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

Part 4. UGANDA

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WAGENINGEN UNIVERSITY & RESEARCH

BoP INNOVATION CENTER

Fair & Sustainable Consulting

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This publication reports the results of a study of the small-scale aquaculture producers' situation in Uganda that was carried out in March-April 2018. The study was commissioned by Msingi East Africa. The study comprised two main parts: a desk study and a field study. The latter consisted of visits and interviews with fish farmers, fish feed producers and importers, fish traders, service providers and other key informants and served as validation of the results of the desk study. The methodology for field data collection was semi-structured interviews.

Three small-holder aquaculture segments have been identified. Segment I comprises of small-holders producing Nile tilapia (ponds and cages) and/or African catfish (ponds). Production varies from 1-5 tonnes/year. They lack affordable and high quality inputs, knowledge and capital. Segment II includes small-holders producing Nile tilapia (ponds and cages) and/or African catfish (ponds). Production varies from 6 to 40 tonnes/year. They have some degree of knowledge on farm management and some capital to invest. Access to affordable and high quality inputs is problematic. Segment III consists of small-holders with higher education and on-job-skills. Production varies from 41 to 50 tonnes/year. They import high quality feed and have access to family capital. Their business is expanding and they will soon be medium-scale farmers.

Opportunities for development support consist of better coordination and an integrated approach within a new aquaculture platform in which lead-farmers train farmers via a training-of trainers approach. The platform should concentrate on segment I and II farmers; they urgently need better feed, improved knowledge, skills and access to capital. Segment II farmers need better local feed of affordable prices and improved knowledge and skills for farm management. Models to link farmers to markets and support services include cluster farming (joined buying of inputs and distribution), aquaparks (improved production infrastructure) and empowering investors with access to capital and organised markets.

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

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Photo cover: Mr Nantongo, owner of Jonak Farm (approximately 6 km south of Kampala) owns 9 ponds for tilapia and catfish. This Segment II farmer has family capital and is looking for land to expand his business Photo: Bas Bolman

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List of abbreviations and acronyms

ACF	-	Agricultural Credit Facility (Uganda)
AEZ	-	Agro-Ecological Zones (Uganda)
BoU	-	Bank of Uganda
DFO	-	District Fisheries Office (Uganda)
DFR	-	Department of Fisheries Resources (Uganda)
DRC	-	Democratic Republic of the Congo
DWLE	-	Department of Water, Lands, and Environment (Uganda)
EAC	-	East African Community
EIA	-	Environmental Impact Assessment
EU	-	European Union
FAO	-	Food and Agriculture Organization
FCR	-	Food Conversion Ratio
FTI	-	Fisheries Training Institute (Uganda)
LVHD	-	Low Volume High Density
MAAIF	-	Ministry of Agriculture Animal Industry and Fisheries (Uganda)
MDI	-	Micro Deposit Taking Institution (Uganda)
NaFIRRI	-	National Fisheries Resources Research Institute (Uganda)
NBS	-	National Bureau of Standards (Uganda)
NDA	-	National Drug Authority (Uganda)
NEMA	-	National Environment Management Authority (Uganda)
NGO	-	Non-Governmental Organisation
NPF	-	National Fisheries Policy (Uganda)
PFI	-	Participating Financial Institutions (Uganda)
PMA	-	Plan for Modernisation of Agriculture (Uganda)
ToT	-	Training of Trainers
UCFFA	-	Uganda Commercial Fish Farmers' Association
UDBL	-	Uganda Development Bank Ltd
USAID	-	United States Agency for International Development
WAFICOS	-	The Walimi Fish Farmers' Cooperative Society (Uganda)
WCDI	-	Wageningen Centre for Development Innovation, Wageningen University & Research
WFI	-	Women Fish Network
WUR	-	Wageningen University & Research

1 Introduction

East Africa is endowed with excellent natural freshwater resources and climate. Currently freshwater aquaculture is practised by thousands of small-scale fish farmers producing Tilapia and Catfish, mainly in ponds but also in artisanal cages in lakes in the region. 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 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 are inadequate to inform clear strategy at this level. The countries in East Africa that are part of this study include Kenya, Tanzania, Rwanda and Uganda. This report focuses on Uganda. Msingi in collaboration with BoP Innovation Centre contracted Fair and Sustainable Consultancy who teamed up with Wageningen University and Research to do 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[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 (e.g. 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 main parts: a desk study and a field study. The desk study was undertaken by Arie Pieter van Duijn and Bas Bolman in collaboration with Justus Rutaisire 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. Documentation and data not available online but accessible locally was supplemented by the national consultant.

Visits and interviews of fish farmers, fish feed producers and importers, fish traders, service providers and other key informants served as additional validation method. The methodology for field data collection was semi-structured interviews by category of actors guided by the content and scope of the research questions. Data gathering was based on face-to-face interviews of key informants and fish farmers and included both open-ended and closed questions.

The field work of this study was undertaken by Bas Bolman and Justus Rutaisire. 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.

Key informants in this study included sample groups of fish farmers, fish traders, finance providers, consultancy service providers, fish feed producers and importers, extension officers, officials at the Ministry of Agriculture Animal Industry and Fisheries (MAAIF), a development donor, and researchers and scientists from academic institutes. The names of respondents can be found in Appendix 3.

The desk study was drafted before the start of the field work. The findings of interviews and observations in the field work were analysed, added and integrated in this final report.

[1] The detailed study objectives and subjects to be covered were outlined in the Work Plan of February 23, 2018, and are found in Appendix 1.

3 Brief overview of the aquaculture sector of Uganda

Aquaculture in Uganda started in 1953 with the establishment of the Kajjansi experimental station. The early fish farming was primarily for providing fish for home consumption and was done in small backyard ponds, based on fertilization and feeding with kitchen left-overs. Despite its long history the sector largely remained at the small-scale, subsistence level with insignificant contribution to national fish production till the early 2000s (Rutaisire, 2018 personal communication).

In 1959-1960 the Food and Agriculture Organisation (FAO) supported a comparative study on Common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*), resulting in the endorsement of carp. According to the Department of Fisheries Resources 11,000 ponds were constructed by 1968, all focussing on subsistence farming. Between approximately 1970 and 2000 many farmers abandoned fish farming due to a lack of support and more specifically inputs and technical knowledge. In 1999 it was estimated that Uganda had 4,500 functioning ponds and a production of 285 tonnes (FAO, 2005). Note that aquaculture statistics from Uganda have to be interpreted with caution. While most experts state the figures are grossly over-estimated (Dickson et al., 2011; Dalsgaard et al., 2012), other experts claim figures are grossly under-estimated (Mwanja, 2018 personal communication).

During the late 1990s and the early 2000s the government of Uganda, together with development partners, introduced strategic interventions to boost aquaculture with the aim to contribute to food and nutrition security and employment. It was decided to focus on African catfish (*Clarias gariepinus*) and Nile tilapia instead of carp (FAO, 2005; Frimpong & Anane-Taabeah, 2014; MAAIF, 2012). The reason for this relates to the fact that carp is alien to Uganda and the region, therefore not many people consume carp. Hence, there is a limited market. Carp has Y shaped bones, typical of cyprinid fishes that are not liked by consumers in the region. However, the fish tolerates lower temperatures and therefore it is popular in high altitude areas of the country where temperatures fall to less than 19 °C. On the other hand Tilapia and catfish are indigenous and have local and regional markets. Catfish culture was made possible at that time by the adoption of its induced spawning technologies by a private hatchery, called Sunfish Farms Ltd (Rutaisire, 2018 personal communication). Whereas the period 1953 – 2000 was dominated by strong public interventions focussing on subsistence farming, the period 2000 – 2018 was dominated by incremental private involvement focussing on commercial small-holders. This paradigm shift was embedded in the Government's Plan for Modernisation of Agriculture (PMA) and the National Fisheries Policy (NFP), introducing new rules for private licenses and foreign investment (Rutaisire, 2007; Mwanja, 2018 personal communication).

As a result of this paradigm shift the first commercial fish farms emerged, with the first private hatchery (Sunfish Farms Ltd.) established in 1999, breaking the sole reliance on the government fry centre at Kajjansi. Subsequently several commercial fish farms emerged, targeting the regional table fish market as well as the baitfish market. Since that time aquaculture in Uganda has continued to change rapidly due to the involvement of the private sector. Several other hatcheries and commercial pond based fish farmers sprang up across the country in the subsequent years (Rutaisire, 2007; Rutaisire, 2018 personal communication).

The turning point, however, occurred in 2006 with the introduction of cage culture in Lake Victoria. At the time, the lack of an affordable industrially manufactured pelleted feed remained one of the major constraints to the development of the sector. It was chicken and egg situation of who goes first. The feed manufactures required a sufficient and sustained demand for fish feed to warrant the high investment costs. They reasoned that it was not economically viable to invest in machinery in a situation where they were not sure that the feed would be bought. On the other hand the farmers could not commercialise without high quality feeds on the market. With start of the cages and sensitization and support from the US FISH project, poultry feed manufacturing firms (NUVITA and Ugachick) started producing pelleted (sinking) fish feed. Of the two only Ugachick continued and

improved to produce floating fish feeds in 2010. Meanwhile cage culture grew by leaps and bounds. The new culture system demanded very high quality feeds leading to importation of fish feeds from several countries outside East Africa including; Mauritius, Israel, Brazil, Vietnam and others (Rutaisire, 2018 personal communication).

By 2003-2005, between 20,000 and 30,000 ponds were operated by approximately 7,000 farmers with an estimated total production of 1,500 – 5,500 tonnes. The average surface of a pond was 200 - 500 m^2, with 50 m^2 - 200 m^2 for subsistence farmers and up to 7,000 m^2 for small-scale commercial farmers. Production has been estimated at 1,800 kg/ha/year in the period 2003-2005. By 2010, 25,000 ponds were recorded with a production of 100,000 tonnes (Rutaisire, 2007; UBOS, 2004; NARO-MAAIF, 2002; Frimpong & Anane-Taabeah, 2014; MAAIF, 2012). In 2015 it was estimated by the National Fisheries Resources Research Institute (NaFIRRI) that there were 2,135 cages in the different lakes of Uganda, with 28 farmers and a production of 1,349 tonnes per annum. Over the past years a significant growth in cage farming has occurred. No exact figures are available but it is estimated that the number of cages and the production have doubled in the period 2015-2018. Employment in the aquaculture sector accumulated to 24,160 persons in 2015 (Ogutu-Ohwayo et al., 2016; Mbowa et al., 2016; FAO, 2004; Rutaisire, 2018 personal communication).

As of 2018 aquaculture in Uganda consists of subsistence farmers, small-scale farmers and a few medium-scale farmers. Subsistence farmers are producing with the aim to directly increase the food and nutrition security of their families. As such the fish produced is directly consumed by farmers and their families with no commercial purpose. The production of subsistence farmers is less than one tonne per annum. Small-scale farmers are the focus of this study. They are the largest group and produce up to 50 tonnes per annum; production is for commercial purposes in order to generate income. Lastly, a very small group of medium-scale farmers has recently emerged out of the small-scale sector and are producing more than 50 tons per annum.

As illustrated in figure 3.1 below, the total African catfish and Nile tilapia production in Uganda in 2016 amounted to 117,841 tonnes with a value of USD 263 million. However local and regional markets for African catfish improve when fish is smoked. It is anticipated that the production of this species will also increase when tank systems are adopted. Nile tilapia and African catfish are the only fish species cultured on a commercial scale in Uganda. According to FAO statistics 74,654 tonnes of Nile tilapia and 43,187 tonnes of African catfish were produced in 2016 (FAO, 2018b).

In spite of increasing aquaculture production, the average per capita consumption is currently 8.3 kg/year, compared to 12 kg/year in 1991. This decrease has been attributed to a reduced supply from capture fisheries and a high demand as a consequence of human population growth (Hammerle et al., 2010; Geheb et al., 2008; Ogutu-Ohwayo et al., 2016; Rutaisire, 2018 personal communication; Kirema-Mukasa & Reynolds, 1991). In 2016, Uganda's total fish exports amounted to 17,814 tonnes with a value of USD 117 million. Import amounted to 2,111 tonnes with a value of USD 2.2 million (FAO, 2018a). During the field mission reports of tilapia imports from China were found but the total quantities and value are unknown. The Government of Uganda is considering import tariffs, possible in cooperation with the East African Community (EAC) (Rukuunya, 2018 personal communication). Currently most of the aquaculture production is exported to Kenya and Rwanda. The latter country re-exports the fish to countries such as the Democratic Republic of the Congo (DRC) and Zambia (Rothuis et al., 2014; Mwanja, 2018 personal communication).

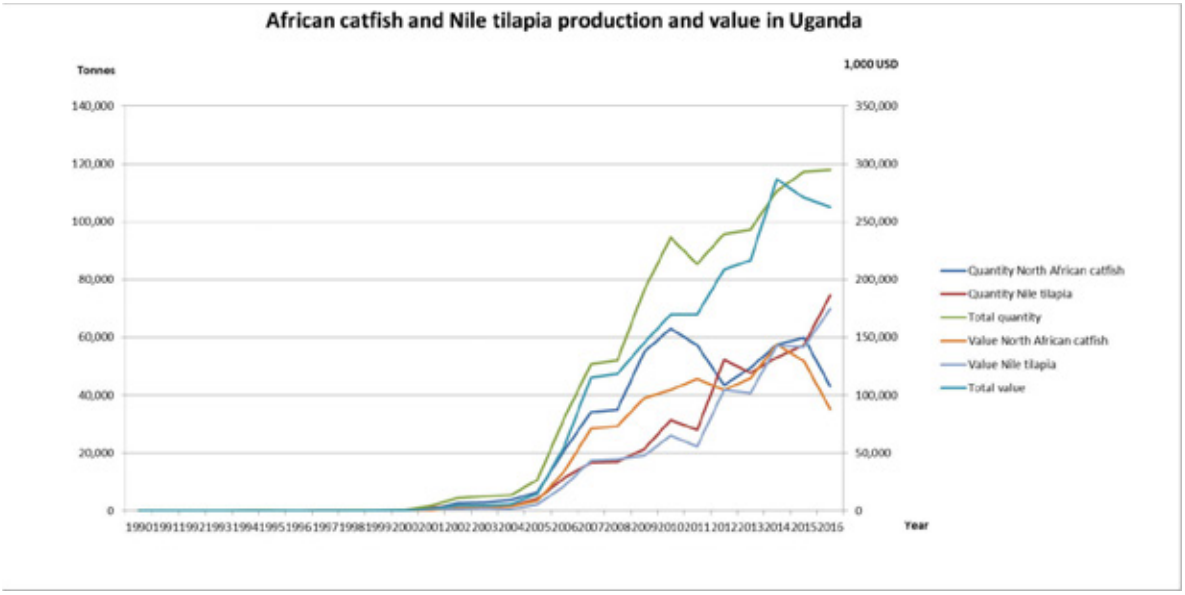

Figure 3.1 *African catfish and Nile tilapia production in Uganda in 1990 – 2016 (FAO, 2018b)*

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

4.1 Main small-scale commercial fish farming segments/groupings

Small-scale commercial fish farmers can be categorised into three segments. These segments are based on factors such as production levels (< 50 tonnes per annum), farming practices and a focus on financial profit (see tables 1.3, 1.4 and 1.5 for more details):

Segment I: Small-holders producing Nile tilapia (ponds and cages) and/or African catfish (ponds). Farmers in this segment lack crucial aspects such as affordable and high quality inputs, knowledge and capital. Their production varies from 1-5 tonnes/year.

Segment II: Small-holders producing Nile tilapia (ponds and cages) and/or African catfish (ponds). Farmers in this segment have some degree of knowledge on farm management; they have a bit of capital to invest. However access to affordable and high quality inputs is still a problem for them. Their production varies from 6-40 tonnes/year.

Segment III: Farmers in this segment attained tertiary level of education and have acquired on-job-skills. They can afford high quality imported feed (e.g. from Brazil, Israel, Mauritius and other countries). Some of them have their own hatchery to produce fingerlings of the desired quality. They have access to substantial amounts of family capital. Their production varies from 41-50 tonnes/year. This group is continuously investing in expanding their businesses and thus transiting from small holder (by this assignment's definition) to medium scale aquaculture.

4.2 Management systems

Record management systems for aquaculture in Uganda - such as record keeping and accounting - are largely absent. This is specifically the case for small-holders in Segment I, and to a lesser extent for small-holders Segment II. Small-holders in Segment III do have some farm management systems with varying levels of adequacy. It was found that most small-scale commercial farmers did not record basic farm transactions resulting in paucity of data to support enterprise analyses. Examples are (EFIFAP, 2018):

1. Costs of pond construction
2. Fish species and number stocked
3. Records of all inputs like stock materials, manure, feeds, fertilizers and lime
4. Harvest and sales

Absence of basic transaction records causes a lack of information to guide the running of the farm. A lack of information causes three main problems (EFIFAP, 2018):

1. It is not possible to evaluate the profitability and general economics of the farm;
2. Planning for the farming business becomes problematic;
3. No evidence to get funding support from financial institutions.

From several interviews during the present study it became clear that this situation can be explained partly by a lack of skills. However, some small-scale commercial farmers do have the knowledge acquired from trainings; nevertheless, they did not practice any record keeping or accounting. This was specifically the case with fishermen who stopped fishing and started fish farming. It seems that the paperwork involved in record keeping is not liked by this group. Another mentioned reason for not doing the paperwork is the fear for paying taxes. In addition lack of discipline and failure to consider aquaculture as an independent business entity contributes to a lack of record keeping.

4.3 Disease and health management

The field data illustrated that fish diseases are not very common in Uganda. Those incidents that are known are limited and isolated cases. No outbreaks are known. For some hatcheries there have been reports of a Columnaris infection with African catfish. In cage cultivation some small-scale commercial farmers report wounds and subsequent infections; the common perception is that these wounds are caused by the fish fighting for feed or stress after stocking or grading. Some small-scale commercial farmers apply salt in the cages to treat the wounds. Also, there are some reports of Nile tilapia blindness due to a lack of vitamin A (corneal opacity), caused by low quality feed.

In recent years NaFIRRI has identified some pathogens in Nile tilapia and African catfish. These pathogens include protozoa, bacteria, and various genera of ectoparasites. Most information available is on the protozoan pathogens, which are listed in the table below (NaFIRRI, 2017).

Table 4.1 *Protozoan pathogens of Nile tilapia and African catfish identified in aquaculture systems in different Agro-Ecological Zones (AEZ) of Uganda (NaFIRRI, 2017)*

Species	Production system / Location	Host fish species
Apiosoma sp.	Ponds and cages in northern AEZ	African catfish
Chilo1donella sp.	Ponds in Northern AEZ	Nile tilapia
Epistylis sp.	Fish farms. Northern & eastern AEZ	African catfish
Ichthyobodo sp.	Ponds & cages. Northern & eastern AEZ	Nile tilapia
Trichodina sp.	Ponds and cages	African catfish, Nile tilapia
Ichthyopthirius multifillis	Ponds in northern and eastern AEZ	Nile tilapia, African catfish

In order to combat bacterial and fungal infections in Nile tilapia and African catfish, NaFIRRI has conducted research on potential bio-control agents. Plant extracts of basil (*Occimum sp.*); banana (*Musa sp.*); Black Jack (*Bidens pilosa*) and garlic were identified as having high antibiotics and anti-oxidant characteristics (NaFIRRI, 2017). It is not known if these bio-control agents are actually applied in practice. On the whole the above parasites occur in fish raised in poor quality water and are not widely spread. Their prevalence and spread is not a significant factor in aquaculture in Uganda.

4.4 Geographic clusters and key production areas

During the field mission the following geographic clusters were found[2]. Cage farming in Uganda is concentrated along the shores of Lake Victoria from Rakai though Masaka, Mpigi, Entebbe to Kampala and Jinja, Mayuge up to Busia districts and also the numerous islands (AEZ VI, see table 4.2 and Figure 4.1. However the activity also occurs further away from Lake Victoria. The practice also occurs along the River Nile and Albert Nile, Lake Edward and in smaller inland lakes. Pond cultivation occurs throughout the country, since many parts are suitable for aquaculture due to the availability of water and other required factors. It is only in a few areas where aquaculture is not practiced especially in the so-called "cattle belt". This area stretches across the middle of Uganda from the base of the highlands in southwestern Uganda through the area around Lake Kyoga to north-eastern Uganda (Benson & Mugarura, 2013). Farmers living in the cattle belt earn their income from cattle farming and their culture despises eating fish. Traditionally cattle move from place to place; therefore this farming practice cannot be combined with fish farming. In the Southwest highlands, the Rwenzori and Elgon Mountain ranges in the west and East respectively aquaculture is less frequent as water temperatures are low falling to as low as 17^{o}C. In these areas Mirror Carp (*Cyprinus carpio*) is the dominant species since it tolerates the low temperatures. African catfish farming performs better in the Northern parts of the country; specifically the Northwest (AEZ III) because of high water temperatures of 26 – 28 ^{o}C. The other areas are mostly dominated by Nile tilapia cultivation.

[2] No data could be found on the size of these clusters in terms of number of farmers and/or production levels per cluster.

Table 4.2 *Aquaculture activities in Uganda's AEZs*

#	Agro-Ecological Zone	Aquaculture activities
I	Eastern Dry lands	Very few aquaculture due dominating cattle activities
II	North Eastern Savannah Grasslands	Dominated by Nile tilapia in ponds
III	North Western Savannah Grasslands	Dominated by African catfish in ponds
IV	Para Savannahs	Dominated by African catfish in ponds
V	Kyoga Plains	Dominated by Nile tilapia in ponds
VI	Lake Victoria Crescent	Dominated by Nile tilapia in cages (Lake Victoria)
VII	Western Savannah Grasslands	Nile tilapia in ponds. Nile tilapia in cages (Lake Albert)
VIII	Pastoral Rangelands	African catfish, Nile tilapia in ponds (Lake Edward)
IX	South Western Farmlands	Mirror carp in ponds
X	Highland Ranges	Dominated by Nile tilapia in ponds

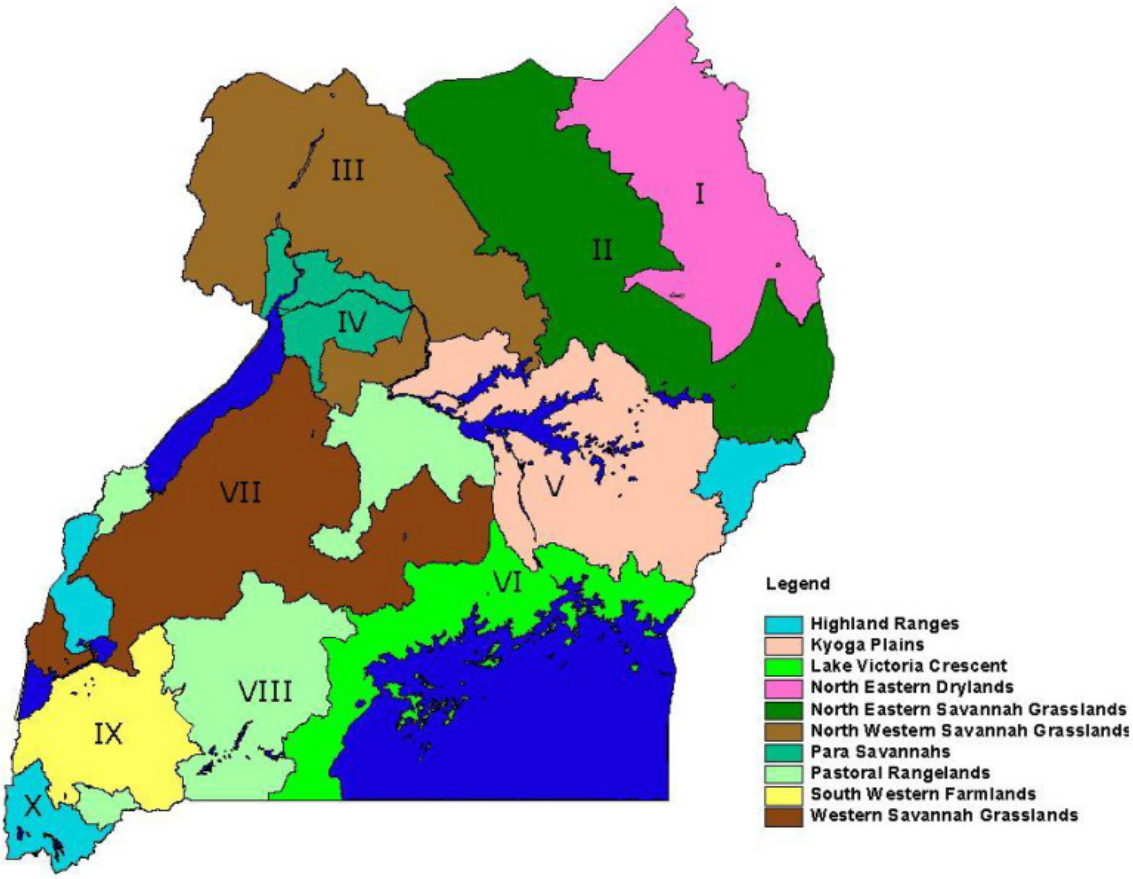

Figure 4.1 *Agro-Ecological Zones in Uganda (Mubiru, 2010)*

4.5 Supporting systems

Different types of supporting systems are discussed here. First support via education and training is discussed. Then financial support is discussed. Subsequently inputs such as feed and seed are discussed.

Education and training

Support via education and training is available in Uganda via various institutes, including Makerere University, District Fisheries Offices, Ministry of Agriculture Animal Industry and Fisheries (MAAIF) extension department, Fisheries Training Institute (FTI) and international donors such as FAO and United States Agency for International Development (USAID). Makerere University offers a Bachelor's degree course in Fisheries and Aquaculture and Postgraduate training in the same field. Graduates

work in the industry as mid-level managers while others are officials in MAAIF. The District Fisheries Offices often help new small-scale commercial farmers with obtaining permits and other aspects such as a site assessment and business plan development. The MAAIF extension department has approximately 500 extension workers in Uganda; from the interviews it become clear that this staffing level is not enough to serve the needs of the small-scale commercial farmers. Logistics are a problem here; small-scale commercial fish farmers in Segment I often do not have any means of transportation. As such MAAIF has plans to organise small-scale commercial farmers in groups so that extension workers can easily reach more of this type of famers. FTI at Entebbe offers both Certificate and Diploma courses (2 years) and tailor-made short courses (modules of one or more months). Graduates of the institute are employed as farm workers by private sector and Non-Governmental Organisations (NGOs). Examples of skills acquired at the institute are farm management, feeding and breeding. The costs of courses vary; from USD 82 for a five day Entrepreneurship course to USD 273 for a 4 week breeding course and USD 874 for a 2 year course covering multiple aspects of the aquaculture practice. About 40% of the total budget of the FTI is financed by the Government of Uganda; the other 60% comes from private sources. During the field mission it became clear that FTI lacks resources, both human resources (well-trained staff specialised in aquaculture) as well as financial resources. Development partners such as FAO and USAID are not so much involved in training; however they do help small-scale commercial farmers in Segment I with the provision of feed and seed, subsidies. The quality of education and training has not been assessed during the field mission. However, some respondents report that most institutes in Uganda lack the resources to conduct practical training.

Financial support

The agricultural sector in Uganda contributes 30% of GDP and is the backbone of Uganda's industrial activity, employment, household incomes and food security. The sector receives only 7% of total private sector credit with 82.7% constituted by short and medium (3 years or less) term loans. This is mainly because the terms and conditions for accessing loans set by financial institutes are not conducive for small-scale commercial fish farmers. As such, agricultural financing is a major bottleneck to commercialisation and of a serious concern to small-scale commercial farmers in Uganda. There are collateral-related challenges; interest rates are high as agriculture is seen as a high risk area. The vulnerability of agriculture to weather, pests and other hazards means that reliable production is not possible. This makes aquaculture a high risk area which is shunned by the commercial banks. Commercial banks in Uganda have continued to charge high interest rates of up to 30% even when the Central bank rates have reduced to the current level of 9% (March 2018). In attempt to make affordable credit available to small-scale commercial farmers the Government of Uganda set up the Agricultural Credit Facility (ACF) in partnership with Commercial Banks, Uganda Development Bank Ltd (UDBL), Micro Deposit Taking Institutions (MDIs) and Credit Institutions all referred to as Participating Financial institutions (PFIs). The facility was intended to provide medium and long term loans to projects engaged in agriculture and agro-processing on more favourable terms than are usually available from the PFIs. The scheme is administered by the Bank of Uganda (BoU), with provision for a maximum grace period of 3 years and the interest rate to the final borrower being a maximum of 10% per annum. However, the process of accessing the facility was again complicated by the above institutions who have in some cases hiked the interest rates and thus far only a handful of small-scale commercial farmers have been able to access the facility. Recently the East African Development Bank has come up with a credit facility with low interest rates while the Islamic Development Bank has introduced a new facility where there is no interest but profit sharing. Clearly, more interventions are required to make credit facilities available that appreciate agro businesses with the capacity to mitigate risks.

Seed

Currently Uganda has nearly one hundred fish hatcheries, but with only a handful is considered to be medium- to large-scale commercial ventures. An example of a commercial venture is S.O.N. Fish Farm Ltd in Jinja. The hatcheries primarily produce Nile tilapia and/or African catfish seed, with only a few producing carps. Hatchery production is limited by inadequate or inappropriate equipment, quality water supplies, lack of genetic programmes and the availability of specialized hatchery feeds.

Feed

With respect to industrial feed production, Uganda has a number of factories producing between 20,000 to 30,000 tonnes per annum of factory fish feeds including Ugachick, Novel feeds and Sabra and sons Ltd. There are a number of other smaller feed mills, including, the Government of Uganda / Chinese supported feed mill at Kajjansi, and privately owned mills that have been set up to support fish farming enterprises. A number of others are owned and operated independently without engaging in farming or producing for their own fish farms, such as Premier Millers and JODAR Services. These small factories are estimated to produce a further 10,000 tonnes of fish feed annually. Field data on available feed ingredients was not collected. Rurangwa et al., (2016) have analysed the availability of feed ingredients in Kenya, Tanzania and Uganda. It was concluded that most ingredients from both animal and plant origin appear to be available in Uganda.

Novel Feed Factory (approximately 30 km north of Kampala) is one of the few feed mills in Uganda producing feed with and FCR of 1.5-1.6 and a price of 0.80 USD/kg on average (see also table 5.10).

4.6 Marketing and distribution of fish

From the interviews it became clear that small-scale commercial fish farmers in Segment I, II and III sell their fish mainly at the farm gate to middlemen from Kenya and Rwanda. Market prices for Nile tilapia and African catfish vary from USD 1.70 to USD 2.50 per kg, depending on factors such as location, size and quality of the fish. Most of the farmed fish from Uganda entering Rwanda is re-exported to DRC. The exact figures of aquaculture exports from Uganda to the EAC are not known. According to FAO Uganda's total fish exports (from fisheries and aquaculture) amounted to 17,814 tonnes in 2016 (FAO, 2018a). However, given the fact that by far most farmed fish is exported and the total aquaculture production was estimated at 117,841 tonnes in 2016 (FAO, 2018a), it is clear that the destination of tens of thousands of tonnes of farmed fish is not known. The question arises why the farmed fish is not sold on local markets in Uganda. This relates to the fact that most small-scale commercial farmers prefer selling larger volumes of fish at once over selling lower volumes of fish retail basis. The fact that large volumes of fish are not easily distributed in Uganda is illustrative for poorly organised markets and logistics. Furthermore, neighbouring countries demand smaller fish sizes when compared to the Uganda market. This is of interest to small-scale commercial farmers as this favours shorter production cycles. Only one group of small-holders, organised in a cluster, is currently assessing if distribution to local markets in Uganda can be better organised, i.e. via distribution centres and fish shops in Kampala (see section 6.5). Thus, a clear challenge is to create a bulk market for farmed fish in Uganda. This would have the advantage of a more stable demand for farmed fish in terms of volumes and prices.

4.7 Regulations and standards

The Department of Fisheries Resources (DFR) under MAAIF is the competent authority responsible for inspection, certification and approval of aquaculture activities. The overall sector management goal is to ensure increased and sustainable production and utilization of fish and fishery products by properly managing and promoting aquaculture (FAO, 2017).

DFR is mandated to promote, guide and support the public and private sector partners in sustainable development and is responsible for setting and enforcing standards and regulations for aquaculture practices. DFR services include technical back-up and capacity building for Local Governments; provision of information for all stakeholder groups; creation of funding strategies for sector development; ensure sustainable resource use through good policy and ensure that there exists appropriate and equitable legal basis for sustainable aquaculture management. The Aquaculture Rules provide the basis for DFR to work in collaboration with other bodies, such as the National Environment Management Authority (NEMA), the National Drug Authority (NDA), the National Bureau of Standards (NBS) to ensure that practices in aquaculture comply with national legislation and standards (FAO, 2017).

MAAIF is also the main branch of the Government of Uganda responsible for aquaculture administration, regulation and promotion. All aquaculture production activities are required to adhere to the Statutory Instruments Supplement No. 31, which is more commonly referred to as The Fish Aquaculture Rules (2003). To initiate a farming operation, the rules require a Certificate of Approval based on an Environmental Impact Assessment that is issued by NEMA. All prospective farming operations are required to apply for, and receive an Aquaculture Establishment Certificate; and dependent on the specific farming activity, a Fish Seed Production Certificate, a Fish Breeding Permit, a Fish Import/Export Permit, and a Fish Transfer Permit may be required.
The development of commercial fish farms is supported by the following Government policies and strategies:

- The National Fisheries Policy (2004)
- The MAAIF Development Strategy and Investment Plan (2010-2014)
- The Uganda National Aquaculture Development Strategy (2008)
- The Draft 'Aquaculture Parks Investment Policy'
- The Draft 'National Aquaculture Development Strategy'
- The Draft 'National Aquaculture Development Plan'
- Investment terms provided by the Uganda Investment Authority

Access and use of space on water bodies for aquaculture production is currently similar to that used for assigning fishing rights and licenses. Government provides and guarantees fish farming rights to a specific space for an agreed period of time. In practice, the interested party (investor) identifies a site and discusses the development with the local communities (fishing communities) so as to agree on working arrangements that guarantees the security of the aquaculture production facilities and activities while allowing for passage and fishing activities by the communities. In addition, the investor must undertake a site suitability analysis and seek environmental clearance from the National Environment Management Authority which requires an Environmental Impact Assessment (Uganda National Environment Act, 1995) to be undertaken as part of the process. Under the draft aquaculture policy, the government is seeking to identify and map out areas for concentrated aquaculture production, akin to industrial or business parks that will be solely for purposes of commercial aquaculture development for both land and water based aquaculture.

The Department of Water, Lands, and Environment (DWLE) is responsible for issuing water permits and works closely with NEMA to ensure that issuance of these permits are in full compliance with environmental regulations. The cage culture activities require a special water permit. The maximum permit term under the current guidelines is five years, but senior officials at DWLE are open to the possibility of extending them beyond five years. The terms of the water lease are negotiated directly with the Government of Uganda and drafted as an MoU. Lease extensions are to be contingent on the proposed project meeting its environmental objectives. Land-based operations require a water extraction permit, and additionally, a waste discharge permit may be required.

From the field interviews it became clear that small-scale commercial farmers do experience some administrative burden of having to switch between 3 or even 4 different government offices to fill out different forms. Quite often the responsible government officers are out of office, necessitating the small-scale commercial farmers to make several trips to check on the status of the forms. Moreover the forms are in English which is not easily understood by small-scale commercial farmers in segment I.

The costs of obtaining a permit have been increasing from approximately USD 7 in 2004 to approximately 14 USD in 2018. The time span for issuing a permit varies from 2 weeks to 2 months, depending on the availability of resources at MAAIF and the degree in which "extra money" is provided to speed up the process. The government also has further plans to improve the legal environment. Examples are electronic licensing via Internet and a "one stop set", i.e. a ticket booth where all licensing matters are being handled.

From the field study it became clear that MAAIF lacks capacity, both in terms of human resources as well as financial resources.

4.8 ESG effects of small-scale commercial fish farming (by production model)

In table 4.3 the potential effects of environmental, social and governance factors/issues on small-scale commercial fish farming are summarised. Considering environmental factors/issues, current extreme weather events and climate change already limit the growth of aquaculture in Uganda; this will increase in the future. Small-scale commercial cage farmers have an advantage over pond farmers regarding the fact that there are still many suitable sites available. Regarding social factors/issues, lack of organisations addressing issues affecting various segments along the value chain is currently a major issue. The fact that most women do not own land, although they may have access, affects their decision making and poses limitations to aquaculture growth. Considering governance factors/issues, it seems that the lack of resources by government institutes and the lack of well-trained extension workers will limit the future growth of the small-scale commercial sector. Corruption is a last issue that negatively affects small-scale commercial aquaculture, even though this was only mentioned by a few respondents during the field mission.

In table 4.4 the potential effects of small-scale commercial farming on environmental, social and governance factors/issues are presented. Small-scale commercial farmers have an increasing effect on the environment regarding the release of nutrients into the environment. Currently nutrient loading into the environment is not a significant issue due to extensive geographical spaces between farms but is likely to increase with increasing intensification of small-scale commercial aquaculture and should therefore be monitored to limit the undesirable ecological consequences that can arise. If not controlled especially in case of cage farming an overload of nutrients may cause algae blooms, resulting in oxygen depletion and fish mortalities. Regarding social factors/issues, small-scale commercial aquaculture competes for land and water resources. For pond farming this results in competition with other agricultural activities. For cage farming this results in potential spatial conflicts with other users such as fisheries, tourism and shipping. Regarding governance factors/issues, an increasing problem may arise when the demand for governmental services further rises. Already governmental organisations are not able to cope with the various requests from small-scale commercial farmers; this problem will increase in the future. Lastly, corruption by small-scale commercial farmers, e.g. by offering additional benefits to governmental officials to speed up procedures, creates a lack of level playing field for others.

Table 4.3 *Potential effects of environmental, social and governance factors/issues on small-scale commercial fish farming*

Segment	Environmental	Social	Governance
I	• Lack of clean water due to erratic rainy season (ponds) • Higher prices of feed ingredients due to extreme weather & climate change • Lack of land in (peri) urban areas (ponds) • Limited Mukene (dried silver cyprinid) supply causes high prices	• Lack of cooperation • Theft • Ownership of land limited among women farmers • Earthen pond based small-scale commercial aquaculture in ponds not feasible in marginal rainfall areas such as the cattle corridor. • Some cultural norms still negatively impact on fish farming. E.g. aquaculture is a taboo in cattle farming communities because of a belief that fish have a negative effect on milk production (Rutaisire et al., 2017).	• Lack of well organised and functioning producer organisations from grassroots to the National level • Lack of resources at governmental organisations • Lack of well-trained extension workers • Corruption tendencies
II	• Lack of clean water due to erratic rainy season (ponds) • Higher prices of feed ingredients due to extreme weather & climate change • Lack of land in (peri) urban areas (ponds) • Limited Mukene supply causes high prices	• Lack of farmer organisations • Lack of well-trained staff • Theft • Ownership of land limited among women farmers • Small-scale commercial aquaculture in ponds not feasible in cattle areas, due to nomadic farming practice	• Lack of well organised and functioning producer organisations from grassroots to the National level • Lack of resources at governmental organisations • Lack of well-trained extension workers • Corruption tendencies
III	• Higher prices of feed ingredients exacerbated by extreme and unpredictable weather conditions.	• Lack of Lack of farmer organisations • Lack of well-trained staff • Theft	• Lack of resources at governmental organisations • Corruption tendencies

Table 4.4 *Potential effects of small-scale commercial farming on environmental, social and governance factors/issues*

Segment	Environmental	Social	Governance
I	• Nutrient release & algae blooms	• Pond farmers compete with other users for the same land / water • Reduced income due to fish diseases • Competing claims: Mukene is also used for human consumption	• Increasing demand for permits and need for compliance control causes higher pressure on governmental authorities • Corruption tendencies
II	• Nutrient release & algae blooms	• Pond farmers compete with other users for the same land / water • Cage farmers compete for space with other users of water bodies • Reduced income due to fish diseases • Competing claims: Mukene is also used for human consumption	• Increasing demand for permits and need for compliance control causes higher pressure on governmental authorities • Corruption
III	• Nutrient release & algae blooms	• Cage farmers compete for space with other users of water bodies • Reduced income due to fish diseases	• Increasing demand for permits and need for compliance control causes higher pressure on governmental authorities • Corruption

4.9 Key trends with relevance to small-scale commercial fish farming

The key trends are listed below. Also the scale of the trends is indicated, i.e. national (in Uganda) or regional (in the EAC).

- Increasing demand for fish (regional). The key trends in Uganda are a high demand for fish; this not only applies to Uganda but for the entire region of East Africa. Supply cannot meet demand, resulting in a fish deficit of 180,000 – 300,000 tonnes in Uganda and resulting in a decline in per capita fish consumption over the past decade.
- Declining fish supply (regional). The lack of supply is a result of the decline of fish production from capture fisheries while aquaculture is not yet able to fill the gap.
- Increasing production from small-scale commercial fish farming (national). Cage farming is increasing in terms of number of cages, sizes and volumes. Production volumes from cages are higher and increasing faster than the volumes from ponds. However, pond production is also on the increase by size and stocking densities.
- Increasing commercialization of small-scale commercial fish farming (national). Like cage cultivation, pond cultivation is increasingly focussing on commercial production.

5 Detailed description of small-scale commercial fish farming by production model

5.1 Main small-scale commercial fish farming segments/groupings

Below the three segments of small-scale commercial fish farmers are further specified. A summary can be found in table 5.1 below. Detailed information regarding production cycles and FCRs can be found in section 3.2.

Mr Nantongo, owner of Jonak Farm (approximately 6 km south of Kampala) owns 9 ponds for tilapia and catfish. This Segment II farmer has family capital and is looking for land to expand his business.

Segment I

Small-scale commercial farmers in segment I produce 1 – 5 tonnes per annum. Two production systems are used to cultivate Nile tilapia and African catfish: small earthen ponds (average 600 m^2) and square cages (High Density Low Volume). The ponds are constructed with family labour and the cages are locally fabricated from bamboo or metal bar frames. The production intensity can be classified as extensive.

Segment II
Small-scale commercial farmers in segment II produce 6 – 40 tonnes per annum. In this segment, larger earthen ponds (average 1,000 m^2) and square cages (Low Density High Volume) are used to cultivate Nile tilapia and African catfish. The ponds are constructed with hired labour and the cages are locally fabricated from bamboo or metal bar frames. Some cages are imported from China. The production intensity can be classified as extensive to semi-intensive.

Segment III
Small-scale commercial farmers in segment III produce 41 – 50 tonnes per annum. In this segment only cage farmers are active, focussing on the production of Nile tilapia. Square cages are self-made from metal or imported from China. Circular cages are also self-made from PVC tubes and barrels. The construction of cages occurs with hired labour. The production intensity can be classified semi-intensive.

Table 5.1 *Characterisation of small-scale aquaculture in Uganda*

Small-holder segment	Production (tonnes)	Production systems	Construction ponds/cages	Production intensity	Produced species	Production cycles and Food Conversion Ratio (FCR)
I	1 – 5	Small earthen ponds (average 600 m^2) and square cages (High Density Low Volume)	Ponds: constructed with family labour Cages: locally fabricated cages from bamboo, or metal bar frames	Extensive	Nile tilapia, African catfish and Mirror carp in the high altitude parts of the country	Tilapia: 1.3 cycles per annum, 8-9 months to grow to 400-500 grams, average FCR is 2 – 2.5. Catfish: 1.3-1.5 cycles per annum, 8-9 months to grow to 1 kg, average FCR is 2.0-2.2. Mostly use of family made feeds
II	6 – 40	Larger earthen ponds (average 1,000 m^2) and square cages (Low Density High Volume)	Ponds: constructed with hired labour Cages: locally fabricated / import from China	Extensive / semi intensive	Nile tilapia and African catfish	Tilapia: 1.3 – 2.0 cycles per annum, 6-8 months to grow to 400-500 grams, average FCR is 1.9 – 2.0. Catfish: 1.5 – 2.0 cycles per annum, 6-7 months to grow to 1 kg, average FCR is 1.7-2.0. Mostly use of locally made feeds but a few of them use imported feeds
III	41 – 50	Larger square and circular cages (Low Density High Volume)	Square cages: self-made from metal / import from China, made from metal Circular cages: self-made from PVC tubes and barrels	Semi-intensive	Nile tilapia	Tilapia: 2 cycles per annum, 6 months to grow to 400-500 grams, average FCR is 1.4-1.5

Researchers are investigating the tilapia cages of Marinas Aviators Ltd. (near Entebbe). This company is owned by a group of 11 young farmers. These Segment I farmers are currently searching to find suitable locations on Lake Victoria, as they cannot further grow due to other activities in the same area.

5.2 Technological assessment

Segment I

The production cycle of Nile tilapia starts with the fingerlings that take at least 3 months from hatching to 20 grams, depending on the quality of the feed. Since recent years hormone treatment is used to ensure all male fingerlings[3]. For cage farming there are small-holders who buy the fingerlings from 0.3 grams and grow them to 20 grams in land-based tanks. The costs of fingerlings (0.3 grams) are USD 0.02. After this phase the fingerlings are transported to the cage for grow-out to 400-500 grams. Other small-scale commercial cage farmers buy fingerlings at 20 grams and continue with the grow-out in cage farming up to a market size of 400-450 grams. Small-scale commercial pond farmers in Segment I often have a polyculture system, with Nile tilapia males and females in their ponds, and a number of African catfish to control the reproduction. Broodstock are placed in a pond at ratios ranging from 1 male to 1 female, up to 1 male to 5 females. The size of broodstock used is anything above 300 gram in weight (Kubiriza, 2009). It takes 6 to 9 months to grow Nile tilapia from 20 gram to 500 gram market size. Small-scale commercial farmers in Segment I have limited access to capital, therefore they mostly use self-made feed. In this segment an average FCR of 2 to 2.5 is common. Nile tilapia grows from 20 gram to market size in 7-9 months. They can therefore realise 1.3 cycles per annum.

The production cycle of African catfish starts with the fingerlings that take at least two months to reach 5 grams, depending on the quality of the feed. The costs of fingerlings (5 grams) are USD 0.04-0.06. The size of broodstock used is anything above 800 gram. It takes 6 to 9 months to grow African catfish from 5 gram to 1 kg market size. Small-scale commercial farmers in Segment I use self-made feed; they achieve an average FCR of 2.0 to 2.2. They are able to grow African catfish from 5 gram to market size in 8 to 9 months. These small-holders achieve 1.3 to 1.5 cycles per annum. African catfish production has not increased as much Nile tilapia. This can be attributed to a lack of market preference and appropriate rearing systems. African catfish hatcheries produce at relatively high costs while improvised hatcheries register high African larval and fry mortalities due to poor egg and water quality, and lack of larval and fry diets.

[3] The current price for hormones is USD 8 per gram. The hormones are imported from the Philippines.

The production systems of small-scale commercial farmers in Segment I consist ponds and cages. Ponds are made with family labour; they are earthen and relatively small (600 m^2). The economics per pond (African catfish) are summarised in table 5.3. The assumptions are summarised table 5.2 (Rutaisire, 2018 personal communication).

Table 5.2 *Assumptions to calculate the economics per pond in Segment I for African Catfish in ponds*

Description	Numbers and units
Pond Size (m^2)	600
FCR	2.3
Survival Rate	0.8
Fish/m^2	5.0
Catfish/m^2	5.0
Average harvesting weight of Catfish (kg)	1.0
Growth Period (Months)	8.0
Exchange Rate: 1 USD / UGX (EU, 2018)	3,661.39

Table 5.3 *Calculations of economics per pond in Segment I for African Catfish in ponds*

Item	Description	Unit	Quantity	Unit Cost (USD)	Total (USD)
Gross receipts					
Catfish	Whole fish	Kg	2,400	2.32	5,572
Total gross Receipts					**5,572**
Variable costs					
Catfish fingerlings	Hatchery Raised	No.	3,000	0.07	205
Pelleted Feed	30% - 35% Crude Protein	Kg	5,520	0.82	4,523
Fertilizers	DAP	Kg	16	0.55	9
	CAN	Kg	32	0.41	13
Lime		Kg	156	0.16	26
Labour (mainly family labour)	Pond repairs & harvesting	Months	8	8.19	66
Interest on Operation Loan		USD	0		
Total Variable Costs (TVC)					**4,841**
Net Returns Above TVC					**731**
Fixed Costs (FC)					
Depreciation	Ponds	USD			38.51
	Equipment	USD			19.17
	Machinery	USD			
	Buildings	USD			
	Water Supply System	USD			
Interest on Capital Investment					28.84
Total Fixed Costs (TFC)		**USD**			**87**
Total Costs (TC)		**USD**			**4,927**
Net Returns Above TC		**USD**			**645**
Breakeven price per Kg sold	Above TVC	USD/Kg			2.02
	Above TC	USD/Kg			2.05

The stocking size for ponds varies from 0.5 to 5 gram with a stocking density of 2 to 3 kg/m^3. Small-scale commercial farmers in Segment I were found to also engage in cage culture using Low Volume High Density (LVHD) cages with volumes ranging from 4 m^2 to 25 m^2. Such cages are self-made or locally fabricated and made from bamboo or metal bar frames combined with PVC barrels. The stocking size of HDLV cages varies from 0.3 to 1 gram for nursery and 5 to 10 gram for grow-out. The stocking density for HDLV cages varies from 150 to 300 kg/m^3. The production systems in Segment I can be characterised as extensive. Considering innovations, one farmer reported to cultivate worms and maggots as a feed ingredient. They are dried with a dryer and processed into powder. The

reasons for experimenting with alternative sources of animal protein are 1) Mukene (dried silver cyprinid) is very expensive and 2) issues with the quality of Mukene.

Segment II

The production cycle of Nile tilapia and African catfish is similar to the cycles described in Segment I. However, small-scale commercial farmers in Segment II have access to small amounts of family capital. Therefore these small-scale commercial farmers can afford to buy locally produced feed. With an FCR of 1.9 – 2.0, Nile tilapia grows from 20 gram to market size in 7-8 months. They can therefore achieve 1.5 - 1.7 cycles per annum. With African catfish an FCR of 1.7 – 2.0 is common in Segment II. This species grows from 5 gram to 1 kg market size in 6-7 months, with 1.5 to 2.0 cycles per annum. The production systems of small-scale commercial farmers in Segment II consist of ponds and cages. Ponds are mostly made with hired labour; the average size is 1,000 m^2. The economics per pond (Nile tilapia) are summarised in table 5.5. The assumptions are summarised table 5.4 (Rutaisire, 2018 personal communication).

Table 5.4 *Assumptions to calculate the economics per pond in Segment II for Nile Tilapia in ponds*

Description	Numbers and units
Pond Size (m^2)	1,000
FCR	2.0
Survival Rate	0.9
Fish/m^2	5.0
Tilapia/m^2	5.0
Average harvesting weight of Tilapia (kg)	0.35
Growth Period (Months)	8.0
Exchange Rate: 1 USD / UGX (EU, 2018)	3,661.39

Table 5.5 *Calculations of economics per Cage in Segment II for Nile Tilapia in ponds*

Item	Description	Unit	Quantity	Unit Cost (USD)	Total (USD)
Gross receipts					
Tilapia	Whole fish	Kg	1,575	2.32	3,656
Total gross Receipts					**3,656**
Variable costs					
Tilapia fingerlings	Hatchery Raised	No.	5,000	0.07	341
Pelleted Feed	30% - 35% Crude Protein	Kg	3,150	0.82	2,581
Fertilizers	DAP	Kg	16	0.55	9
	CAN	Kg	32	0.41	13
Lime		Kg	156	0.16	26
Labour (mainly family labour)	Pond repairs & harvesting	Months	8	8.19	66
Interest on Operation Loan		USD			
Total Variable Costs (TVC)					**3,035**
Net Returns Above TVC					**621**
Fixed Costs (FC)					
Depreciation	Ponds	USD			38.51
	Equipment	USD			19.17
	Machinery	USD			
	Buildings	USD			
	Water Supply System	USD			
Interest on Capital Investment					28.84
Total Fixed Costs (TFC)		**USD**			**87**
Total Costs (TC)		**USD**			**3,122**
Net Returns Above TC		**USD**			535
Breakeven price per Kg sold	Above TVC	USD/Kg			1.93
	Above TC	USD/Kg			1.98

The stocking size for ponds varies from 0.5 to 5 gram with a stocking density of 2 to 3 kg/m^3. Cages used by this category are High Volume Low Density (HVLD) with surfaces ranging from 4 m^2 to 25 m^2. The cages are locally fabricated and made from metal bar frames combined with PVC barrels or imported from China. The stocking size of HVLD cages varies from 0.3 to 1 gram for nursery and 5 to 10 gram for grow-out. The grow-out stocking density for HVLD cages varies from 40 to 75 kg/m^3. Mesh sizes for the cages are 8 mm for nursery and 13 mm for grow-out. The production systems in Segment II can be characterised as extensive / semi-intensive. Reported innovations include camera systems to prevent theft and to monitor the feeding practices by farm workers. Some small-scale commercial farmers have made their own air pumps to increase oxygen levels in their ponds.

Segment III

The production cycle of Nile tilapia in cages is similar to the cycles described in Segment I. Small-scale commercial farmers in Segment III have access to larger amounts of family capital. They can afford high quality imported feed and usually achieve an average FCR of 1.4 to 1.5 and are able to grow Nile tilapia from 20 grams to market size in 5-6 months. This category of small-scale commercial farmers achieve two cycles in a year.

The production systems of small-scale commercial farmers in Segment III consist of larger HVLD cages. Square cages are 25 m^2; there are locally made from metal bar frames and PVC barrels or they are imported from China. Circular cages have a diameter of 8 m (8 tonnes) to 12 m (15 tonnes) and are self-made from PVC tubes and barrels. The economics per cage are summarised in table 5.7. The assumptions are summarised table 5.6 (Rutaisire, 2018 personal communication):

Table 5.6 *Assumptions to calculate the economics per cage in Segment III for Nile Tilapia in cages*

Description	Numbers and units
Cage Size (m^3) - (6x6x6)	216
FCR	1.5
Production (kg/m^3)	80
Survival Rate	0.9
Stocking Density (fish/m^3)	200
Weight of fish at harvesting	0.4
Exchange Rate: 1 USD / UGX (EU, 0218)	3,661.39

Table 5.7 *Calculations of economics per cage in Segment III for Nile Tilapia in cages*

Item	Description	Unit	Quantity	Unit Cost (USD)	Total (USD)
Gross receipts					
Tilapia	Whole fish	Kg	15,552	2.32	36,104.32
Total gross Receipts					**36,104.32**
Variable costs					
Tilapia fingerlings	Hatchery Raised	No.	43,200	0.07	3,055.89
Pelleted Feed	30% - 35% Crude Protein	Kg	23,328	0.93	21,662.59
Boat	Operating the cage	No.	1	136.56	136.56
Labour	Repairs & harvesting	Months	12	136.56	1,638.72
Total Variable Costs (TVC)					**26,493.76**
Net Returns Above TVC					**9,610.56**
Fixed Costs (FC)					
Cage (6x6x6)m = 216 m^3	Frame, floaters, Cover, Ropes, Anchor and Bouys	No.	1	3,277.44	3,277.44
TFC Amortarised over 8 harvest i.e. 4 years		USD			409.68
Total Fixed Costs (TFC)		USD			3,687.12
Total Costs (TC)					30,180.89
Net Returns Above TC		USD			5,923.43
Net Returns per cage		USD/cage			5,923.43
Breakeven price per Kg sold	Above TVC	USD/kg			1.70
	Above TC	USD/kg			1.94
Breakeven yield at USD/Kg	Above TVC	USD/cage/year			11,412.24
	Above TC	USD/cage/year			13,000.47

The stocking size of HVLD cages varies from 0.3 to 1 gram for nursery and 5 to 10 gram for nursery while the grow-out stocking density for the cages varies from 32 to 45 kg/m^3. Mesh sizes for the cages are 8 mm for nursery and 13 mm for grow-out. The production systems in Segment III can be characterised as semi-intensive. The technology for production systems in Segment III proves to be most successful; the reason is that high production volumes can be realised and growth by increasing the number of cages is easy. Reported innovations include the circular ponds; they have been "invented" to tackle cage farming in windy areas. In this segment there has been one report of solar power cameras to prevent theft and monitor feeding practices by workers. Also the use of PVC for circular cages is new in Uganda. In addition this segment constructs floating houses on the lake which accommodate men and dogs that guard the cages. Lastly, in one hatchery owned by a segment III farmer, experiments were conducted with the cultivation of Nile perch (*Lates niloticus*). They have been caught at Lake Albert and they are stocked in ponds for reproduction. See appendix 4 for more information about the Nile perch.

Table 5.8 *Access and availability of feed, seed, knowledge, capital and technology for small-holders*

Small holder segment	Access to quality feed	Availability and quality of feed	Type of feed	Access to quality seed	Availability and quality of seed	Education, knowledge, skills, and training	Access to capital	Availability of capital	Access to technology /equipment	Availability of technology/ equipment
I	No access due to lack of collateral and financial track record/ banking history	Use of local feed ingredients with main challenge being the high price of Mukene. The quality of feed is low.	Made on farm or local. Feed is in form of powder, paste or sinking, irregular pellets. Chicken litter & pig manure is also used.	No access due to lack of capital	Reasonable availability, fair price, fair quality	Education: low Knowledge: low Skills: no business skills Training: access/availability limited Literacy: very limited English: very limited	No access to loans (cannot meet requirements)	Poor family capital	No access to technology/equipment due to low education levels. Some farms are located in hard to reach areas.	Materials and local technology/equipment available; no distribution of imported technology
II	Limited to fair access; mainly from NGOs	Use locally made feeds whose prices and quality fluctuates.	Local and factory made. The feed is floating. Unable to fill and import containers of feed but sometimes imported feeds are bought on local markets at high prices.	Fair access to seed	Reasonable availability, fair price, fair quality	Education: limited Knowledge: limited Skills: poor business skills Training: access/availability limited Literacy: fair English: fair	Very limited access to loans (difficulty meeting requirements)	Limited family capital	Able to access technology/equipment through producer associations and NGOs	Materials and local technology/equipment available; no distribution of imported technology/equipment
III	Fair access due to family capital	Use imported feed from Brazil, Israel, Mauritius, Vietnam and other countries. Very high price, very high quality	Imported	Good access to seed (some own hatchery)	Reasonable availability, fair price, fair quality	Education: fair Knowledge: fair Skills: fair business skills Training: access/availability limited Literacy: good English: good	Limited access (can access capacity but the cost are high)	Fair family capital	Fair access to technology/equipment due to high level of education which enables small-scale commercial farmers to seek technology from various sources including web based.	Materials and local technology/equipment available; no distribution centre to make imported technology/equipment easily available.

Table 5.9 *Record keeping, selling, marketing and distribution, permits, environment and growth potential for small-holders*

Small holder segment	Record keeping / accounting	Markets & sales	Marketing and distribution	Permit requirements	Environment	Growth potential
I	Non existent	Farm gate to neighbours and proximal markets	Not organised; hard to sell the little amounts produced on the farms	Ordinarily required to seek permission from NEMA to undertake a regulated activity in a wetland but requirement not strictly enforced. Most of them do not have the permits.	Ponds: land scarcity in urban and peri-urban areas. Water scarcity in dry season. Water quality reasonable to good. Cages: good site availability	Very limited
II	Poor to scanty	Farm gate. Middlemen from Rwanda, Congo, Kenya	Fairly organised through telecommunications with each other.	Site suitability assessment or EIA (Environmental Impact Assessment) and business plan	Ponds: land scarcity in urban and peri-urban areas. Water scarcity in dry season. Water quality reasonable to good. Cages: good site availability, good water quality	Fair
III	Fair	Middlemen from Rwanda, Congo, Kenya	Organised through the Uganda Commercial Fish Farmers' Association.	EIA and business plan	Cages: good site availability, good water quality. Required to submit monthly water quality data to the Department of Fisheries Resources.	Good

5.3 Differences and similarities between different small-scale segments and production models

From the tables in paragraph 3.2 the detailed differences and similarities between the three segments can be found. Below a selection is presented of the most important differences and similarities.

Differences:

1. The first difference between segments is the types of production systems. Small-scale commercial farmers in Segment I use small ponds and cages, segment II uses larges ponds and cages and segment III uses only larger cages.
2. The use of feed is a second difference. In segment I feed is mostly home-made, in segment II feed is mostly from locally produced feed mills and small-scale commercial farmers in segment III use imported feed.
3. Due to the quality of feed there is also a difference in FCR and production cycles. In segment I a production cycle of 1.3 harvests per annum is common with an FCR of 2.0-2.5. In segment II a production cycle a production cycle of 1.3-2.0 is common with an FCR of 1.9-2.0. In segment III a production cycle of 2.0 is common with an FCR of 1.4-1.5. Record keeping is absent in segment I, poor in segment II and fair in segment III.
4. Availability of capital also differs between segments. In segment I there is no availability of capital, in segment II there is availability of smaller amounts of family capital and in segment III there is availability of larger amounts of family capital. The same applies to access to capital such as micro financing. For segment I there is no access, for segment II there is very limited access and for segment III there is a limited access to funding.

Similarities

Some similarities also exist between the segments.

1. They mostly cultivate the same species and
2. They all experience challenges in feed; in other words, they lack affordable, high quality and readily available local feed.
3. All segments face the challenge of marketing and distribution of fish, which is largely not organised. As a consequence middlemen from other countries have created a powerful coordination mechanism; kind of a cartel. During the field mission it became clear that middlemen buy Nile tilapia at USD 2.3 per kg while selling at USD 3.4, thus creating a profit margin of 50%. Lastly, all segments face the challenge of the high costs of capital due to interest rates and requirements that are hard to meet.

5.4 Motivation of small-scale commercial fish farmers

First the reasons for small-scale commercial farmers to engage in fish farming are discussed. Second the aspirations and growth plans are discussed.

The overall motivation of small-scale commercial fish farmers in Uganda to engage in fish farming is the dwindling fish supply that is greatly outstripped by demand. There is ready market for farmed fish due to declining competition from capture fisheries whose production has plummeted. In fact the declined capture fisheries on one hand and the availability of market for farmed fish on the other has motivated fishers to organise themselves and start cage fish farming as a viable alternative source of income and livelihood. This was clearly demonstrated by the Cage Youth Group in the Masese Jinja District where former fishermen now own 250 cages with a production of more than 400 tonnes per annum. This transition, however viable, is a challenge due to the lack of capital to start a cage farm and feed the fish throughout the production cycle this especially so for those who start at a production level in segment I. (see tables referring to Segment I in paragraph 3.2).

It was found that former fishermen lack knowledge, education, skills and training to properly run cage fish farms but they are motivated by their experience on the lake and water environment. Unlike other

new small-scale commercial cage farmers who fear deep water environment, fishers are already used to the lake and water environment.

Small-holders with a background in small-scale agriculture also may enter fish farming in ponds. Although profits are very limited there are good prospects for growth for this group, on the condition that structural training is provided. Further motivation is derived from the ease of integrating pond-based fish farming with other farming enterprises such as poultry and horticulture in a synergistic manner through nutrient recycling which increases yield and profitability. Small-holders engaged in pond cultivation in Segment II are often originating from larger farming families that own land and/or capital. Many of them have been engaged in fish farming for several years; they started with subsistence farming and gradually expanded their business thanks to access and availability of family capital. Persons with an education in aquaculture (e.g. a bachelor in aquaculture at Makerere University) are also motivated by possession of technical knowledge to engage in aquaculture. Often these persons already have some years of experience in aquaculture, e.g. at governmental agencies or in consultancies. This middleclass group has also saved some capital to invest; as such they have the means and the skills to engage in aquaculture production systems.

The aspirations and growth plans differ per segment. In segment I and II small-scale commercial pond farmers reported to have the desire to acquire new land for further growth of their farms. A youth group of small-scale commercial cage farmers in the same segment has ambitions to apply for a new site so larger cages can be put in operation. They need more space since they are currently locked in between other users of the same areas, such as fishing vessels, tourism (marina) and other shipping activities. A female small-scale commercial farmer in segment II reported that she does not have the ambition to grow in terms of her own production; rather she wants to facilitate the growth of other small-scale commercial farmers to ensure their net income will be at least USD 5,000 per annum. In segment III impressive growth plans were reported. One small-scale commercial farmer operating in Lake Albert reports to increase production capacity from 3 circular cages of 12 m in diameter to 15 cages by the end of 2018.

5.5 Skill levels and information access

The skill levels of small-scale commercial farmers are categorised according to the three segments. Small-scale commercial farmers in Segment I generally have received little education with no higher education. These small-scale commercial farmers gain most experience via “learning by doing”, via neighbouring farmers. Their business skills are low, often no record keeping and/or accounting occurs and a business plan is often absent. Specifically those small-scale commercial farmers who are practicing their business in remote areas find it difficult to access training via extension workers.

Small-scale commercial farmers in Segment II have received some education. Most of them followed primary and secondary school; however, some of them have followed fisheries and aquaculture courses in higher education. The knowledge level is insufficient in this segment and business skills are poor. Some small-scale commercial farmers have learned to manage their farm via record keeping and/or accounting; these small-scale commercial farmers also have a simple business plan. Therefore these small-scale commercial farmers have a general understanding of their inputs, outputs and financial transactions. Small-scale commercial farmers in segment II have followed some aquaculture trainings; however this still depends on the remoteness of their farm.

Small-scale commercial farmers in Segment III have mostly attained higher education, e.g. a bachelor or even a master degree in various fields with some in fisheries and aquaculture. As such they have a fair education background and their knowledge on farm management is also fair. During the interviews it became clear that quite some small-scale commercial farmers have had previous experience in aquaculture in positions such as consultants or government officials. Therefore their business skills are fair; as a consequence they structurally conduct record keeping and accounting. Also they have an elaborated business plan, so they are quite aware of the status of their business. What distinguishes this group is that they have a long term vision, e.g. a growth of a certain number of ponds or cages in a specific time span, including a specific strategy to get there. These small-scale commercial farmers are

regularly in contact with other small-scale commercial farmers in Segment III, as a consequence they learn quickly. They follow trainings in a limited manner since these trainings do not offer them new knowledge/skills; rather they go abroad to visit countries that have been successful in aquaculture development. The attitude of these small-scale commercial farmers is focused on continuous learning. Below the level of entrepreneurship for each segment is presented.

- In segment I small-scale commercial farmers do not have entrepreneurship skills. This relates to the fact that there education is generally very limited and therefore their knowledge on how to run a business is also extremely limited.
- In segment II small-scale commercial farmers have medium entrepreneurship skills. Most of these small-scale commercial farmers have received some degree of education and therefore they have some knowledge on how to run a business. This is illustrated by the fact that record keeping and accounting frequently occurs in this segment.
- In segment III small-scale commercial farmers have fair entrepreneurship skills. Most of these small-scale commercial farmers have attained higher education and therefore they have a fair understanding on how to run a business. Record keeping and accounting is common in this segment so small-scale commercial farmers are well aware of the current status of their business.

During the field visit some small-scale commercial farmers in Segments I and II reported that they started as a subsistence farmer. Due to growth in production and a surplus after home consumption these subsistence farmers gradually became a small-scale commercial farmers in Segment I.

5.6 Access to Inputs

Currently Uganda has nearly one hundred fish hatcheries, but with only a handful considered to be medium- to large-scale commercial ventures. The hatcheries primarily produce Nile tilapia and/or African catfish seed, with only a few producing carps. Hatchery production is limited by inadequate or inappropriate equipment, quality water supplies, lack of genetic programmes and the availability of specialized hatchery feeds.

Seed

For most small-scale commercial farmers in Segments I, II and III there is a reasonable availability of seed; prices (USD 0.02 for a 0.03 gram Nile tilapia fingerling) and quality are fair. There may be exceptions, specifically for those small-scale commercial farmers who are operating in remote areas. Several larger hatcheries are concentrated around Jinja in the vicinity of Lake Victoria and many cage farms. An example of a larger commercial hatchery is S.O.N. Fish Farm Ltd in Jinja. However, small-scale commercial farmers in Segment I do not have access to seed due to a lack of capital. Small-scale commercial farmers in Segment II have a fair access to seed and small-scale commercial farmers in Segment III have a good access to seed. Some of the small-scale commercial farmers in Segment III operate their own hatchery.

Feed

With respect to industrial feed production, Uganda has a number of factories producing between 20,000 to 30,000 tonnes per annum of factory fish feeds including Ugachick, Novel feeds and Sabra and sons Ltd. In table 5.10 the field data is presented regarding different types of feed. There are a number of other smaller feed mills, including, the Government of Uganda / Chinese supported feed mill at Kajjansi, and privately owned mills that have been set up to support fish farming enterprises. A number of others are owned and operated independently without engaging in farming or producing for their own fish farms, such as Premier Millers and JODAR Services. These small factories are estimated to produce a further 10,000 tonnes of fish feed annually.

Table 5.10 *Field data showing feed producers, origin, FCR and prices*

Producer	Origin	FCR	Price (USD) / kg
Novel Fish Feeds	Uganda	1.5-1.6	0.80
Sabra Feed	Uganda	1.6-2.0	0.96
Raanan (distributor)	Israel	1.4-1.5	1.30-1.77
Raanan	Israel	1.4-1.5	1.10
Prime Feed	Israel	1.4-1.5	0.96
Invovo Feed	Brazil	1.4	0.80

Small-scale commercial farmers of Segment I cannot access locally produced feed or imported feed as they lack capital. These small-scale commercial farmers use local feed ingredients; the high price of Mukene is the main challenge for them. In general these small-scale commercial farmers lack the knowledge to apply a proper feed formulation when producing their own feed. Therefore the quality of the home-made feed is low. Small-scale commercial farmers in Segment II have a limited to fair access to quality feed; often they have a bit of family capital and/or they are supported by NGOs such as FAO and USAID. These small-scale commercial farmers mostly use locally made feed. The prices and quality of locally made feed fluctuate significantly, depending on climatic conditions and seasons. Small-scale commercial farmers in Segment III have a fair access to feed due to family capital or equity. As such they can afford to import feed from countries such as Brazil, Israel, Mauritius and other countries. The price of this feed is high but the quality of the feed is also high.

Equipment
Small-scale commercial farmers in Segment I do not have access to equipment due to low education levels. Moreover, some farms are located in remote areas, which is an additional barrier to access equipment. Small-scale commercial farmers in Segment II do have access to equipment, mainly via producer associations and NGOs. Small-scale commercial farmers in Segment III have a fair access to equipment due to a relatively high level of education which enables small-scale commercial farmers to seek technology from various sources including web based. Local equipment is available for small-scale commercial farmers in all segments. Imported equipment needs to be imported directly from abroad since there are equipment distribution centres are non-existent.

5.7 Sector coordination

Small-scale commercial farmers are poorly organised in Uganda. However in several districts associations have been formed to collectively organise harvesting and marketing. Also one association specifically considers the role of women in fish farming.

There are two main private sector producer associations on the national level, Walimi Fish Farmers' Cooperative Society (WAFICOS) and Uganda Commercial Fish Farmers' Association (UCFFA). WAFICOS provide its members with essential services such as technical advisory services, input supply, and equipment rental for pond construction, fish harvesting and transport, collective marketing, information dissemination and value addition of farmed fish products. WAFICOS cooperates with DFR on all issues of aquaculture development and management (Pawiro & Urbani, 2013). As of 2018 WAFICOS has 315 members. The entry fee is USD 13.66 and the annual fee is USD 8.19.

UCFFA brings together commercial fish farmers to support and promote the industry. UCFFA was established in 2017 by a group of seven small-scale commercial farmers with the vision to make aquaculture in Uganda competitive and profitable and to create unity among the fish producers to a counterbalance the traders who are better organised. Access to support services and means of production was and is a challenge for small-scale commercial farmers; as a result the success of the sector is limited. UCFFA mainly focuses on jointly buying inputs and the common organisation of marketing to create added value (UCFFA, 2018). It is not known how many members UCFFA has and what the fees are.

The Women Fish Network (WFI) engages with women throughout the value chain, including fisheries, aquaculture and processing. The Network has 130 members, most of them working in the processing industry and a few of them working in aquaculture. Specifically for small-scale commercial female farmers, skills, capital and lack of land are a problem. Therefore WFI tries to help these women in overcoming these obstacles. This is done via lobby, training, programmes, and influencing policy frameworks. Although skills and capital are a common issue for most segment I and segment II small-scale commercial female farmers, women specifically deal with the fact that men own the land and that their permission is required to conduct activities such as pond cultivation. Women can become a lifetime member of the network for USD 13.66.

Policy dynamics
Small-scale commercial farmers mostly interact with governmental organisations such as the District Fisheries Offices (DFOs) and MAAIF. Interactions with DFO take place during the process of obtaining permits; this applies to all segments. DFOs often help new small-scale commercial farmers to obtain a permit. DFO staff in some cases clearly lack professional capacity and resources. Regardless of capacity and resource issues, Fisheries Officers (FOs) still offer a supportive environment for small-scale commercial farmers by facilitating the elaboration of site assessments, business plans and EIA. The latter procedures are official requirements for obtaining a permit; as such there is an open and facilitative attitude from the District Fisheries Offices towards the small-scale commercial farmers. However, now that the small-scale commercial aquaculture sector is growing, the demand for FOs officials will increase. In the near future the lack of professional capacity and resources may become problematic. This may potentially result in new obstacles for new small-scale commercial farmers to enter the business.

Small-scale commercial farmers also interact with the governmental officials from MAAIF and more specifically extension workers. However, due to the lack of professional extension workers the supportive environment regarding extension services must be classified as weak. Many farmers in segment I and to a lesser extent in segment II are in urgent need of more skills regarding farm management (feeding) and business competencies (record keeping & planning).

5.8 Key challenges and limiting factors in small-scale commercial fish farming by segment/production model

Based on the field interviews the following key challenges and limiting factors were identified. A summary can be found in tables 1.12, 1.13 and 1.14.

1. A lack of high quality and affordable feed
2. A lack of high quality and affordable seed
3. Lack of knowledge and skills
4. Poor cooperation
5. Lack of capital
6. Environmental issues
7. Under-capacity of extension services

The first problem, a lack of high quality and affordable feed, is caused by a lack of high quality and affordable local feed. For local feed production the fluctuating prices of raw materials are a problem; this is specifically the case for silver cyprinid (*Rastrineobola argentea*, locally known as Mukene). As a consequence, small-scale commercial farmers in Segment I lack the capital to buy commercial feed. Therefore they produce their own feed; however without proper knowledge of the right feed formulation (FCR is 2.0–2.5). It is estimated that 85-90% of all small-scale commercial farmers make their own feed. Small-scale commercial farmers who do have access to some capital (Segment II) often buy low quality local feed (FCR is 1.8–2.0). It is estimated that 8% of all small-scale commercial farmers use locally produced feed. Small-scale commercial farmers with good access to capital (Segment III) buy imported feed from Israel, Mauritius and Brazil (FCR 1.4–1.6). It is estimated that 4% of all small-scale commercial farmers use imported feed.

The second problem, a lack of high quality and affordable seed, relates to issues with quality. The challenge to cultivate all male Nile tilapia has been tackled by the use of hormones. Still, the quality of the seed is variable and it is perceived as being too expensive. Reported causes of fingerling mortality vary; it is uncertain what the exact causes of mortalities are. However, respondents agree that there is a need for improved genetics, for example via a national breeding programme.

The third problem, lack of knowledge and skills, is certainly one of the key issues. Respondents report that a lack of business attitude is constraining the development of most small-scale commercial farmers (i.e. Segments I and II); most of them do not have a proper business plan. Records are only structurally kept by the larger small-holders (Segment III). Also knowledge and skills regarding planning of production (cycles) is often lacking. Small-holders in segment I often run out of capital, resulting in a lack of feed and starving fish. This segment of small-holders also lack technical skills, such as pond and cage construction, water quality monitoring and site selection.

The fourth problem, poor cooperation, is visible in the entire value chain. Most small-scale commercial farmers are not well-organised; Famers in segment I sell low volumes at low prices often to their neighbours, while middlemen are searching for high volumes and low prices to maximise their profit margins at the expense of the small-scale commercial farmers. This means that producers and distributors are not well connected. As such, small-scale commercial farmers are not yet cooperating to be able to buy cheaper inputs and create higher volumes and lower prices. Some small-scale commercial farmers are also complaining that middlemen have too much power and taking too many profits. Some of the small-scale commercial farmers in Segment III have plans to organise the distribution of fish by themselves, and have already formed Uganda Fish Farmers' Association which has somehow stabilised farm gate prices.

The fifth problem, lack of capital, is experienced especially by small-scale commercial farmers in Segment I. These small-scale commercial farmers do not have access to sufficient own (or family) capital while at the same time they cannot get a commercial loan. As a consequence they run out of feed with starving fish in the ponds or cages. Improvements and expansion of farming operation in the other categories is also hindered by the cost of capital.

The sixth problem, environmental issues, is related to reduced dissolved oxygen levels. For example there are incidental reports of the invasion of Kariba weed (*Salvinia molesta*) in Lake Kyoga. This aquatic fern is an invasive species native to south-eastern Brazil. The weed causes dissolved oxygen levels to drop, which can cause suffocation of cultured Nile tilapia. Small-scale commercial pond farmers experience erosion problems during the rainy season. Organic matter flushes into the ponds, also causing dissolved oxygen levels to drop. During the rainy season the flushing of ponds is not possible due to poor drainage of the ponds by gravity flow.

The seventh problem is the under-capacity of extension services. Although all small-scale commercial farmers should have access to at least one extension worker, this is often not the case. Currently there are 250-500 extension workers in Uganda. Due to large travel distances, extension workers cannot reach all small-scale commercial farmers while small-scale commercial farmers themselves do not have the means to visit extension workers.

Table 5.11 *Overview of how key challenges and limiting factors apply to different segments*

#	Key challenge / limiting factor	Applicable to segment		
		I	**II**	**III**
	A lack of high quality and affordable feed	+	+	+/-
	A lack of high quality and affordable seed	+	+	+/-
	Lack of knowledge and skills	+	+/-	-
	Poor cooperation	+	+	-
	Lack of capital	+	+	+/-
	Environmental issues	+/-	+/-	-
	Under-capacity of extension services	+	+/-	-

+ = major challenge, +/- = challenge, - = minor challenge

5.9 Which production models are proving most successful and why?

This section first discusses the key factors of success for small-scale commercial fish farming in Uganda. The section ends with the most successful production models in the different segments. From the collected data three key factors of success have been identified for small-scale commercial fish farming in Uganda. They include:

1. Institutional system
2. Availability of own (or family) capital or equity
3. Knowledge, education and attitude of small-scale commercial farmers

The legal and policy environment for aquaculture in Uganda is perceived as relatively supportive, although the administrative burden is still an issue. General requirements include a site suitability assessment for smaller (small-scale commercial) farmers and an Environmental Impact Assessment for larger small-scale commercial farmers. Also a business plan is required. The process is not too expensive and does not cost too much time. In case of cage farming the costs of getting a license are USD 5.46 per cage. Once all required information has been submitted to the District Fisheries Office it takes between 2 and 7 days to issue the license. To arrange the paper work the District Fisheries Offices help small-scale commercial farmers in the process. The foundation of this supportive legal environment has been laid by the National Fisheries Policy from 2004, which will be updated in 2018. This policy contains relatively effective rules and regulations for the development of aquaculture. It can be characterised as having a modern vision with a focus on profitable aquaculture with a value chain approach. Also the policy focuses on measures to improve technology for production (e.g. high quality local feed). The government also has further plans to improve the legal environment. Examples are electronic licensing via Internet and a "one stop set", i.e. a ticket booth where all licensing matters are being handled and setting up of a one stop centre of acquisition of all the licences for fish farming.

Access and availability of capital is a second key factor of success for small-scale commercial farmers. From the field data it has become clear that family capital (owners equity) is of key importance to start a business in aquaculture. The reliance of family capital is caused by the difficulties /hurdles in the accessibility of commercial loans. Banks are hesitant to invest in aquaculture due to the fact that is a new sector. Moreover, interest rates are on average 24% which is too high for small-holders, and aquaculture inclusive.

Knowledge, education and the attitude of small-scale commercial farmers is the third key factor of success. During the interviews it became clear that those small-scale commercial farmers with an educational background (segment III, e.g. a BSc and/or MSc in fisheries or aquaculture) are the most successful. They know how the legal and regulatory environment works, they have the right network, they know how to do proper farm management and they often have business skills. The attitude of these small-scale commercial farmers is also relevant; most of the successful small-scale commercial farmers are continuously improving their knowledge and skills. Often they have visited other countries for field studies, e.g. Ghana, Thailand, Philippines, China and Vietnam.

The most successful production models can be found in segment II and III. In these segments, small-scale commercial farmers operate medium size cages of 5x5x5 meters (LDHV). In one case on Lake Albert a farmer was operating circular cages diameter of 12 and 7 meters. Both types of production models are successful since there is plenty of space to grow and the water quality and temperature is good. Due to the available (family) capital small-scale commercial farmers in Segment III can afford imported feed; with an FCR of 1.4-1.6 they are able to realise 2 production cycles per annum. As a consequence these small-scale commercial farmers make profits that can be re-invested in further growth of the business.

6 Analysis and insights

6.1 Common conditions, habits or other factors determining success of small-scale commercial fish farming

Based on the literature and the field visit the following common conditions and success factors have been found for small-scale aquaculture in Uganda. The common conditions facilitating the success and growth of small-scale commercial farmers are:

- Wide variety of aquatic and agricultural resources that can support the growth of aquaculture
- Nearly 18% of Uganda's total surface area is covered by rivers and lakes, and wetlands
- Existence of 5 large lakes and 162 minor lakes, suitable for aquaculture
- Sufficient water availability with rainfall ranging between 600-2,500 mm per annum
- Wide agricultural resource base required for the production of ingredients for fish feed
- Increased networking and linkages with experts, institutions, markets, inputs suppliers and technical staff
- The Ugandan population is used to eating fish
- Widening gap between demand and supply of fish in Uganda & expanding regional markets
- Uganda is strategically located to develop export markets within the EAC Region
- A fish deficit of 180,000 – 500,000 tonnes (MAAIF, 2012; Fortune of Africa, 2018; Ogutu-Ohwayo et al., 2016)
- Overfished (and/or destroyed) natural fish stocks, creating a business case for aquaculture
- Highly developed fish processing sector due to the export of Nile perch products to the EU

Aquaculture in Uganda has as such witnessed a major shift, from predominantly subsistence production and a livelihoods support approach during the 1950s to the 1990s, to a more recent diversified market driven approach that emphasizes profit-oriented expansion. The country is currently developing industrial support measures for establishing the commercial aquaculture sector, a professional and reliable technical service provision network, and promoting investment across the aquaculture production and marketing along the value chain. These efforts have paid off in terms of attracting local and foreign investors into the subsector. A number of studies and interventions indicate that there is potential for the growth of commercial scale fish farms in Uganda (Delegation of European Union (EU) to Uganda, 2011). The country has begun to witness a shift in practice from subsistence to commercial production technologies and the use of formulated feeds; the adoption and use of cage fish culture systems, the development in the local and regional markets for cultured fish, and the establishment of University level technical bachelor and master degree courses in fisheries and aquaculture development and management.

Currently, the nascent Ugandan commercial aquaculture industry comprises a number of locally and foreign-owned cage based fish farms on Lake Victoria and Lake Albert (Segment III) that are actively building significant production capacity. Small-scale commercial farmers in Segment III are successful due to larger amounts of family capital and the possibility to attain higher education. As a consequence high quality imported feed is used and the farm management is well organised. There are further more than 2,000 (Segment II) fish farms operating mostly ponds, plus a few small cage farms. The majority of these farms are operating well below production capacity. Many thousands of small-scale commercial farmers (Segment I) are also typified by less productive fish ponds. National production has been a growing at an annual rate of 300% over the past 10 years, albeit from a small base.

Emergence of Segment III small-scale commercial fish farmers and those that have already transited small scale description demonstrate the potential to develop aquaculture businesses if interventions are put in place to solve the critical issues of financing for production and marketing including market

infrastructure development. The shift experienced in the 2000s demonstrated that the industry is able to respond to the challenges and farm on business principles. Indeed, this period marked the end of state hatchery dominance in fish seed production and supply. Subsequently, there is a need for continued technical and financial support to small-scale commercial farmers, especially in the area of feed manufacturing and supply, and in the adoption of more intensive culture without creation of the donor dependency syndrome as it undermines business principles. The donor dependency syndrome refers to the practice of giving seed, feed, fertilisers and equipment by international donors to farmers, as occurred in several projects in Sub Sahara Africa. Once such an international donor project finishes, farmer support also ends. In many cases farmers will stop farming due to the fact that international donors have not facilitated the independence of a farmer on the longer term, for example by developing appropriate skills such as farm management and business competencies.

Recent investments into large-scale Nile tilapia cage culture and feed manufacturing do indicate that aquaculture sector is beginning to establishing itself as an economically viable sector. It can be deciphered that well focussed support to overcome critical challenges will trigger fast transformation of the sector. These critical challenges are further elaborated below.

6.2 Key problems by segment and production model and opportunities for improving productivity

Based on the field interviews the following key problems were identified. They have been elaborated in section 3.9. A summary of these key problems can be found in tables 1.12, 1.13 and 1.14.

1. A lack of high quality and affordable feed
2. A lack of high quality and affordable seed
3. Lack of knowledge and skills
4. Poor cooperation
5. Lack of capital
6. Environmental issues
7. Under-capacity of extension services

6.3 Key barriers to entry

The key barriers to entry small-scale aquaculture in Uganda are:

1. Lack of zoning
2. Limited access to knowledge
3. Lack of capital or high cost of capital

The first barrier, lack of zoning, applies to both cage and pond cultivation. Currently the government of Uganda has not allocated appropriate areas for aquaculture (i.e. aquaculture zones). Therefore cage cultivation may occur in areas where the environmental and/or socio-economic conditions are not optimal. In some instances entrants who would like to start with cage farming are limited by long distances to water bodies. Environmental constraints include locations that are partly land-locked. As a consequence nutrients cannot flush away and dissolve in larger water bodies. Socio-economic constraints include the interaction with other users, such as shipping, tourism and fisheries.

The second barrier, limited access to knowledge, is also a key barrier. For example, many newcomers do not have proper access to training, or they do not know how to access or contact facilities. Also, there is a lack of training programmes and extension workers. Moreover, it is questionable if the current training and extension facilities are fully capable of providing the right services to both newcomers and practising small-scale commercial farmers.

The third barrier to access fish farming, lack of capital, has also been discussed above. Currently only newcomers with own (or family) capital can invest in farm construction. Those newcomers with a lack of capital often run out of feed during the production cycle, causing many to abandon fish farming.

6.4 Define and prioritise opportunities to expand small-scale production by number of producers or size of farms

Below the opportunities to expand small-scale production are listed. The most important opportunities are listed first.

The first opportunity is more coordination of the sector. At this time the efforts of various public, private and non-governmental organisations to improve the key factors in the development of the aquaculture sector in Uganda are mostly uncoordinated. Every organisation seems to work on a particular issue; as a consequence key issues are approached in isolation rather than in an integrated manner. This is important because, most of these 'separate' issues are in fact highly interconnected. A farmer with capital, but without knowledge will not succeed and vice versa; the same goes for a farmer with proper knowledge, but without access to high quality feed and seed. An opportunity to expand small-scale commercial fish farming is to work towards a systematic and integrated approach (both in and along the value chain), where efforts of public, private and non-governmental organisations to tackle key issues are coordinated in order to create synergy. As far as possible this also implies the combining of budgets so that more can be done. As such there is an opportunity to establish a multi-stakeholder aquaculture platform. A first element of this aquaculture platform could be the establishing of farmer groups with lead farmers. Instead of trying to reach all small-scale commercial farmers, lead farmers are educated in a Training of Trainers (ToT) approach, so that they become the ambassadors of best aquaculture practices. Each farmer could then train other small-scale commercial farmers in the field. The aquaculture platform could also help in tackling the challenge of better cooperation in the marketing and distribution of fish. To initiate the platform it is important to start informal and low-profile in workshop settings. Once the platform is gaining momentum it may be efficient to formalise the cooperation.

A second opportunity is to have a tailor-made approach towards helping small-scale commercial farmers to move from segment I to II and from segment II to III. Looking at the three segments it becomes very clear from the analysis that small-scale commercial farmers in segment III are of the least concern. These small-scale commercial farmers are successful and continuously growing. Within a matter of a few years their production will rise above 50 tonnes and they will become a medium-scale farmer. The most concern is therefore with segment I; these small-scale commercial farmers are struggling to make a living from aquaculture. They urgently need better feed, improved knowledge and skills and access to capital. Only then the small-scale commercial farmers from segment I may be able to move towards segment II. Small-scale commercial farmers in segment II also need better local feed of affordable prices in order to grow. Although this segment does have the basis knowledge and skills for farm management, they urgently need to improve them so as to improve their business and future outlook.

6.5 Consider models through which smallholders could be linked to the market and support services

Three potential models to link small-holders with markets and support services are discussed here:
1. Cluster farming
2. Aquaparks
3. Empowering investors (Egyptian model)

Cluster farming has potential as a commercial small-holder production model. An example is Pearl Aquatics Ltd in Lake Victoria, Entebbe. First, a separate group of investors was formed under the name of Garuga Tropical Aqua Pact. Some of these investors are active as a small-holder in cage farming, and others are not. The minimum amount of investment per investor was USD 23,000[4]. With

[4] All prices in this report are based on UGX/USD conversion of March 2018. 1 USD = 3661.39 UGX (EU, 2018).

a total of approximately USD 400,000 a production capacity of 14 cages was installed, with the involvement of 54 small-holders. In 2017 their combined annual production amounted to about 89 tonnes, with the ambition to produce 160 tonnes in 2018. The small-scale commercial farmers use high quality starter feed from Raanan (Israel) and grow out feed from Invovo (Brazil). Due to the high quality feed an FCR of 1.4 is reached, with 2 annual production cycles. Due to this model, these small-holders have a serious voice in the aquaculture politics of Uganda. Furthermore, they are able to buy inputs in large volumes at a reduced price. However, the cluster farm still faces the challenge of middlemen, consuming a large part of their profit. As such the ambition of Pearl Aquatics Ltd. is to develop the local fish market by starting fish outlets in Kampala, using a cold chain.

Through EU funded project Uganda, is trying out Aquaparks as a means to expand the production of small- to medium-scale farmers in Uganda. Aquaparks, similar to the concept of industrial business parks are designed to provide more appropriate production infrastructure for small-scale commercial fish farmers while tapping into the advantages of economies of scale brought about by concentrating production at particular sites.

Other approaches that can be considered include empowering knowledgeable but struggling investors with access to capital and organised markets modelled on the EU supported aquaculture development in Egypt. In the late 1970s the Egyptian aquaculture development plan was proposed to boost the development of the sector. By the end of the plan in the mid-1980s, annual aquaculture production had jumped from a mere 17,000 tonnes to 45,000 tonnes. In the mid-1990s, intensive pond aquaculture was introduced with the aim of replacing the semi-intensive and traditional farms. Aquaculture in Egypt has since continued to grow the present production of 1.37 million tonnes in 2016 (FAO, 2018b).

6.6 Current and potential production

For this analysis it is assumed that the current estimated aquaculture production of approximately 120,000 tonnes will double to 240,000 tonnes in a time span of 10 years. A doubling in production is based on previous production data and measures to tackle bottlenecks such as feed, seed and knowledge. To assess the price effects of a doubling in production the method of Smit (2008) is used. Since there is a lack of quantitative data, price effects will be discussed in a qualitative manner. According to Smit (2008) the expected price effects are mainly dependent on the size of the market in which a small-scale commercial farmer operates. In case of small-scale commercial fish farming in Uganda, different markets can be distinguished and therefore price effects of a doubling in production differ between segments. As illustrated in table 6.1, price effects are expected to be more significant in segment I and to a lesser extent in segment II. Price effects are expected to be minor in segment III. The difference between segments can be explained by differences in the degree remoteness, the state of logistics and market linkages with middlemen.

Table 6.1 *Effect of doubling production in different segments*

Segment	Markets & sales	Marketing and distribution	Price effect of doubling production
I	Farm gate to neighbours and proximal markets	Not organised; hard to sell the little amounts produced on the farms	Price will go down as local markets are less able to absorb an increase in production. Specifically applies to small-scale commercial farmers remote areas with poor logistics
II	Farm gate. Middlemen from Rwanda, Congo, Kenya	Fairly organised through telecommunications with each other.	Farm gate selling: price will go down as local markets are less able to absorb an increase in production. Specifically applies to small-scale commercial farmers remote areas with poor logistics. Middlemen: Price will not be affected; regional markets are large and demand is high.
III	Middlemen from Rwanda, Congo, Kenya	Organised through the Uganda Commercial Fish Farmers' Association.	Price effects will be minor; regional markets are large and demand is high.

6.7 Data and information gaps

Substantial efforts have been put on retrieving data and information for this study. Nevertheless, the following gaps in data and information were found.

1. The exact number of ponds
2. The total surface and volume of ponds
3. The exact number of cages
4. The total surface and volume of cages
5. The number of small-scale commercial farmers (per segment)
6. The number of cooperatives

Although production data per specie (quantity in tonnes, value in USD) is available via FAO, it is highly questionable if these figures are trustworthy. While most experts state the figures are gross over-estimated (Dickson et al., 2011; Dalsgaard et al., 2012), other experts claim figures are gross under-estimated (Mwanja, 2018 personal communication). The result of a lack of trustworthiness of data is that the exact size of the aquaculture sector is not known, as well as its development in terms of growth over the years.

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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 farmers:

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

Questions 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 donors:

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 Names and affiliation of respondents

First name	Last name	Affiliation	Function
Rashid	Asiimwe	A.A. Fisheries Ponds & Hatchery	Owner
Gertrude	Atukunda	NaFIRRI	Researcher
Faith	Atukwatse	Pearl Aquatics Ltd.	Technical administrator
Gladys	Bwanika	Makerere University / Pearl aquatics Ltd.	Researcher / co-owner
Basil	Chieng	Samaki Express E.A. Ltd.	Operational manager
Gertrude	Abalo	Fisheries Training Centre	Principal
Joyce	Ikwaput Nyeko	MAAIF	Commissioner
Ben	Kiddu	Walimi Fish Cooperative Society	Coordinator
Lovin	Kobusingye	Women Fish Network	Founder
Majidu	Magumba	Masese Cage Fish Farmers	Co-owner
Mathew	Mwanja	NaFIRRI	Station head
Margareth	Nabulime	Novel Feed Factory	Manager
Gudula	Naiga Basaza	Gudie Leisure Farm	Owner
Margret	Nantongo	Johnak Farm	Manager
Mujibu	Nkambo	NaFIRRI	Researcher
James	Obenga	Marinas Aviation Ltd.	Co-owner
Jacob	Olwo	FAO	Fisheries & aquaculture specialist
Edward	Rukuunya	MAAIF	Director
Michael	Walugada	District Fisheries Office	District Fisheries Officer
Waiswa	Wilson Mwanja	Former MAAIF	Former Policy Commissioner
Andrew	Zzimbe	Microfinance Support Centre Ltd.	Credit officer

Appendix 4 Nile perch

The Nile perch (*Lates niloticus)* is a large freshwater fish that can grow to attain weight of up to 200 kg and a length of 1.93m (Ribbink, 1987). In Uganda this fish is a major contributor to the national fish catch for local consumption and exports. Nile perch constitutes up to 96% of the fish exports to premium markets, 40% of the exports to region markets, and 30% of the fish consumed locally. The demand for Nile perch fish to meet the local, regional and international needs has surpassed the supply from the wild due to increasing human population and reduced fish stocks. The Nile perch has a well-established local and export market. The white firm flesh of the Nile perch has been found to be comparable to the cod that is highly competitive on international markets. These desirable qualities of the fish are responsible for its export to distant places such as the United States of America (USA) in spite of the very high freight costs. On the local markets, Nile perch is scarce with most of it being exported to the European Union (EU).

The increased demand for Nile perch in local, regional, and international markets; the growth of the Nile perch fish processing capacity and the increased value of Nile perch have all combined to bring extraneous pressure to its natural stocks disrupting the natural reproductive activities and recruitment. Information from fish processing factories indicates that the average size of landed fish has decreased from over 50kg in 1980 to less than 10kg in 2017. The current declining trend of Nile perch if not reversed has resulted into collapse of several processing factories with resultant severe socioeconomic consequences on the nation given the contribution of fish to the economy and people's nutrition. The reported decline in catch and increasing prices for Nile perch and its by-products provide impetus for farming of the species to a supplement sustainability of national catch and export market. Experience indicates that successful aquaculture industries are usually preceded by vibrant fishing industries, which establish markets for fisheries products and infrastructure for processing and distribution. The opportunity for aquaculture is usually best when fishery production begins to decline and prices for fish products start to increase. Through the Millennium Science Initiative (MSI) in 2009, research was conducted to understand biological parameters that can lead to inducing spawning and culture of the Nile perch. From the study established that Nile perch is a protracted batch spawner, releasing small sized (0.55 ± 0.04 mm) floating eggs between November and January. The observed unimodal spawning peak was out of phase with the bimodal rainfall pattern in central Uganda. The ovulated eggs did not hatch but exhibited embryo development similar to that reported in other species such as Baramundi, Lates niloticus and white perch, *Roccus americanus*. It was deduced that Nile perch resembles marine fishes in physiology as exhibited by the pelagic eggs with long hatching period and high levels of PUFA's. The long protracted batching spawning and the long hatching periods imply that the existing knowledge on fresh water fishes of East Africa cannot be directly applied on the Nile perch but knowledge of the cultured marine fishes will be more relevant. However the study found difficult in restrain of the big sized brood fish which required plenty of oxygen to remain alive. The large brood fish could not be easily manipulated as they died fast. It was therefore thought that if juvenile Nile perch caught from the wild can be raised in ponds can perhaps sexually mature at a smaller size that can be manipulated and induced to spawn. It is in this respect that the farmer is raising Nile perch in his ponds.

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Wageningen Centre for Development Innovation supports value creation by strengthening capacities for sustainable development. As the international expertise and capacity building institute of Wageningen University & Research we bring knowledge into action, with the aim to explore the potential of nature to improve the quality of life. With approximately 30 locations, 5,000 members of staff and 10,000 students, Wageningen University & Research is a world leader in its domain. An integral way of working, and cooperation between the exact sciences and the technological and social disciplines are key to its approach.