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

Part 2. RWANDA

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WAGENINGEN UNIVERSITY & RESEARCH

BoP INNOVATION CENTER

Fair & Sustainable Consulting

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Part 2. RWANDA

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This report presents the findings of a desk study and a field work conducted in Rwanda on small-scale commercial aquaculture and is part of a regional study commissioned by Msingi East Africa Limited.

The aquaculture sector in Rwanda is dominated by small-scale producers of mainly Tilapia and African catfish (to a lesser extent) in ponds, and an increasing number of Tilapia producers in cages in Lakes Kivu and Muhazi. Based on production infrastructure used and production volumes, three segments have been identified:

1. Small-holder farmers producing Tilapia in ponds using animal manure to fertilise the ponds and feeding with bran and vegetables. The production of fish farmers in segment 1 range between 1.5 and 17 tonnes of fish per year.
2. Small-holders producing Tilapia in low volume cages using farm-made feed and locally manufactured feed. The production of fish farmers in segment 2 range between 17 and 30 tonnes of fish per year.
3. Small-holders producing Tilapia in high volume cages using locally manufactured feed and imported feed. The production of fish farmers in segment 3 range between 30 and 50 tonnes of fish per year.

Key constraints encountered by the sector are the lack of fingerlings in quantity and quality, the low quality of locally manufactured feed, the high cost of imported feed, the lack of skills and access to finance.

Opportunities to expand small-scale commercial fish farming exist in mass on-growing of tilapia fry, semi-intensification of pond production, and clustering of small-scale commercial cage farmers for improved access to inputs, services, information and training, and a consistent supply of fish products to the markets.

Recommended production models for small-scale commercial fish farmers include aquaculture park systems linked through farming contracts to input/service suppliers and fish traders.

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

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

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Photo cover: Ms Byukusenge Christine, owner and manager of Fresh Fish Ltd, observing Tilapia behaviour during feeding of her circular cages at Lake Muhazi. Photo: Eugene Rurangwa

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List of abbreviations and acronyms

AfDB	-	African Development Bank
AIC	-	Aquaculture Innovation Community
ARES	-	Académie de Recherche et d'Enseignement Supérieur
BDF	-	Business Development Fund
BMP	-	Best Management Practices
BRD	-	Banque Rwandaise de Développement
BSc	-	Bachelor of Sciences
CAVM	-	College of Animal Sciences and Veterinary Medicine
CP	-	Crude Protein
DRC	-	Democratic Republic of Congo
EAC	-	East African Community
EDCA	-	Enhancing Development of Commercial Aquaculture
EIA	-	Environmental Impact Assessment
ESG	-	Environmental Social Governance
FAO	-	Food and Agriculture Organisation
FCR	-	Feed Conversion Ratio
GIFT	-	Genetically Improved Farmed Tilapia
GMO	-	Genetically Modified Organism
GoR	-	Government of Rwanda
HACCP	-	Hazard Analysis and Critical Control Point
HDPE	-	High-Density PolyEthylene
HVLD	-	High Volume Low Density
K.U.Leuven	-	Katholieke Universiteit Leuven
LVFO	-	Lake Victoria Fisheries Organisation
LVHD	-	Low Volume High Density
MINAGRI	-	Ministry of Agriculture and Animal Resources
MINICOM	-	Ministry of Trade and Industry
NGO	-	Non-Governmental Organisation
PAIGELAC	-	Inland Lakes Integrated Development and Management Project
PD/CRSP	-	Pond Dynamics/Collaborative Research Support Program
RAB	-	Rwanda Agriculture Board
RDB	-	Rwanda Development Board
REMA	-	Rwanda Environmental Management Agency
RSB	-	Rwanda Standards Board
RWF	-	Rwandan Franc
SME	-	Small and Medium Enterprise
TCP	-	Technical Cooperation Project
UK	-	United Kingdom
UNDP	-	United Nations Development Programme
UR	-	University of Rwanda
USA	-	United States of America
USAID	-	United States Agency for International Development
USD ($)	-	United States Dollar
WCDI	-	Wageningen Centre for Development Innovation, Wageningen University & Research
WUR	-	Wageningen University & Research

1 Introduction

East Africa is endowed with excellent natural freshwater resources and climate. Currently freshwater aquaculture 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 (www.msingi.com) is an East African industry development organisation that 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 policy, technology transfer, research and development, human capacity building or support to key sector organisations.

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

2 Methods

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

2.1 Definition of aquaculture smallholders

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

2.2 Literature and field studies

The study is comprised of two main parts: a desk study and a field study. The desk study was undertaken by Eugene Rurangwa in collaboration with Jean Bosco Kabagambe 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 an 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 both Eugene Rurangwa and Jean Bosco Kabagambe. 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 at the Rwandan Agriculture Board, officials at the Ministry in charge of Aquaculture, a development donor, and researchers and scientists from academic institutions. The list of persons interviewed is 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.

3 Findings

3.1 Brief overview of the aquaculture sector in Rwanda

Fish farming was introduced in Rwanda at the end of the 1940s by the Belgian colonial administration as a subsistence farming activity (MINAGRI, 2011a[1]). The colonial administration constructed two main fingerlings production centres at the Ecole des Assistants Agricoles of Butare in 1952 and the Kigembe Station in 1954. The Kigembe fish station (Photo 1) was established to provide fish fingerlings and extension services to the small-scale farmers. In 1959, many existing ponds were abandoned, and infrastructure destroyed due to civil strife. During the period 1960-1965, the development of fish culture in Rwanda came to a standstill.

Photo 1 *Hatchery at Kigembe Station, Southern Province*

From 1967 to 1973, the Government undertook the revitalisation of fish farming through various UNDP/FAO projects, focussing on small holder subsistence aquaculture. It was characterized by low inputs and low outputs, based on pond fertilisation from livestock wastes. The projects reactivated the Kigembe Centre and carried out trials on culture of the common carp (*Cyprinus carpio*), Tilapia species and catfish (*Clarias gariepinus*). Tilapia fingerlings were produced and several ponds in rural areas were stocked. These projects were followed by several others including the National Aquaculture Project (Projet Pisciculture Nationale – PPN) financed from 1983 to 1988 by the USAID to support aquaculture sustainability. The project recorded impressive results and led to the creation of the National Aquaculture Service in 1989. However, each time at the expiry of the project, production declined, and ponds were abandoned.

In the 80-90's, Belgian inter-university cooperation (K.U. Leuven, University of Namur) and USAID funded a number of projects. The Pond Dynamics/Collaborative Research Support Program (PD/CRSP) was carried out in collaboration with Universities in the USA and has focused on aquaculture research and development and the transfer of knowledge and technology into the country. Artificial breeding and rearing of African catfish was introduced in this period through the Clarias project funded by the

[1] MINAGRI (2011a). Masterplan for fisheries and fish farming in Rwanda. 89 pages.

Flemish Inter-University cooperation with K.U. Leuven. After the 90's, the University of Namur has supported projects on the functioning of integrated fish farming systems in swamp area, the potential of rearing rabbits over fish ponds to fertilise earthen ponds and the use of local agricultural by-products in feeds for African catfish.

Cage culture of fish has been carried out in Rwanda from 2000 to 2003 in Lake Kivu by fishermen cooperatives through FAO and USAID funding. The most recent project promoting fish farming in ponds and cages, the Inland Lakes Integrated Development and Management Project (PAIGELAC) (2006-2013) was funded by the African Development Bank and the Government of Rwandan (MINAGRI, 2011b[2]). The project has imported 5.6 million fingerlings of *Oreochromis niloticus* from Uganda (Lake Albert) to the Kigembe Station to produce broodstock for the supply of fingerlings to fish farms on the claim that the strain produced better broodstock than the local broodstock (AfDB, 2013[3]). The project has rehabilitated nearly 218 ha of abandoned fish ponds and stocked them with Tilapia fingerlings. Under PAIGELAC project, fish farmers have been organized under cooperatives and given various forms of support ranging from training, study tours to direct provision of inputs. During the PAIGELAC project, a Masterplan for fisheries and fish farming in Rwanda was developed.

The common feature of these donor-funded projects and state interventions was always a boom during project times followed by a decline in production and ponds abandonment at the end of the projects, clearly demonstrating a lack of sustainability. The interventions under PAIGELAC project were not any different. Some ponds and cages were not restocked after the first harvest and the ending of subsidised project inputs. Farmers did not have funds to buy feed and fingerlings as money from fish selling was not reinvested in fish farming.

However, at the end of the PAIGELAC project, a few fish farmers with a certain level of education, capital and a business mind-set emerged from the project dependence and engaged in small-scale commercial fish farming alongside new entrepreneurs entering into fish farming and inputs production and supply. They received a support from a two-year FAO project "Support to Enhancing Development of Commercial Aquaculture (EDCA) in Rwanda. FAO/ TCP/ RWA/ 3502 (2014–2016)". The project supported 10 fish farmers cooperatives and three individual fish farmers to develop entrepreneurial skills, increase their productivity, and develop value addition within the sub-sector. The beneficiaries received training on fish seed and feed production, hatchery, pond and cage management, leadership, design of business plans, as well as farming equipment.

For the first time and with the involvement of the private sector, the first commercial fish farms were born in 2013-2014. The small-scale commercial fish farming is dominated by nationals some of which are growing to medium-scale level, especially in cage farming. There are also foreign investors heavily investing in modern cage farming. With a zero-corruption policy, a conducive business environment, vast natural water resources and a strategic position between East and Central Africa, the country became attractive for investment in fish food production and as a redistribution platform to the Democratic Republic of Congo (DRC). Moreover, the country performs well in a number of the World Bank's global Ease of Doing Business indicators, ranking highest in East Africa (World Bank Group[4]). Rwanda is endowed with an abundant network of inland lakes, rivers and wetlands which constitute a natural resource to support aquaculture development. There are in total, 24 inland lakes with 128,000 ha of total surface area most of which are suitable for aquaculture production.

The most farmed fish is Nile Tilapia (*Oreochromis niloticus*) as the market and consumers prefer this species. Some farmers produce African catfish (*Clarias gariepinus*) in polyculture with Tilapia in ponds, but this practice is not common. The demand for fish, especially for fresh Tilapia, is far above the supply and prices for fish are among the highest (USD3.50-4.00/kg) in the region. The per capita fish consumption in Rwanda is still low and is lower than the average sub-Saharan (6.7 kg per caput/year)

2 MINAGRI (2011b). Annual Report FY 2010/2011. 94 pages.

3 AfDB (2013). RWANDA INLAND LAKES INTEGRATED DEVELOPMENT AND MANAGEMENT SUPPORT PROJECT. Project Completion Report. 36 pages.

4 World Bank Group. http://www.doingbusiness.org/rankings?region=sub-saharan-africa. Accessed on 04-04-2018).

and East African fish consumption (Rwanda: 2.3 kg, Burundi: 3.6 kg, Kenya: 4.5 kg, Tanzania: 8 kg and Uganda: 10 kg (Lattice, 2016[5]). Nevertheless, fish is considered a healthy product as it provides high value proteins and micro-nutrients. More critically, the consumption of fish combats stunting and malnutrition, which unfortunately still forms a serious problem in Rwanda. There is reason to believe that the demand for fish will grow.

For this review we have retained and listed small-scale commercial fish farms from the aquaculture desk office at Rwanda Agriculture Board (RAB) that we could assess face-to-face during field visits, group discussions or through mobile phone discussions. Currently out of 1,413 ponds registered in 2018 as used for production, 616 ponds totaling 6,557 ares (655,700 m^2) of surface area are considered as small-scale ponds commercially managed for profit by 37 cooperatives and individuals having each at least 100 ares (10,000 m^2) of ponds on one site. Out of 430 cages with a total volume of 27,846 m^3 operating on Lakes Kivu and Muhazi, 252 cages with a total volume of 6,602 m^3 are small-scale commercial cages belonging to 10 companies or cooperatives with at least 100 m^3 per farm. Each farm in these 2 categories produces <50 tonnes per annum. Seven other farms are of medium-scale size and produce each more than 50 tonnes per year from 70 cages (16,036 m^3) on Lake Kivu and 108 cages (5,208 m^3) on Lake Muhazi. There is also an unknown number of small-scale ponds below 10,000 m^2 and cages below 100 m^3 which are scattered throughout the country and are commercially managed but for which production data are not easily accessible nor reliable.

According to FAO statistics 1,580 tonnes of fish have been produced by aquaculture in 2016 in Rwanda (Figure 1, FAO, 2018)[6]. According to this survey, 37 small-scale pond-based commercial farms contributed 218 tonnes from 616 ponds (surface: 65.57 ha) in 2017. 8 small-scale commercial cage farms contributed 168 tonnes to aquaculture production from 186 cages (volume: 6,014 m^3). Five out of seven registered medium-scale commercial cage farms contributed 730 tonnes from 114 cages (17,304 m^3). This reported production concerns only farms above 10,000 m^2 of ponds or 100 m^3 of cages in one location and does not include production from small farms nor from subsistence farming.

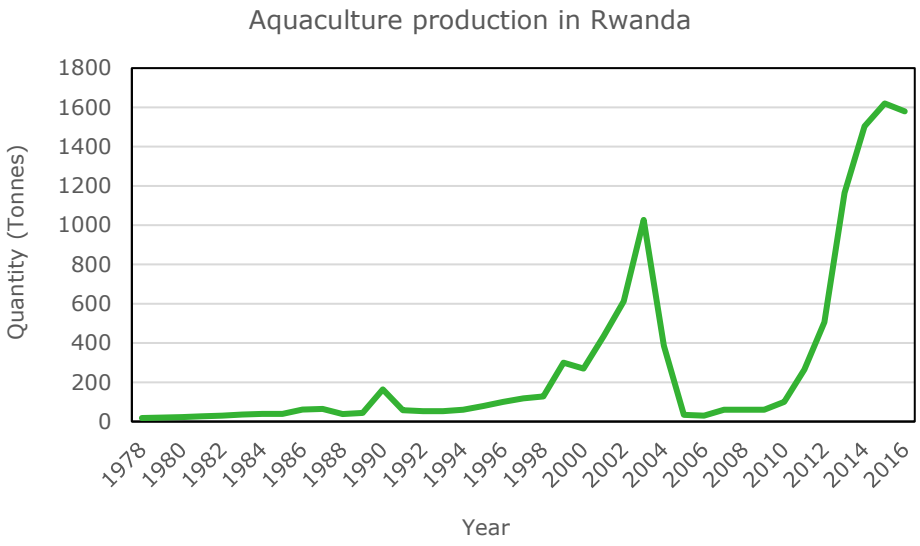

Figure 1 *Aquaculture production in Rwanda. Source FAO (2018)*

[5] Lattice Research (2016). Market analysis of aquaculture in the East African Community. Impact of Tilapia Imports on Aquaculture Development November 2016. 26 pages.

[6] FAO (2018). Global Aquaculture Production (online query). http://www.fao.org/fishery/statistics/global-aquaculture-production/query/en Accessed 26 March 2018.

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

3.2.1 Main small-scale commercial fish farming segments/groupings

Commercial fish farming in Rwanda is predominantly small-scale and produces tilapia in ponds and increasingly in cages. A few small-scale cage farmers are continuously investing in growth and will soon be producing above the threshold of 50 tonnes per year moving to medium-scale category.

Three segments of small-scale commercial fish farmers have been identified based on production systems, scale of production output, level of investment, management and skills.

Segment I: Smallholder farmers producing Tilapia commercially in ponds. Their production varies from 1.5 to 16.6 tonnes per year in 2017.

Segment II: Smallholder farmers producing Tilapia commercially in low volume cages. Their production varied from 10 to 30 tonnes per year in 2017.

Segment III: Smallholder farmers producing Tilapia commercially in high volume cages. Their production varied from 30 to 50 tonnes per year in 2017.

A detailed description of the different segments is made in sections 3.3.1 and 3.3.2. The list of small-scale commercial fish farms registered at the aquaculture desk of RAB in Rwanda is found in Appendices 4 to 6.

3.2.2 Management systems

One of the main drawbacks on the economic operation of aquaculture in Rwanda is the lack of economic records of production (Spliethoff and Murasira, 2013[7]) and the quality of the records if they exist. Differences in record keeping and accounting exist between individual farmers and farmers organised into cooperatives, and between smallholder segments. During interviews, we have found out that differences are rooted in education level and the motivation of farmers to record production data.

Segment I
In segment I of pond-based farms, farms are predominantly organised into cooperatives of fish farmers. Cooperatives keep records. Members have been trained on the importance of records keeping, nature of records to be collected and how to interpret and use the recorded data. Different forms to record production data have been developed by RAB Extension officers and other service providers. Individual pond farmers do not keep records.

Segment II & III
In segments II and III of cage farmers, most fish farmers record farm data and are able to provide evidence-based information about production, amount of feed, number of fingerlings stocked or to assess whether they are making profit or not. These 2 categories are dominated by individually owned cage farms.

[7] Spliethoff, P. and Murasira, P. (2013). Quick scan to identify and discuss options for improved fish production in Rwanda. 30 pages.

3.2.3 Disease and health management

There are no major cases of fish diseases so far reported in fish farms in Rwanda. However, given the uncontrolled transfer of fingerlings from ponds between small-scale commercial fish farmers in segment I, disease can spread easily from one to another farm.

In segments II and III of small-scale commercial fish farmers, Tilapia cage operators have known at least once fungal infections following transport and stocking depending on the quality of fingerlings and the transport conditions. Farmers have reported broken or wounded fingerlings with fungi that have been treated with salt bathes. Because the import of live fish and brood stock seems not to be sufficiently regulated, there is always a risk for the segment III to import diseases and the genetic contamination of wild stocks.

For all the 3 segments, high mortality occurs during the first month after stocking and during bad weather. Such mortality after stocking results from fish stress and wounds caused by transportation, stocking practices including the fingerlings size and the high stocking density.

Without effective disease control measures, disease outbreak is always a risk and a long-term threat to the sector, mainly in intensive fish farms operating without best practices and good health management.

3.2.4 Geographic clusters/distribution or (key) existing production areas

All pond-based small-scale commercial production systems (segment I) are implemented in all districts of the country showing a great concentration of ponds in the Eastern Province due to the presence of irrigation dams for rice growing followed by the Southern province (Table 1).

Table 1 *Distribution of fish ponds by province*

Province	2014 # ponds	2014 Area (ha)	2018 # ponds	2018 Area (ha)	This survey # ponds	This survey Area (ha)
Eastern	-	-	385	111.69	228	23.27
Southern	389	36.60	416	34.61	142	14.34
Northern	145	18.14	210	23.23	85	12.90
Western	265	19.00	292	22.17	116	9.86
Kigali City	-	-	110	10.00	45	5.20
Rwanda			1,413	201.70	616	65.57

Sources: Rothuis et al. (2014[8]); Aquaculture desk office at Rwanda Agriculture Board (RAB). This survey = small-scale commercial ponds.

NA: not available.

Small-scale commercial cage farms (segments II and III) are found in Lake Muhazi and Lake Kivu (Table 2). Lakes Burera and Ruhondo also had a few cages in the past but their number has reduced significantly during the last years because of the low water temperature (9^0C). Lake Kivu, being the biggest and deepest lake, the policy of aquaculture development recommends it as the most suitable lake for cage fish farming while most investors prefer Lake Muhazi, because of its proximity to the Kigali city market despite its shallow water. It seems that peri-urban fish-farmers are more likely to generate higher incomes, net returns and longer-term financial viability, than similar producers in more remote rural areas due to access to both inputs and higher value markets (Arthur et al., 2013[9]).

[8] Rothuis A., M. Turenhout, A. van Duijn, A. Roem, E. Rurangwa, E. Katunzi, A. Shoko. and J. B. Kabagambe (2014). Aquaculture in East Africa; A regional approach. Wageningen, LEI. Wageningen UR (University & Research centre), LEI Report IMARES C153/14| LEI 14-120. 54 pp.

[9] Robert Arthur, Chris Béné, William Leschen and David Little (2013). Fisheries and aquaculture and their potential roles in development: an assessment of the current evidence. 92 pages.

Table 2 *Distribution of cages by province and lake*

Province	Lake	2014 # cages	2014 Volume (m^3)	This survey # cages	This survey Volume (m^3)
Eastern	Muhazi	20	240	64	4,382
Western	Kivu	150	1,200	188	2,220
Northern	Burera	195	1,660		
	Ruhondo	130	1,040		
Southern	NA	-	-		
Kigali City	NA	-	-		
Rwanda		495	4,140	252	6,602

Sources: Rothuis et al. (2014); This survey: Aquaculture desk office at Rwanda Agriculture Board (RAB). NA: not available.

A schematic representation (with precision at the sector level) of the location of small-scale commercial fish farms is found in Figure 2. For the completion of the sector picture, medium-scale commercial cage farms have also been added.

- Small-scale commercial pond farms (segment/category I)
- Low volume small-scale commercial cage farms (segment/category II)
- High volume small-scale commercial cage farms (segment/category III)

Figure 2 *Schematic representation of the geographic location of small-scale commercial fish farms in Rwanda*

Lake Kivu
Lake Kivu (2,700 km^2) is one of the African Great Lakes in the Albertine Rift shared between the DRC (58%) and Rwanda (42%). Lake Kivu is approximately 90 km long and 50 km wide. The surface of the lake sits at a height of 1,460 metres above sea level. The lake is amongst the world's deepest lakes with a mean depth of 220 m and a maximum depth of 475 m. Lake Kivu water temperature ranges from 21.7 to 22.8°C.

Lake Muhazi
Lake Muhazi is situated at the East of Kigali and at an elevation between 1,227 m to 1,333 m above sea level. It is a shallow lake with an average depth of 5 to 8 m and an average water temperature ranging between 23.3 to 24.6°C.

Lakes Burera and Ruhondo
Lake Burera is situated on the southern slopes of Mount Muhabura in Northern Rwanda at 1,862 m above sea level. The lake is 12 km long and 8 km wide, has a maximum depth of 173 m and an open water surface of approximately 3,500 ha. Lake Ruhondo is 9 km long, 3 km wide and 65 m deep. The lake has an area of 2,800 ha. Because of the cold-water temperature in both lakes, only cold tolerant species like the Blue Tilapia (*Oreochromis aureus*) which can tolerate temperature as low as 9^{o}C can be farmed in these lakes while Nile tilapia will have a slow growth.

3.2.5 Supporting systems

Five types of supporting systems are discussed here, namely education, research, extension, consultancy services and financial services.

Education
There is in Rwanda no institution offering complete professional training in the domain of aquaculture. The University of Rwanda (UR) offers courses at the Master and PhD levels. The College of Animal Sciences and Veterinary Medicine (CAVM) of the University of Rwanda offers some aspects of aquaculture and fisheries as course modules. The university produces high academic graduates with theoretical knowledge of aquaculture but who are said to lack practical skills that are needed by small-scale commercial farmers.

The shortage of well-trained staff in aquaculture is remarkable at the farm level where farm managers and technicians lack basic knowledge of fish biology and best management practices (BMP) of fish farming. They are not skilled for fish breeding, fish handling, fish nutrition and water quality management. Most operators do not undertake the innovative and adequate management practices such as optimum stocking, stock manipulations, sexing and grading, disease control and prevention, records keeping of inputs and outputs due to lack of knowledge, know-how skills and sometimes good will. Some small-scale commercial fish farms recruit farm technicians abroad in Kenya and Uganda. This lack of support affects mostly fish farmers in segments II and III.

Research
The University of Rwanda also has a fish culture research station in Rwasave devoted to research, practical training and production. The laboratory is not operational and research infrastructure is weak. Research activities are dependent on external funding from foreign donors. Aquaculture research activities are currently supported by the Belgian Development Cooperation through the programme of the Académie de Recherche et d'Enseignement Supérieur (ARES) in collaboration with the University of Namur and the PhD programme with the Swedish University of Agricultural Sciences. A new recirculation aquaculture system funded by the ARES programme was installed and will be used for the hatchery of African catfish (Photo 2). Absence of research institutional capacity underlies the paucity of information on the water quality environment, aquaculture technologies such as induced spawning, feeding, genetics and selective breeding, production systems design, post-harvest processing, value addition, product development, data collection, socio-economics and others. Despite limited human and financial resources, research is focused on searching for practical solutions to the problems of fish farmers regarding feeds, fingerlings, pond fertilisation. Part of the station has been leased for the production of fish for the market.

Photo 2 *Recirculating Aquaculture System for breeding of Catfish, Huye, Southern Province*

Extension services

Presently, the Rwanda Agriculture Board (RAB) is mandated to undertake aquaculture and fisheries research and training in Rwanda. The fish farming extension service of the RAB is under-staffed to provide advisory services at the district level across the country. Local authorities at the district level and co-operatives are playing an important role as aquaculture is considered a decentralized activity. Nevertheless, local authorities say they are overloaded by the work to the extent of neglecting fish farming and to privilege husbandry of terrestrial animals, especially cows, for which they are evaluated on their annual performance contracts. In most cases, agents in charge of agriculture at the local administration are trained as veterinarians (of terrestrial animals) or generalists in animal production. This lack of extension support affects significantly fish farmers in segment I.

The Kigembe fish station was established with the aim of providing fish fingerlings and extension services to fish farmers. Despite the rehabilitation of the station, which has all the necessary infrastructure, it is unable to provide the services assigned to it. During our visit in Kigembe, the station and hatchery were not operating after more than 5 months without fish feed. Hapas in ponds and hatching trails in the hatchery were empty. Brood stock introduced from Lake Albert in Uganda was more than 5 years old and is known to be not pure from the introduction period. The RAS system for the production of catfish fingerlings has not been operated since its installation. The Kigembe station faces challenges of sustainability due to inadequate and sometimes irregular support from government and lack of a clear capacity building strategy (Rutaisire, 2015[10]). With the support of FAO, a training program was organised in 2015 on fish hatchery and nursery techniques for 74 participants, fish farmers and Government technicians from RAB[11]. The Indian Ocean Commission's Smart Fish Programme provided an assortment of laboratory equipment and training to trainees identified by RAB on the use and handling of laboratory and field equipment, laboratory design and setup, water quality analysis, fish health management (Rutaisire, 2015).

Consultancy services

There are few registered private consultants and consultancy companies in fish farming, but they are unable to meet the demand for consultancy services from an increasing number of people interested in fish farming. This has resulted in improvised non-certified consultants sometimes giving wrong advice to fish farmers. Only a few farmers in segment III can afford to pay the fees of consultancy while those in segments I and II depend on projects to benefit from consultancy services.

[10] Rutaisire (2015). DEVELOPMENT OF A BUSINESS PLAN FOR KIGEMBE FISH LABORATORY – RWANDA AND TRAINING OF STAFF IN BASIC LABORATORY PROCEDURES AND PRACTICES. 35 pages.

[11] Badiane Aziz Abdoul (2015). Hatchery Training at Kigembe station. 36 pages.

Financial services

We have visited and interviewed three financial institutions that have already offered or are interested to offer bank credit in fish farming. These are the Development Bank of Rwanda (BRD), Urwego Bank and Inkomoko Microfinance.

At the **Development Bank of Rwanda**, only a few small-scale commercial farmers have obtained a credit for a fish farming project. Their project is analysed by experts of the bank and external experts. Each project is analysed for its risk. To support the client without conflicting bank interests, the BRD recommend the client services outside the Bank to develop a business plan following the BRD template. The Bank approves the financing of the project based on the recommendation of the Ministry of Agriculture and Animal Production. Credits cover the production of fish: farming, processing and value addition but not trading of fish and fishery products which is seen as non-agriculture business (commercial bank and interest rate is at 19%). The interest rates of loans for fish farming projects fluctuate between 13% and 16% based on the risk of the project.

The permit and concessions are not accepted as a guarantee since they do not belong to the loan seeker. Bank guarantee to get the loan are: the project itself (50%) and a house/building (50%) located in Rwanda. The value of the house is calculated by an expert and the value taken to calculate the guarantee is 70% of the house value in Kigali city and 50% for a house outside Kigali city. Guarantees for agriculture projects are also available at BDF (www.bdf.rw), a financial instrument owned by the BRD established in 2011 to promote SMEs with the objective of assisting them to access finance, particularly those without sufficient collateral to obtain credit from traditional financial institutions at reasonable rates. BDF's role was to promote alternative financing avenues at reasonable costs to help small businesses access credit by providing credit guarantees. The Government also consolidated the different funds provided for SME financial support that had been spread across various ministries and agencies under BDF. These included the SME Guarantee Fund, the Agricultural Guarantee Fund, the Rural Investment Facility, the Women's Guarantee Fund and the Retrenched Civil Servants Guarantee Fund. BDF has since harmonized the management of these funds and delivered through comprehensive agreements with the financing institutions. Rural Investment Facility guarantees up to 25% of investment; Agriculture Guarantee Fund guarantees up to 50% of investment (COFREPECHE, 2013).

At BRD, the minimum amount of the credit for agriculture projects is 50 Million RWF ($58,854.94) and there is no maximum limit. The total amount of the project is topped with the risk value to form the total amount of the loan. The amount to pay at the start of the repayment of the loan is 1% of the loan +VAT/year

URWEGO Bank (formally known as the Urwego Opportunity Microfinance Bank) has the objective to grow business and to create jobs. The Bank does not exclude any business but did not have clients yet in fish farming, but they did have clients in fishing. The Bank provides cooperative loans instead of individual loans and conditions to obtain group loans are simple. As the name states, the Bank targets small clients with potential to grow. A group of minimum 15 persons with permanent address known from local authorities is eligible for a loan. When the loan is granted, the new clients are trained free of charge in finance management, saving and investment. The clients are required to take a life insurance policy equal to 0.8%/year of the loan. The smallest loans range between 50,000 RWF ($60) and 250,000 RWF ($300) and is raised based on the performance and the payback. The interest rate is 2.5% per month. Individual loans are also available for matured investors with fixed assets such as a house. The bank analyses the cash flow, the work place, the payment of taxes (amount paid and regularity) of the individual client. The bank does not request a business plan since most of the group clients have their business in mind but not on paper. For individual starters, it is difficult to obtain a credit as they first need to build up a capital.

Banks and many other actors do not know the subsector of fish farming and his stakeholders. The fish farming sector can learn from the mining sector which was also at the start not well known from Banks but with intense workshops, testimonies and discussions has been able to prove the potential of the sector and its value chain to the banks. Urwego Bank is looking to carry out study visits in fish farms to understand better the fish farming business and to physically see the activities. Stakeholders

should pro-actively contact the banks and learn more on their activities. Starting with pilot projects financed by the bank was one of the suggestions made by Urwego Bank to better understand the aquaculture sector business and the fish farmers as potential clients.

INKOMOKO Microfinance is a Rwandan affiliate of the African Entrepreneur Collective which is a USA based organisation. The objective of this organization is to provide training and technical assistance to entrepreneurs to grow business and to create jobs. The Microfinance has a business development program that selects entrepreneurs and provides them with an 8-month training in finance, market research, marketing and pricing and financial records after which they receive a training certificate. Candidates who are selected pay once a training fee of 1,000 USD per year of training which can be paid in different instalment of 100-150 USD per month. Some groups of clients like refugees receive training for free as this is supported by Master Card Foundation. Selected entrepreneurs sign a contract to become a client of Inkomoko Microfinance, their cash flow is screened (for example monthly sales). The maximum loan amount is 50,000 USD and there is no minimum. The interest rate is 10%/year. The repayment rate of the loans is high at 98%. Inkomoko has also a branch in Tanzania and is planning to open offices in 3 other countries in 2019 in Africa to support SME development. Inkomoko Microfinance does not know the fish farming sub-sector and related businesses well. So far four fish farming entrepreneurs have signed collaboration agreements with Inkomoko to benefit from its financing scheme[12].

3.2.6 Marketing and distribution of fish

Tilapia is the first choice of fish across local and regional markets and 500 to 800 grams is the preferred tilapia size for consumers in Rwanda (Msingi[13]). Currently, market of fish is driven by high prices which can be as high as 3,500 RWF ($4.12) per kg of Tilapia in Rwanda. Wealthy consumers in the neighbouring DRC have a high appetite for fish and a high purchasing power with transactions made in USD. Demand for fish is likely to remain high due to increasing human population, a growing middle-class population and awareness of fish-eating health benefits. Fresh fish is sold faster than frozen fish and big fish is sold faster than small fish (Photos 3 and 4).

Photo 3 *Live Farmed Tilapia on the market, Kimironko, Kigali*

Photo 4 *Frozen Tilapia on the market, Kimironko, Kigali*

[12] AgriProFocus (2015). Annual Report 2015.

[13] Msingi (201x). East Africa Aquaculture Industry Development. Phase 3: Strategic Vision and Value Chain Analysis Part 3: Value Chain Analysis. 33 pages.

Farmed fish

Segment I:
Pond farmed Tilapia from segment I of small-scale commercial farmers are in many cases sold at farm gate to neighbours and consumer households and part is consumed by family or cooperative members. Fish farmers tend to sell a higher percentage of fish than they consume. Thus, the primary goal of fish farming is to earn money from fish sold than meeting nutritional needs of the household. Some days prior to the drainage, fish farmers inform neighbours about the sale of their harvest on the pond site. In a few cases middlemen buy from fish farmers to supply local and urban markets. The farm gate prices of small-scale farmers vary between 1,500 RWF ($1.77) and 2,000 RWF ($2.35) per kg of fish.

Segment II & III:
At least three tilapia cage farmers in segments II and III close to Kigali have outlet kiosks in the city of Kigali with fresh fish sold alive in tanks with pump-aerated water or on ice. They sell their fish for around 3,000 RWF/kg ($3.53/kg). Due to the lack of sexed fingerlings, cage operators who stock mixed sex fingerlings practise a partial selective harvesting to remove marketable size tilapia. Small size fish are either kept in the cage for one or more months until they reach the desired market size, or they are sold on a parallel informal market of small sized fish.

Lakeside (segment II) has a fish outlet in the Embassies area of Kacyiru. The whole tilapia prices of Lakeside[14] depend on the volumes purchased: 3,500 RWF/kg ($4.12/kg) below 10 kg, 3,400 RWF/kg ($4.00/kg) between 10-24 kg, 3,200 RWF/kg ($3.77/kg) between 25-50 kg and negotiable above 50 kg. Fresh Fish (segment III) is soon opening an outlet in down town Kigali with a starting supply of 500 kg of live fish per week.

Fine Fish Ltd supplies his outlet at Kimironko market from his cages in Lake Muhazi with 300 to 500 kg per day of live fish. Live tilapia is sold at 3,000 RWF/kg ($3.53/kg) and can be cleaned on the spot ready for preparation free of charge. Tilapia cage farmers from Lake Kivu have plans to supply fish retailers in the city of Kigali.

Imported fish
Rwanda imports around 15,000 tonnes of fish per year (Rutaganira, 2017[15]). Imported frozen tilapia are not a threat at this moment to the aquaculture industry in Rwanda since the gap between fish supply and demand is still high and the market is more interested in fresh, even live fish. While wealthy consumers prefer fresh to frozen fish and can afford it, frozen fish is bought by those who do not have access to fresh fish because of the high price. Small-scale fish farmers in segments I and II could be in the future the first to be affected by increasing imports of small frozen tilapia from China because of its competitive prices and similar sizes.

[14] Lakeside website: https://www.lakesidefishfarm.com/fresh-fish.html Accessed on 27-03-2018.
[15] Rutaganira Wilson (2017). Interview Why government should invest more in fish farming? http://www.newtimes.co.rw/section/read/217607 Accessed on 04-04-2018.

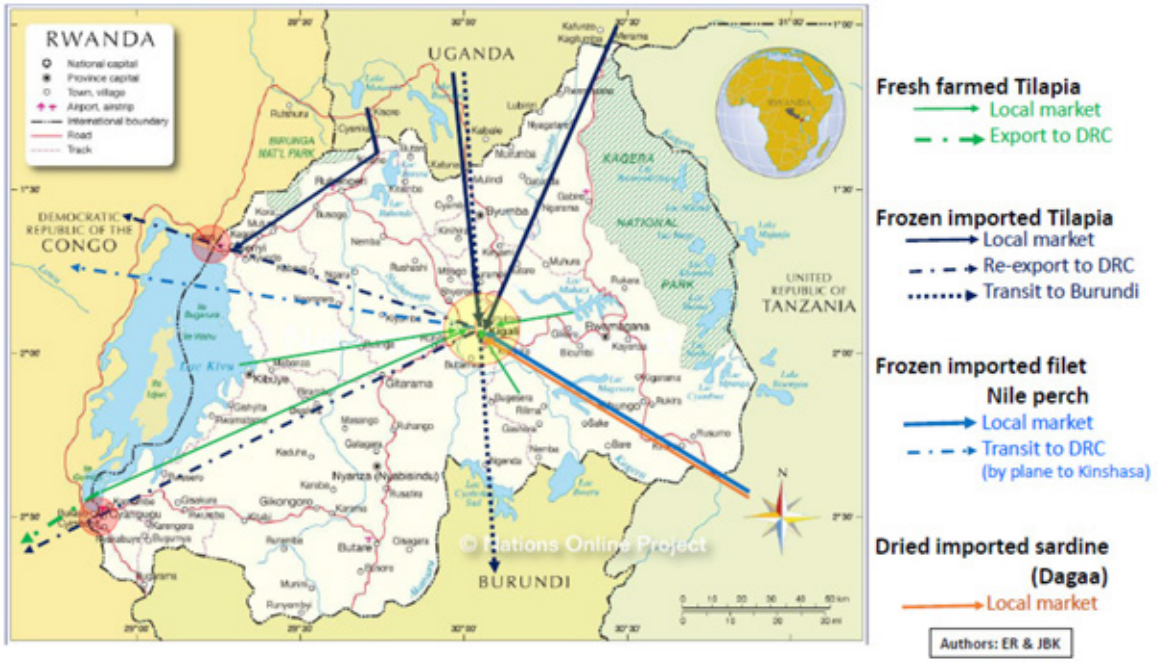

Figure 3 *Movement of fish in- and out- Rwanda*

Until recently tilapia was imported from Uganda, but informant traders said that not much tilapia is arriving from Uganda (Figure 3). This was confirmed by our visit to the fish markets where we could not find any tilapia from Uganda. A high demand for fish in Eastern DRC has diverted part of tilapia imported from Uganda. According to traders, no tilapia can be exported from Tanzania neither. The government of Tanzania has banned the exports of tilapia from the capture fishery as a food security measure. Imported fish were mainly frozen fillet of Nile perch and dried sardines from Uganda and Tanzania. Frozen tilapia on the market were imported from China and India. Fish is transported in refrigerated trucks or simply in trucks with boxes filled with ice, as well as by bicycles, motorcycles, or cars (Promar Consulting, 2012[16]). Fish is brought through the borders to Kigali city and then redistributed in secondary cities. There are several small cold storage facilities in Kigali and Gisenyi (on the lake shores). These cold storage facilities help traders distribute fish to urban areas. Part of frozen fish is re-exported to DRC and cross the borders to Goma and Bukavu in baskets and continued to distant cities inside DRC. Nile perch fillets were transported from Rwanda by air to Kinshasa.

In Kigali, imported fish are sold in bulk to supermarkets, traders and in retail to consumers coming to business sites located near Agrotech in front of the Nyarugenge market. The Kimironko market sells fish per kilo and is visited mainly by middle and high-income clients. Frozen tilapia from India were sold 3,500 RWF/kg ($4.12/kg) irrespective of the size (range: 500-1600 gr) at the Kimironko market during the market visit. Caution: We could not verify the origin of the big frozen tilapia, the so-called tilapia from India, since they were new on the frozen tilapia market which mainly consists of Chinese small tilapia between 350-500 g.

Other fish present on the Kimironko market were smoked Nile perch, smoked African catfish and dried Dagaa from Tanzania. The Nyabugogo fish market sells fish per piece and its clients are people with low income. Trials to sell small size Tilapia on this market have been sporadic and unsuccessful. Alpha Choice Rwanda Ltd is a fish wholesaler company owned by Pankaje Kapse and operating in Gikondo sector of Kicukiro district. The company imports and sells about 40 tonnes of fish per month. The fish product sold most by the company is Nile perch imported from Kenya.

Retail supermarkets selling tilapia, mainly from imports and segments II and III, in Kigali city include Simba supermaket, La Galette, Nakumatt, Alimentation Ndoli, Kigali Treat Ltd. Hotels serving Tilapia

[16] Promar Consulting (2012). Fact-finding Survey for the Support of Aid to Developing Countries (Fiscal Year 2011 Research Project) Supported by the Ministry of Agriculture, Forestry and Fisheries. 181 pages.

products on their menu include Hotel des Milles Collines, Serena Hotel, Hotel Lemigo, Hotel Chez Lando and many others. Bar and restaurants sell fish at prices as high as high as 12,000 RWF ($14.13) per piece (Tilapia of 1.0-1.5 kg).

The buying price for Tilapia traders in Kigali city depends on the size of the fish and whether the fish is fresh or frozen (Table 3). This price for fresh Tilapia corresponds more or less to the selling price of small-scale commercial fish farmers but can vary depending on the volumes bought and the location of the transaction, being cheaper when fish is bought far from the urban area. Farm gate prices of small-scale farmers to retailers and individual consumers vary between 1,500 RWF ($1.77) and 2,000 RWF ($2.35) per kg of fish in rural areas and between 2,500 ($2.94) and 3,000 RWF ($3.53)/kg near the cities. By selling, Tilapia traders make a profit between 200 RWF ($0.24) and 300 RWF ($0.35) per kg over the buying price.

Table 3 *Buying price for Tilapia traders in Kigali city*

Tilapia product	Size range	Buying price (RWF/USD) per kg
Fresh Tilapia (locally produced)	800gr +	2500-2800 ->3000 ($2.94-$3.30 ->$3.53)
Frozen Tilapia (imported)	800gr +	2400 ($2.83)
Frozen Tilapia (imported)	500-800 gr	1700 ($2.00)
Frozen Tilapia (imported)	300-500 gr	1600 ($1.88)

Fish processing in the farmed fish value chain is limited to heading, gutting and filleting. A kilo of tilapia is processed for 500 RWF ($0.59) at household level or for free in outlets selling live fish like at the Kimironko market.

3.2.7 Sector coordination

The aquaculture sector is governed by the Ministry of Agriculture and Animal Resources (MINAGRI). The implementation of policies is administered by the Rwanda Agriculture Board (RAB), one of the agencies of the Ministry of Agriculture and Animal Resources. Under RAB, the Fisheries and aquaculture section is headed by a desk officer since July 2011. RAB is mandated to coordinate the whole aquaculture sector including subsistence, small- and medium-scale aquaculture through its extension officers appointed in different provinces of the country.

At the local government level, the fisheries and aquaculture sectors are managed by administrative and technical staff whose training is not directly related to fisheries discipline. District Veterinary or Agricultural Officer is in charge of livestock activities, including extension work and implementation of the fishery and aquaculture policy. This institutional weakness affects the small-holders in segment I more than in other segments since the first depends on their services and information.

Depending on the site location and size of the farms, applications for new farms are addressed to the mayor of the District (small scale farms) or to the Ministry of Natural Resources (large scale farms). Application documents are submitted either to the Reception Desk or the Public Relations office of the Rwanda Development Board (RDB) or the Rwanda Environmental Management Agency (REMA). The Rwanda Development Board (RDB) is a governmental agency in charge of promoting investments. The agency issues environmental certificates.

There is currently no umbrella organisation of small-scale commercial fish farmers in Rwanda, but discussions have been initiated to put in place an association that groups actors in the fish value chain for advocacy and lobbying. After a focus group discussion with small-scale fish farmers, one farmer was asked to lead the process with the support of the national consultant. The absence of such an organisation seems to affect small-scale producers in segment I more than others since they have no bargaining power over prices for inputs and output products and have limited access to information and knowledge.

3.2.8 Regulations and standards

Rwanda has a Fisheries and Fish Farming Master Plan (2011 – 2020[17]) and an Aquaculture and Fisheries Policy. At the regional level, the East African Community (EAC) has elaborated the East African Community Fisheries and Aquaculture Policy (LVFO, 2015[18]). The implementation of policies is administered by the Rwanda Agriculture Board (RAB), an agency of the Ministry of Agriculture and Animal Resources (MINAGRI).

The Organic law n° 58/2008 determining the organization and management of aquaculture and fishing in Rwanda was enacted on 10/09/2008 to repeal the decree law of 21 April 1937 relating to Game and Fishing. The ministerial order n° 007111.30 of 18/11/2010 determines the terms and conditions for granting fishing licenses which may be for sport, professional or for research.

The ministerial order n° 011/11.30 of 18/11/2010 regulates the importation, marketing and distribution modalities of aquaculture and fisheries products, equipment and materials.

The ministerial order n° 006/11.30 of 18/11/2010 determines the form and content of the aquaculture and fishing concession contract and finally the ministerial order n°010/11.30 of 18/11/2010 determines aquaculture and fishing zones.

Fishing licences and concessions in Rwanda are regulated by law no 58/2008 of 10/09/2008 which determine the organization and management of aquaculture and fishing in Rwanda and the ministerial order which determines the form and content of aquaculture and fishing concessions. The establishment of a fish farm is subject to an Environmental Impact Assessment (EIA) that is submitted to the Rwanda Development Board (RDB). The cost of the application for an aquaculture concession costs 35,000 RWF ($41.20). The application letter should be accompanied by the project proposal and the proposal for the EIA. The procedure is fast, and the district inspection is conducted within 7 days of the application and generates an EIA report which is endorsed by the Mayor of the District.

From field interviews, it was found that the cost for a detailed EIA constitutes a financial burden for small-scale commercial farmers as the cost can vary from 1 to 2 million RWF ($1,200-2,300).

The Rwanda Standards Board oversees testing, traceability and certification of products. The Board supervises fish and fisheries products for local consumption and export. The Rwanda Hazard Analysis and Critical Control Points (HACCP) standard was developed and approved in 2013. It is used to certify food safety.

3.2.9 Environmental, Social and Governance (ESG) effects of small-scale commercial fish farming (by production model)

During the surveys, it has not been easy to assess the role of the youth and gender in the aquaculture value chain business. Women participate in fish farming and are highly engaged as independent fish farmers in cooperatives, wage farmers and unpaid family labor. However, they face many challenges including lack of access to credit from financial institutions and less technical skills. Tradition pushes women into a disadvantaged situation in terms of access to land, credit, decision-making and ownership in male controlled production systems. Men perform tasks requiring tools that are owned by men and which are perceived to be physically difficult such as digging the pond and harvesting. Women are exclusively responsible for collecting household waste for feeding the fish and participate extensively in collecting compost materials to fertilise the ponds (Aghebi et al., 2016[19]). Many more women are involved in the trading of all kinds of fish on the market.

[17] MINAGRI. (2011a). Master Plan for Fisheries and Fish Farming in Rwanda. 89 pages.

[18] LVFO. 2015. The East African Community Fisheries and Aquaculture Policy, Lake Victoria Fisheries Organization, Jinja, Uganda, 42 pp.

[19] Agbebi F., Kibogo A., Ngirinshuti L. and Mindje M. (2016). Contribution of women to aquaculture development in Rwanda. IIFET 2016 Scotland conference proceedings. 10 pages.

Among small-scale commercial fish farms interviewed, the relative number of women and young members is lower in fish farming cooperatives than men and elders. The role of women and youth is slowly improving as reflected from the feedback of participants in the farmer's focus group discussions. They participate in farming activities and have equal leading responsibilities as men and elders in cooperatives. A young entrepreneur woman owns and manages Fresh Fish Ltd, a cage farm in Lake Muhazi that is planning to start supplying in April 2018 the Kigali city market with 500 kg of live fish on a weekly basis.

ESG effects of small-scale commercial fish farming are summarised in tables 4 and 5.

Table 4 *Effects of environmental, social and governance factors/issues on small-scale commercial fish farming*

Segment	Environmental	Social	Governance
I	• Land scarcity • Extreme weather • Inundation, flooding (rain season) • Droughts (dry season) • Cold water temperature • Higher prices of feed	• Competition for water and land • Theft • Conflicts with other users • Ownership of land not possible in marshlands	• () • Lack of trained extension workers and budgets • Sector administered by non-professionals at the district level • Ownership of land in marshlands • Various institutions and steps in EIA permits, smooth process
II	• Bad weather and natural calamities • Heavy rains, strong winds • Low dissolved oxygen • Cold water temperature • Higher prices of feed	• Conflict with other users of the water body • Lack of well-trained staff	• Lack of trained extension workers and budgets • Sector administered by non-professionals at the district level • Lack of market information • Various institutions and steps in EIA permits, complex process
III	• Bad weather and natural calamities • Heavy rains, strong winds • Low dissolved oxygen • Cold water temperature • Higher prices of feed	• Conflict with other users of the water body • Lack of well-trained staff	• Lack of trained extension workers and budget • Lack of market information • Various institutions and steps in EIA permits, complex process • Lack of transparency in water parcel attribution

Table 5 *Effects of small-scale commercial farming on environmental, social and governance factors/issues*

Segment	Environmental	Social	Governance
I	• Nutrient release & algae blooms • Biological pollution due to fish escapees	• Pond farmers compete with other users for the same land / water • Abandonment of fish ponds	• Increasing demand for relocation after natural disasters
II	• Nutrient release & algae blooms • Biological pollution due to fish escapees	• Cage farmers compete for space with other users of water bodies	• Increasing demand for permits and need for compliance control causes higher pressure on governmental authorities • Policy to regulate cage farming and introduction of alien strains
III	• Nutrient release & algae blooms • Biological pollution due to fish escapees	• Cage farmers compete for space with other users of water bodies	• Increasing demand for permits and need for compliance control causes higher pressure on governmental authorities • Policy to regulate cage farming and introduction of alien strains • Increased demand for best parcel and water body • Risk of hidden corruption

The terminology of "hidden corruption" is used here to indicate the existing risk of bribery with individual officers in charge of delivering services. The country has engaged in good governance and fighting institutionalised corruption found in many other sub-Saharan African countries. On corruption perception index, the country is performing very well in the region and worldwide.

Proper spatial planning will stimulate and guide the growth of the sector by providing incentives and safeguards, attracting investment and boosting development. With intensification of fish farming activities in open water systems, the planning of its development will become increasingly important to prevent environmental threats due to pollution and fish diseases.

Besides the preservation of the farming environment from any kind of pollution whether biological or chemical and from habitat degradation, successful implementation of aquaculture policies depends also on overcoming challenges related to weak human capacity, institutions and monitoring systems and to inadequate financial resources.

The high prices of farmed fish are criticised by low income consumers which consider current fish farming as targeting only a minority of the population, the rich consumer segment. High fish prices of farmed fish can slow down the growth of the sector in the future unless productions costs, mainly the feed costs, are reduced. Governance of tilapia imports is also expected to affect the development of the sector in the future.

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

Key trends for fish farming development in Rwanda can be grouped into 4 categories:

- **Increasing investment in the small-scale commercial fish value chain.** As highlighted above, there are investors coming into the fish value chain whether into fish farming or production and supply of inputs to small-holder commercial fish farmers.

- **Increasing capacity for fish feed production.** Three established feed manufactures in the country have recently added a fish feed production line and sell fish feeds to farmers, mainly in segment I and II: PIFA in Rwamagana (Photo 5), Aquahort Export located in Gasabo and Huye animal feeds in Huye. Gorilla animal feeds located in Kicukiro District imports and distributes fish feed.

Photo 5 *Feed Manufacturing, Rwamagana, Eastern Province*

- **Increasing productivity and production from small-scale commercial fish farming.** Fish production is increasing due to the increment in production units, being the number of cages/ponds, or the size of production units (size of cages/ponds). The production increases also due to unit productivity. In segment I of small-scale commercial fish farmers, pond productivity has increased on average 3-fold between 2014 and 2017. The productivity of ponds was 3.26 tonnes per ha per year on average in 2017. The average productivity of small-scale commercial cage farms increased from 26 kg/m^3/year in 2015 to 30 kg/m^3/year in segment II and 27 kg/m^3/year in segment III in 2017, respectively.

- **Increasing capacity for fish seed production**. After the governmental hatchery in Kigembe (production capacity: 5 Million fingerlings annually) has failed to produce sufficient quantities of fingerlings of good quality, private hatcheries have engaged in production of fingerlings and diversification of tilapia strains for their own use and for selling to other fish farmers. Over 1.4 Million fingerlings were produced in private hatcheries in 2017. Only 2 Million fingerlings were produced in Kigembe hatchery the same year.

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

3.3.1 Main small-scale commercial fish farming segments/groupings

Small-scale commercial fish farming in Rwanda is concentrated in the production of tilapia in ponds (segment I) across the country and in cages in Lake Kivu and Muhazi. Small-scale commercial fish farmers in segment II farm tilapia at high density (187 to 250 fish/m^3) in low volume cages (8-40 m^3). Farmers in segment III farm tilapia at low density (50-100 fish/m^3) in high volume cages (40-500 m^3).

Table 6 *Characterisation of small-scale fish farming in Rwanda*

Small holder segment	Production (tonnes/ year)	Production systems	Production Surface or Volume	Construction ponds/cages	Ownership	Investment	Production intensity	Production cycle (500 gr +)
I	1.5-17.0	Aggregated ponds on the same site	Minimum 100 ares in total on the same site	Self-made ponds	Mainly cooperatives or individuals	Low: 10.000 - 25.000 USD	Semi-intensive	8-12 months
II	17-30	Low volume high density (LVHD) cages	8-40 m^3 per cage and 200-500 m^3 per farm	Square cages, self-made metal/wood frame, empty/closed barrels	Mainly individually owned companies and few cooperatives	Low to medium: 25.000-50.000 USD	Semi-intensive	6-8 months
III	30-50	High volume low density (HVLD) cages	40-500 m^3 per cage and 1000-2000 m^3 per farm	Rectangular cages with self-made inox metal frame cages, circular cages with HDPE frames, outboard engine boat	Big local investors	Medium to high: 200.000-500.000 USD	Intensive	6 months

3.3.2 Technological assessment

Two production systems coexist within small-scale fish farming: Fish farming in ponds and cage culture.

Segment I

The production system of segment I farmers consist of earthen ponds. More than 90% of ponds are constructed in the lowlands and fed by water derived from a river or water canal. Feeder canals are made of earth. The outlet device is made of an assemblage of PVC pipes and elbows. The minimum pond size recommended by MINAGRI is 400 m^2. For this survey on small-scale commercial fish farms we have considered groups of ponds with more than 10,000 m^2 on one site. These are called aquaculture parks and are registered at the aquaculture desk office at Rwanda Agriculture Board (RAB) with reliable production data. There are also small-scale ponds scattered throughout the country which are run commercially but for which production data are not easily accessible. Usually these farmers do not have access to a hatchery for the supply of fingerlings; they run at least 3 ponds for breeding, nursery and grow out. Fingerlings of the Nile tilapia are harvested prior to pond drainage and juveniles of less than 10 g are kept alive, stored and re-stocked for a following production cycle.

Farmers stock 2 to 3 fingerlings of 10 to 30 gr per square meter. During the group discussion with farmers, some of them stock up to 4-6 fingerlings per square meter. The pond monitoring is irregular and consists mainly of water level check in the pond. There is no water quality monitoring except in

cases of fish mortality where farmers report to extension officers who can then control the water quality. Kits for water quality control are not common and therefore not known by farmers.

The monoculture of the Nile tilapia is the dominant practice. The majority of small-scale commercial farmers raise mixed sex Tilapia. Few small-scale commercial farmers have introduced polyculture of tilapia and African catfish as a secondary species, to efficiently use natural food and supplemental feeds in ponds and mainly to control the overpopulation of tilapia breeding in ponds. There are also a few farmers who integrate fish farming and animal husbandry (pig, rabbits, ducks or chickens) as a source of continuous organic pond fertilisation (Photo 6). However, although both polyculture with Clarias and fish-animal integration result in better yields than monoculture, they are not a common practice.

Photo 6 *Ponds integrated with animal husbandry, Huye, Southern Province*

Fish farmers fertilize their fish ponds using organic matter. Compost cribs cover less than 5% of the pond surface and are installed in a corner of the pond. Although there is high competition for organic fertilizers between agriculture crops and fish farming, fish farmers are aware of the impact of organic fertilizer for the fish growth and pond production. Farmers use agriculture by-products as rice, wheat and maize brans. Some of them supplement with farm-made feeds and occasionally with locally manufactured feed and fish feed imported from Uganda (Ugachick feed). Feed Conversion Ratio (FCR) obtained in fish ponds fertilised with animal manure and fed farm-made feed is 2.3.

The grow-out period goes between 8 to 12 months depending on the level of management. At harvest fish have an average weight of 500 grams with a minimum weight of 300 grams and a maximum weight of 800 grams. 68% of the fish harvested are 500 grams and above.

Ponds, sometimes covered with plastic liners, are also used by hatcheries for broodstock and rearing of fry in hapas.

Segment II

Segment II consists of small-holders producing tilapia in Low Volume High Density (LVHD) cages (Photo 7). These are small cages with a water volume ranging between 8 and 40 m^3. Based on the pilot phase by the PAIGELAC project, all cage sites are in shallow areas with depths of less than

7 meters. Cage frames are produced in the country and are made of polystyrene floats and wooden/iron steel walkways.

Photo 7 *Low Volume High Density cages, Lake Muhazi*

Since the initial period of cage culture setting in Rwanda, the majority of tilapia cage operators have used the low volume cages and high stocking densities as recommended by PAIGELAC (187 to 250 fish/ m^3). The size of stocked tilapia fingerlings varies from 10 to 30 g average weight in most of the operators while a few cage farmers stocked bigger sized fingerlings of 50 to 100 g individual weight. Commonly farmed fish species is Nile Tilapia (*O. niloticus*). Recently improved strains of GIFT and Super Male (YY) tilapia have been introduced and are stocked in some cages. These farmers use locally manufactured feed and feed imported from Uganda (Ugachick feed). A few of them combine with farm-made feed. An FCR of 2.0 with locally manufactured feed and 3.0 with imported feed is achieved in cages of segment II.

The majority of farmers in segment II inspect their cage only when there is a problem or an incident such as fish not responding to feeding or mass mortality. Due to lack of divers, cage operators do not clean the cage nets or do it only at harvest. The practice of fish sampling is known but is not implemented to avoid fish stress and mortality. Only few operators sample their cages on a monthly basis.

The grow-out period in segment II is 6-8 months from stocking to harvesting of a market size fish above 500 gr.

Segment III

The last decade has seen innovations taken up in segment III of small-scale commercial cage fish farming in Rwanda. Small square cages of 2x2x2m introduced by the PAIGELAC project have been gradually replaced by bigger cages between 5x5x4m and 10x10x4m. Some keep investing in the growth of the farm and own already bigger circular cages with HDPE frames of 21 m diameter x 4 m deep and more depending on lake water depth in the lake (Photo 8). These operators have reduced stocking density to control mortality and to improve growth in cages. These so-called High-Volume Low Density (HVLD) cages are big cages with a high-water volume between 40 and 500 m^3 which are stocked at lower density varying between 50 to 100 fish per m^3. Commonly farmed fish species is Nile

Tilapia (*O. niloticus*). Improved strains of GIFT and Super Male (YY) Tilapia are increasingly being stocked in cages. These farmers use locally manufactured feed and imported feed from Israel and China. An FCR of 1.6 on average is achieved in cages of segment III with imported feed.

Photo 8 *High Volume Low Density circular cages, Lake Muhazi*

Operators in segment III inspect their cages monthly or every two weeks by hiring services of divers from KivuWatt, a project that extracts and uses methane from the waters of Lake Kivu to generate electricity. They monitor their fish stock by sampling once or twice during the grow out period to follow up changes in fish biomass.

Cage farmers in segments II and III follow the feeding chart provided by the fish feeds manufacturers in accordance with the age of their stock. Feeding is done two to three times a day by spreading the feed over the surface of the water in a stocked cage. Most of the farmers reported that they feed their fish based on fish response. They state that the recommended optimal feeding rate is not always respected due to unskilled labour employed to feed the fish, and due to the lack of fish stock monitoring to align the feeding ration to the biomass of fish in the cage.

The grow-out period in segment III is 6 months from stocking to harvesting of a market size fish above 500 gr.

From collected data, we could build afterwards the production costs and calculate the gross income of producers for the three segments as illustrated in tables below.

Segment I: pond farmers (mainly cooperatives)
The production cycle of Nile tilapia in ponds starts with the stocking of the fry in hapas. It takes at least 3 months to grow from hatching to 20 gr, depending on the quality of the feed and the water temperature. The cost of fingerlings (10-30 gr) is $0.04 per piece. After this nursery phase, fingerlings of 10-30 gr are stocked at 2-3 fingerlings per m^2 in big ponds for grow-out to 400-500 gr. A few farmers reported that they stocked up to 4-6 fingerlings per m^2. Small-scale commercial fish farmers in segment I raise mixed sex Tilapia. It takes 8 to 12 months to grow Nile tilapia from 20 gr to 500 gr market size. Small-scale commercial farmers in segment I have limited access to capital, therefore they mostly use organic pond fertilization and agricultural by-products or farm-made feed to improve fish yield. In this segment an average FCR of 2.0 to 2.5 is common. They can therefore realise 1-1.5 cycles per annum.

Ponds are earthen ponds of relatively small size (1,065 m^2 on the national average) made with family labour. The assumptions are summarised in Table 7. The economics of Tilapia ponds are summarised in Table 8.

Table 7 *Assumptions to calculate the economics of one production cycle per ponds of 10,000 m^2 in segment I*

Description	Numbers and units
Surface of the pond	10,000 m^2
Stocking density	2 fingerlings /m^2
Number of fingerlings	20,000
Average weight Tilapia at stocking time	20 gr
Average weight Tilapia at harvesting time	450 gr
Survival rate	80%
FCR	2.3
Amount of required organic fertilizer	2,500 kg/ha
Amount of required feed	22,000 kg home-made feed -Agriculture by-product (lump sum)
Total yield per ha (10,000 m^2)	7,200 kg

Table 8 *Calculations of economics of one production cycle per ponds of 10,000 m^2 in segment I*

Description	Amount (USD)
Total operational costs	13,150
• Cost of pond construction	120 (It costs 2400 USD to construct 1 ha pond which lasts for 20 years)
• Cost of organic fertilizers@ 0.012USD/kg	30
• Cost of seed@ 0.04 USD/piece	800
• Cost of feed@ 0.5 USD/kg	11,000
• Miscellaneous costs (10% of total operational costs)	1,200
Gross income (USD 2.1 per kg)	15,120
Gross profit	1,970

Price of fish $2.1 per kg

Segment II: LVHD cages

The stocking size varies from 10 gr to 30 gr with a stocking density of 187 to 250 fish/m^3. Small-scale commercial farmers in segment II use LVHD cages with volumes ranging from 8 m^3 to 40 m^3 with an average size of 25 m^3. These cages are locally fabricated and made from metal bar frames combined with PVC barrels. The production cycle of Nile tilapia is 6 to 8 months to reach a marketable fish size of 500-800 gr. They can achieve 1.5 – 2.0 cycles per year. 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 and achieve an FCR of 2.0.

The assumptions are summarised in Table 9. The economics per cage (Nile tilapia) are summarised in Table 10.

Table 9 *Assumptions in the calculation of the economics of one production cycle per cage of 25 m^3 in segment II*

Description	Numbers and units
Volume of the cage	25 m^3
Stocking density	200 fingerlings per m^3
Number of fingerlings	5,000
Average weight Tilapia at stocking time	20 gr
Average weight Tilapia at harvesting time	500 gr
Survival rate	80%
FCR	2.0
Amount of required feed	3,840 kg
Yield per m^3	80 kg
Total yield	2,000 kg

Table 10 *Calculations of economics of one production cycle per cage of 25 m^3 in segment II*

Description	Amount (USD)
Total operational costs	4,626
• Cost of cage	400 (a cage costs 2000 USD/25 m^3 and lasts 5 years)
• Cost of seed @ 0.07 USD/piece	350
• Cost of feed @ 0.90 USD/kg	3,456
• Miscellaneous costs (10% of total operational costs)	420
Gross income (USD 3.5 per kg)	7,000
Net profit per cage	2,374

Price of fish $3.5 per kg

Segment III: HVLD Cages

The stocking size of HVLD cages varies from 10 gr to 30 gr for grow-out. The stocking density for HVLD cages varies from 50 to 100 fish/m^3. The production systems in segment III can be characterised as intensive. The cages are either locally fabricated or made from metal bar frames combined with PVC barrels or imported from China (big circular cages). Small-scale commercial farmers in segment III have access to larger amounts of family capital and bank loans – although only a few farmers have access to bank loans. They can afford high quality imported feed and usually achieve an average FCR of 1.6. They are able to grow Nile tilapia from 20 grams to market size in 6 months. This category of small-scale commercial farmers achieves two production cycles in a year.

The assumptions are summarised in Table 11. The economics per cage are summarised in Table 12.

Table 11 *Assumptions in calculating the economics of one production cycle per cage of 100 m^3 in segment III*

Description	Numbers and units
Volume of the cage	100 m^3
Stocking density	75 fingerlings per m^3
Number of fingerlings	7500
Average weight per Nile tilapia at stocking	20 gr
Average weight per Nile tilapia at harvest	500 gr
Survival rate	80%
FCR	1.6
Amount of required feed	4,608
Yield per m^3	30 kg
Total yield	3,000 Kg

Table 12 *Calculations of the economics of one production cycle per cage of 100 m^3 in segment III*

Description	Amount (USD)
Total operational costs	7,429
• Cost of cage	700 (a cage costs 3500 USD/100 m^3 and lasts 5 years)
• Cost of seed @ 0.07 USD/piece	525
• Cost of (imported) feed @ 1.2 USD/kg	5,530
• Miscellaneous costs (10% of operational costs)	674
Gross income (USD 3.5 per kg)	10,500
Net profit	3,071

Price of fish $3.5 per kg

In general, in all segments, one permanent employee works at the farm every day and is assisted in segment I by one cooperative member on average during 4-6 h per day. Additional (seasonal, occasional) labor is hired during harvest and cleaning post-harvest. Labor cost is included in miscellaneous in the tables.

By crossing information provided by farmers to different questions, data of the most recent production cycle proved to be more accurate and consistent than those of previous production cycles. According to the local consultant, farmers deliberately report underestimated production values to foreign consultants in expectation of support and give overestimated values to extension agents to confirm their achievements. Under these circumstances, the reliability of orally reported data is doubtful.

The tables 13 and 14 below considers 3 categories of small-scale commercial fish farmers per segment.

In the three categories, some farmers own a hatchery received with the support from FAO, that produces few fingerlings of decent quality for their own use and resell to other farmers. The rest of fingerlings is obtained from the governmental hatchery in Kigembe. In category III, some farmers import fingerlings from abroad, namely from a hatchery in Bujumbura, Burundi. This last group is continuously investing in growth and will soon be moving to medium-scale category.

Table 13 *Access and availability of feed, seed, knowledge, capital and technology for small-holders*

Small holder segment	Access to quality feed	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	Availability of materials / technology
I	Limited access due to limited capital	Low quality	Farm-made feed dominant	Fair access to seed, rely on governmental hatchery	Bad quality, very expensive	Education/knowledge limited; Poor business skills; Training from RAB, MINAGRI, PAIGELAC, FAO	No access to loans (cannot meet requirements)	Limited cooperative capital	No access to technology due to limited capital	Materials and local technology available; no distribution of imported technology
II		Medium quality	Locally manufactured feed and imported from Uganda	Fair access to seed. Own hatchery	Good quality (GIFT or YY), expensive	Education/knowledge fair; Fair business skills; Training from RAB, MINAGRI, PAIGELAC, FAO	Limited access	Fair savings	Fair access to Technology	Materials and local technology available; no distribution of imported technology
III	Fair access due to family capital and other businesses	Imported from China, Israel.	Locally manufactured feed and imported	Own hatchery or Imported from good hatchery	Good quality (GIFT or YY), expensive mainly due to transport costs.	Education: Good	Limited access with the use of guarantee fund as collateral	Fair family capital	Good access to technology due to capital	Materials and local technology available; use of imported technology
						Knowledge: Good				
		High quality, too expensive				Skills: Good business skills				
						Training: access/availability limited				

Table 14 *Record keeping, selling, marketing and distribution, permits, environment and growth potential for small-holders*

Small holder segment	Record keeping / accounting	Selling	Marketing and distribution	Permit requirements	Environment	Growth potential
I	Not consistent	Farm gate.	Not organised	Site suitability assessment	Ponds: land scarcity, inundation and flooding. Water scarcity in dry season. Water quality reasonable to good.	Very limited
II	Fair	City outlets, retailers	Organised	EIA and business plan	Cages: good site availability, good water quality	Good
III	Fair	City outlets, Middlemen	Organised	EIA and business plan	Cages: good site availability, good water quality	Good

3.3.3 Differences and similarities between different small-scale segments/production models

- Different production segments require an infrastructure set-up with a significant amount of start-up capital although the start-up capital is higher for ponds (segment I) than for cages (segment II). In segment III, the use of high-volume cages increase significantly investment costs, as material is imported.
- Cages are more productive than ponds. Nearly 85 times more space is needed for pond farming to produce the same amount of fish of small-scale cage farms.
- Fish in cages depend exclusively on complete feeds. In ponds fish have permanent access to natural food which is enriched by manure fertilisation and supplemental fish feed for intensification purposes.
- Stocking rates are higher in cages than in ponds.
- In ponds fish have enough space while in cages fish are confined due to high densities used.
- The high densities used in cages facilitate easy spread of diseases and deterioration of water quality. The risk is higher in segment II than in segment III of small-scale commercial cages because of the low level of cage management in segment II.

3.3.4 Motivation of small-scale commercial fish farmers

From group discussions with small-scale fish farmers in segment I and II, profit, fish scarcity and market demand emerged as key motivations to engage in fish farming followed by fish as source of protein/healthy lifestyle and fish farming as self-employment. In one case, motivation to farm fish started as a hobby that turned into fish farming as business.

3.3.5 Skill levels and information access

- Segment I consists of small-holder farmers producing tilapia in ponds mainly in cooperatives. Their skills vary from one group to another from poor to limited.
- Segment II consists of small-holders producing tilapia in low volume cages. They have some degree of knowledge on farm management and entrepreneurship.
- Segment III consists of small-holders producing tilapia in high volume cages. They are well trained and have a higher education degree.

Cooperatives and active farmers in segments I and II have received training organised by MINAGRI, RAB, PAIGELAC, FAO and occasional training in the country and outside the country.

At all levels hands-on skills in fish farming are lacking and this constitutes a serious problem faced by all small-scale segments. Two small-scale commercial fish farms employ foreign technicians with better hands-on skills from Uganda and Kenya to manage the daily farming activities.

There is no professional organisation or platform of actors in the farmed fish value chain to channel information. In most cases and in all segments, information is transmitted word of mouth between neighbouring farmers, extension agents and during training. The fisheries desk officer in RAB is responsible for advisory services in aquaculture and fisheries in the whole country and for all sizes and types of fish farms. A few small-scale farmers in segments II and III use the services of consultants. Small-scale fish farmers in segment I cannot afford the costs of consultants and use their services only when there is a project that will support them financially to do so. Incorrect information is also communicated by opportunistic low- profile consultants.

In 2015, the Aquaculture Innovation Community (AIC) developed and disseminated a fish farmer working manual with assistance of RAB fisheries extension offices, supported by FAO (AgriProFocus, 2015[20]). The manual was developed in 2014 for use by fish farmers in ponds (segment I). So far 250 booklets have been handed over to extension officers.

[20] AgriProFocus Rwanda (2015). Annual report 2015. 37 pages.

3.3.6 Access to inputs

The Government of Rwanda has facilitated the import of aquaculture inputs free of taxes to support the aquaculture industry including small-scale producers.

3.3.6.1 Access to fish feed

Evidence from this study suggests that home-made feed is commonly used in all provinces, followed by imported feed in ponds of segment I and then locally manufactured feed in cages of segment II.

With the support of the FAO project, many small-scale fish farmers make their own fish feed on-farm which was not the case in the past. Cooperatives of Lake Kivu, Nyanza, Nasho and Musanze have received equipment from the PAIGELAC project to manufacture fish feed for their own use and also for sale to other farms. Three companies: FINE FISH Ltd (Eastern Province), BARAKA (Western province) and KUNGABU (Western province) have been supported by FAO with fish feed manufacturing equipment. They produce farm-made fish feed for their own use and supply surrounding fish farmers with limited quantities.

- The production cost of farm-made fish feed ranges between 425 RWF ($0.50) per kg in the South and 850 RWF ($1.00) per kg in the West.
- Locally manufactured feed costs 850 RWF ($1.00)/kg.
- Imported feed from the region delivered at the farm costs between 920 RWF ($1.08)/kg in the North and 1100 RWF ($1.29)/kg in the West.
- International imported feed has been used by one cooperative in the East and prices at the farm ranged from 2700 RWF ($3.18)/kg for starter feeds (40%CP), 1450 ($1.71) RWF/kg for grow-out feed (37% CP) and 1400 RWF ($1.65)/kg for finisher feed (35%CP).
- Locally made tilapia feed at the factory located in Rwamagana, Eastern Province, range between 900 RWF ($1.06)/kg (40% CP) to 600 RWF ($0.71)/kg (25% CP).
- The Huye Feed Factory has not yet put volumes of fish feed on the market as the factory encountered technical problems of the cooling system at the start of the production of fish feeds. The factory constructed with funds from South Korea under bilateral cooperation with Rwanda has produced since July 2017 less than 2 tonnes of fish feed of 2 sizes (2.5 mm and 3.5 mm) (compared to 100 tonnes of poultry feed). The factory has given this feed free of charge to farmers in Gikongoro and at the university research center of Rwasave for feeding trials. The production cost of fish feed at Huye Feed Factory is 633 RWF ($0.75)/kg.
- Imported floating feed from China sold locally has a negotiated delivery price of 0,75 USD/kg. This is far below the achievable feed price produced in East Africa at 0.85 USD/kg as estimated by Msingi ([21]).

Fish feed manufacturers explain the high cost for fish production as due to the cost of the raw material for feed production which is in big part imported. At PAFI, main ingredients are imported from neighbouring countries: Uganda (80% mais, 20% soja), soja (80% Uganda and 20% DRC), Tanzania (sardine fish, cotton and sunflower seed cake). Maize whole, wheat Pollard, maize-wheat-rice brans and crustacean shells are locally sourced. Cereal flour is found in processing factories like Minimex and Azam installed in the Kigali Free Economic zone in Masoro, near Kigali. Wheat pollard is one of the by-products of the wheat milling industry.

The Huye Feed Factory supports small-scale fish farmers under the bilateral cooperation agreement with South Korea. The factory uses dried Haplochromis species from lake Muhazi in replacement of sardines Indagara. Other feed ingredients used at the Huye Feed Factory to produce fish feeds include: sorghum (Rwanda), sorghum bran, soybean (from Zambia, 20% and from Uganda, 80%; and irregularly small amount of soja from Kayonza); cassava flour (Rwanda). This factory has made a long list of potential ingredients for the production of fish feed. The list includes meat and bone meal which is not of good quality since its production process involves the burning of car tyres. The factory has produced fish feed since July 2017 as a trial and applied for a license at the Ministry of Agriculture and Animal Production in February 2018.

[21] Msingi (201x). East Africa commercial aquafeed market report.

Feed mineral and vitamin premixes of Evonic (Germany) and Avotec (Greece) are imported from Kenya or from Eagle Vet (Uganda).

Many countries in Africa do not allow genetically modified (GM) crops which has an impact on cost when sourcing imported materials on the global market. Feed manufacturers source soybean from non-GM soybean producing countries: Zambia, Malawi, Rwanda (Msingi).

The price of feed ingredients is affected by the seasonality of production-supply of raw material and the moisture content of feed ingredients. Some farmers buy small volumes of feed and do not feed regularly using feeding charts since money from fish farming is not always reinvested in the fish farming business. Feed producers condemn the mind-set created by subsidising inputs including fish feed without a clear business plan after the funding by projects ends. This has created a dependence of farmers on public money to produce instead of engaging them in doing aquaculture as business. Farmers stop fish farming after the first subsidised cycle of production, and when they continue to farm they buy commercial feed erratically and use farm-made feed which is cheaper but of low quality. This practice is found with some small-scale commercial fish farmers in segment I.

The quality of feed produced is affected by the quality of the raw material and the processing. The fish meal from Haplochromis contain too much fibre that reduce the floating quality of pellets. Aflatoxin in stored maize is a common threat. Only 3 food processing companies are equipped to analyse this poisonous carcinogen produced by certain mould. A single FOSS 2500 analyser is available at PEAL (Poultry lab), private company in Bugesera for routine control of the composition of raw materials and final feed product. This analyser gives a range of composition and should be calibrated regularly. The costs of the analysis is 5,000 RWF ($5.89) per sample. A second analyser which is more accurate is available in a public institution, the RSB but the costs of the analysis is too high i.e. 200 USD per sample and it takes 2 weeks to receive the results of the analysis. Without a central and affordable testing facility, the feed formulation is biased without efficient use of ingredients and the true composition of the final product is not necessarily corresponding to that on the feed bag label with consequences of poor performances of fish in fish farms and distrust in feed manufacturers.

3.3.6.2 Access to fingerlings

Unless they have their own hatchery, farmers buy fingerlings from Kigembe fish station, a government hatchery at a subsidized price of 30 RWF ($0.04) a fingerling of 15 to 20 gr transport cost included but they complain about the bad quality of fingerlings and the long waiting time to fulfil the order. Many farmers in segment I source fingerlings from their neighbours or from their own ponds as they do not obtain sufficient fingerlings from the distant governmental hatchery. Small-scale farmers in segment I who do not have a hatchery are the most affected by this lack of fingerlings.

There are private farmers that have been supported with incubators from FAO to establish a hatchery to supply fingerlings to farmers though the latter complain about the long waiting time for the delivery as well as for the quality of fingerlings. These hatcheries are not specialised since they combine the production of fingerlings, the grow-out and sometimes the production of fish feed. Hatcheries do not produce enough fingerlings to stock their own cages or ponds and to sell to other farmers.

Because of the high cost, all hatcheries have stopped the use of synthetic male hormone like the 17α-methyl-testosterone for the production of all-male Tilapia. Alternatively, a few commercial farmers and hatcheries have introduced YY super-male and GIFT tilapia. One fish farm in segment III bought GIFT fingerlings of 1-2 g from a hatchery of Kivu Tilapia in Bujumbura, Burundi and has plan to start his own hatchery. The import of tilapia strains is allowed from anywhere with an import permit from MINAGRI.

3.3.6.3 Equipment supply

There is no supplier of fish farming equipment in the country. Farmers in segment I rely on equipment from extension agents for example for water quality measurement. Farmers in segment II and III use locally available material to build cage frames and still import nets from abroad. A few farmers in segment III import equipment directly from China (cages, nets, frames).

3.3.6.4 Supply of finance

Bank loans for agriculture investments have different conditions than loans for commercial businesses. Development banks and microfinances provide agriculture loans with low interest rates compared to commercial credits. Guarantees for agriculture projects can be obtained from Business Development Funds.

However, the fish farming sector and related businesses are not well known by financial institutions. This has resulted in limited number of credits granted to small-scale commercial fish farming compared to other agriculture sub-sectors. Their conditions seem difficult to meet by most small-scale farmers. One cooperative (PISCI-COOP) in segment I has received a credit from the Rwandan Bank of Development (BRD). From field interviews, it was found that template forms asked for a business plan are in English which is not easily understood by most farmers in segments I. For detailed information on financial services, we refer to section 3.2.5 Supporting systems/Financial services.

3.3.7 Key challenges in small-scale commercial fish farming by segment/production model

From this survey, three key challenges in small-scale commercial fish farming have been cited by the majority of informants irrespective of the production systems.

- The lack of high-quality seed (fingerlings). All three segments are affected by the lack of quality fingerlings. Poor quality fish seed is a result of weak genetic improvement programs & poor hatchery management, and a lack of a seed certification & quality assurance systems.
- The lack of local commercial feeds of good quality at affordable prices. Segment II is the most affected by this bad quality feed and high price. The nutrient composition of feed is not correctly reported. Feed pellets have bad quality and shape. Feed has higher Feed Conversion Ratio (FCR) than expected. Starter diets- for larval and fry stages and catfish feed are lacking on the market.
- The generalised lack of skilled manpower in fish farms. The segment III is the most affected by this lack of specialised skills since it does not find skilled technicians to work on fish farms.

Small-scale fish farmers in segments I and II have ranked the limiting factors per order of importance during a group discussion.

- Feed (sub-optimal quality of locally manufactured feed mainly for segment II, high price for both segments I and II). The major barrier to competitive cage culture development asserted in segment II is the inadequacy or lack of availability of domestically made high-quality extruded fish feeds at competitive prices
- Fingerlings (insufficient quantity and low quality)
- Equipment (mainly nets for segment II and kits for water quality measurement for segment I)
- Skills (mainly lack of know-how, lack of continuous training)
- Finances.

Small-scale fish farmers in segment III have ranked the limiting factors per order of importance during a group discussion.

- Fingerlings (insufficient quantity and low quality)
- Skills (mainly lack on practical know-how of labor force, technicians).

From our assessment, small-scale commercial fish farmers are encountering four common constraints:

- the lack of fingerlings in quantity and quality,
- the high cost of feed and the low quality of locally manufactured feed, and
- the absence of technically skilled manpower in fish farming on the local job market,
- the lack of business skills in segments I and II.

Other barriers to segment III include a lack of or insufficient storage/processing facilities and difficulties in marketing due to the unavailability of roads connecting production sites and developed markets, lack of training in cage culture.

Other key constraints faced by all small-scale fish farmers are inaccessibility to low-cost credit facilities, and a limited number of fast-growing fish species in local (climatic) conditions. Coupled with this, lack of

entrepreneurship skills, low public funding of the sub-sector and lack of capital are major constraints for new entrants. Poor record keeping by farmers and inefficient statistical data collection have impeded the demonstration of the profitability of the fish farming sub-sector to the financial service providers.

There is also a generalised lack of expertise in fish disease identification and management in the country.

Fingerlings. The quantity and quality of fingerlings of tilapia are priority limiting factors for the small-scale commercial fish farming. Fingerlings supply does not meet the demand in terms of quality and quantity. Inbreeding is very high in most fish farms, hatcheries and even in the governmental hatchery in Kigembe, Southern Province. The Kigembe national aquaculture station has been equipped to produce at least 5 million fingerlings every year. But considering the bureaucratic burdens in its daily management, this station is not capable to produce enough seeds of good quality to satisfy the demand. During our visit at the Kigembe station, the station and hatchery were not operating after more than 5 months without fish feed. Hapas in ponds and hatching trails in the hatchery were empty. Broodstock introduced from Lake Albert in Uganda is more than 5 years old and is known to not be pure from the introduction period. The RAS system for the production of catfish fingerlings has not been operated since its installation.

A public private partnership in hatchery can help to solve on the medium-term the issue of quantity and quality of fingerlings available with the involvement of specialised on-growers. While the government could play a role of facilitator and regulator, and introduce a certification process, current private hatcheries with the support of financial services could specialise and increase their capacity of production of fingerlings. It was observed that private hatcheries were doing better than the governmental hatchery and have introduced better performing Tilapia strains of GIFT and YY males.

Feed. According to small-scale commercial fish farmers, the price of feed is too high and the quality of locally manufactured feed is not yet optimal at different levels: nutrient composition, shape of pellets.

It is recommended to team up farmers and feed manufacturers to conduct fish feed performance trials in farm conditions. Access to quality feed ingredients and analytical facility for feed factories is needed to support further development of local quality feed.

Skills. According to all categories of small-scale commercial fish farmers, hands on skills in fish farming are lacking at all levels in Rwanda, despite different trainings. In 2013, RAB has trained 1 634 fish farmers on modern fish farming. 31 Technicians from RAB, Districts, UR, PAIGELAC were also trained on modern fisheries and aquaculture techniques like ponds construction and management, massive Tilapia seed production, feed formulation and cage culture (MINAGRI/PAIGELAC (2013[22]).

Training should be continuous and not be limited to project life. Urgent training needs are in fish farm management, feed management, water quality measurement, data analysis and interpretation, record keeping and data exploitation.

Most trainings in the past have been focussing on technical aspects of fish farming while they should also include training in business and entrepreneurship. The level of entrepreneurship of small-scale commercial farmers differ by segment and production model. The entrepreneurship seems higher with cage farmers (segments II and III) compared to pond farmers (segment I). Small-scale farmers in segment III have a high level of education and long experience in doing business. They invest a lot of money in fish farming and are more profit-oriented from fish farming as the main business. In other segments, they are farmers who do fish farming as a secondary business aside other income generating activities.

Finances. During interviews with farmers and representatives of financial institutions, we have noticed that small-scale commercial fish farmers and banks are not communicating on existing opportunities. Farmers especially in segments I are not aware of financing possibilities and conditions. banks do not know the fish farming sector at all.

[22] MINAGRI/PAIGELAC (2013). The commercialisation of aquaculture and capture fisheries in Rwanda.

Dialogues and study visits in fish farms can help to improve the understanding of the subsector fish farming by the bank and the financial services available for the farmers. Record-keeping and economic results of successful fish farms should be made available to convince financial institutions looking for diversifying their financial products to fish farming activities. There is a need to document success stories to give confidence to bankers and other institutions to lend or co-invest with promoters.

The three constraints highlighted by this survey namely fingerlings-feed-skills are among the very urgent problems to solve to develop and sustain the small-scale commercial fish farming sector. They confirm the findings of Kampayana et al. (2016[23]) from 52 respondents practicing commercial cage culture in different lakes in Rwanda and illustrated in Figure 4.

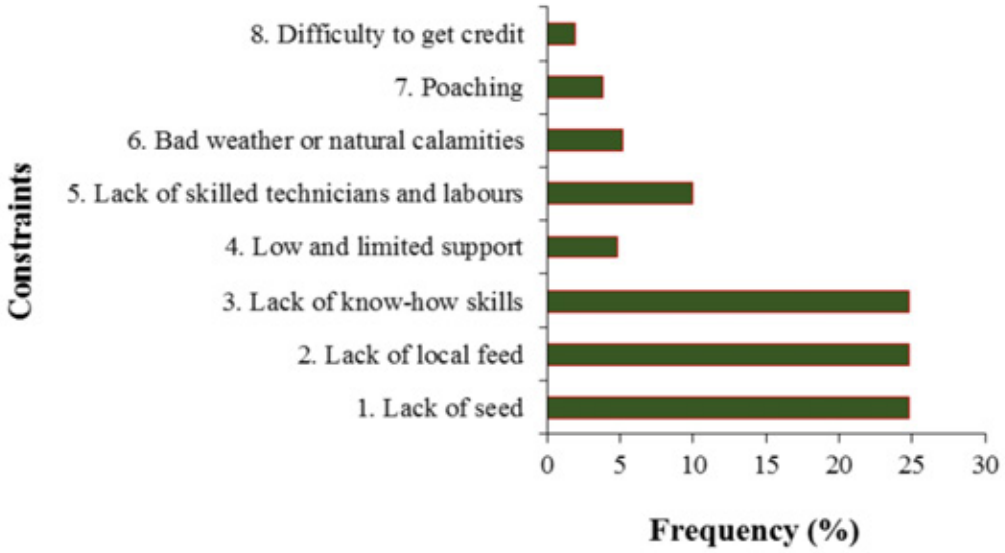

Figure 4 *Constraints affecting current tilapia cage culture production in Rwanda in 2014 (source: Kampayana et al., 2016)*

When comparing pond and cage farming, there are commonalities and specificities in challenges encountered in each production system, as illustrated in the Table 15 below.

Table 15 *Challenges in pond and cage fish farming*

Challenges	Ponds	Cages
Lack of seed in sufficient quantity and adequate quality	√	√
Lack of quality fish feeds		√
Lack of know-how skills and skilled technicians and laborers	√	√
Low and limited support	√	√
Low extension efforts	√	-
Lack of training in cage culture	-	√
Difficult access to credit	√	√
Lack of economies of scale in operations	√	√
Poaching	√	√
Competition with other agriculture crops	√	-
Conflict where water bodies have multiple uses	-	√
Lack of potential investors or serious engagement of the private sector to invest in cage culture	-	√
Environmental threats due to pollution and fish diseases	-	√
Lack of prerequisite legislation and regulation	-	√

[23] Fidele Kampayana, Sy Tan Nguyen and Minh Hoang (2016). Le Tilapia cage culture in Rwanda: Current status and prospects for future development. International Journal of Fisheries and Aquatic Studies 2016; 4(3): 428-435.

3.3.8 Which production models are proving most successful and why?

The cage culture, at least of segment II (low volume cage), is proving to be the most successful fish farming technology due to the following:

- It is a simple technology accessible to everybody, even to farmers with limited education;
- It does not compete with other agriculture crop production;
- It can be intensively and easily managed;
- It generates high fish yields.

High production records of 75 kg/m^3 have been achieved by some producers in 8 m^3 cages (Kampayana et al., 2016). The productivity of such small-scale commercial cages (segment II) surveyed was 30 kg/m^3 on average.

Small-scale fish farmers and most informants have confirmed the existence of a good market environment:

- Fish markets exist in the country and in the neighbouring DRC and can act as a pulling factor of the production.
- According to the coordinator of the aquaculture desk at RAB, Eastern DR Congo imports more than 100,000 tonnes of fish annually. By investing more in fish cages on Lake Kivu bordering Eastern DRC, Rwanda would tap in this huge market (Rutaganira, 2017. The New Times).
- For cage farms, feed and hands-on skills are unquestionably a fundamental success factor.

The GoR is promoting cage fish farming because of shortage of land for cultivation thus limiting expansion of fish farming using ponds. Marshlands are being used to cultivate crops and people are encouraged to invest in cage farming, said a responsible official at the aquaculture desk office.

3.4 Analysis and insights

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

We have listed a number of common conditions and success factors for small-scale fish farming in Rwanda.

Abundant aquatic resources. In Rwanda, small-scale commercial cage farming has more potential to develop compared to pond farming. The country is densely populated (over 500 inhabitants per km^2) and there is a very high competition for land. Therefore, cage farming offers an opportunity to produce food on water. The country has abundant aquatic resources including 24 inland lakes with a total surface of 128,000 ha. Lake Kivu with a constant water temperature of 25^0C and 100.000 ha on the Rwanda part of the Lake is estimated to have the capacity to produce annually 1 million tonnes of fish using a conservative estimate of production (2% total surface, 500 tonnes/ha). Other lakes in the Eastern part of the country can also contribute an additional 200,000 tonnes of fish per year from cage farming.

Local and Eastern DRC market. Aquaculture production in lakes can suppress fish imports and supply the export market in Eastern DRC. Despite high fish prices, there is an increasing demand for fish on the local and regional market, especially in Eastern DRC. Per capita fish consumption in Rwanda has increased more than 50% from 1.5 kg to 2.3 kg per capita in less than 5 years between 2011 and 2016. With increasing population, the growing elite and urban population, as well as increased health challenges, demand for fish is real and the demand for farmed fish will continue to increase to compensate for the declining supply from fisheries. Considerable additional quantities of fish need to be produced. The country occupies a strategic position between East Africa and Central Africa and toward the Eastern DRC fish market which imports around 100,000 tonnes of fish per year. To achieve substantial productions, fish farmers need to be grouped into production clusters to improve productivity, to organize smallholder producers and to link them backward and forward along the fish value chain to local and regional markets of inputs and products.

Education level, technical skills and experience in business. These are secondary factors that affect the success of small-scale fish farmers beside production factors. They constitute a weak side of small-scale farmers in segments I and II which if not handled in time will have negative impact on the growth of the sector. Moreover, the lack of know-how reduces the employability of young school leavers in fish farm enterprises. Personal commitment and determination, management skills, and smart investments of small-scale fish farmers are needed to reduce production costs as drivers to success.

Constraints to aquaculture development in Rwanda are mainly the lack of quality and affordable feed and seed, the lack of technical skills in aquaculture on the labor market and the lack of capital. Private public partnerships, involving both local and foreign investors and knowledge institutions can fill the existing gap. Despite the constraints, a big step has already been made in shifting from subsidised fish farming to profit-oriented commercial fish farming among small-scale fish farmers of segments II and III who are continuously investing in their fish farms. These are serious engaged small-holders some of which in segment III are already growing and moving fish farming as business to a higher level of medium-scale commercial fish farming.

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

Key problems for small-scale commercial fish farmers are:
- the lack of fingerlings in quantity and quality,
- the high cost of feed and the low quality of locally manufactured feed,
- the lack of skills in farm day-to-day activities and,
- the lack of access to finances.

Since the ending of subsidised inputs, improvements in productivity have been observed in all segments of small-scale commercial fish farmers although they are not yet optimal, showing the potential of the sector to improve and to achieve higher outputs per surface or volume of production unit. Productivity of earthen ponds (segment I) has increased 3-fold. The productivity of low volume cages (segment II) has increased from 26 kg/m^3/year to 30 kg/m^3/year and that of high-volume cages (segment III) has slightly increased from 26 to 27 kg/m^3/year.

The lack of quality fingerlings in quantities can be solved through the professionalization of hatcheries and the introduction of a certification scheme of hatcheries and fingerlings. At the moment, all small-scale commercial fish farmers are involved in the grow-out to produce marketable size fish, though some combine hatchery activities in their operations and even production of feeds. This practice of combination of different sometimes unrelated activities spreads the resources available, both human, financial and infrastructure with minimum output in terms of quality and quantity. By professionalization of production activities in which small-scale fish farmers are involved, resources will be best used for a maximum output. Production of fingerlings can be organised in different steps with different responsibilities. The role of commercial hatcheries can be limited to the management of brood stock, the conservation of genetic purity and the production of fry and of fingerlings:
- hatchery/nursery for the production from eggs to 1 g fry. This can be done indoors in intensive tank systems.
- On-growing from fry (1g) to fingerlings (30g) can be done also intensively in hapas in tanks and in ponds by hatcheries and on-growers.
- grow-out from fingerlings (30 gr) to market size (>500 g) in ponds (segment I) and in cages (segment II and III).

By segmentation of the hatchery/nursery/on-growing activities, the production of fingerlings can be boosted in quantity and quality. With research and public-private support, hatcheries can concentrate on tailor made low-cost breeding programs targeting small-scale fish producers and the (cold) farming environment in Rwanda. The basic principle of low-cost breeding programs is to minimise the number of facilities and to integrate breeding activities with existent farm infrastructure as much as possible. In practice, breeding programs have shown improvement of selected traits, e.g. growth rate, of 10-15% per generation. In the case of tilapia, generation time is short and such breeding programs

can result in quick returns. Breeding of cold tolerant fish strains could also expand the potential of fish farming in the country. Rwanda does not benefit from warm water in some places where fish can be farmed.

Local feed producing companies should improve their collaboration and communication with fish farmers. During the survey, the impression was that feed manufacturers are selling fish feed only for profit without organising feedback from fish farmers. The proximate composition of feed indicated on fish bags does not always correspond to the true composition of the feed and this is also acknowledged by feed fabricants who lack lab facilities to analyse feed ingredients and feed products. The physical quality and the shape of feed pellets of locally manufactured feed is not far from that of farm-made feed using small extruders provided by FAO to fish farmers. The performance of fish of this feed should be investigated in collaboration with fish farmers under different production conditions and in different production systems and collected data should be used to improve the quality of locally manufactured feed. Partnerships of local feed manufacturers with well-known foreign feed companies is needed to acquire best technologies in extrusion, feed coating and improvement of feed floatability and palatability.

In order to improve further productivity, root problems need to be tackled all at once since they are interconnected. A good feed without a good fingerling and vice-versa, a good input without appropriate knowledge will never turn into profitable fish farming. The solving of root problems will accelerate the growth of the sector and prepare it for competition in the future by reducing the production costs in anticipation of the drop in prices when the supply and the demand of fish will become balanced.

3.4.3 Key barriers to entry

From the different constraints mentioned, two seem to be the key barriers for entry: **Skills** and **Finances**.

Skills
Aquaculture is a specific agriculture sub-sector in which skilled persons are lacking in quantity and quality. At all levels hands-on skills in aquaculture are lacking and this constitutes a serious problem faced by most of the actors in this sector. Rwandan graduates and undergraduates are not sufficiently skilled in aquaculture techniques as in other animal production sectors. Together with those who followed vocational training programs in TVET, they have received more theory than practice in fish farming or have visited once a fish farm in their study time. Those involved in aquaculture are generalists in animal production, animal veterinarians, or in food sciences and in most cases prefer white collar jobs to “not-clean” jobs. Those few who have received advanced academic training in aquaculture up to the PhD levels abroad are employed in research and teaching at University or have positions in the Ministry of Agriculture and Animal production or at the Rwanda Agriculture Board. In the field, the few extension officers in aquaculture are not sufficiently supported to reach all fish farmers scattered throughout the country.

Opportunities for training in aquaculture are dependent on donor or government funded projects. For a more sustainable solution, the fish farming industry and universities should engage in partnerships to consistently train technicians in fish farming through the revision of training curricula and to organise on-farm training in commercial fish farms in the form of internships. Before this happens, fish farm managers and hatchery managers should be trained first to be able to supervise interns, in collaboration with their academic supervisors. The training of trainers (ToT) will ensure that technicians are quickly available and operational.

For the segment III which lacks crucially skilled labor, a short-term solution could be to send undergraduates for short training in commercial fish farms in Kenya and Uganda or in training centres like the Asian Institute of Technology in Thailand. The training should target those who are willing to start their business in fish farming and to work with their hands in fish farms as farm or hatchery managers and who are willing to train others. In the long term, a private driven innovation centre or

incubator of aquaculture projects and a training centre in aquaculture in the region can provide sustainable practical training solutions to the shortage of technical skills in aquaculture.

Finances
For individual starters in all segments, it is difficult to obtain a fish farming loan as they first need to build up a capital and do not always have sufficient collateral to use as a guarantee for the bank loan. Furthermore, the time for the payment of the loan is calculated to one production cycle set to 6 months.

From the financial institutions that we visited we have concluded that:
- The financial products of the Rwandan Development Bank (BRD) are more suitable for small-scale commercial fish farmers in segment III but the interest rates of 13-16% per year remain high and can discourage some farmers to use bank loans. The bank finances projects above 50 Million RWF ($58,854.94) and there is no maximum limit.
- Urwego Opportunity Microfinance Bank has conditions that favour cooperative and group loans of segment I but the interest rate of 2.5% per month is too high and the amount of loan is too small (50,000-250,000 RWF) ($58.85 - $294.27).
- The Microfinance Inkomoko has interesting financial services and products that could be used by small-scale commercial farmers in segment I and II. The company offers candidate entrepreneurs an intensive training in finance, market research, marketing and pricing, financial records and a credit up to 50,000 USD for their project with the lowest interest rate of 10%/year in the country. The training offered is needed in any type of business and is lacking to most small-scale commercial fish farmers. Nevertheless, the training fee of 1,000 USD can discourage small-scale starters who do not value the skills gained from a training.
- Banks, microfinances and many actors in finance do not know the subsector of fish farming and his stakeholders. Success stories, production and economic data in fish farming should be shared through advertisement workshops or at the occasion of guided business visits to prove the potential of the sector and its value chain to the banks. There is a need for a few success stories to encourage the private sector to invest in fish farming, as well as reassuring the banking and financial sector.

3.4.4 Opportunities to expand small-scale production

To expand small-scale production in the current context, we propose to solve first the lack of fingerlings through the **professionalization and the specialisation of hatcheries**, the reorientation of the pond production (segment I) to profitable fish farm sizes and the **organisation and empowering of small-scale cage farmers in segments II.** These 2 segments seem to need more attention, especially segment II which represents the future of the sector in a context of increasing competition for land and agriculture inputs to produce fish feeds.

- **Mass on-growing of tilapia fry in hapas in tanks and in ponds.** There is a problem of insufficient fingerlings and high mortalities after transport. More hatcheries close to the out-growing farms are not feasible but existing hatcheries can be supported by on-growers. Small-scale producers can partner with hatcheries for the mass on-growing of the fry to the stocking size. Small fry support better transport than old fingerlings. Throup PPPs, private hatcheries can be supported, and the production and distribution of fingerlings regulated and certified to solve sustainably the crucial lack of quality and quantity of fingerlings.
- **Semi-intensification of pond production targeting small-size tilapia market segment**. Pond aquaculture is more cost effective in case of production of smaller tilapia (up to around 200-300 gr), whereas cage culture is more cost effective for the production of larger sized fish. In order to reduce feed costs (about 60-70% of the production costs), agricultural by-products and animal waste can contribute to the fertility of the ponds and increase yields from natural production reducing the feed budget by replacing some of the formulated feeds needed. Protein levels needed are much lower (18%) and pond micro fauna provides many of the specialised nutrients and growth factors that have to be built into cage feed. With appropriate management, yields can be increased to 10 tonnes/ha/year through use of pond feed. With this constraint removed, the number of semi-intensive producers and the amount of fish produced at a cheap cost can increase. With appropriate marketing pond farmed fish can compete against Chinese imported frozen tilapia in a local market

looking more for fresh tilapia. Chinese tilapia imports into East Africa and in Rwanda predominantly relate to smaller fish sizes, generally in the 100-300 grams range. This 200-300 grams range offers the most popular fish sizes for the low-income category as fish is generally served individually in households and in popular bars.

- **Small cage clusters.** LVHD cages are more cost effective for small-scale holders than big cages. Investment is not too high and small cages are easily manageable and risks are less for small-scale farmers. However, artisanal cages are generally cheap but not entirely safe and care should be made to protect them against breaking. By clustering, small-scale cage farmers in segment II can negotiate good prices for inputs/output products and services, easily access information and training and reduce labor and management costs since one skilled technician can manage several small cages.

3.4.5 Models linking smallholders to the market and support services

Models such as farm estates in urban and peri-urban centres or on a given water body and contract farming with input suppliers and fish traders are also possible with linkages to the fish market and inputs/service suppliers. Such an aquaculture park system allows for substantial collective fish production. With experience gained in fish farming as business, these cluster fish farms can grow into small and medium-scale fish-farming enterprises (SMEs) taking over the marketing and commercialisation of inputs and products.

An association grouping aquaculture producers and actors in the farmed fish value chain does not exist in Rwanda. It can link the farmers to markets of inputs and of farmed products as well to support services.

3.4.6 Production and price analysis

We have assumed that the current aquaculture production will double in the next 5 years given the speed of development of cage fish farming in Rwanda and the involvement of the private sector. The doubling in production depends on measures to be taken over a short term to remove the constraints in fish farming such as feed, seed, knowledge and finance. Fish smallholder farmers' mentality has shifted to commercialise aquaculture and many entrepreneurs recognise that the aquaculture industry must be driven by the private sector with the support of the public sector. They are convinced that the production will continue to grow, and market shocks are not expected soon given the high prices fetched by fish on the market. Because of the lack of quantitative data, price effects will be discussed in a qualitative manner. According to Smit (2008[24]) the expected price effects are mainly dependent on the size of the market in which a small-scale commercial farmer operates. Different markets can be distinguished for small-scale commercial fish farming in Rwanda in which price effects differ between segments.

As illustrated in Table 16, 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.

[24] Smit, J.G.P (2008). Globale inschatting van het marktpotentieel van in Nederland te kweken vissoorten. Den Haag: LEI rapport.

Table 16 *Price effect of doubling production in different segments*

Segment	Markets & sales	Marketing and distribution	Price effect of doubling production
I	Farm gate to neighbour households and proximal markets	Not organised; hard to sell sometimes and forced home-consumption	Price will go down as proxy markets are less able to absorb an increase in production. Specifically applies to small-scale commercial farmers in rural remote areas with poor logistics. This category has little power to control price
II	Outlets in Kigali city, Retailers	Fairly organised through established selling points on markets	Outlet price in Kigali city will not be affected as fresh fish supply is still low even with doubling production. Farm gate price will go down for small-scale commercial farmers in remote areas with poor logistics. Retailers: Price will not be affected as their price is depending on that of outlets and agreements made with small-scale farmers owning these outlets.
III	Outlets in Kigali city, Middlemen	Few are fairly organised through established selling points on markets Other depend on networks of middlemen	Prices on local markets may be affected as many of them do not have outlets as in segment II and depend on middlemen. However, price effects will be minor on regional Eastern DRC markets since this market is huge and demand is high.

3.4.7 Data and information gaps

The following gaps were found in data and information:

- The exact number of fish farmers in different segments including both small-scale and medium scale
- The exact number, surface and volume of production systems (ponds, cages, tanks) and their geo-localisation
- The number and size of individual small-scale commercial pond farmers in segment I
- The exact number of fish production systems integrating animal husbandry and crop production
- The exact number of hatcheries, species/strains being bred and their production capacity
- The size and quality of brood stock in hatcheries
- The exact number of small-scale commercial fish farmers who benefited from bank loans
- The exact production data of Tilapia and Catfish (quantity in tonnes, value in USD)
- The feed production capacity of local feed manufacturers, both industrial and on-farm
- The exact fish market size and prices in Eastern DRC for both farmed tilapia and catfish from Rwanda
- The volume and value of tilapia imports from China and India

3.5 Small-scale commercial fish farming suitability maps

Based on a temperature map, the most suitable locations for small-scale commercial tilapia farming are found in the Eastern and Southern parts of the country and on the shores of Lake Kivu. Other lakes which are most suited for fish farming are Lake Muhazi, Mugesera and other lakes in the Eastern Province. These lakes have an average depth of 5 to 8 m and an average water temperature ranging between 23.3 to 24.6°C (Figure 5) and are the most rewarding in terms of yields and economic performance among all the lakes in Rwanda. With the support of a land-based hatchery and early rearing facility to support internal seed requirements, it seems possible to grow-out 50 g fish in LVHD cage culture in 2 crops per year with a final average harvest weight near or above 500 g within 6 months in Lake Mugesera.

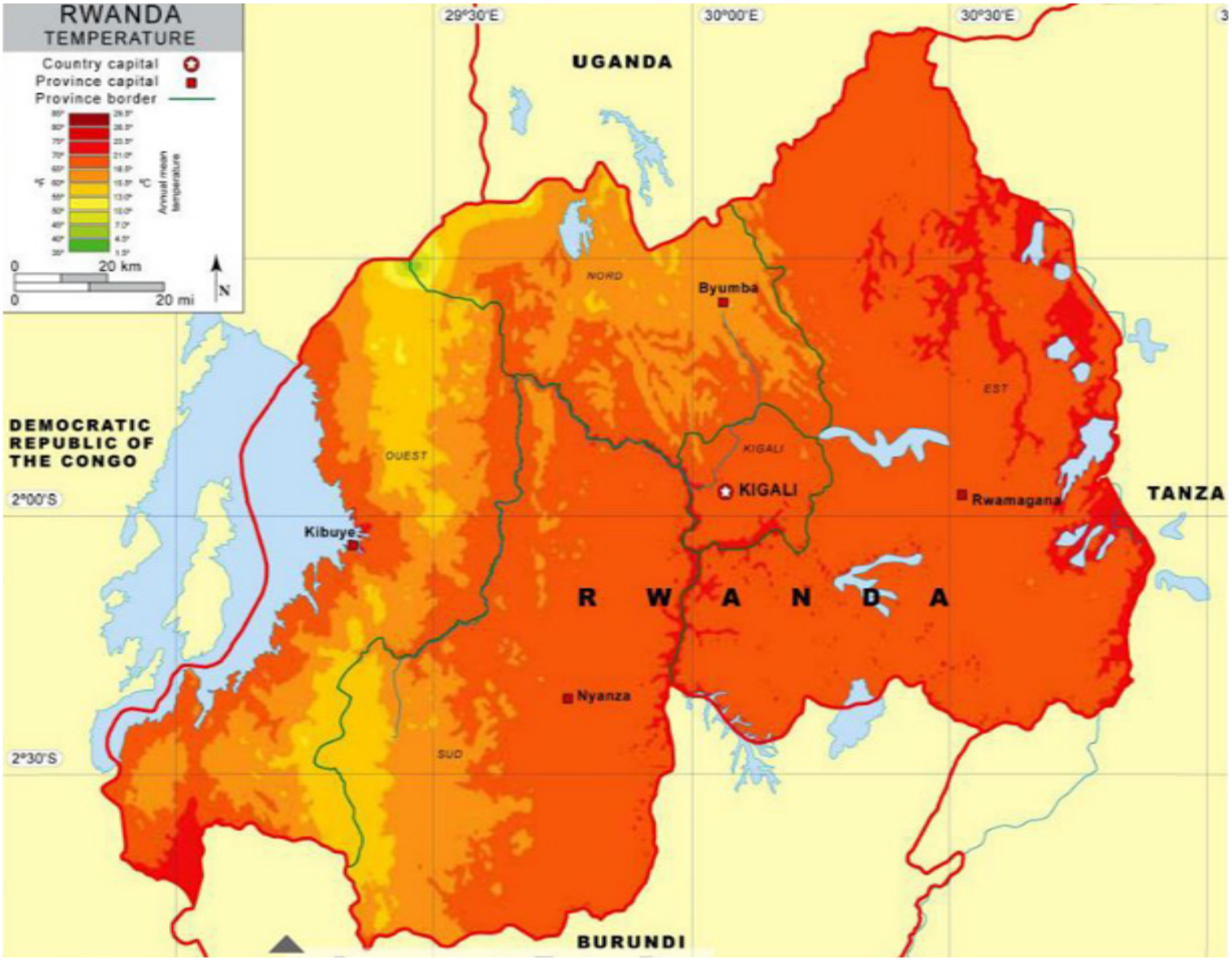

Figure 5 *Map of temperature in Rwanda. Source:[25]. http://www.bestcountryreports.com/Temperature_Map_Rwanda.php*

[25] http://www.bestcountryreports.com/Temperature_Map_Rwanda.php Accessed 4-4-2018.

4 Recommendations

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

Four key challenges should be removed for the further development of the small-scale commercial aquaculture sector in Rwanda:

1. The lack of high-quality seed. All segments are affected by the lack of fingerlings in quality and quantity. We recommend:
   - A tailor-made programme of genetic improvement of primarily tilapia and secondly catfish, with distribution of brood stock to certified hatcheries
   - A professionalization and specialisation of hatcheries
   - A quality compliance of fingerlings, supported by seed certification & quality assurance systems.

2. The lack of local commercial feeds of good quality. We recommend:
   - A facilitation of local fish manufacturers to access quality feed ingredients and Western technological support in fish feed formulation and production. This can be achieved through public-private partnerships to improve technological capacity of local fish feed manufacturers.
   - A quality control of fish feed available on the market. The price of fish feed needs to be regulated on the basis of their nutritional composition and effective feed conversion rates.

3. The lack of skilled manpower in fish farms. We recommend:
   - Training curricula with more practical oriented training in aquaculture and business skills development.
   - The establishment of an aquaculture training center with industry involvement.

4. The access to capital for investment in aquaculture.
   The aquaculture sector is still immature and not well known by finance service providers. Like other agriculture sectors, we recommend:
   - Aquaculture should get an opportunity to prove its profitability and sustainability.
   - Organisation and empowering of small-scale commercial farmers, especially cage farmers, through clustering (aquaculture parks, farm estates) and linkage of clustered aquafarms to inputs/services/output products markets.
   - A mandatory data collection and record keeping throughout the whole fish value chain to prove the profitability of the sector to the banks and micro-finances.
   - An investment in a central database that supports the sector with market information.

5. The information gaps mentioned above should be addressed as soon as possible to have credible numbers of production and market size.

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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 farmer:

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

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

Questions for input suppliers:

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

Question for fish farmer organisations representative:

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

Questions for financial service institutes:

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

Questions for NGO or International donor

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

Questions for regional organisation

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

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

Questions for people with a good overview of the sector

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

Appendix 3 List of key informants interviewed

Name	Institution/Organisation	Type of KII	Function
Jean Claude Ndorimana	MINAGRI	Government Institution	Advisor to the Minister
Mathilde Mukasekuru	MINAGRI	Government Institution	Fish Farming Specialist
Dr. Rutaganira Wilson	RAB	Government Institution	Aquaculture and Fisheries Program Coordinator
Bugabo Hilaire	RAB	Government Institution	Extension Officer Southern Zone
Gregoire Dusabemungu	RAB	Government Institution	Aquaculture Research Officer
Hon. Munyeshyaka Vincent	MINICOM	Government Institution	Minister
Robert Opirah	MINICOM	Government Institution	DG, Head Dpt Trade and Investment
Dr. Ossiniel Nshimiyumukiza	MINICOM	Government Institution	Community Processing Centers Specialist
Otto Vianney Muhinda	FAO	Donor	Assistant FAO Representative/Programme
Annick Kenny Kanyamuneza	BRD	Financial service	Agriculture Investments Analyst
Solange	URWEGO BANK	Financial service	Product Manager Agriculture Unit
Claude Mazimpaka	INKOMOKO Microfinance/AEC Rwanda	Financial service	Portfolio Manager
Kabagambe Jean Bosco	AFAS Rwanda Ltd	Consultancy service	Aquaculture and Fisheries Advisor
Mfashingabo Ntwali		Consultancy service	Aquaculture and Fisheries Specialist
Dr. Laetitia Nyinawamwiza	UR/CAVM	Research and Academic	Principal of UR-CAVM
Dr. Simon Rukera Tabaro	UR/CAVM	Research and Academic	Senior Lecturer at UR-CAVM
Léon Niyibizi	UR/CAVM	Research and Academic	Assistant Lecturer/PhD student at SLU, Sweden
Rashid Mwimba	UR/CAVM	Research and Academic	Assistant Lecturer/Station Manager
Léonce Ngirinshuti	UR/CAVM	Research and Academic	Lab technician
Dr. Sang Ju Park	GORILLA FEED	Input (feed) supplier	Managing Director
Iradukunda Jean d'Amour	GORILLA FEED	Input (feed) supplier	Finance Manager
Wachira Githinji	GORILLA FEED	Input (feed) supplier	Sales Manager
Kwizera Hubert	PAFI	Input (feed) supplier	Managing Director
Noella Mukamabano	PAFI	Input (feed) supplier	Production Officer
Chantal Uwamahoro	HUYE FEED FACTORY	Input (feed) supplier	Manager
Adolphe Niyonsenga	HUYE FEED FACTORY	Input (feed) supplier	Production Manager
South-Korean	HUYE FEED FACTORY	Input (feed) supplier	
Christine Byukusenge	FRESH FISH	Fish Farmer	Owner and Manager
James Ntafula Joseph	FRESH FISH	Fish Farmer	Technician in Cage Farming
Boniface Ngwabije	FRESH FISH	Fish Farmer	Technician in Cage Farm Construction
Munyansanga Théoneste	PISCI-COOP	Fish Farmer	Technicien
Gasana Alphonse	PISCI-COOP	Fish Farmer	Cooperative member
Hafashimana Alphonse	PISCI-COOP	Fish Farmer	Cooperative member
Nzaramyimana Isiaka	COOPILAK	Fish Farmer	Cooperative member
Uwambajimana Pauline	ISUGI	Fish Farmer	Cooperative president
Ntamagezo Jean de Dieu	KOKABIB	Fish Farmer	Cooperative president
Justin Bisengimana	KUNGABU	Fish Farmer	Cooperative president
Murenzi Straton	INDORERWAMO	Fish Farmer	Cooperative controller
Havugarurema Darius	URUMURI RWACU	Fish Farmer	Cooperative president
Fine Fish Ltd	OUTLET MARKET KIMIRONKO	Farmer Outlet	Fish Trading
Kamana Francois	MARKET KIMIRONKO	Fish Trader	Fish Trading
Clement Nizeyimana	MARKET KIMIRONKO	Fish Trader	Fish Trading
Muragijimana Salomon	MARKET KIMIRONKO	Fish Trader	Fish Trading
Nsengumuremyi Safi	MARKET KIGALI TOWN	Fish Trader	Fish Trading

Appendix 4 List of small-scale commercial pond farms above 10,000 m^2 (Segment I)

Nr	Cooperative	Province	District	Sector	Number of pond	Surface Area (ares)	Production 2014 (kg)	Production 2017 (kg)
1	ABADASIGWA	EASTERN	GATSIBO	KAGEYO	12	200	2,200	7,000
2	COABMK	EASTERN	NGOMA	KAREMBO	43	268	3,216	8,040
3	COOPIGAMU	EASTERN	GATSIBO	MUHURA	13	242	2,420	8,470
4	COPFIKA	EASTERN	GATSIBO	KAGEYO	10	120	1,320	4,200
5	CUCURIGI	EASTERN	NGOMA	RURENGE	12	180	2,160	6,300
6	GWIZA NYAGASAMBU	EASTERN	RWAMAGANA	FUMBWE	25	230	2,530	8,510
7	INGENZI GATSIBO	EASTERN	GATSIBO	GATSIBO	14	140	1,540	4,900
8	KOAKI	EASTERN	KIREHE	KIGINA	14	179	2,148	6,623
9	LAKESIDE	EASTERN	BUGESERA	GASHORA	14	120	1,440	5,400
10	PISCI-COP	EASTERN	RWAMAGANA	FUMBWE	46	368	3,680	13,616
11	RAFIKI JUVENAL	EASTERN	GATSIBO	GATSIBO	25	280	3,360	9,800
12	COPAMAGA	KIGALI CITY	GASABO	NDERA	25	240	2,640	6,960
13	EJO HEZA-RUSORORO	KIGALI CITY	GASABO	RUSORORO	10	160	1,600	4,800
14	NKURIKIYIMFURA Janvier	KIGALI CITY	GASABO	GIKOMERO	10	120	1,200	3,600
15	COPROPIRU	NORTHERN	RULINDO	NGOMA	14	249	2,739	8,715
16	DUKOREREHAMWE	NORTHERN	BURERA	CYERU	14	175	1,225	6,625
17	IJUTE	NORTHERN	RULINDO	NGOMA	12	240	2,640	8,400
18	INDORERWAMO	NORTHERN	RULINDO	TUMBA	8	100	1,150	3,750
19	INYONGERABUZIMA	NORTHERN	RULINDO	RUKOZO	18	190	2,090	6,650
20	ISUGI	NORTHERN	BURERA	KINONI	10	100	700	1,500
21	TWITEZIMBERE RUTARE	NORTHERN	GICUMBI	RUTARE	3	119	1,309	3,451
22	URUNANA	NORTHERN	RULINDO	BASE	6	117	1,287	4,095
23	ABAHARANIRA AMAJYAMBERE	SOUTHERN	GISAGARA	Muganza	33	150	2,550	4,350
24	BAHONEZA NGANZO	SOUTHERN	Muhanga	Nyamabuye	9	108	1,296	3,024
25	CODEANYA	SOUTHERN	NYAMAGABE	Kamegeri	15	200	2,200	5,600
26	DUFATANYE	SOUTHERN	Nyanza	Busasamana	10	60	1,500	2,700
27	HUYE URUMULI RWACU	SOUTHERN	HUYE	Huye	25	187	1,832	4,675
28	ISD	SOUTHERN	Nyanza	Kibirizi	6	216	2,376	6,480
29	ISOKO Y'UBUKIRE	SOUTHERN	NYAMAGABE	Kamegeri	17	205	2,255	5,740
30	NYAMAGANA FISH	SOUTHERN	Nyanza	Busasamana	10	200	2,200	6,000
31	URUGWIRO/Maraba	SOUTHERN	HUYE	Maraba	17	108	1,058	2,700
32	CIADI	WESTERN	RUSIZI	NKUNGU	11	100	900	3,500
33	ISANGANO	WESTERN	RUSIZI	MURURU	45	350	3,150	16,625
34	KIMARANZARA CYANYA	WESTERN	KARONGI	GISHYITA	10	120	1,200	3,000
35	KOBUFI	WESTERN	NYAMASHEKE	BUSHEKERI	20	200	2,000	5,800
36	KUNGABU	WESTERN	NYAMASHEKE	RUHARAMBUGA	16	100	1,000	2,900
37	TERIMBERE KAZABE	WESTERN	NGORORERO	NGORORERO	14	116	1,276	3,132
	TOTAL				**616**	**6,557**	**71,387**	**217,631**

Source: RAB, Aquaculture desk office

Appendix 5 List of small-scale low volume commercial cage farms above 100 m^3 (Segment II)

Nr	Name of the farm	Lake	District	# cages	Volume (m^3)	Production in 2017 (Kg/year)
1	World Vision	Kivu	Rutsiro	30	240	9,120
2	Lakeside Fish Farm Ltd	Kivu	Karongi	30	240	10,800
3	COABONYA	Kivu	Nyamasheke	30	240	10,800
4	Fingers Fish Ltd	Muhazi	Rwamagana	6	216	8,640
5	Fish Innovation & Technology	Muhazi	Gicumbi	30	810	13,500
6	Trinity Fish Farming Ltd	Kivu	Karongi	4	108	NA
7	M.N. Sopicaki	Kivu	Rubavu	60	480	NA
	TOTAL			**190**	**2,334**	**>52,860**

Source: RAB, Aquaculture desk office

Appendix 6 List of small-scale high-volume commercial cage farms above 100 m^3 (Segment III)

Nr	Name of the farm	Lake	District	# cages	Volume (m^3)	Production in 2017 (Kg/year)
1	Baraka	Kivu	Karongi	34	912	31,980
2	Rwafil Ltd	Muhazi	Kayonza	26	2,000	36,400
3	Fresh Fish Ltd	Muhazi	Rwamagana	2	1,356	47,000
	TOTAL			**62**	**4,268**	**115,380**

Source: RAB, Aquaculture desk office

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Report WCDI-18-022

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To explore the potential of nature to improve the quality of life

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