions such as the recently established Aquaculture Association of Tanzania (AAT - http://www.aat.or.tz/)

AAT was established on December 2016 with 60 registered members and 300 members on the waiting list. AAT represents members from various stakeholders across the aquaculture value chain in Tanzania including fish farmers at all levels, fish feed and seed producers, processors, marketers, service providers, research and training institutions, local and international partners and government agencies. The objective of AAT is "to contribute positively to the growth of the Fisheries Sector in order to tap into the existing potential that can provide reasonable employment to youth, increase income, improve nutritional status and finally make a meaningful contribution to the growth of the Fisheries GDP." Within AAT voting rights are reserved to members whose income derives primarily from aquaculture production and services. Only one vote is given per company. Others can join meetings and receive all publications etc. but shall not have the right to vote. The first AAT conference plus trade show is planned to take place in November 2018.

In areas surveyed by Shoko et al. (2018a) most fish farmers especially the youth had organized themselves to form groups through the formation of *WhatsApp* groups such as *Aquafeeds, Aquaculture Tz networking* and *Fish farming oriented*. Such groups were established specifically for sharing information on aquaculture. Members come from all over the country and beyond and they share and/or seek information about the source of inputs (quality feeds and seeds, medicines etc), markets, and technical knowledge on solving various problems.

In the Zanzibar Aquaculture Resolution (see 3.2.7.2) the signatories call upon the government to:

1. "Facilitate the establishment of a platform for information sharing between the governance, aquaculture researchers and entrepreneurs;
2. Facilitate development of aquaculture farmer-based associations/ clusters/ networks of small-scale fish farmers to improve accessibility to technologies for genetic improvement, feed formulation, farm health management etc.; facilitate accessibility to services, attaining bargaining power;
3. Organize periodic forums involving policy makers/resource managers, natural and social science researchers, entrepreneurs, and development partnersto foster national and regional cooperation, ensure informed policy making machinery, and promote development of world class entrepreneurs." (Zanzibar Aquaculture Resolution, 2016)

At regional level MLF works with sister ministries in the East African Community (EAC) through various organizations such as Lake Victoria Fisheries Organization (LVFO, http://www.lvfo.org/). LVFO which was established in June 1994 is an institution under the EAC. The aim of LVFO is to harmonise, develop and adopt conservation and management measures for the sustainable utilisation of living resources of Lake Victoria and its entire basin to optimise socio-economic benefits from the basin for the EAC partner states. The organization has developed Fisheries and Aquaculture Policy for EAC in which details of aquaculture development, research and management are given. The organization has also developed Cage Culture Guidelines for Lake Victoria to streamline development of cage culture on Lake Victoria. Furthermore, the Organization is playing a vital role in the implementation of various aquaculture projects including the EDF-11 (TRUEFISH) Aquaculture project in which farmers will be brought together to address key challenges that are impeding aquaculture development in the region.

In September 2015 aquaculture scientists from Kenya, Tanzania and Uganda met in Arusha (Tanzania) and established the Aquaculture Network for East Africa (ANEA) which forms another platform aiming to promote aquaculture best management practices (BMPs) and exchange of information in the region.

3.2.10 Regulations and standards

In 2015 a reform was made to the then Fisheries Policy of 1997 to ensure that it was a comprehensive policy that encompasses the aquaculture component (URT-MLF, 2015). The new policy emphasizes the professionalization of the aquaculture industry making it more attractive for foreign companies to invest. It gives more emphasis on the development of commercial aquaculture, including cage culture. The Department of Aquaculture Development (DAD) can only issue license for cage culture after a "strategic" environmental impact assessment has been carried out. With regards to importation, transportation and handling of live fish, section 29 and 33 of the Aquaculture regulations stipulate that permits from MLF are required for the importation of any live fish into the country. The permits can only be issued after TAFIRI has ascertained the need for such an importation. Furthermore, the permit will possibly (especially at the beginning) be issued for experimental purposes only (Shoko, 2017)

No specific regulation has yet been made for importation of fish feed or raw materials for the manufacturing of fish feed. However, in order to prevent dumping, the Government of Tanzania may impose import restrictions if it is not proven that local market exists for the imported product. Concerning import taxes, the National Treasury may exempt import tax on imported agriculture equipment, including products for Aquaculture (Rothuis et al., 2014). The Tanzanian government itself reports that "barriers such as feed subsidies and a complex regulatory framework need to be removed as a priority, along with developing a mechanism for financing small to- medium enterprises (SME) investments in the sector." (MLF, 2016).

Candidly, in 2016 MLF admitted that "the government has struggled to establish the right policy environment for private sector investment in aquaculture to take off." The Ministry also noted that "The development of cage culture in Tanzania is slowed down by reported complexity of multiple licensing requirements with several agencies, namely the National Environment Management Council, Ministry of Environment and the Ministry of Agriculture, Livestock and Fisheries." (MALF, 2016, p. 18).

Regulations require that to acquire land for aquaculture investment one should obtain a permit from the MLF. However, the permit can only be issued after the investor has proved that the intended

project is accepted by the local community where the project is going to be implemented. There are forms that must be filled by local government authority through the fisheries/aquaculture officer at district council where the project is to be implemented before is it sent to the ministry for approval. Other important documents required included the "strategic Environmental Impact Assessment (EIA) which is usually done by TAFIRI" (Shoko, 2017).

3.2.11 Key trends

From the literature and the farmer's survey that was undertaken as part of this study the following key trends were distilled:

- After a number of years with rather stable total farmed fish production, considerable growth seems to have taken place since 2016.
- Increasing private investments are taking place in aquaculture by Tanzanians, resulting in an increase of the number of small-scale producers (with ponds, tanks and cages) and traders selling aquaculture-related inputs. Shoko (2017) provides a list of 19 small and medium scale private fingerling producers and 5 feed producers. Growing demand for fish seems to be driving this growth.
- Although a majority still use on-farm materials to feed the fish, farmers are increasingly applying commercially produced fish feeds. The percentage of farmers in Dar es Salaam and Coastal regions that apply aeration during transport of fingerlings and brood stock and during culture is increasing.
- High demand for tilapia fingerlings stimulates medium-scale farms to focus more on production and sales of fingerlings than of table-sized fish.
- Retail prices for farmed fish depend on the price for fish caught from lakes and rivers. In larger cities this is also the case but there seems to be a high demand for fish.
- Producers are organizing themselves on national level (Aquaculture Association of Tanzania, AAT). Information about aquaculture is exchanged in WhatsApp groups.
- The National Fisheries Policy of 2015 includes an aquaculture component that emphasizes on professionalization of aquaculture industry making it more attractive for foreign companies to invest. It gives more emphasize on the development of commercial aquaculture including cage culture.
- Cage culture has started in Lake Victoria and Lake Kumba. Experiments with fish cages are on-going in Lake Tanganyika and Lake Nyasa.

3.3 Detailed description of the small-scale freshwater aquaculture producer

To know the actual situation of small-scale aquaculture producers and other aquaculture stake holders in Tanzania 30 fish farmers and 8 fingerling and fish feed producing companies located in Dar es Salaam and Coastal regions were visited and interviewed in April – May 2018. In addition, 9 key informants from the public sector (national and regional), research and academic institutes were interviewed to obtain additional information about major sector developments. Names and location of farmers and companies that were interviewed are found in Appendix 3. A very recent study among 67 fish farms in Dar es Salam, Coastal, Morogoro and Lindi regions that focussed on the aquaculture value chain by Shoko et al. (2018a) also contributed valuable up-dated information.

Somewhat older but still informative for this study were research reports by

- Wetengere (2011) about the constraints to marketing of farmed fish among 217 small fish pond owners growing tilapia in Morogoro region;
- Mwaijanda & Lugendo (2015) who investigated 293 randomly selected fish farmers from Dar es Salam, Coastal, Morogoro, Njombe, Mbeya, Ruvuma, Kagera and Kilimanjaro regions and
- S.W. Chenyambuga et al. (2014) who investigated 86 fish farmers from Mvomero district (Morogoro region) and Mbarali district (Mbeya region).

3.3.1 Small-scale fish farmer segments

The main system described in detail in the available literature and in the field-work undertaken as part of this study about Tanzanian smallholder aquaculture producers is small-scale pond farming, producing mainly tilapia and occasionally catfish. Descriptions of other small-scale freshwater production systems (such as cage or tank culture) that were of sufficient detail to enable analysis and comparison with the small-scale tilapia production in ponds were not found/available.

Wetengere (2011) distinguished the farmers in the following categories:

- Operating ponds over 100 m^2 size; feeding at least once/day; maintaining green water colour; targeting to grow big fish for the urban market; frequent partial harvest and at least once/year total harvest. Fifteen % of the farmers surveyed were in this category. They had a productivity of 4-6 tons/ha/year.
- Operating ponds of all sizes; irregular fertilizing, feeding and harvesting (depending on availability of inputs). Sixty-five % of the farmers surveyed belonged to this category. They harvested an estimated 1.5 to 3 tons/ha/year.
- Operating ponds of all sizes; no feeding or fertilizing; clear pond water and irregular, partial harvests of insignificant and often only small fish. Ponds looked in bad shape and were to be abandoned any time. Twenty 20% of the surveyed farmers belonged to this category.

In the study by Shoko et al (2018a) number & size of ponds per farm and the type of fish feed used were used to distinguish various segments of smallholders. Forty-five (45%) of the farmers visited harvested over two tonnes per farm during the last year; 13% of visited farmers harvested between one to two tonnes per farm and the rest (24%) harvested less than one tonne per farm (Figure 3).

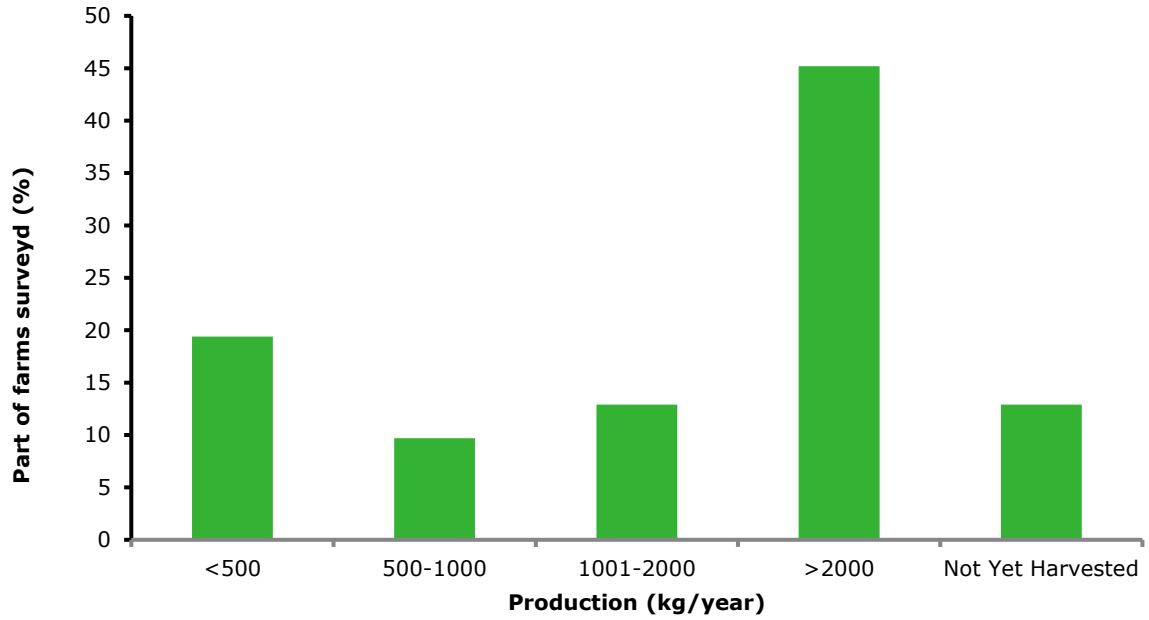

Figure 3 *Fish harvested (kg) during the last year by individual farms in Dar es Salaam and Coast regions*

Sixty-six % of the farmers used only on-farm sources (maize and rice bran, food leftovers, vegetable remains, cocoyam leaves) as fish feed. These farmers admitted that they prefer commercial industrial feeds to the feeds that are available on-farm but the high price asked by commercial industrial feed suppliers restrains these farmers from using commercial fish feeds. The remaining part applied locally (= in Tanzania) produced commercial fish feed (32.8%) or imported commercial fish feed (1.5%).

Sixty-one % of the farmers surveyed in Morogoro, Dar es Salaam, Coast and Lindi region owned only one or two ponds. These ponds were in 61% between 100 and 500 m^2 in size (average 220 m^2 – Shoko et al, 2018a).

Farms visited as part of this study include Indian Ocean Aqua Ltd, Eden Agri-Aqua limited, Righa's Safina Aqua Ltd, Polopolo and Noni's farm Ltd. Eden Agri-Aqua limited and Righa's Safina Aqua Ltd are located in Dar es Salaam region whereas Indian Ocean Aqua Ltd, Polopolo and Noni's farm Ltd are located in Coast region. The details of aquaculture farms located in Dar es Salaam and Coast region that deal with fingerlings and grow-out production are shown in Table 4 below as obtained from Shoko and Komugisha (2018). It should be noted that these are the larger and more advanced farms found in Tanzania. They do not represent the average Tanzanian small-scale fish farm.

Table 4 *Facilities for breeding and production in selected hatcheries in Tanzania (Shoko and Komugisha, 2018)*

Name of hatchery	No of breeding facilities	No of nursery facilities	No of brood stock facilities	Grow out facilities	Incubation facilities	Other facilities
TAFIRI, Dar es Salaam	• 9 circular concrete tanks (9.6 m^2, diameter of 3.4 m each)	• 12 circular concrete tanks (diameter of 2 m each)	• 4 ponds (3.4 m diameter each)	• Nil	• 24 (20 L) buckets	• Overhead water tank
Ruvu Fish Farm Ltd	• 10 ponds of 450 m^2 each	• 6 ponds of 450 m^2 each • hapas	• 4 ponds of 450 m^2 each	• 19 ponds of 450 m^2 each	• 7 fibre glass tanks	• paddlewheels for aeration • one (20 ft) container feed store • one (20 ft) container warehouse for equipment
Eden Agri Aqua LTD	• 8 (20 m x 20 m) ponds • 3 (10 m x 20 m) ponds	• 5 round concrete tanks • 12 rectangular concrete tanks	• 3 (20 m x 20 m) ponds	• 4 (25 m x11 m) ponds	• 12 incubation jars • 6 hatching trays • 4 concrete tanks • 1 m^2 concrete tank	• 1 (7 m x 25 m) concrete reservoir pond • Indoor RAS system • Paddle wheels for aeration • feed mill /factory
Indian Ocean Aqua Ltd	• 20 (75 m x 25 m each) ponds	• 12 recirculating tanks	• 6 (8 x 2.4 x 1.2 m each)	• 44 (75 m x 25 m each) ponds	• 6 incubation jars • 6 hatching trays	• Green house hatchery

3.3.2 Freshwater fish farmer socio-economic characteristics

The studies showed that fish farming is male –dominated; 82% to 87% of the fish pond owners in the studies by Wetengere (2011), Chenyambuga et al (2014), Mwaijanda & Lugendo (2015) and Shoko (2018) was male. The women who do own fish ponds are mostly widowed, divorced or unmarried. Sixty-nine % of the respondents were between 18 and 50 years of age. 69% of the farmers surveyed by Mwijanda & Lugendo and 81% of the farmers surveyed by Chenyambuga et al. (2014) finished primary school only.

Shoko (2018a) reported that the age of most pond owners surveyed in Morogoro, Dar es Salaam, Coast and Lindi region were between 35 and 55 years (Table 5). According to Shoko et al. (2018a) the considerable involvement of youth in aquaculture (25%) shows the (potential) importance of the sector in providing youth employment & income. Fifty-two % of the farmers in the studied region have attained only primary school education (Table 5).

Table 5 *Characteristics of fish farmers in Morogoro, Dar es Salam, Coast and Lindi regions (from Shoko et al., 2018a)*

Variables		Percentage
Sex	Male	87
	Female	13
Age	15-35	25
	36-55	75
	56-65	14.1
	>65	10.9
Education	Primary education	52.2
	Secondary education	14.9
	Diploma	11.9
	Degree	16.4
	MSc	4.5

The part of the farmers surveyed by Mwijanda & Lugendo (2015) that had some training on aquaculture was remarkably high (82%), but only 12% had followed a course on entrepreneurship. The duration and level of training received was however not specified. 74% of fish farmers interviewed had 1 to 5 years of experience in fish farming.

Chenyambuga et al. (2014) report that "Furthermore, most fish ponds (43.8%) were owned by men and most of fish farming activities were done by men (54.2% of the households). Also, men had more access to fish farming knowledge and income accruing from fish farming activities. This is because local customs and cultural practices in many communities in Tanzania make it impossible for a woman to own assets and land as these are acquired mainly through inheritance which favours men to women."

A study among 217 fish farmers from 24 villages in Morogoro Region by Wetengere (2011) showed that only 42% were full-time farmer, the other also had other (mainly business) sources of income (such as small retail, selling timber or home-made beer, etc.).

3.3.3 Production systems and culture techniques applied

Fish farmers in Kilimanjaro region had ponds of average size of 200 - 400 m^2 whereas fish farmers in Njombe and Morogoro region had ponds smaller than 200 – 400 m^2 (Mwaijande & Lugendo, 2015). In Mvomero region farmers had 1-2 ponds of 345 m^2 average size while in Mbarali region farmers had 1 to 4 ponds / owner (on average 2.7 ponds) with an average size of 631 m^2 (Chenyambuga, 2014). Shoko et al. (2011a) reported that 96% of the ponds sampled in the Lake Victoria region had an average area of 166 m^2 (in Shoko et al, 2017) Most farmers (96%) dug their ponds themselves. For 60.4% of the farmers rivers were the source of water while irrigation schemes supplied water to 17% of the farmers.

Thirty-seven % of the owners do not exchange/refresh pond water and 82% of the owners do not use any type of energy to exchange pond water. Only 5% of the farmers interviewed by Mwaijande & Lugendo (2015) used pumps, 4% used weight balances and 3% applied a generator. Fish nets (for harvesting) and scope nets were used by 17% resp. 1% of the respondents. The large part of the farmers that have only a small pond (or a few ponds) and no other piece of equipment confirms that aquaculture is still very much practised at subsistence level. (In Dar es Salaam there are a few suppliers of machines that can be used in fish farms: pelleting machines, auto feeder machines, air pumps, etc.).

Ninety-seven % (Mwaijanda & Lugendo, 2015) resp. 83% (Chenyambuga et al, 2014) of the farmers raised tilapia, the others raised both tilapia and African catfish and only a few raised only catfish. Catfish is stocked to control excessive tilapia reproduction. 86% of the farmers were found to stock their ponds with less fish than was recommended (i.e. less than 3 fingerlings / m^2). Most of the farmers in Mvomero (65.5%) stocked their ponds twice/year while 68.4% of the farmers in Mbarali

district stocked their ponds only once/year. Twenty-two % of respondents did not know the sex of their fish and 76.5% raised both male and female fish. After 6 months of rearing the fish had not attained the weight of 0.5 kg/piece for 37% of the farmers, while 26% did not know the weight of the fish harvested. It seems the technique of raising only male tilapias was not applied by the farmers that took part in these surveys.

Shoko et al (2018a) reported that about 40% of fish farmers they surveyed culture Nile tilapia, 21% culture African catfish while 39% culture both Nile tilapia and African catfish in monoculture or polyculture. The majority (70.4%) of Nile tilapia farmers still practice mixed sex while only 29.6% practice mono-sex. Mono-sex seeds have been recommended for increasing fish farming productivity. Unfortunately, most farmers (76.1%) still are not aware of the importance of culturing mono-sex Nile tilapia. They still believe that using mixed sex is the best traditional farming system which gives them more fish when they reproduce. Additionally, fish farmers may not use mono-sex seeds because they are not easily accessible and affordable. Some hatcheries also purport to produce mono-sex seeds, but they are actually producing mixed sex due to inadequate skills in sex reversal procedure.

Shoko et al. (2018a) showed that 68.7% of aqua-farmers experienced death of fish at stocking. The deaths were also experienced during transportation of brood stock and fingerlings. The mortality was associated with lack of aeration in aqua-farms and during fish transportation because the majority of farmers reported that they don't use aeration when transporting fish. The study also found out that aqua-farmers are not aware of the optimum fish stocking density since they stock mixed sex of Nile tilapia at a stocking density of six to ten fish per square meters. Interestingly, there are some developments in aquaculture in Tanzania. Observations from some aqua-farms in Dar es Salaam and Coast regions showed that 43% of farms use aeration in their aqua-farms and during transportation. Aqua-farms such as Ruvu Farm Ltd and Eden Aqua Ltd use aeration.

From the information available about the predominant farming system & techniques and summarized above emerges that most farmers experience a shortage or complete lack of al basic inputs needed to operate as a small-scale commercial fish farm: capital to hire labour to build larger, more or better ponds and harvest equipment (net, weighing scale); sufficient fertilizer, feed and fingerlings of good quality, preferably all male.

3.3.4 Motives to start with fish farming

Motives to start with fish farming were: household food supply (65% of the respondents); Source of income (24.6%); Leisure activity (5.5%) and induced by friends (4.8%; Mwaijanda & Lugendo, 2015) Chenyambuga notes that 'This might be due to the fact that most small-scale fish farmers were persuaded and encouraged by either NGO or research and development projects to establish fish farming enterprise."

From this information follows that in the past a major part was attracted to fish culture because they perceived it as an additional source of food for their own household and not as a source of cash income. However, this situation seems to be changing: during the field work undertaken for this study in Dar es Salaam and Coastal Regions the farmers mentioned as most important motive to start fish farming business opportunity (85%), followed by learning from neighbour (5.9%), use advantage of natural pond (2.9%), learned from media (2.9%) and both home consumption and business (2.9%). Although at the moment aquaculture in Tanzania is still at small scale level, there are indications that the sector will shift towards commercial undertakings and may become a major source of fish supply (Shoko et al., 2018a).

3.3.5 Fingerling supply

In 2016 MALF (2016) reported "There are nine hatcheries for tilapia in operation (three of them being government owned and operated) with production reaching slightly over 5,000,000 fingerlings, against a demand estimated by the Department of Fisheries Development to be over 30,000,000 fingerlings countrywide. There is an apparent lack of good quality fry, and the excess demand over supply results in lower quality and higher levels of mortality, undermining productivity" (MALF, 2016).

The results of value chain analysis of fish seeds in the regions of Dar es Salaam, Coast, Morogoro and Lindi showed that 80% of the seed producers were private operators whereas the remaining 20% were government operated hatcheries (Shoko et al., 2018). The majority (70%) of hatchery operators produce tilapia (believed to be Nile tilapia) seeds while only 30% of these hatcheries produce African catfish seeds. The private hatcheries studied had separate seed production and grow-out facilities. Production of fingerlings is done throughout the year due to favourable climatic conditions especially temperature. The value chain of fish seed production in Tanzania involves input supplies, seed production and finally a fish farmer (see Figure 1, page 14 of the report, Shoko et al., 2018a). Hatcheries operators produce both mono-sex and mixed sex Tilapia seeds. The seeds are sold mostly at fry or fingerlings stage (1- 5 g) due to high demand (Shoko and Ulotu, 2016, Shoko et al., 2018a).

There is no National Aquaculture Research and Breeding Centre where quality brood stocks can be kept as gene banks for supply to hatchery operators in Tanzania. Tilapia and African catfish seed producers obtain brood stocks from different sources of which the quality cannot be ascertained. Shoko et al. (2018) reported that Tilapia seed producers obtain brood stocks from wild environment (40%), formal stations/hatcheries (30%) and either other fish farmer's ponds or self-produced (30%). Whereas, African catfish seed producers obtain brood-stocks from the wild environment (60%), formal stations/hatcheries (20%) and unidentified sources (20%). The number of brood stock present per hatchery ranged from 1,000 to 10,000 for tilapia and 500 to 6000 for African catfish. On average a female to male ratio of 3:1 was adopted. The size of brood stock ranged from 300 g to 400 g for tilapia and 500 to 1000 g for African catfish. The brooders were stocked at a stocking density of 6 fish per square meters for both Tilapia and African catfish (Shoko et al., 2018a).

According to Shoko et al. (2018) the majority (50%) of tilapia hatchery operators produced between 2,000,000 and 5,000,000 seeds per year whereas about 20% of these tilapia seed producers produced between 10,000,000 to 25,000,000 fingerlings per year. About 40% of African catfish seed producers produced between 1,000,000 and 2,000,000 seeds per year where as 20% produced between 2,000,000 to 3,000,000 per year. About 10% of African catfish seed producers produced only about 100,000 seeds per year. The remaining 30% of both Tilapia and African catfish hatchery operators had no records of the seeds produced. The seeds are sold at the weight range of 3 to 5 g and 5 to 10 g for Tilapia and African catfish respectively, normally at the age of 30 to 50 days. Seeds are sold at a price range of USD 0.09 to 0.13 and USD 0.22 to 0.27 for Tilapia and African catfish respectively. The fingerlings are mostly sold directly to aqua-farmers (about 99%).

There are differences between the regions with regard to the most common source of fingerlings for fish farmers. Mwaijande & Lugendo note that 'Most of fish farmers (60.4%) obtain their fingerlings from each other. Only a few farmers obtain their fingerlings from the government (23.5%) while 11.9% obtain their fingerlings from the rivers. About 2.7% obtain their fingerlings from private breeders". A table in the article by these authors showing how farmers cope with shortage of feed and fingerlings (see page 27 of this study report) indicates that 30% of the respondents use (also) fish from rivers to stock their ponds. However, a study by Shoko and Onyango done in 2005 found that *O. leucostictus* was mistakenly identified as *O. niloticus* and cultured in some fishponds supervised by NGOs and Community-based organisations CBOs in Lake Victoria region (Shoko et al, 2017). The use of such slow-growing, wild species or their hybrids may partially explain low fish production from such ponds. The fact that neighbours or other fish farmers (who may have obtained their fish from rivers and streams) are the main source of fingerlings for a great part of the farmers contributes to and maintains the use of such slow-growing fingerlings.

3.3.6 Pond fertilization

In Mvomero and Mbarali districts 85% of the farmers fertilized their ponds, with cattle manure being mostly used (by 52%), followed by goat/sheep manure (33%) and chicken manure (8.3%). Manure was applied once/week by 12.5% of the respondents, once/month (31.3%) or once/3 months by 37.5% of the farmers. Forty-six to 60% of the farmers reported to place the manure in cribs. Lime was applied by only 2% of the interviewed farmers.

According to Shah et al (2012) integrated aquaculture is common in especially the Eastern region, with the combination of fish and duck being the more popular. "Organic waste from cattle and poultry production is applied to fish ponds, 2-7 times weekly at around 100 kg/ha/annum" (Shah et al, 2012, p. 8673).

Also more recent studies confirm the common use of animal manure to fertilize ponds. Shoko et al. (2018) reported that 80% of aqua-farmers use on farm manure preferably animal manure to fertilizer fish ponds. Integrated Aquaculture Agriculture (IAA) is used in some places to provide fertilization to fish pond water through vegetable or poultry integration to enhance production of natural food for fish. IAA demonstrations have been done in Tarime, Mara (Shoko et al., 2011b), Morogoro (Shoko et al., 2018b; Limbu et al. 2016). Iringa and Songwe (Shoko and Ulotu, 2016). Wherever it is demonstrated IAA seemed to be preferred by most aqua-farmers because it reduces the cost of feeding, diversify on farm production and hence increase overall farm yields.

3.3.7 Fish feed

In Mvomero and Mbarali districts 44% of the farmers depended on natural feed (stimulated with fertilizers) and supplemental feed. 96% applied maize bran, 23% kitchen left-overs and 19% vegetables/ weeds as supplemental feed. The farmers fed their fish twice (52%) or once per day (33.3%) (Chenyambuga et al 2014).

Seventy-six % of the farmers interviewed by Mwijande & Luzengo (2015) produced the fish feed themselves while only 17% obtained their fish feed from local feed manufacturers who produce their feed from locally obtained materials like maize and paddy husks, remains of vegetables, cocoyam leaves and cattle dung. The researchers note that many of these local feed manufacturers lack the basic knowledge of producing the right feed.

To overcome feed shortage on the market, fish farmers make their own feed. Other ways to overcome or cope with input constraints are in Table 6.

In 2016 there was one fish feed producer and supplier based in Dar es Salaam (MALF, 2016). Government supports the distribution of affordable fish feed by subsidised 85% of the commercial selling price to fish farmers. There are a few commercial operators with vertically integrated facilities, which include small-scale fish feed mills, using locally available raw materials such as fish meal (from dagaa), soya beans, sun flower oil, cassava flour, wheat and maize bran. Some feeds are also imported directly by larger producers, to ensure better quality and productivity. In Dar es Salam there are a few companies that provide aquaculture equipment and machines such as fish feed pelleting machines, auto feeder machines, air pumps, etc.

But also, on the use of feeds change is taking place. Shoko et al. (2018a) report that in spite of the fact that the majority (66%) of aqua-fish farmers in Tanzania use on-farm feeds, a good number of the farmers they surveyed (33%) use industrial commercial feeds. There is an emerging group of aqua-farmers (2%) that combine both on-farm and industrial commercial feeds. The higher price asked by industrial commercial feed suppliers force aqua-farmers to strategize and mix part of commercial feeds and locally made feeds. Aqua-farmers mostly use locally available diets such as maize and rice bran, food and vegetables remains; cocoyam leaves etc as previously reported by Mwaijage and Lugengo (2015). As pointed out earlier in this report the increasing use of industrial commercial feeds such as extruded or non-extruded diets in Tanzania aquaculture industry is a good indication of sector transformation.

Table 6 *Ways farmers used to overcome fish-farming challenges (n = 293)*

Strategy to overcome shortage of feeds	Percentage	Confidence Interval (95%)	
		Lower	Upper
Make own feeds	90.0	85.3	94.0
Purchase	5.3	2.0	8.7
Reduce required feeds	.7	.0	2.6
Substitute with garden vegetables	1.3	.7	2.7
Do nothing	2.7	.7	5.3
Strategy for medication			
Do not use	91.3	88.0	94.7
Unaware	7.3	4.0	10.7
Follows best practices	.7	.0	2.0
Strategy to overcome shortage of fingerlings			
From own pond	28.0	21.3	35.3
Purchase from others	15.3	10.0	20.7
Friendship hospitality	26.0	20.0	32.7
From local ponds/ rivers	30.0	22.7	37.3
Strategy to overcome shortage of extension services			
Learn from peers	12.7	8.0	18.6
From government and private extension services	20.7	15.3	26.0
Do not seek extension services	64.0	58.0	70.7
Self-learning	2.0	.0	5.9
Strategy to overcome loans			
No strategy	63.3	56.7	70.0
Personal savings	21.3	15.3	27.3
Never sourced	9.3	5.3	14.0
Sourced but failed access	5.3	2.0	8.7
Strategy for fish preservations			
Nothing	83.3	78.0	88.0
Sun drying	4.7	2.0	8.0
Cold containers	8.0	4.7	12.0
Smoking	1.3	.0	3.3
Freezer / fridge	1.3	.0	3.3

Source: Authors' analysis.

Source: Mwaijande & Lugendo (2015)

The study by Shoko et al (2018a) further showed that the quality of the main types of feed used can be grouped into good quality (42%), moderate (13%) and poor quality (45%; Shoko et al. 2018a). These researchers also cross-tabulated aqua-farmer's perception of the quality of the feed types against feed types used. Around 79% of the interviewees acknowledged that industrial commercial feeds are of better quality (Table 7). This perception shows a need for a deliberate effort to make industrial commercial feeds available at affordable price. Farmers clearly prefer to use commercial feed to the use of only on-farm feed but the high price asked by suppliers is a prohibiting factor. Aqua-farmers who use commercial pelleted diets spend between USD 1.00 and USD 1.34 per kg compared to less than USD 0.50 per kg spent for on-farm made feeds (Shoko et al., 2018a).

Table 7 *Cross tabulation among types of feed used*

		Feed Quality			Total
		Good quality	Moderate	Poor quality	
Feed type	Industrial feeds	79	0	0	33
	Local feeds	18	100	100	66
	Industrial & local feeds	4	0	0	1
Total		100	100	100	100

3.3.8 Marketing

Shoko et al. (2018a) give details about the harvesting and sales process in Morogoro, Coast and Dar es Salaam regions. Most tilapia fish farmers normally harvest their fish when they are between six and seven months old. The majority of African catfish farmers harvest their fish at six (20.5%), eight (20.5%) and twelve (17.9%) months. However, in both tilapia and African catfish, there are farmers who have no specific harvest time while some harvest on demand. Total amount of fish harvested ranged from 100 to 200 kg per harvest. The final weight at harvest of Nile tilapia from most farmers (94.7%) is less than 500 g while that of African catfish ranges from 500 g to 4,000 g. The majority (93.2%) of farmers sell their fish while fresh, only 6.8% process their fish through frying (25%), smoking (25%) or both (50%).

The sale process of freshwater farmed fish in Tanzania is in most cases simple: the producers sell fish themselves directly to the consumers in their neighbourhood or at nearby local markets, or they sell to traders who sell directly to consumers. Ninety-one % of the farmers surveyed sell their harvested fish within their own locality and the remaining part of the farmers sell to nearby villages, aiming to get relatively better price.

The results of the field survey that was undertaken as part of this study in Dar es Salaam and Coastal regions show that 60% of aqua-farmers sell their fish in nearby towns while the rest (40%) sell their fish on farm. Fishes are sold fresh by weight (kg) to traders (31% of respondents), to both individual customers and fish traders (59%) and to individual customer only (10%; Shoko et al., 2018a).

In Morogoro region, men sell in 66% of the cases the fish harvested from the ponds, women do this in 14% of the cases and children in 15%. In 5% others (= other relatives, friends, hired person) take care of the sale of the farmed fish.

The value chain of farmed fish includes input suppliers, fish farmers and marketers/traders. Major findings of the study of this value chain by Shoko et al (2018a) is summarised in Figure 4.

Recent price data collected by Shoko et al (2018a) showed that fish prices in Morogoro and Lindi regions ranging from USD 1.34 (farm gate) to USD 2.23 per kg (retail market). The price in Dar es Salaam and Coast regions ranged from USD 3.13 (farm gate) to USD 4.47 (retail market) per kg. The highest price was observed in Dar es Salaam and Coast urban areas. However, it was observed that the fish prices in Mkuranga district of Coast region are lower compared to other urban areas surveyed in this study. It is interesting to note that most farmers (85.5%) in the surveyed areas indicated that they had not attained their planned fish farming targets which shows that they perceive space for aquaculture expansion.

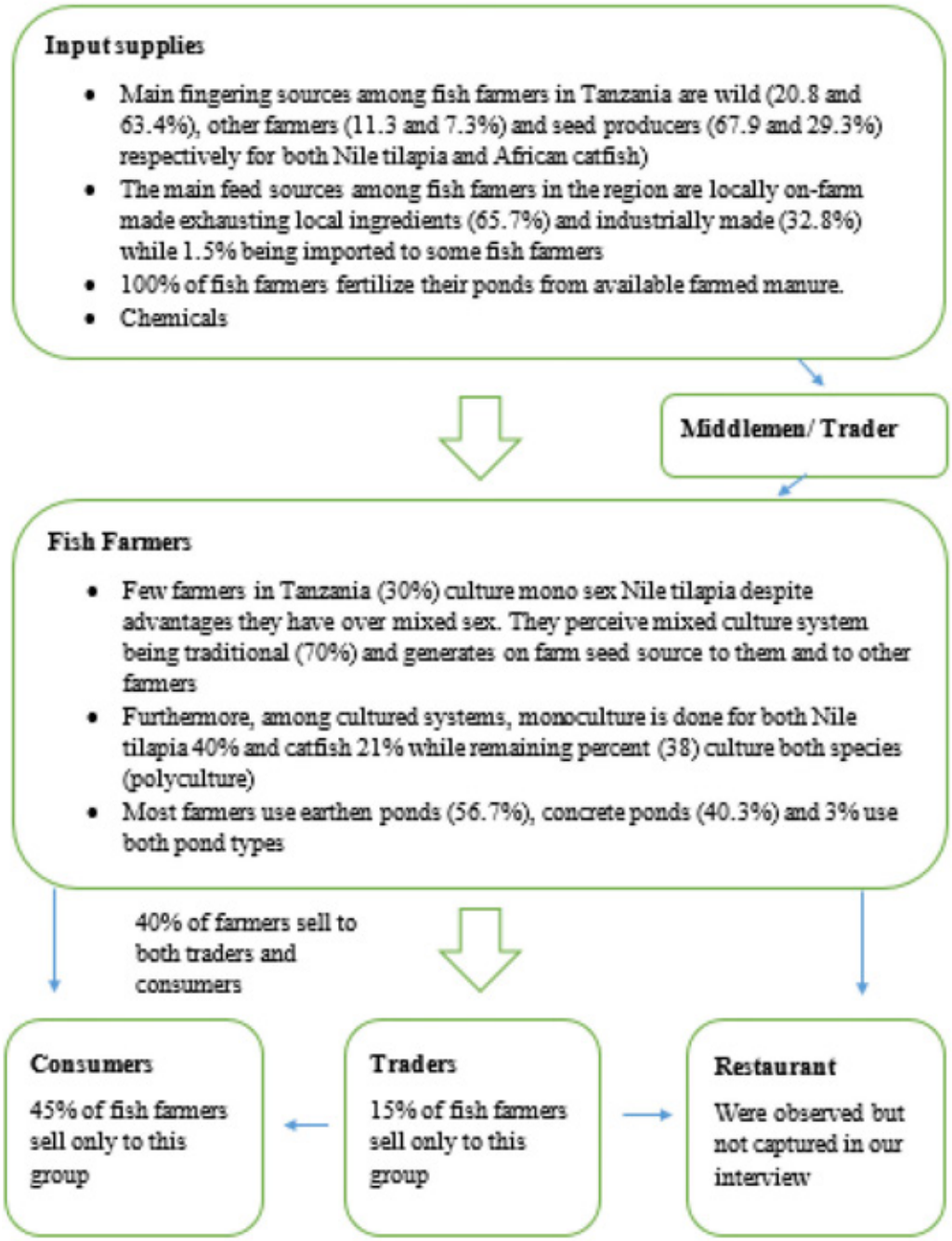

Figure 4 *Fish farming value chain in Tanzania (from Shoko et al., 2018a)*

3.3.9 Environmental, social and governance effects

Two environmental concerns related to aquaculture were mentioned in the literature available. The first concern relates to the use of Nile Tilapia in fish farms in water sheds where this species is not endemic. Nile tilapia (*Oreochromis niloticus*) but also *Oreochromis leucostictus* are reported to have entered lake Nyassa (Lake Malawi) as result of aquaculture activities taking place in the watersheds that drain in this lake. Lake Nyasa/Malawi has an exceptional high biodiversity with 835 endemic Cichlid species. *Oreochromis niloticus* and *O. leucostictus* may compete with, predate upon and hybridise with the endemic species, leading to biodiversity loss in this unique freshwater ecosystem (Genner, 2014).

The widespread of the introduced *Oreochromis* species within Tanzania was also reported by Shechonge et al. (2018), largely associated with deliberate stocking of these species in water bodies and aquaculture facilities. The authors suggested "zoned aquaculture" to reduce major environmental impacts for native species caused by escapees from aquaculture facilities. Translocation of native

Oreochromis species beyond their native range was also reported (Shechonge et al., 2018). Utilization of large-bodied species that are native to specific catchment where aquaculture facilities are established was also recommended as an alternative aquaculture approach (Lind et al., 2012).

The second concern relates to the environmental impact of cage farming. The Ministry of Environment and MALF are concerned with the pollution caused by cage culture (faeces, antibiotics) and with escaped fish.

The literature available does not suggest that concerns related to the environmental impact affected small-scale pond fish farming in any way. The small-scale nature of the majority of the farmers plus the absence of antimicrobials used support these findings.

3.3.10 Key challenges and limitations for small-scale commercial fish farmers

3.3.10.1 Lack of critical inputs

Investment in aquaculture development is financed by personal / private sources. Banks have not started yet providing loans to fish farming activities because in their view, aquaculture has not yet been demonstrated to be a viable economic generating activity. This indicates a lack of credit for investments and operations, as is also indicated by farmers surveyed by Wetengere (2011) in Morogoro Region, who after lack of necessary inputs (feed, fingerlings) cite the lack of bank loans as their second most important constraint for development. Fishery education ranked 3rd, lack of fish preservation equipment ranked 4th, theft and wild animals 5th and the limited extension services ranked 6th. Insufficient availability of good quality fingerlings and feed was also cited as a bottleneck for small-scale producers in many parts of the country.

In the studies cited it was shown that farmers buy feed from neighbours / companies that produce fish feed, when available. Even cow dung was mentioned as an ingredient for such producers. However, many such "back-yard" fish feed producers lack the knowledge and equipment to make fish feed of decent quality in sufficient quantities. Critical inputs that are lacking are: sufficient ingredients of good quality, knowledge about how to make quality fish feed and access to equipment.

Shoko et al (2011) mentions poor pond management as the major cause of low productivity. Poor management is caused by lack of inputs (quantity but also quality) and knowledge about how to improve production. The latter is related to lack of extension officers and facilities. But this researcher also mentions a lack of entrepreneurial skills both as an individual and as a group. "Most people cannot see aquaculture as a stand-alone economic activity despite its potential." (Shoko et al, 2011, p. 92).

Recently, the same author identified main critical factors affecting the aquaculture subsector in Tanzania (Shoko et al., 2018b). The identified factors were categorized into feed, seeds and fish farmers.

- **Quality fish feed:** The high price of commercial fish feed (both imported and locally produced feed) is a prohibiting factor for the aquaculture industry to grow. The high feed price is also caused by the increasing price of the feed ingredients and the high prices of imported machinery, equipment and tools for feed production. It was pointed out by feed producers visited that the prices of machinery and tools are high due the importation charges. Inadequate technology in fish feed manufacturing and inadequate competent skilled labour to operate the installed machines contributes into poor quality of feed produced. Sometimes suppliers bring low quality machinery and tools.
  Quality feed for brood-stocks are not readily available. The limited amount of quality feed for brood-stocks that is available is too expensive to be affordable by hatchery operators.
- **Quality fish seeds:** Hatcheries do not have a reliable source of quality brood-stock. Most of the brood-stock is obtained from the wild environment.
- **Factors in fish farming:** The most important factor affecting fish farming in Tanzania is inadequate knowledge in fish farming and poor extension services due to insufficient number of extension staff. During the survey about 50% of aqua-farmers received fish farming knowledge from social networking while government extension staff accounted for only 16%. Other factors include unreliable financial support and inadequate quality and quantity of fish seed and feed (Table 8).

Table 8 *Challenges identified by fish farmers in response to open-ended questions (from Shoko et al., 2018b)*

Challenges mentioned	Percentage of respondent
Insufficient extension officers	**17.9%**
Fish predators	**22.4%**
Absence of quality feed	**37.3%**
High prices of feed raw materials	**44.8%**
Absence of quality seed	**40.3%**
Higher price seeds	9.0%
Distant to quality seed	6.0%
Fish death	1.5%
Lack famers network	9.0%
Power failures	6.0%
Lack of education on fish farming	**67.2%**
Absence of farming equipment	17.9%
Lack of sufficient water or too expensive	26.9%
Water seepage in ponds	6.0%
Lack proper harvesting technique	3.0%
Absence of reliable fish market	19.4%
Flooding	1.5%
Lack of capital	**49.3%**
Total number of respondents	67

Almost all factors pointed out by Shoko et al. (2018) were also suggested by aqua-farmers during the present field study for Msingi. However, findings from the present study added more factors such as high costs of electric power, lack of aerators, predation, unreliable market, lack of cold storage facilities and government support.

At a regional level, the Lake Victoria Fisheries Organisation (LVFO) representative identified problems that hinder aquaculture programmes at regional level. These include inadequate skilled operators, quality seeds and feeds, unstructured approach to improvement of brood-stock, lack of coherent brood-stock development programme and directed research on genetic improvement. Other problems are limited networking of different actors along the value chain and lack of financing as aquaculture is perceived as a risky investment. According to LVFO, investors interested in starting an aquaculture smallholder's support project should consider providing technical support to aqua-farmers and assisting in accessing high quality seeds and feeds. Other aspects include provision of training to farmers on pond and cage day to day BMP and assisting farmers with securing a market (Kaynda, pers. comm., 2018).

Lee & Namisi (2016) present a list with Strengths, Weaknesses, Opportunities and Threads (SWOT) facing Tanzanian aquaculture:

14.5 Aquaculture

Strength	Weakness
URT is endowed with many Lakes, Rivers, reservoirs and basins not yet used for aquaculture production. Good environmental conditions and native species with aquaculture potential High and unfulfilled demand for fishery products provides ready market for aquaculture products (at least 250,000 tonnes/year). Under-utilised processing capacity could be used for packing aquaculture products for domestic, regional and international markets. Legal framework in place to manage environmental impacts and sustainable aquaculture production practices. Existing aquaculture projects producing 3,800 tonnes in 2014.	No aquaculture development zones established leading to delays and refusals of licences. Excessive regulatory burdens in establishing aquaculture facilities. Small scale operators unrecorded/not monitored. Limited commercial technical expertise in Tanzania to move towards commercial aquaculture. Low quality domestic feeds coupled with high costs of imported feeds Lack of sufficient feed mills to take aquaculture to commercial production levels. Poor quality seed locally produced. Inadequate hatcheries in terms of quantity and quality of seed. Lack of investment funds Weak enabling environment to stimulate growth and investment in
Evident commercial interest in development Systematic testing of water quality National Aquaculture Development Strategy adopted. Government incentives in place to promote investment in aquaculture	aquaculture Lack of monitoring facilities for certain elements / parameters (e.g antibiotics, chemicals, heavy metals, not in line with international requirements. No fish disease surveillance or control system in place.
Opportunities	**Threats**
Development of a sustainable aquaculture sector, producing 250,000 tonnes/year in the medium term, based on cage and pond culture of tilapia and other species such as *clarius spp.* Development of modern fish feed facilities maximising inputs from local raw materials. Selective breeding of native species to develop high quality genetic stock Development of hatcheries to deliver high quality fry and fingerlings to grow out units. Improved utilisation of existing processing plants that are operating below capacity processing/packing farmed tilapia for domestic and export markets. Supply of good quality technical equipment for aquaculture farm such as Monitoring systems, pumps, hatchery equipment, processing equipment, refrigeration equipment, efficient energy systems using solar and wind power Collaboration in research between Universities and research institutions	Excessive regulation and ineffective policy support measures stifles investment, especially for SME producers. Uncontrolled disease outbreaks due to lack of effective monitoring and control system.

Source: Lee & Namisi (2016) p. 75-76.

In addition to the lack of critical inputs these researchers also mention excessive regulatory burdens, weak enabling environments, absence of aquaculture zones, monitoring facilities and fish disease surveillance and control mechanisms as weaknesses affecting Tanzanian aquaculture development.

3.3.10.2 Policy and regulatory environment

The development of cage culture in Tanzania was slowed down by reported complexity of multiple licensing requirements with several agencies, namely the National Environment Management Council, Ministry of Environment and the Ministry of Livestock and Fisheries.

The Tanzanian government itself admitted that: "Until now, despite the best efforts of the Department of Fisheries Development, and considerable investments, the Government has struggled to establish the right policy environment for private sector investment in aquaculture to take off." (MALF, 2016). But according to Department of Aquaculture Division (DAD), efforts have been made to remove the restrictions for cage culture. Now only a strategic EIA by TAFIRI and thereafter a permit from the Director of Aquaculture Development Division (ADD) are needed.

Restrictions to the import of fish feed ingredients resulting from GMO crops may impact fish feed producers.

3.3.10.3 Constraints related to marketing

The marketing situation seems to be different in rural, remote areas and in or near urban centres. Wetengere (2011) found that 79% of the surveyed fish farmers in Morogoro region reported problems with the sales of their produce. The problems related to the perishable nature of the produce and having no way of preserving the freshness of the fish, poor roads, lack of means of transport to larger urban markets, selling at local markets where most customers are poor. All these factors result in having to sell at low prices. The author believes that market conditions are a major constraint to aquaculture development. He believes that better market conditions (such as involvement of traders who could sell the produce for a higher price at larger urban markets) would result in higher earnings, also for the farmers, from fish sale, followed by higher investments and higher production.

The dominant species farmed in Tanzania are also available in markets throughout the country as result of capture from lakes and rivers. In many places the amount of fish on the market that resulted from catch far exceeds the quantity resulting from fish culture and hence, the price received for farmed fish is determined by the common prices for the captured fish in that market. In addition, Darko et al (2016) report that when given the choice, most consumers were in general willing to pay a lower price for farmed fish compared to fish resulting from capture, showing a lower preference for farmed fish. The consumers who valued farmed fish less explained this lower preference with the following reasons: farmed fish is less available (83%); farmed fish is relatively more expensive (1.1%); farmed fish does not taste good (11%); farmed fish is inconsistent in size (1.1%). However, 24% of the consumers surveyed showed a willingness to pay TZS 300 more for farmed tilapia than for captured fish. The authors conclude that 'these are encouraging results for fish farming, in that such consumers could be targeted for marketing purpose'" (Darko et al, 2016, p. 140). All consumers were willing to pay more for large-sized fish, a feature that can be capitalised upon by fish farmers.

However, in the most recent studies most aqua-farmers (96.6% during Shoko et al. (2018b) and 85% of the farmers surveyed in the present study) pointed out that they have not yet satisfied the market, indicating a high market demand for fish. In addition, according to author's experience, the demand for fish from aquaculture is very high. In Dar es Salam it is very difficult to find fish from aquaculture for domestic consumption. The reason given for this scarcity is the increased demand for fingerlings that causes fish producers to prefer producing fingerlings rather than grow-out. This is particularly true for tilapia. It is however true that market for fresh fish is more a problem in rural areas due to the absence of storage facilities that can keep the fish fresh for a longer time.

On the other hand, the market for African catfish may be a problem in Dar es Salaam since most catfish producers are looking for buyers and market outlets where they can sell their fish. Further study is needed to confirm this hypothesis.

3.3.11 Most successful production models

All the available literature about freshwater aquaculture in Tanzania and our field study deal with small-scale tilapia production in ponds only. Due to the absence of detailed studies of other production models (such as cage farming or fish culture in concrete tanks) it is hard to assess if this production model is more or less successful.

3.4 Perspectives from small-scale commercial fish farmers

Perspective from various researchers, based on their studies and observations, have already been summarised above in paragraph 3.2 and 3.3.

3.5 Small-scale commercial fish farming suitability map

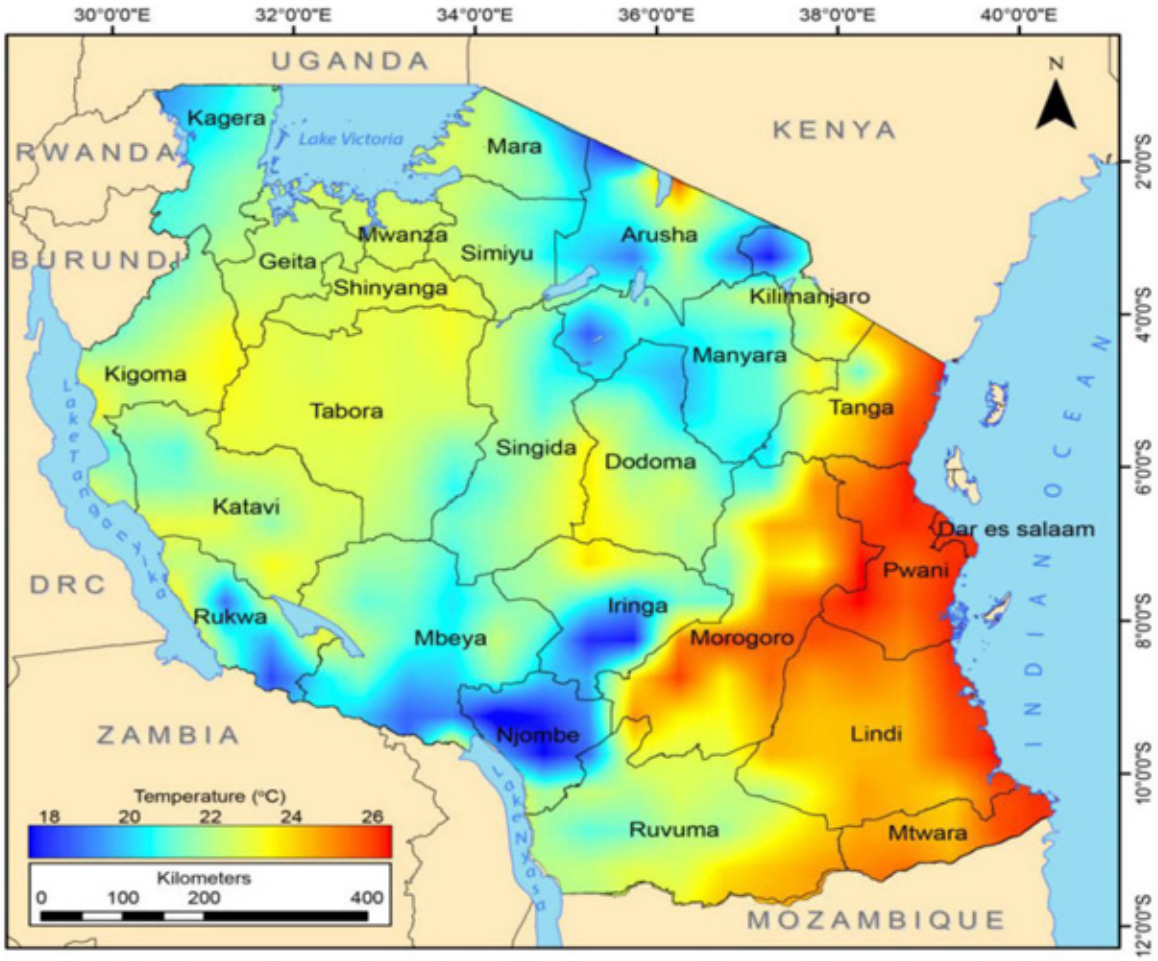

Figure 5 *Tanzania mainland map showing average temperatures*
(By courtesy of Mr. M. Semba of the Nelson Mandela African Institution of Science and Technology, P.O. Box 447, Arusha, Tanzania. Source: Rothuis et al. 2014)

In Figure 5 the yellow to orange areas are suitable for tilapia and catfish farming (Shoko, 2017).

3.6 Analysis and insights

Lee & Namisi (2016) describe a hopeful future for aquaculture in Africa and Tanzania in particular, with which we agree:

> "… the encouraging lessons from aquaculture production in Asia provides a linchpin for consideration of aquaculture development in Africa and particularly Tanzania. Facilitated by improved technology, many countries in Africa that have suitable aquaculture production environment can now move into aquaculture production without re-inventing the wheel in the technologies developed. The lessons learnt from Asian aquaculture development successes should provide great confidence for any prospects in aquaculture investments in Tanzania.
>
> There is a need for the aquaculture development policy to be translated into meaningful measures to overcome the identified challenges."

The same authors concluded: **"**Overall the performance of the sector has been weak and does not reflect the potential. This is due to factors such as:

- Lack of availability of good quality feeds at reasonable prices
- Unreliable and variable costs in seed supply
- Inadequate credit facilities
- Poor extension services
- Complexity of regulatory environment."

Some of the factors mentioned by Lee and Namisi have been addressed by the government of Tanzania as described in par. 3.2.10. Also, as result of new and expansion of existing farms, total farmed fish production is reported to increase in the past 2 years.

Barriers for new entrees in the sector

In general, for a small or medium scale farmer/investor starting fish farming as a commercial activity have considerable **risks**. It requires a considerable investment to start (building costs for cages/ponds & water supply infrastructure, electricity supply, vessel to reach cages from the shore line), for purchase of fingerlings. The cost of construction and stocking (with tilapia) of a new pond measuring 100 m^2 and 1 m deep would be up to Tshs 0.5 million (USD 333; (Kleih, Kishe, and Yunus, 2010). Operational costs (feed, labour for care taking or security) add up during the time (5 to 9 months) the fish are growing. In this period there are the risks of theft, natural predators and natural disasters (drought, storms and flood, destruction by hippo's, crocodiles, diseases, pollution) which may ruin part or the complete crop. The starting farmer needs the financial reserve or back-up to repair and restock their facilities and start again. If not, (s)he may call it quits.

The success to raise a good crop depends on the knowledge and skills of the owner and/or his personnel. The fact that aquaculture is in most areas not a traditional agricultural activity means that considerable amount of new knowledge and skills need to be learnt or hired. Having experienced staff will surely help and reduce the risks mentioned above, but even experienced staff can nor foresee and prevent and remedy all events that can harm the fledgling enterprise.

When finally, after 5 – 8 months without income and only expenses, a good harvest can be made, the farmer may receive a price for the fish that is too low (as result of competition on the market from wild-caught or imported fish from Asia) to recover all the costs. There is also the prospect of the costs related to starting a new production cycle.

Compared with investing in trade or in the production of a product (plant crop of animal) that is better known, with a shorter rotation cycle and less risky, aquaculture may not be the most attractive sector for investors and financers. It is not a fast way of earning money; often real profits are made only after several production cycles (which may take some years) and after learning some expensive lessons.

The banks or credit institutions may not know aquaculture very well but they may have heard about failed initiatives. Hence the remark that banks in Tanzania do not provide loans because "aquaculture has not yet demonstrated to be a viable economic generating activity" (Shoko, 2017). When credit institutions consider loan programmes for aquaculture they are often patterned after (or part of) agricultural credit programmes. The conditions for agricultural loans may not be suitable and adjustment to the specific features of the aquaculture sector may be required. Longer grace periods and a facility that takes care of the risks (i.e. buffer to recover from (partial) crop failure resulting from natural or man-made disasters) should be part of such programmes.

Especially for new investors in aquaculture the legal environment is important. Is it easy to obtain a permit? Is the government supportive? are there long procedures and bureaucratic hurdles for obtaining a permit? The 2015 reform of the Fisheries Policy seems to have addressed a number of the constraints and bureaucratic hurdles that affected aquaculture start and development before.

Opportunities to expand small-scale production for existing farmers

The majority of fish farmers in Tanzania are small scale and struggle with limitations to production as a result of lack or inputs (quantity and quality), equipment, knowledge and skills, and in rural areas also markets. Despite all these limitations a small percentage (approx. 15%) manages to do better than others, reaching a productivity of 4-6 tons/ha/year with the means available to them. This group seems to have the conditions, drive and skills to perform better. Analysis as to why this group outperforms the others is needed. A programme that addresses the limitations confronting especially this group may be successful. Support with investment that will enable them to expand and/or improve, training aimed at additional technical and management skills and support with reaching better markets for their produce may be effective in overcoming the constraints.

With medium-scale farms focussing on tilapia fingerling production seeds may become more available. There is however no certification that guarantees the quality of the fingerlings.

In major cities the supply of farmed fish is reported to be less than the demand. This is reflected in a high price paid for tilapia in urban centres (up to USD 4.50/kg). This offers opportunities for small-scale farmers near urban areas who would like to intensify and/or expand their production.

Lee and Namisi (2016) mention the following opportunities for investors interested in supporting Tanzanian aquaculture:

- Investment finance (credit or grants) for entrepreneurs investing in feed mills and hatcheries
- Relaxation of regulatory requirements (zoned EIAs)
- Public infrastructure investment (roads, power, water supply canals to defined aquaculture zones)
- Provisions of technical assistance for smaller scale operators
- Investment in technical education and training for aquaculture

More details of some of these opportunities include:

- Identifying and establishment of areas for placing fish cages and fish ponds will require government to conduct mapping studies to zone out the suitable places and ensure clear property rights concerns.

- Establishment of hatcheries and procurement of fingerings (Tilapia, Trout and catfish). This will be guided by technical support from government or private sector certified entities. Currently, there are 9 low capacity local hatcheries including 3 belonging to government but they all need upgrading and standardization. The government should prepare guidelines to guide prospective investors in hatcheries and fish farmers on better and approved fingerlings and prepare fact sheets about how to handle of manage fingerlings

- Investment in fish feeds (pelletizer or pellet) production, storage and distribution. There are no serious fish feeds companies in the country apart from small-scale producers, yet this is a very promising area for investment. Aquaculture cannot take off without better feeds. This calls for the quality and quantity of the feeds. The government will have to scale up this industry by promoting strategic agricultural produce that feed into the aquaculture fish feeds industry. The bulky raw

materials that include fish protein (potentially utilising Dagaa), wheat bran, maize bran and soybean are present in the country and can be up scaled. An alternative would be for the government to allow imports of quality feeds from big companies like FF Skagen from Denmark, Omaurci, SA from Venezuela, Khan Traders Fish Meal in Pakistan, King Fish Products in India, NuBlend from Australia, etc. However, that means the government will need to weigh the options of promoting commercial fish farming and increasing tax revenue for the country and decide whether to waive VAT or import tax on these raw materials meant to boost the aquaculture industry and increase the base from taxation from producers.

- It is clearly in the interest of Nile perch fish processors to invest in the diversification of their supply chain, into processing products from aquaculture, with a view to employing some of their under-utilised facilities for packing and distribution.

- Establishment of transport infrastructure (nets, boats/vehicles, and other equipment) and logistics systems: There is need for operations support in the aquaculture investment and provision of throughput for infrastructure. At least lessons learnt from neighbouring Uganda and Kenya indicate that equipment for putting up cages can be made locally as it includes metal frames that can be fixed locally and plastic containers from local industries for floating. The investor may need to buy quality nettings as those locally used are not of good quality and cannot last long in water.

- Other requirements for ensuring good quality and improving oxygen levels in the ponds or cages and also soil and water testing equipment

- Training and imparting skills for staff/employees and prospective fish farmers: This will be taken care of by government and NGOs or service providers and there seems to be plentiful skills and knowledge to be tapped in the country and region.

- Training and skills for Beach Management Units (BMUs): When investing in cage fish farming the BMUs will be very important to ensure conflict resolution and better management of the sites as they are co-managers with government and that means they will need to upgrade their skills in cage fish farming. Lessons learnt from Uganda indicate that fishers can work mutually with the cage fish farmers and help to police and offset losses from thieves. In the case of Son fish farm in Uganda, some fishers have been employed and integrated into the business as frontline workers. These workers place the cages, monitor them and harvest the fish, they are in support of cage fish farming as they act as fish aggregating devices (FADs) and they are able to catch fish easily without going very far.

- Training and skills for LGA staff: Under decentralization, the local government administration are mandated to mobilize communities for involvement in viable development programmes and they ensure monitoring and evaluation of the programmes. That means they will need to know about this new venture and understand how they would work to ensure success of the investors. Licenses and clearance for operations can also be obtained from their offices in some cases.

- Investment in marketing (radio and TV airtime, websites, etc.) to promote fish farming can be undertaken by government or NGOs.

- Strengthening market infrastructure to cater for fish (i.e. market places); As for now, the fish farmers have been selling their fish direct from their farms to small scale traders. The government may need to encourage private sector and fish farmer organization to have a collection point like that one in Kirumba, where the product is collected and auctioned to local and regional traders. This will go a long way in streamlining the trade and avoiding cheating fish farmers.

- Environmental management (training, skills and demonstration)- The aquaculture managers will need training or refresher courses on regulatory requirements and guidelines will be prepared to support this by government and NGOs.

3.7 Information gaps

During the study of the smallholder aquaculture situation in Tanzania the following information gaps were identified:

1. Cost of investments in aquaculture farms; cost of pond or cage construction, equipment, etc.;
2. Marketing situation of African catfish in Tanzania;
3. Presence, volume and price of imported tilapia in Tanzania; impact on local tilapia prices;
4. Cage culture situation in Lakes Victoria and Kumba (numbers, volume, intensity, investment & operating costs, market, etc.).

4 Recommendations

The following recommendations address the main challenges and information gaps identified during this study:

1. The challenge impacting aquaculture production that was mentioned most often by the small-scale farmers interviewed is the lack of education about fish farming. The development of a training programme for small and medium scale fish farmers that includes responsible and better aquaculture techniques, farm and business management is recommended. Record-keeping and calculation of cost of production and profit should surely be a subject of such training.
2. A lack of credit hampers both new entrants in the sector as well as expansion, innovation and intensification of production by existing farmers. Development of a targeted credit programme to ensure broader financing of aquaculture development is recommended. As a first stage such a programme could target the most promising part of the small segment of existing farmers that is obtaining a higher productivity than most small-scale producers because this segment has the conditions, drive and skills to perform better than others.
3. The genetic quality of tilapia and catfish brood stock and fingerlings used is in most cases unknown and there is probably much space for genetic improvement. A programme or project aimed at genetic improvement and distribution of improved brood stock (including a certification scheme for good-quality brood-stock and fingerlings) is recommended. Whether such a programme or project should be national or regional in scope (providing improved brood stock to the East African region) should be studied in more detail.
4. Develop formula for fish feed that can be produced for an acceptable price and as much as possible from locally available ingredients and make this formula available to (potential) fish feed producers.
5. The information gaps mentioned in paragraph 3.7 should be addressed. The first and third gaps seem most urgent to address when an investment in the small-scale aquaculture producer segment is considered. The second and fourth gaps are urgent when investments targeting farmers of African catfish or fish farming in floating cages are considered.

These recommendations are in line with the recommendations of Lee and Namisi (2016, see paragraph 3.6).

References

ASARECA Association for Strengthening Agricultural Research in Eastern and Central Africa- (2013) Consultancy to carry out a review of legal and regulatory frameworks and prepare a harmonized aquaculture policy pertaining to the aquaculture sub-sector in the ECA Region – Final report.

AU-IBAR, 2017. Best Practices and Guidelines to Support Commercial Aquaculture Enterprise Development in Africa. Guidelines for Developing Viable Aquaculture Business Models in Africa. AU-IBAR Reports (48 pp plus references & appendices).

Britz, P., J. Rutaisire, T. Shipton, G. Johnson and W. Schoonbee (2015) Mapping of market opportunities for Norwegian suppliers of technology and services for aquaculture in South Africa, Kenya, Uganda and Tanzania. Report for Innovation Norway.

Chenyambuga, S.W., Mwandya A., Lamtane H. A. and Madalla N. A., 2014: Productivity and marketing of Nile tilapia (Oreochromis niloticus) cultured in ponds of small-scale farmers in Mvomero and Mbarali districts, Tanzania. Livestock Research for Rural Development. Volume 26, Article #43. Retrieved February 2, 2018, from http://www.lrrd.org/lrrd26/3/chen26043.htm

COFREPECHE (2013) Analytical review of private sector involvement in aquaculture in EAC partner states, with recommendations for future areas of growth and support – final technical report. ACP Fish II, project ref nr. EA-1.3-B5. 44 pp plus annexes.

Darko, F. A., Kwamena K. Quagrainie & Sebastian Chenyambuga (2016) Consumer preferences for farmed tilapia in Tanzania: A choice experiment analysis, Journal of Applied Aquaculture, 28:3, 131-143. Link to this article: https://doi.org/10.1080/10454438.2016.1169965

Genner, MJ, E Connell, A Shechonge, A Smith, J Swanstrom, S Mzighani, A Mwijage, BP Ngatunga & GF Turner (2013) Nile tilapia invades the Lake Malawi catchment, African Journal of Aquatic Science, 38: sup 1, 85-90.

Kleih, U., M. Kishe, and K.B. Yunus (2010) Financial Services for SME Aquaculture and Fisheries Producers -Tanzania Case Study. Final Draft. Report prepared for German Agency for Technical Cooperation GTZ. 25pp plus annexes.

Lee, R.L. and P. Namisi (2016) Baseline study on Tanzanian Fisheries – Draft final report. Ministry of Agriculture, Livestock and Fisheries & Danish Ministry of Foreign Affairs.

Limbu, S. M., Shoko, A. P., Lamtane, H. A., Kishe-Machumu, M. A., Masanja, C. J., Mbonde, A. S., Mgana, H. F. & Mgaya, Y. D. (2016) Fish polyculture system integrated with vegetable farming improves yield and economic benefits of small-scale farmers. Aquaculture Research, 48 (7), 3631-3644, DOI:10.1111/are.13188

Lind, C. E., R. E. Brummett & R. W. Ponzoni (2012) Exploitation and conservation of fish genetic resources in Africa: issues and priorities for aquaculture development and research. Reviews in Aquaculture 4: 125–141.

MALF Ministry of Agriculture, Livestock and Fisheries Development (2014) Fisheries annual statistics report – 2013. Fisheries Development Division. 58 pp.

MALF Ministry of Agriculture, Livestock and Fisheries Development (2016) The Tanzanian Fisheries sector – challenges and opportunities. 26 pp plus annexes.

Mwaijande, F. and P. Lugendo (2015) Fish farming value chain analysis: policy implications for transformations and robust growth in Tanzania. Journal of Rural and Community Development, Vol. 10 (2), p. 47-62.

Olingo, Allen (2018) China imports hurting processors, traders and fishermen in East Africa. The EastAfrican, February 3-9, 2018, p. 8-9.

Rothuis, A., M. Turenhout, A. van Duijn, E. Rurangwa, E. Katunzi, A. Shoko and J. Bosco Kabagambe (2014) Aquaculture in East Africa - A regional approach. Report for FoodTechAfrica by LEI, Wageningen University & Research. 40 pp plus annexes.

Shah, S.Q.A., J. D. Colquhoun, H.L. Nikuli, and H. Sorum (2012) Prevalence of antibiotic resistance genes in the bacterial flora of integrated fish farming environments in Pakistan and Tanzania. Environmental Science & Technology, p. 8672 – 8679.

Shechonge, A., B. P. Ngatunga, S. J. Bradbeer, J. J. Day, J. J. Freer, A.G.P. Ford, J. Kihedu, T. Richmond, S. Mzighani, A.M. Smith, E.A. Sweke, R. Tamatamah, A.M. Tyers, G.F. Turner, M.J. Genner (2018) Widespread colonisation of Tanzanian catchments by introduced Oreochromis tilapia fishes: the legacy from decades of deliberate introduction. Hydrobiologia https://doi.org/10.1007/s10750-018-3597-9

Shoko, A., H.A. Lamtane, K. Wetengere, O.O. Kajitanus, F.E. Msuya, A.J. Mmochi & Y.D. Mgaya (2011) The status and development of aquaculture in Tanzania, East Africa. P. 85-96 in: Proceedings of the International Conference on Ecosystem Conservation and Sustainable Development (ECOCASD 2011). Natarajan et al (Eds.), 468p. Organised by Ambo University, Ambo, Ethiopia, 10-12 February 2011.

Shoko, A. P. A., Matola, H. D. Mzighani, S. & Mahika, G. C. (2011a) Fishpond Performance of Nile Tilapia Oreochromis niloticus (Linnaeus, 1758) in the Lake Victoria Basin, Tanzania. Journal of Aquaculture in the Tropics: 26 (1-2). 17-28

Shoko, A. P. & Ulotu, E. (2016) Fish-Poultry-Vegetable Integration Technology: A Final Report, LandO'Lakes, Dar es Salaam. 35pp

Shoko, A. (2017) An overview of fish farming sub-sector in Tanzania. Desk study report for Norgesvel, The Royal Norwegian Society for Development. 20 pp plus appendices.

Shoko, A.P. & Komugisha, B. R. (2018) Assessment of the conditions for genetic improvement in East Africa: Genetic performance, organizational capacity and policy: Tanzania: A consultant report submitted to Worldfish-Msingi. 22 pp.

Shoko, A. P., Ulotu, E. E., Shayo, S. D., Silas, M. O., Chimatiro, S., Madalla, N. & Tamatamah, R. (2018a) A Value Chain Analysis of Aquaculture Industry in Tanzania. Worldfish Report. 59 pp.

Shoko, A. P., Limbu, S. M., Lamtane, H. A., Kishe-Machumu, M. A., Sekadende, B., Ulotu, E. E., & Masanja, J. C. (2018b) The role of fish-poultry integration on fish growth performance, yields and economic benefits among smallholder farmers. African Journal of Aquatic Science, under review.

URT - Ministry of Livestock and Fisheries Development (2015) National Fisheries Policy of 2015.

Wetengere, K. (2010a) The influence of technology characteristics on the adoption of fish farming technology: the case of selected villages in Morogoro Region, Tanzania. Asian Journal of Agricultural Sciences 2(2): 69-77.

Wetengere K. (2010b) The actual valuation of fish ponds: the case of selected villages in Morogoro and Dar es Salaam regions, Tanzania. African Journal of Food, Agriculture, Nutrition and Development, Vol. 10 (10): 4139-4155.

WorldFish (2017) WorldFish in Tanzania. Penang, Malaysia: WorldFish. Factsheet: 2017-18.

Zanzibar Aquaculture Resolution (2016) Resolutions of "the Stakeholders' Workshop on Tilapia Aquaculture in Tanzania and the Way Forward". Mazsons Hotel, Zanzibar, 5th -7th October, 2016. 6 pp.

Appendix 1 Study objectives and subjects covered

a. Provide an analysis of the sector that answers the following questions:

- Establish smallholder baseline. Identify main segments/groupings by scale (number of ponds, volume of output or other factor), species farmed, production system used, geographic clusters, management systems (record keeping, accounting etc.), technology used, supporting systems including extension services, funding and so on and any other relevant data.
- Map geographic distribution of small-scale producers and identify key existing or potential production areas based on temperature, water availability, logistics, market access, etc.
- Assess the motivation of small-scale producers: why are they engaged in fish farming? What are their aspirations (growth plans)? What is their level of knowledge about the opportunity?
- Describe in detail the main small-scale production models in use and their production dynamics for example setup costs, cost of production/gross margins realistically achieved, use of inputs, cost of labour (including cost of family/own labour).
- How do production dynamics/economics differ between the small-scale production models and segments? Which models are proving most successful and why?
- Define key challenges in small-scale fish farming for each segment/production model. Focus especially on access to inputs (seed, feed), financing, labour, market linkages, availability of knowledge/expertise and extension services.
- Technological assessment: what are the current technologies in use, which ones are proving successful and why? Are there any real technological barriers currently faced by small-scale producers?
- Level of entrepreneurship – movement from subsistence to small-scale commercial production?
- What it is that is limiting the development of small-scale production? Development Capital? Working Capital? Technical knowhow? Quality and availability of inputs? Access to markets? There is both an objective assessment and also an understanding of what small-scale fish farmers perceive to be their constraints.
- To what extent does current small-scale fish farming create (or is adversely affected by) environmental, social (including gender) and governance (including corruption, rent-seeking) factors? And how and to what extent will ESG issues be a limiting factor in the growth of the small-scale sector in future?
- What are the key trends within the subsector? Are these local or regional?
- To compare and contrast the "classic" issues facing smallholder agriculture and livestock in East Africa with small-scale fish farming and see whether or not aquaculture is a "special case" or just another farm livestock activity.
- What are the critical success factors?
- Skill levels – what formal aquaculture training has been received? From where? Informal training? Knowledge networks? Access to skills and knowledge by smallholder?
- Interaction with Government? What are the policy dynamics – supportive/unsupportive environment. What kind of support would be required?
- Supporting ecosystem i.e. extension services, input (fingerlings, feed, equipment etc.), financing etc.
- Disease and health management in the smallholder sector.
- Marketing and distribution of fish – pricing data and dynamics, selling points, supply chain, how is fish in the smallholder sector sold etc.
- Where do smallholders get information from?
- Production cycles – how long do the fish take to mature, harvesting cycle etc.
- Access to Inputs: e.g. feed quantities and pricing, fingerlings etc – pricing, packaging, reliability; who are the key input suppliers.
- Innovations if any?
- What is extent of sector coordination? Do smallholders recognise/participate in organised associations? How do sector organisations engage with smallholders? If at all.

- Regulations and standards – what are these? What compliance, licensing requirements etc. are there.

b. Make analysis and give insights

- Identify where small-scale producers are successful and growing, and any common conditions, habits or other factors which may determine this.
- Describe the key/root problems faced by small producers in each segment, and show where the productivity can be addressed through better inputs, adoption of technology, improved management, access to markets (input/output), finance or other services.
- Analyse the key barriers to entry and estimate how much this contributes to the current gap in production.
- Define and prioritise opportunities to expand small-scale production by number of producers or size of farms. Which locations and production models offer the best potential for growth?
- Consider models through which smallholders could be linked to the market and support services.
- Specifically explore the potential for larger companies and investors to profitably engage with smallholders.
- Quantify the current and potential production of current fish farmers and do some kind of analysis on the elasticity if some of the factors are influenced e.g. impact of a potential drop in price of feed? Availability of higher quality fingerlings?

c. Formulate recommendations to Msingi

- In collaboration with the aquaculture industry team, determine clear focus area (s) for Msingi programme to invest in small-scale producers as part of overall sector development programme. Such investment could cover the full scope of Msingi interventions and include technical assistance, training, grants, or commercial investment.
- Define a potential implementation plan for the recommended areas of intervention and prioritize potential actions by impact, time lines, cost and any other relevant parameters.

Appendix 2 Interview questions for various categories of informants

Questions for government key informants, researchers:

1. What are the key trends within the small-holder aquaculture subsector? Are these local regional?
2. What are the critical success factors?
3. What are the main policies/strategy documents? Is the environment supportive or unsupportive?
4. Is there a policy with regard to fish imports?
5. Any programmes or projects about fish disease and health management in the smallholder sector?
6. **Sales**: pricing data and dynamics, selling points, supply chain, how is fish in the smallholder sector sold etc.
7. How do production cycles for the most important species look like: average stocking size; how long do the fish take to mature, harvesting cycle etc.
8. What are the most important regulations and standards with regard to fish farming? What is known about compliance?
9. What are licensing requirements? Where and how to get, what does it cost, how long does obtaining a license take?
10. Are there regions where small-scale producers are more successful and growing? What are common conditions, habits or other factors which may influence this?
11. What do you consider to be key/root problems faced by small producers in each aquaculture segment?
12. What are according to you the key barriers to entry of new fish farmers?
13. Can you estimate how much these barriers contribute to the current gap in production?
14. How can productivity be improved? (through better inputs, adoption of technology, improved management, access to markets (input/output), finance or other services?)

Questions for fish farmer:

1. Name farmer, gender, name of village/ward, age, number of children.
2. Number and size of ponds/tanks owned. How many are in actual operation?
3. What were the investment / starting costs?
4. Why did (s)he start with fish farming? What did he learn about this activity? From whom?
5. Have you moved from subsistence to small-scale commercial production? (For small-scale commercial)
6. Who is doing day-to-day operations on the fish farm? How much time does farmer or family spend on fish farming per day?
7. Is additional labour hired in peak season or for harvest? If yes, what are the costs?
8. What is cost of production (seed, feed, labour, other inputs)?
9. How much fish was harvested in past year? (amount harvested from each pond, if possible)
10. Where and how is fish sold? Bought by whom? (trader, individual consumer, etc.)
11. Gross income from fish sales per harvest / year?
12. What are main problems / challenges experienced? (techniques, accessibility of inputs, markets and price for products, support, credit, feed, seed, etc.).
13. What are his/her aspirations (growth plans)?
14. What is limiting the development of your farm?
15. Which linkages, availability of knowledge/expertise and extension services are relevant?
16. What possibilities does (s)he have for increasing knowledge and skills?
17. What formal aquaculture training have you received? From where? Informal training? Knowledge networks?
18. What trends does he observe with regard to fish farming in the area?
19. What are the current technologies in use? Which innovations?
20. Which technologies ones are proving successful and why?
21. Which real technological barriers are currently faced by small-scale producers? Which innovations?

22. Do you practice disease and health management? How?
23. Do you see potential for larger companies and investors to profitably engage with smallholders? Why?

Questions for input suppliers:

1. Name, location,
2. Describe type of company/farm (feed producer, equipment producer, etc).
3. What products are sold? Price/unit? (If feed: describe pellet size, size, protein content, etc).
4. Volume of sales in past year? (quantity and gross turn-over)
5. What ingredients / inputs are purchased? Where is it bought? (local or imported?)
6. Price of inputs/ingredients per unit?
7. Any issues with supply of inputs/ingredients?
8. Any issues with demand/marketing/distribution?
9. What regulations are in place with regard to your product (quality or safety standards)
10. Any issues with permits/licenses/tax or regulations?
11. Any support given or available? (subsidy, advise, etc.)
12. Link with small scale aquaculture

Question for fish farmer organisations representative:

1. Name of organisation
2. Location / address of office (if any)
3. Number of members?
4. Requirements for members? (Should have farm or not? Fee? etc)
5. How does communication between members and with organisation board/executives take place?
6. What is objective of the organisation?
7. What activities are carried out to reach the objective?
8. Do you receive support from gov't or other outside institutions/organisations?
9. What do you think are main issues / bottlenecks for aquaculture development in TZ?

Questions for financial service institutes:

1. Do you have credit programmes that are open to, or specially designed for fish farmers or aquaculture input suppliers?
2. If yes, what are the conditions for these programs?
3. What problems do (fish) farmers experience with meeting these conditions?
4. Is assistance available when meeting the conditions is hard for some (i.e. assistance with application for a loan, with writing a business plan, etc)?
5. What are the experiences with this programme? How many fish farmers or aquaculture input suppliers have obtained a loan / credit so far, how many are in the pipeline?
6. What can you say about loan repayment rate?
7. Any focus on small scale aquaculture? Or other? Which farms?

Questions for NGO or International donor

1. Is your organisation involved in projects / programmes aimed at aquaculture?
2. If yes, in what scale, since when?
3. Who is the target group, where is the activity located and what is the approach?
4. What were the considerations when the target group, location, and approach were selected?
5. What are the experiences so far?
6. Any problems / issues that hinder the programme?
7. Based on your experiences, what lessons can you share with an organisation that considers involving in (start) an aquaculture smallholders support project?

Questions for regional organisation

1. Is your organisation involved in aquaculture development/support/regulations on a regional scale?
2. If yes, please describe the nature of the programme / project.
3. What are the experiences so far?
4. Any problems / issues that hinder the programme?

5. What issues and limitations are special in relation to the regional nature of the project / programme (related to differences in policies, laws, regulations of the countries concerned).
6. Based on your experiences, what lessons can you share with an organisation that considers involving in (start) an aquaculture smallholders support project in this region?

Questions for people with a good overview of the sector

1. What is the level of entrepreneurship in small-scale non-commercial and is their movement into the commercial segment?
2. What it is that is limiting the development of small-scale production?
3. Are small-scale commercial fish farmers facing the "classic" issues facing smallholder agriculture and livestock in East Africa?
4. Is small-scale commercial aquaculture a "special case" or just another farm livestock activity?
5. Do you see potential for larger companies and investors to profitably engage with smallholders?

Appendix 3 Key informants consulted/visited

Name	Organization/company
Ms Renalda Lema (MSc,	LandO'Lakes International Development, Dar es Salaam, Tanzania
Prof. Yunus Daud Mgaya (PhD, Aquaculture)	National Institute for Medical Research (NIMR)
Dr Semvua Mzighani (PhD, Molecular Ecologist)	Tanzania Fisheries Research Institute, P.O. Box 9750, Dar es Salaam
Dr. Charles Mahika (PhD, Aquaculture)	Aquaculture Development Division, Ministry of Livestock and Fisheries
Mr. Kajitanus Osewe (MSc, Aquaculture)	Department of Aquaculture Development, Ministry of Livestock and Fisheries
Mr. Anthony Dadu (MSc, Aquaculture)	Department of Aquaculture Development, Ministry of Livestock and Fisheries
Mr Geofrey Rucho	Aquaculture Association of Tanzania
Dr Nazael Madalla (PhD, Aquaculture)	Department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture
Dr Robert Kayanda (PhD Fisheries)	Lake Victoria Fisheries Organization, Jinja, Uganda

Fish farmers interviewed:

	Name of a farmer	Name and type of company	Location
1	Ms Deborah Amsi	Eden Aqua Farm Ltd, Seed producer, Manager,	Pugu Kinyamwezi, Dar es Salaam
2	Mr. Willaim Bwemelo	Eden Aqua Farm Ltd, Seed producer, Director	Pugu Kinyamwezi, Dar es Salaam
3	Mr Nkumbo Kathenga	Ruvu Farm Ltd, Seed producer,	Coast Region
4	Mr AmbonisyeAmbwene	Green Fish Investment ltd,	Dar es Salaam region
5	Nzigula Masumbuko	Nasha Aqua Fish Services and Marketing LTD,	Coast Region
6	John Venance Kafyote	Feed and Seed producers; Fish processing	Dar es Salaam and Coast regions
7	Abraham Mndeme	Big Fish Safina Ltd, Seed producer,	Dar es Salaam region
8	Juliana Nyaki	Seed producer / Growout,	Dar es Salaam and Coast regions
9	Ramadhani Siame	Farmer	Mlandizi, Coast region
10	Emanuel Nkya	Farmer	Mlandizi, Coast region
11	Mwanaidi Mwanga	Farmer	Mlandizi, Coast region
12	Kaguo	Farmer	Mlandizi, Coast region
13	Sebastian Shayo	Farmer	Kibaha, Coast region
14	Dismas Masumbuko	Farmer	Kisarawe, Coast region
15	Valentino Martin	Farmer	Kingolwira, Morogoro
16	Emanuel Kiangi	Farmer	Mlandizi, Coast region
17	Saul Adam Machui	Farmer	Mkuranga, Coast region
18	Mustafa Yakubu	Farmer	Kigamboni, Dar es Salaam
19	Norah Usiri	Farmer	Kigamboni, Dar es Salaam
20	Aidan Mgidula	Farmer	Mkuranga, Coast region
21	Badged	Farmer	Kigamboni, Dar es Salaam
22	Juma Said Waiguti	Farmer	Ruvu, Coast Region
23	Abdul Kamugisha	Farmer	Kigamboni, Dar es Salaam
24	Kadula Msumi	Farmer	Mkurnga, Coast region
25	Mzee Chipata	Farmer	Kibaha, Coast region
26	Bahyagati	Farmer	Mkuranga, Coast region
27	Julius Kitigwa Farm	Farmer	Mkuranga, Coast region
28	Norah Usser Farm	Farmer	Kiziko, Coast region
29	Ezekiel Kalaule Farm	Farmer	Vikindu, Coast region
30	Daud Kagolo Farm	Farmer	Vianzi, Coast region
31	Mathias Ntawiha Farm	Farmer	Mbezi, Coast region
32	Mwandege	Farmer	Mwandege, Coast region
33	Azan Zungu Farm	Farmer	Dundani, Coast region
34	Charles Meshack Farm	Farmer	Vikindu, Coast region
35	Mch Aidan Mgidula	Farmer	Kiparang'anda, Coast region
36	Jerry Mushi	Farmer	Shungubweni, Coast region
37	Dr W. Pallangyo	Farmer	Vianzi, Coast region
38	Mrs Machui	Farmer	Malela, Coast region

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