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BUSINESS CASE FOR FISH MEAL PRODUCTION AND AQUACULTURE IN RWANDA

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SUBMITTED TO

MINISTRY OF TRADE AND INDUSTRY (MINICOM), RWANDA

SUBMITTED BY:

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ABBREVIATIONS

MINICOM	Ministry of Trade and Industry
CAGR	Compound Average Annual Growth Rate
DMRS	Domestic Market Recapturing Strategy
DRC	Democratic Republic of the Congo
EAC	East African Community
FAO	Food and Agriculture Organization of the United Nations
FCR	Food Conversion Ratio
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GoR	Government of Rwanda
HDLV	High Density Low Volume
HS	Harmonised System
IOC	Indian Ocean Commission
kWh	Kilowatt-hour
LDHV	Low Density High Volume
LVFO	Lake Victoria Fisheries Organisation
PAFI	Premier Animal Feed Industries
PAIGELAC	Inland Lakes Integrated Development and Management Support Project
RDB	Rwanda Development Board
RWF	Rwandan franc
UN	United Nations
USD	United States Dollar

1 EXECUTIVE SUMMARY

Over the period 2009 & 2011-2013 Rwanda imported a total of 21.5 million USD worth of dried fish, representing an average annual import value of 5,361 thousand USD. Although Rwanda's imports of dried fish were almost non-existent before 2006, they have grown fast in recent years, with a Compound Annual Growth Rate of 45.7% over the 2009-2013 period.

Virtually all of the dried fish is being imported from the region, in particular from Tanzania and Uganda, and the vast majority of imports consist of small pelagic fish from Lake Victoria called *dagaa*, which are sold in bulk and used either for human consumption or in animal feed production. Some table fish is also imported by Rwanda, in particular Nile tilapia. It can be noted however that about 80% of Rwanda's imports of dried fish are in fact re-exported to DRC through informal cross-border trade.

Although Rwanda's fish production has grown steadily in recent years, it is still low and cannot meet the domestic demand, which is expected to continue growing in the coming years. The country is still a net importer of Nile tilapia, which accounts for more than 90% of consumption on the domestic market. There is however considerable potential for aquaculture growth.

In the light of this situation and in line with the GoR's proposed domestic market recapturing strategy (DMRS), this business case proposes investment in:

1) Commercial production of fishmeal made from locally available small-sized fish species (haplochromines), for both human consumption and animal feed manufacture (as ingredient for the production of feeds for poultry, pigs and farmed fish);
2) Aquaculture of Nile tilapia and catfish. Two options are considered: (i) cage fish farming and (ii) tank-based aquaculture.

The fish meal and fish produced as part of these ventures would not only target the domestic market (and replace a share of Rwanda's current imports of dried fish) but also target export markets, in particular DRC, which takes the bulk of the regional fish trade.

Initial investment and working capital requirements to start the production of 300 tons of fishmeal per year are 424 thousand USD. Initial investment and working capital requirements for the production of 1,200 tons of Nile tilapia through cage fish farming and 300 tons of Nile tilapia through tank culture are 1.56 million USD and 378 thousand USD respectively. Taken together, the total investment cost of the project as proposed in this business case would be 2.36 million USD.

The financial and profitability analysis indicates that the project, as well as each of the three individual components/production units, will be profitable. The average annual sales revenue is estimated at 6.52 million USD – which would also be equal to the net foreign exchange savings, since all inputs would be sourced locally – and the average annual net profit before tax is estimated at 2.62 million USD.

2 SITUATIONAL ASSESSMENT

2.1 Rwanda's imports of dried fish

Over the period 2009 & 2011-2013 Rwanda imported a total of 21.5 million USD worth of dried fish, representing an average annual import value of 5,361 thousand USD (Table 1). Although Rwanda's imports of dried fish were almost non-existent before 2006, they have grown fast in recent years, with for example a Compound Annual Growth Rate of 45.7% over the 2009-2013 period.

Table : Rwanda's net imports of Dried fish (HS 030559)

	2009	2011	2012	2013	Annual average
Value in '000 USD	1,680	5,529	6,659	7,578	5,361
Volume in tons	3,456	10,090	11,206	10,459	8,825

Source: UN Comtrade.

Dried fish imports accounted for close to 90% of all Rwanda's fish imports over the same period (Table 2).

Table : Rwanda's top imports of fish products (HS 0301-0305), in value (USD)

Imported product	2009	2011	2012	2013	Av annual value, 2009 & 11-13	% of total fish imports (HS03-HS05)
030559 Dried fish other than cod, whether/not salted but not smoked	1.679.731	5.529.447	6.658.853	7.577.606	5.361.409	89,3%
030229 Flat fish, fresh/chilled	38.376	191.818	112.770	105.488	112.113	1,9%
030199 Live fish, n.e.s.		182.391	167.418	195	87.501	1,5%
030269 Fish, n.e.s. in 03.02, fresh/chilled	5.966	46.084	260.730		78.195	1,3%
030530 Fish fillets, dried/salted/in brine but not smoked	22.131	87.718	176.023		71.468	1,2%
030379 Fish, n.e.s., frozen		12.386	2.204	210.136	56.182	0,9%
030549 Smoked fish, incl. fillets	2.896	55.581	23.486	121.046	50.752	0,8%
030239 Tunas, skipjack & bonito, fresh/chilled	1.141	112	20.935	83.557	26.436	0,4%
030211 Trout, fresh/chilled	715	6.807	35.131	41.854	21.127	0,4%
030219 Salmonidae, fresh/chilled	70	5.258	3.528	73.844	20.675	0,3%
030429 Fish fillets & other fish meat, frozen fillets	5.271	28.888	39.692		18.463	0,3%
Total HS 0301-0305	**1.826.121**	**6.176.681**	**7.666.317**	**8.357.529**	**6.006.662**	**100,0%**

Source: UN Comtrade.

Virtually all of the dried fish is being imported from within the region, in particular from Tanzania and Uganda (Table 3).

Table : Rwanda's net imports of Dried fish (HS 030559) in thousand USD, by exporting country

	2009	2011	2012	2013	Share of imports (2009-2013)
Tanzania	1,443	4,486	4,597	5,090	72.8%
Uganda	158	912	1,869	2,384	24.8%
Burundi	79	131	193	103	2.4%
World	**1,680**	**5,529**	**6,659**	**7,578**	**100.0%**

Source: UN Comtrade.

Although there is no available disaggregated data showing the type of fish that is imported, sector sources indicate that the vast majority of the imported dried fish consists of small-sized fish, in particular *Rastrineobola argentea*, a small pelagic fish from Lake Victoria, which is called by different names in riparian countries: *dagaa* in Tanzania, *mukene* in Uganda and *omena* in Kenya. Smaller quantities of dried *Limnothrissa miodon* (Lake Tanganyika sardine / *lumpu*) and *Stolothrissa tanganicae* (Lake Tanganyika sprat / *ndagala*), two other small pelagic fishes from Lake Tanganyika, are also being imported from Burundi. The two fish species are similar, differing mainly in size (the Lake Tanganyika sardine being larger) and are generally known collectively in Rwanda as *ndagala*.

Dried *dagaa* is traded by hundreds of small operators around Lake Victoria and finds considerable export markets in the region and elsewhere on the African continent (it is known to be exported as far as South Africa, Malawi and Sudan). There are several *dagaa* trading groups in Rwanda which have working relationships with fishing groups from Tanzania and Uganda. Most of the imported dried *dagaa* is transiting through the area around the Nyabugogo market in Kigali, where it is sold in bulk (packed in large bags of various capacities) to:

(i) Fish traders, who transport and distribute the dried *dagaa* to local markets across the country and beyond (specifically to DRC markets across the border, i.e. Bukavu and Goma);

(ii) Animal feed producers (or farmers that produce their own animal feed), who process the dried *dagaa* into fish flour or fishmeal, which can be used as an ingredient – specifically as a protein supplement – for the production of feeds for poultry, pigs or farmed fish.

Dried *dagaa* can indeed be used either for human consumption or in animal feed production but it is difficult to assess which final use is dominant among Rwanda's imports. Previous studies suggest that a large majority (up to 80%) of the dried *dagaa* sold in Uganda and Tanzania goes into animal feed, but that – with the exception of exports to Kenya – about 80% of the *dagaa* exported by Uganda and Tanzania is used for human consumption in destination countries[1]. However, no reliable estimates are available in the specific case of Rwanda's imports. Regarding the imported dried *ndagala* from Burundi, which fetches higher prices than dried *dagaa*, it is largely used for human consumption.

It can also be noted that a significant share of the imported dried small-sized fish is in fact only transiting through Rwanda to reach eastern DRC markets. Some studies estimate that up to 80% of the imported *dagaa* from Lake Victoria is in fact re-exported to DRC through informal cross-border trade at the Cyangugu/Bukavu and Gisenyi/Goma border points[2].

In addition to the above-mentioned small-sized fishes, the following fish species are also imported by Rwanda in dried form:

- *Lates niloticus L.* (Nile perch);

[1] Legros, Luomba (2011) "Dagaa Value Chain Analysis And Proposal For Trade Development", Smartfish Programme, Report SF/2011/19, August 2011.
[2] Idem.

- *Oreochromis niloticus L.* (Nile tilapia);
- *Clarias gariepinus* (Catfish).

However only small quantities are recorded as these 3 fish species are mostly imported fresh, chilled or frozen, rather than in dried form. All these fish species are imported from Tanzania and Uganda and are used for human consumption.

2.2 Domestic Fish Production

Fisheries has played so far a very minor role in the country's development and accounted for only 0.3% of GDP in 2012. Rwanda's fish production is still low but is growing quickly. Most of the production comes from capture fisheries as aquaculture only started recently in Rwanda. In 2012, capture fisheries accounted for 97.4% of the domestic fish production while aquaculture only contributed to 2.6% (Table 4).

Table : Domestic production of freshwater fish 2008-2012, in volume (tons)

	2008	2009	2010	2011	2012
Capture fisheries	11,587	11,552	13,000	17,159	19,475
Aquaculture	60	60	100	265	516
Total	**11,647**	**11,612**	**13,100**	**17,424**	**19,991**

Source: FAO.

According to sector sources, the total domestic fish production has further grown since 2012 and is currently around 30,000 tons per year. The share of aquaculture has also continued to grow.

2.2.1 Capture fisheries

Fishing is conducted on a total of 17 inland lakes but is largely confined to the lakes of Kivu, Cyohoha and Mugesera. Lake Kivu accounts for about 70% of domestic production. The lake fisheries are all artisanal in nature and the main fish species caught are:

- *Limnothrissa miodon* (*Isambaza*);
- *Haplochromis spp* (Haplochromines);
- *Oreochromis niloticus L.* (Nile tilapia);
- *Claries gariepinuss* (Catfish).

Isambaza is the same small pelagic fish species (*Limnothrissa miodon*) as the one which is imported from Burundi and locally known as *ndagala* as mentioned earlier. It was introduced from Lake Tanganyika to Lake Kivu in 1958 and today constitutes the mainstay of Lake Kivu's fisheries production, accounting for 49% of the total annual commercial catch (2,534 tons) and 65% of the total annual beach value (4,669 million RWF).

Isambaza is largely used for human consumption and fetches higher prices than *dagaa* (*isambaza*'s mean beach price was 1,843 RWF/kg in 2014[3] and it is sold dried on markets at around 3,000 RWF/kg, while dried *dagaa* is sold at 2,000 RWF/kg). Consumers generally prefer *isambaza* (or *ndagala* from Burundi) to the *dagaa* imported from Lake Victoria, as the latter is considered to contain more sand. The fish is in particular appreciated by Congolese consumers, with close to 70% of the *isambaza* caught in Rwanda being exported to DRC through cross-border informal

[3] Mbabazi, Dismas (2014) "Sustainable Capture Fisheries Production And Suitability For Cage Fish Farming In Lake Kivu, Rwanda", Final Report, October 2014.

trade. It can be noted that a small share of the dried *isambaza* is ground to a meal and packed in small plastic bags: the product is well accepted and commands a good price. However, dried *isambaza* or fishmeal made out from *isambaza* cannot compete on price with dried *dagaa* as it is significantly more expensive. Moreover, *isambaza* fishing efforts have increased steadily in recent years and annual catches which were also rising are now stagnating: therefore there seems to be limited scope to increase further the production of dried *isambaza*.

Whereas *isambaza* is only one species, the **haplochromine** group consists of several species of small pelagic fishes. Also, unlike *isambaza*, haplochromines are endemic to Rwanda and are present in all Rwandan lakes, accounting for about 45% of Rwandan lakes' ichthyofauna. Haplochromines are used for human consumption but as the fish has a high percentage of bones, consumers prefer *isambaza* (or the imported *ndagala*). As a result, haplochromines fetch lower prices than *isambaza*. For example, on Lake Kivu haplochromines accounted for 47% of the total annual commercial catch (2,450 tons) but only 32.8% of the total annual beach value (2,351 million RWF), i.e. a mean fish price of 960 RWF/kg[4]. The haplochromine fishery has increased significantly on Lake Kivu in recent years (annual captures amounted to only 1,500 tons in 2005 according to FAO), but haplochromines remain underexploited in other Rwandan lakes. It is estimated that up to 1,300 tons of haplochromines per year can potentially be exploited in Rwandan lakes other than Lake Kivu.

Given haplochromines' lower value and potential for increased exploitation, there is consequently more potential for haplochromines rather than *isambaza* to compete with the imported dried *dagaa* and replace a share of the imports. In terms of commercialisation, given the species' high percentage of bones the most promising option would be to process the haplochromines into fish flour or fishmeal, which could be used for both human consumption and animal feed manufacture (fishmeal can indeed be made from almost any type of seafood but is generally manufactured from small fish species with a high percentage of bones and oil that are not deemed suitable for direct human consumption). Since about 80% of the dried *dagaa* is in fact re-exported to DRC, there is also potential to export this fishmeal to DRC markets.

Finally, while **Nile tilapia** and **catfish** account for a very small share of captures on Lake Kivu (Nile tilapia accounted for only 0.8 % of the total annual commercial catch in 2014, i.e. 41 tons and no catfish captures were recorded), the two fish species account for about 90% of the catch in other Rwandan lakes and ponds. According to the FAO, the annual catch of Nile tilapia and catfish in Rwanda amounted in 2005 to 2,500 tons and 500 tons respectively.

2.2.2 Aquaculture

Following the realization that capture fisheries only could not be sufficient to provide enough fish to the growing Rwandan population, numerous schemes to develop aquaculture have been initiated in recent years in Rwanda, in particular under the PAIGELAC programme, which was funded by the African Development Bank and ended in December 2012. Several pilot aquaculture projects have been launched and in particular cage fish farming has been introduced. However, the aquaculture sector is still in its initial stage of commercial production and fish farming is still for many fish farmers only a part time or subsistence activity. Fish farming requires investment and many of the existing fish farming groups do not have the resources to invest in major commercial production. In spite of the considerable potential for aquaculture growth in Rwanda, private investment in the sector has been limited so far.

[4] Idem.

The two fish species cultivated in Rwanda's aquaculture sector are Nile tilapia and, to a lesser extent catfish. Both species are only used for human consumption. Since Nile tilapia has a wider acceptability in the country and foreign markets and fetches high prices (with a farm gate/beach price of RWF 2,000/kg), Nile tilapia is the most cultivated fish species among Rwandan fish farmers. Another advantage of Nile tilapia is that the fish is very accommodating in terms of fish feed. However, although Rwanda's Nile tilapia production is on the rise thanks to aquaculture, the country is still a net importer of Nile tilapia. Catfish farming is arguably better suited to Rwanda's climate, but marketing is more challenging. Nevertheless, catfish products have the potential to fetch higher prices than Nile tilapia in specialized market niches throughout the region as catfish is considered a delicacy in some markets (e.g. DRC, Sudan, Central and West Africa).

2.3 Proposed investment

In the light of the situation described above, this business case proposes investment in:

1) Commercial production of fishmeal from haplochromines, for both human consumption and animal feed manufacture (as an ingredient in the production of feeds for poultry, pigs and farmed fish);
2) Aquaculture of Nile tilapia and catfish. Two options are considered: (i) cage fish farming and (ii) tank-based aquaculture. Both methods have already been tested successfully in Rwanda.

The fish meal and fish produced as part of these ventures would not only target the domestic market (and replace a share of Rwanda's current imports of dried fish) but also target export markets, in particular DRC, which takes the bulk of the regional fish trade.

3 PROPOSED PRODUCTION IN RWANDA

3.1 Outline of Production Process

3.1.1 Haplochromine fishmeal

In the start-up phase of the project, the producer of fishmeal could source the raw material (fresh haplochromines) by purchasing it from fishermen who are organised into cooperatives. Later, as business develops, investment in fishing vessels and setting up their own fishing units would be recommended. Such vertical integration would provide more control to the processor over the quality of their fish and help to guarantee volumes available for processing.

In this context, we present in this section the entire production process, from the fishing activity to the actual processing of the fish into fishmeal.

3.1.1.1 Haplochromines fishing

While *isambaza* is caught using a light attraction method[5], haplochromines are generally caught in Rwanda using either small seine nets or multifilament gillnets with manually propelled single boats manned by two to five fishermen. It can be noted that the use of gillnets is also the preferred fishing method to catch Nile tilapia and hence catches of haplochromines by gillnets are in fact generally the product of fishing units targeting both Nile tilapia and haplochromines.

However, with a view to targeting specifically haplochromines, the use of gillnets does not appear to be the most suitable option. Given the small size of the fish, unravelling of the net would prove complicated and the mesh size, which would need to be small, would be a danger for juvenile Nile tilapia. The most appropriate method is purse seine fishing which has already been tested successfully on Lake Muhazi to target specifically haplochromines. In this instance, a 100m long and 6m deep seine net with 5mm mesh size was used.

Fishing can be done during both day and night but experience shows that higher catches can be achieved during the night. On Lake Muhazi, catches were for example estimated to be on average close to ten times higher by night. For 1 boat manned by 5 fishermen, catches of 10.3kg per fishing trip were recorded by night, against only 1.3kg per fishing trip during the day.

3.1.1.2 Processing into fishmeal

Fish meal is a solid product obtained by removing most of the water and some or all of the oil from fish. It is generally sold as powder and can be used as ingredient in animal feed production or, if produced under satisfactorily hygienic conditions, as fish protein concentrate intended for human consumption.

There are several ways to make fish meal from raw fish. The simplest way is to let the fresh fish dry in the sun, using drying racks, and then process the dried fish into fish flour /fish powder, using a hammer mill[6].

However, in order to produce a higher quality product a more modern industrial approach to produce fish meal would consist in cooking, pressing, drying and grinding the fish in machinery specifically designed for the purpose. The main processing stages can be described as follows:

- **Cooking**: the fish are cooked in a commercial cooker, which consists essentially of a long steam jacketed cylinder through which the fish are moved by a screw conveyor. This stage is crucial because if the fish are incompletely cooked, the liquor cannot be pressed out satisfactorily and if overcooked, the material becomes too soft for pressing. No drying occurs during this stage.
- **Pressing**: the fish are conveyed through a perforated tube whilst being subjected to increasing pressure, usually by means of a tapered shaft on the screw conveyor. A mixture of water and oil is squeezed out through the perforations and the solid, known as press cake, emerges from the end of the press. During this stage, the water content may be reduced from about 70% to about 50%, and the oil content reduced to about 4%.

[5] This fishing method involves the use of lift nets supported by trimaran fishing crafts fixed with kerosene pressure lamps which attract the *isambaza*. Some other gears may also be used in combination with lights e.g. small seine nets. This is a night fishing method.

[6] Several types of dry mills are available on the market, but given the need for high rates of throughput and ready access for cleaning, hammer mills have proved particularly suitable to grind dried fish.

- **Drying**: the press cake is dried using either a direct dryer (very hot air at a temperature of up to 500°C is passed over the material as it is tumbled rapidly in a cylindrical drum) or an indirect dryer (a steam jacketed cylinder or a cylinder containing steam heated discs, which also tumbles the meal, is used).
- **Grinding**: the last stage is grinding to break down any lumps and particles of bone.

Upon completion of this process, the final product can either be packed into bags or stored for bulk delivery.

The relationship between the weight of fresh haplochromines and that of dried haplochromines is 4 to 1. Therefore, an annual production of 1,000 tons of fresh haplochromines would allow the production of 250 tons of dried haplochromines or haplochromines fish meal / fish flour per year.

Finally, it can be noted that an intensive dried fish / fishmeal production could result in overfishing of haplochromines, so fishing efforts and their impact on haplochromines resources need to be closely monitored.

3.1.2 Aquaculture of Nile tilapia and catfish

Three types of aquaculture are being practised in Rwanda: pond, cage and tank culture. Pond culture was the first aquaculture method to be introduced in Rwanda (as early as the 1950s) and is still the dominant method, followed by cage fish farming which is on the rise. The development of tank-based culture has been limited so far: only the company Lakeside Fish Farm is involved in the production of fish (specifically Nile tilapia and catfish) through tank systems.

We present in this section the production processes of the two methods that we are recommending in the context of this business case – cage and tank culture – which are both more suitable than ponds for intensive culture. Following the presentation of the two methods, we also provide an overview of the key risks related to aquaculture.

We suggest that the production focuses at first on the culture of Nile tilapia and expands in the medium term to catfish production. Both fish species have known qualities for cage culture as well as tank culture. The recommendation to start with Nile tilapia is based on the fact that it has a wider acceptability on the domestic and foreign markets and fetches higher prices. Besides, Nile tilapia is known to be one of the easiest and most profitable fish to farm due to its omnivorous diet, mode of reproduction (the fry do not pass through a planktonic phase), tolerance of high stocking density and rapid growth. Finally, as mentioned earlier, in spite of an existing domestic production Rwanda is currently a net importer of Nile tilapia. Regarding catfish production, as mentioned earlier it also has significant potential due to specialized market niches throughout the region but more marketing efforts will be needed.

3.1.2.1 Cage culture

Cage fish farming consists in raising fish in containers ("cages") enclosed on all sides and bottom with mesh material that secures the fish inside while allowing relatively free water exchange with the surrounding environment. Cages can be made of various materials and the mesh size of the nets depends on the type of fish that is being cultivated (i.e. the smaller the fish, the smaller mesh

should be in order to guard against escape). Compared to other fish culture methods, cage culture has several advantages:

- Cage culture can be carried out in lakes, ponds, rivers, or any existing water body;
- The required start-up capital is relatively low;
- Feeding, monitoring and harvesting operations are relatively simple; and
- Total harvesting and a quick return on investment with limited manpower requirements can be achieved.

Cage culture should be based only on native or naturalized fish species, which both Nile tilapia and catfish are. As mentioned earlier, cage fish farming has recently been introduced in Rwanda to cultivate Nile tilapia. This species is grown in a floating cage system which can be summarised as follows:

- Fish cages, aimed at containing and protecting fish until they are mature for harvesting, are placed in lakes;
- Fish seed (fingerlings) is then stocked in cages, artificially fed (generally 3 times a day) with fish feed in the form of floating pellets, and harvested when the fish has reached acceptable market size (harvesting generally takes place every 6 months).

The two main inputs in the production process are therefore fish seed and fish feed, which we analyse in more detail in section 3.2.

Cages do not need to be large in size as in general the optimum production density decreases with increasing cage volume. Two main types of cages can indeed be distinguished:

- Low Density High Volume (LDHV) cages, which are more suitable for calmer waters in the bays;
- High Density Low Volume (HDLV) cages, which are more suitable for use in open waters (offshore).

Rwanda's Master Plan for Fisheries and Fish Farming (2011) recommended the use of HDLV cages as the most suitable for upstart aquaculture development, given the lower cost of these cages and the fact that they been tested successfully in developing countries including neighbouring Uganda. However, the recent study on the suitability of cage fish farming on Lake Kivu noted that there would also be potential on that lake for LDHV cages and in general for deeper cages to take advantage of the deep oxycline. The study recommended a minimum size of 5m by 5m by 5m for HDLV cages and a standard size of 5m to 10 m in depth and 7m to 10m in diameter for LDHV cages (and specified that in the case of Nile tilapia the stocking should not exceed 300 fingerlings per cubic meter for HDLV cages, and 150 per cubic meter for LDHV cages)[7]. In any event, it is recommended that cages are placed where the depth of water is at least two times the depth of the net cages.

Under the production process described above, Nile tilapia may grow from 15 g to 500-600 g over a period 6 months, which is much faster than in pond culture, where it generally takes over 12 months for Nile tilapia to attain the same weight. However, the growth of the fish depends on several factors. These include the quality of the fish feed and how it is fed (inexperienced farmers tend to overfeed or underfeed their fish); biotic factors such as water temperature (if the water temperature is low, it may take more than 6 months for the Nile tilapia to reach marketable size, even up to year); and water quality (good water quality is important in any type of aquaculture but particularly significant for cage systems because of the confinement and density of fish).

[7] Mbabazi, Dismas (2014) "Sustainable Capture Fisheries Production And Suitability For Cage Fish Farming In Lake Kivu, Rwanda", Final Report, October 2014.

There is significant capacity for increased cage fish farming activities in Rwanda. On Lake Kivu alone (the largest lake), the carrying capacity for cage culture production was recently estimated at 60,073 tonnes for the Rwandan portion of the lake, "with a provision for upward review of the production levels based on the results of regular monitoring of the water quality and socio-economic parameters during the cage culture operations"[8]. In addition to Lake Kivu, other suitable areas for fish production through cage based fish culture have been identified in the Master Plan for Fisheries and Fish Farming, in particular Lakes Burera and Ruhondo, but their respective carrying capacities have yet not been assessed in detail.

3.1.2.2 Tank-based culture

Tank culture is a fast growing branch of aquaculture, which consists in raising fish in tanks that are supplied with clean water. The tanks can be made using various materials, ranging from concrete, fiberglass, metals to high density poly-fibre, supported by wooden or metallic frames – however, the most durable tank materials are concrete and fiberglass.

Fish such as Nile tilapia and catfish grow well at high densities in the confinement of tanks when good water quality is maintained, which is accomplished by aeration and frequent or continuous water exchange to renew dissolved oxygen supplies and remove wastes. Tank systems that discard water after use are called flow-through systems while those that filter and recycle water are referred to as recirculating systems. The two methods can be summarised as follows:

- **Flow-through systems** (also referred to as Raceways): The water is drawn from the supply, used in the tanks and finally discharged into the natural drainage system. Before it is discharged, the effluent water should be filtered in line with environmental management requirements. An option is for example to divert water from a river source, use it to rear fish in the tanks and then discharge it back into the main river through a constructed wetland or water treatment system.
- **Recirculation systems** (also referred to as Water reuse systems): The water from the rearing units is filtered and reused. Since fish live in water, obtain feed from water and discharge wastes into the same water, it is crucial that the quality of water is continuously purified and monitored to ensure that adequate water standards are maintained. Water filtration entails removal of particles and dissolved compounds such as ammonia from the water. In some operations, filtration includes degassing, aeration and disinfection mainly with UV radiation: for these systems, the availability of a reliable energy source is a prerequisite.

As highlighted in the Master Plan for Fisheries and Fish Farming, several factors suggest that recirculation/water reuse systems might be more suitable than flow-through systems in the case of Rwanda:

> *"Aquaculture production requires availability of clean water with respect to dissolved oxygen, pH and conductivity. With the increasing human population, water requirements in Rwanda for domestic use and livestock are likely to rise. The situation is compounded by destruction of forests and wetlands along water catchments. As a result, many natural water bodies dry up or their water volumes reduce drastically during dry seasons. Removal of water retention vegetation along catchment areas leads to heavy silted runoffs that pollute waters and make them unsuitable for aquaculture. Rwanda Environment Management Authority (REMA) regulations require that water effluents from fish farms are filtered before discharge into the natural drainage system. All these factors combined justify the need for water re-use."*

[8] Idem.

In any event, tank culture is recommended for areas equipped with infrastructure for supply of water for production and is appropriate for peri-urban and urban aquaculture production. Several potential sites for tank-based culture (for both flow-through and recirculation systems) have already been identified in the Master Plan.

Tank systems generally allow for more intensive aquaculture and can produce very high yields on small parcels of land. While tank-based culture requires more technical expertise and is more capital intensive (initial investment costs are higher) than cage fish farming, production costs are generally lower over the longer term. The reason for this is that the food conversion rate (FCR) is generally better in tank aquaculture than in cage fish farming (if well managed, the FCR for tank aquaculture can be as low as 1.2 while the FCR for cage fish farming generally ranges between 1.5 and 2). In other words, less fish feed input (the most important cost factor in aquaculture, accounting for up to 70% of production costs) is required to produce an equivalent volume of fish.

Another advantage of tanks over cage systems, is that they allow fish farmers to exert a higher degree of control over parameters such as water temperature, dissolved oxygen, pH and waste, which can therefore be adjusted for maximum production. Control of water temperature is in particular beneficial since as mentioned earlier the growth of Nile tilapia can be significantly reduced by low temperature and given the relatively low temperature in Rwandan lakes, this could be an issue in cage culture. The optimum temperature of Nile tilapia growth is 25-30°C, but the water temperature of Lake Kivu, for example, is estimated to vary between 23 and 25°C, which is still acceptable, but slightly below optimal for Nile tilapia.

The disadvantages of tank culture systems are related to the significant investment in technology and skills that are lacking in the country. The cost of pumping water and aeration is a significant cost factor. The filtration technology of recirculating systems can in particular be fairly complex and expensive, and requires constant and close attention. Also, any tank system that relies on continuous aeration or water pumping is at risk of mechanical or electrical failure and major fish mortality – therefore backup systems are essential.

Finally, it can be noted that recirculation systems can be combined with cage culture. For example, recirculation systems can be used for incubation of the younger specimens while cages are used to continue the fattening of the fish.

3.1.2.3 Key risks related to aquaculture

Several key risks can be highlighted:

a. Risk of loss from poaching or damage from predators or storms

This risk mainly concerns cage culture. Indeed, cages can act as a magnet to a wide range of fish-eating vertebrates – fish, reptiles, birds and mammals – which are attracted by the large numbers of readily detected fish (as well as by the bags of fish feed, if they are left unprotected on the cage walkways). Not only does this constitute a direct threat to the farmed fish, but unsuccessful predators may also damage the mesh material enclosing the cages, which can lead to fish escape and therefore potential large-scale losses, in particular in the case of high-density culture. Even though there are fortunately no large predators in Lake Kivu and other Rwandan lakes, it is therefore recommended that all cages are equipped with specific anti-predator nets.

Rough weather may also damage the netting or mesh and lead to fish escape. The potential for storm damage to cages set over deeper waters is generally greater than for those close inshore where there is more protection. In this context, it might be preferable to start off with inshore (and possibly low density to reduce the risk) cages and once all issues with that system under those conditions are resolved, move into the more technically demanding offshore high density systems.

Regarding (outdoor) tank culture, the above risks are not as great because it is easier to keep the tanks free from predators (e.g. birds) and the fish cannot escape from tanks. Nevertheless, the use of predation protection methods such as nettings, enclosures, covers or wires, is also recommended.

b. Risk of disease outbreaks

Diseases represent one of the major risks in aquaculture operations. Although Nile tilapia are generally known to be more resistant to viral, bacterial and parasitic diseases than other commonly cultured fish species, especially at optimum temperatures for growth, disease outbreaks remain a significant risk and can potentially lead to large scale losses.

Cage culture generally carries more risk of disease than tank culture and an intensification of cage culture production may increase disease outbreaks risks. The recent study on the suitability of cage fish farming on Lake Kivu noted the following on the subject of diseases:

> *"There is real threat to fish disease with intensification of production in the cages which may also impact the related or unrelated species within the lake. (…) Chances for disease incidence and outbreaks in caged fish are most likely caused by bad management or poor husbandry practices as the disease-causing organisms are often ubiquitous and cause few problems until the fish are stressed through inadequate dietary or environmental conditions. Within Lake Kivu, there has not been any report of mass fish mortalities and the lake is generally considered to have environmentally balanced state between fish and the disease causing organisms that can impact caged fish owing to there being no known external stress factors that may cause the imbalance and trigger the disease causing organisms on. However, the introduction of large numbers of fish in enclosures to a system can have a dramatic effect on disease agents. Diseases from outside the enclosure site can easily be introduced by transporting fingerlings/fry from other areas in the country, or importing fish from abroad without proper precautions being taken. It is therefore, imperative that the sources of stocking material have veterinary clearance to avoid incidences of transfer of disease causing agents to the lake environment."*

Since high density culture carries more risk of disease, as mentioned earlier it might be preferable – for both cage and tank culture – to start off with low density systems and once the production technique is optimised, move into high density systems.

Overall, disease occurrences can be reduced by good management practices, including careful control of stocking density, water quality and nutrition that minimizes stress of fish and maintain healthy populations in the culture environment. In addition, regular disease monitoring of stock is essential to be able to effectively treat the stock in the event of an outbreak.

c. General business risks

Finally, there are also business risks as the profitability of an aquaculture operation can vary significantly depending on various parameters including the quality of management practices. The

main challenge is that fish raising is a living system and a learning process is generally necessary before production techniques can be fully optimised. For example, as mentioned earlier whereas experienced farmers have learned to administer the optimal quantity of feed, inexperienced farmers tend to overfeed or underfeed their fish, which in both cases can have a significant impact of the profitability of the operations:

- Underfeeding negatively affects the growth of the fish, which in turn negatively affects the output and therefore sales revenues;
- Overfeeding may raise significantly the production costs (since fish feed is the main cost factor) and therefore negatively affect the profit margin.

Production costs tend to be higher during the set-up phase of new aquaculture ventures because production techniques have not yet been optimised (and in some cases, economies of scale have also not yet been achieved).

In this context and given the current lack of available vocational training dedicated to aquaculture in Rwanda, it could be beneficial to complement the project with corresponding training (e.g. capacity-building in aquaculture technologies, water quality control, disease prevention, construction and water management, feeding, harvesting and overall farm management).

3.2 Input sourcing

This section focuses on the two main inputs for aquaculture, i.e. fish seed and fish feed.

Regarding the production of fish meal, the single input is fresh haplochromines, which can be sourced directly from fishermen/fishers' cooperatives (or caught directly by the fish meal processor, if it invests in fishing vessels and sets up its own fishing units), as already discussed in section 3.1.1.

3.2.1 Fish seed

Fish seed (fingerlings) used to be all imported from neighbouring countries (in particular from Uganda), but can now be sourced locally. There are two domestic producers and distributors of fish seeds:

- Kigembe Fish Farm, a Government-owned tilapia hatchery which was recently rehabilitated and has a capacity to produce at least 10 million Nile tilapia fingerlings annually. Fish farmers can source the fingerlings produced by Kigembe Fish Farm through the Rwanda Agriculture Board (RAB).
- Lakeside Fish Farm, a private aquaculture firm based near Lake Mugesera, which is producing fingerlings for its own activity and for other fish farmers. Lakeside Fish Farm has broodstock on reserve, hatchery equipment and fry ponds and a capacity to produce 6 million fingerlings per year. It has the capacity to produce both Nile tilapia and catfish fingerlings but currently only commercialises Nile tilapia fingerlings.

Some other domestic fish farmers are cultivating fingerlings for their own activity but do not commercialise them.

However, if aquaculture keeps growing in Rwanda, additional investment in the production of fish seed will probably be needed in the future.

3.2.2 Fish feed

Concentrated fish feed is the main input for aquaculture as well as the largest cost factor, accounting for up to 70% of production costs. Fish feeds are in high demand in Rwanda and their sourcing has long been the most significant constraint for the development of aquaculture in the country as until recently fish feeds could not be sourced locally. As a result, fish farmers had to import them from Uganda (from the company *Ugachick*) at the high cost of between 1.5 and 2 USD/kg. Some domestic fish farmers have in recent years started producing fish feeds in Rwanda (for their own activity but also for other fish farmers) but their output is limited. Most fish farmers still seemed to prefer importing feed from Uganda, as this was perceived to be of higher quality[9].

However, the situation is expected to change from now on. A new company entitled *Premier Animal Feed Industries* (PAFI) and specialised in the manufacture of animal feed – including fish feed – was set up in July 2014 and started production in December 2014. PAFI's factory has a capacity to produce 4 tons of animal feed per hour and is expected to be able to cover the domestic demand (PAFI intends to focus first on the domestic market and then at a later stage, target export markets such as Burundi).

Fish feed, like other animal feeds, is made from a wide range of ingredients such as maize bran, wheat bran, soybean meal, cassava flour, vitamin and mineral premixes, etc., including fishmeal which usually accounts for a small share of the content, between 5 and 15%. PAFI indicates that 90% of their inputs – including dried fish which is used to provide the fishmeal ingredient – are currently being imported (only cassava flour is sourced locally). This is an opportunity for the fish meal production proposed as part of this business case, as it could supply PAFI with locally made fish meal.

PAFI has formulated and started commercialising to sell two types of fish feed products (in the form of floating pellets):

- 1 product for juvenile fish (fingerlings), sold at 900 RWF per kg (i.e. about 1.3 USD/kg);
- 1 product for mature fish, sold at 500 RWF per kg (i.e. about 0.75 USD/kg).

The prices above are thus much lower than the cost of fish feed imported from Uganda. Moreover, Rwandan fish farmers that had the opportunity to test the PAFI samples confirmed the quality of their products, and PAFI's products were perceived to be of higher quality than the *Ugachick* products. The start-up of this new animal feed factory is therefore a positive development for aquaculture growth in Rwanda because it is crucial for intensive fish farming practices to have access to quality fish feeds at an affordable price.

The food conversion rate (FCR) of fish production, that is the number of kgs of feed to produce 1 kg of fish, is generally more efficient than the FCR of land based animal production systems. However, the FCR of fish production also varies depending on the quality of the fish feed, the management[10], environmental conditions and the type of aquaculture. The average FCR for cage fish farming is around 1.5 (but can go up to 2.0), while the average FCR for tank culture is around 1.2. As the actual cost of the feed largely determines the profitability of fish farming, the

[9] It must be noted however, that these fish farmers were not entirely satisfied by the quality of the fish feed from Uganda either. Some farmers noted that fish feeds of higher quality could in principle be sourced from countries such as Mauritius or Israel, but these were even more expensive (2 USD/kg or more) so they were importing from Uganda by default.

[10] Inexperienced farmers tend to overfeed or underfeed their fish, whereas experienced farmers have learned to administer the optimal quantity of feed.

FCR should preferably be low, to reduce the costs of production. Previous sensitivity analyses have shown that FCR in cage culture should be below 2 to be profitable.

3.3 Costing & Pricing

3.3.1 Costing

3.3.1.1 Haplochromine fishmeal

As mentioned earlier, the simplest way to produce fish meal would consist in letting the fresh fish dry in the sun, using drying racks, and then process the dried fish into fish meal, using a hammer mill. This method would require two main types of equipment, drying racks and a hammer mill, which are relatively inexpensive (the unit cost for a drying rack would be 1,700,000 RWF, i.e. about 2,460 USD, while the unit cost for a hammer mill with a capacity of 3 tons per day would be 2,000,000 RWF, i.e. about 2,900 USD).

However, in order to produce a higher quality product, which would be more suitable to target not only the market segment for animal feed manufacture but also the market segment for human consumption, we recommend the modern industrial approach to produce fish meal which consists in cooking, pressing, drying and grinding the fish. This method requires the acquisition of machinery specifically designed for the purpose.

Several types of machines can be used and combined to process fishmeal, but we recommend the use of a packaged fishmeal plant, which combines all processes. Compared to other options, it has relatively low installation costs and minimum operation attendance. A small packaged fishmeal production line with a capacity of 300 kg/hour can be purchased and delivered in Rwanda at a total cost around 50,000 USD. As business grows, additional production lines could be set up.

As mentioned earlier, if in the start-up phase the raw material (fresh haplochromines) could simply be sourced from fishermen, as business develops, investment in fishing vessels and set up of own fishing units would be recommended. In this context, additional investment in fishing boats (such as 8m long pirogues, which have a unit cost of 120,000 RWF) and purse seines (such as a 100m long and 6m deep seine net with 5mm mesh size, which has a unit cost of 1,000,000 RWF) would be necessary.

Drawing on the experience of various industry sources, Table 5 presents cost items and indicative costs for producing fish meal from haplochromines in Rwanda. The purchase price of the raw material (fresh fish) indicated in the table below is based on the assumption that since the fish will be bought in bulk and in large volumes, a price significantly lower than the current market price of haplochromines on Lake Kivu could be achieved. Furthermore, it should be noted that the market price of haplochromines on other Rwandan lakes can be significantly lower than the price on Lake Kivu.

Table : Costs associated with the production of fish meal from haplochromines

Item	Unit Cost (RWF)	Unit Cost (USD)
Equipment costs		
Land	3,000,000	4,345
Building and office equipment	2,600,000	3,768
Packaged fishmeal production line (capacity: 300 kg/hr) *(including transportation, insurance, tax and handling)*	34,525,000	50,000
If set up of own fishing units:		
Fishing boat (8m long pirogue)	120,000	174
Purse seine net (100m long x 6m deep, 5mm mesh size)	1,000,000	1,448
Cost of inputs		
Raw material (fresh haplochromines), per kg	600	0.87
Packing material, per kg of product	150	0,22
Labour Rates/month		
Manager	2,000,000	2,896.5
Supervisor	400,000	506.9
Mechanic (Machine maintenance and operation)	175,000	253.4
Security	70,000	253.4
Helpers/Packers	70,000	101.4
Utilities		
Electricity – per kwatts/hour (kwh)	132	0.19
Other Costs		
General Overheads (Admin Staff, transport, etc.)	2% of Turnover	

3.3.1.2 Aquaculture of Nile tilapia and catfish

We present in this section all the costs related to aquaculture production, both for cage culture and tank culture. First, we discuss the costs of the two main inputs for aquaculture, fish seed and fish feed, which are the same for both types of culture. Then we detail the specific costs associated with each type of culture.

Costs of fish feed and fish seeds

As mentioned earlier, fish feed is the largest cost factor in aquaculture and until recently most fish farmers were importing the fish feed from Uganda, which was delivered at a cost between 1.5 and 2 USD per kg. However, with the recent set up of the animal feed factory PAFI, it will now be possible for domestic fish farmers to source quality fish feed locally at a cost of 500 RWF/kg, i.e. about 0.72 USD/kg (and 900 RWF/kg, i.e. about 1.30 USD/kg for juvenile fish), which should improve the competitiveness of Rwanda's aquaculture sector (several studies have pointed out that the cost of fish feed in Rwanda is higher than the regional average).

Fish seed is less costly in relative terms. All fingerlings used to be imported from neighbouring countries but can now be sourced locally at a unit cost of 50 RWF.

Specific costs for cage fish farming

The main equipment needed for cage fish farming are the cages themselves. As mentioned earlier, cages do not need to be large in size as the optimum production density decreases anyway with increasing cage volume. A cage of 5 x 5 x 5 meters dimensions has the capacity to cultivate a total of 9,000 Nile tilapia and produce up to 4 tons of fish at each harvest (i.e. every 6 months). The cages can be assembled locally and the total cost of a fully-assembled 5 x 5 x 5 metre metallic

cage (i.e. the overall structure, equipped with nets and pipes) is 1.8 million RWF (about 2,600 USD). The lifespan of the nets depends on the net quality and may vary from 2 to 5 years.

Additional costs related to cage fish farming include the following:

- Land;
- Building, equipped with office space, storage area (e.g. for fish feed stocks) and cold room;
- Concession fees related to the authorisation to set up cages in demarcated area (to practise aquaculture in public waters a concession contract is required);
- Boat (e.g. pirogue) to be able to access the cages;
- Labour costs: cage fish farming requires in particular labour for stocking, feeding, security, harvesting and marketing;
- Utilities (electricity and water);
- General overheads & miscellaneous (e.g. health/veterinary costs).

Drawing on the experience of existing fish farming activities in Rwanda and other industry sources, Table 6 presents cost items and indicative costs for cage farming of Nile tilapia and catfish in Rwanda.

Table : Costs associated with the cage culture of Nile tilapia and catfish

Item	Unit Cost (RWF)	Unit Cost (USD)
Equipment costs		
Land	3,000,000	4,345
Building & related equipment	2,200,000	3,186
Cage (5 x 5 x 5 m)	1,800,000	2,609
Boat (pirogue)	90,000	130
Concession		
Concession flat fee	35,000	50.7
Cost of inputs		
Fish seed (per fingerling)	50	0.07
Fish feed (per kg)	500	0.72
Labour Rates/month		
Manager	2,000,000	2,896.5
Supervisor	400,000	506.9
Stocking, feeding and harvesting personnel	175,000	253.4
Security personnel	70,000	101.4
Utilities		
Utilities (electricity and water), per month	60,000	86.9
Other Costs		
General Overheads (Admin Staff, transport, etc.)	2% of Turnover	
Miscellaneous (e.g. health/veterinary costs), per month	700,000	1,014

In the medium term, as business grows, additional investment in an ice making machine and a refrigerated vehicle for the commercialisation of products (i.e. to bring the products directly to markets) could be considered.

Specific costs for tank-based farming

Tank-based culture requires more investment than cage culture. In addition to the tanks themselves, which can be made out of concrete or fibreglass, tank culture requires other related equipment such as PVC pipes and fittings, water and air pumps, and aerators/diffusers. Furthermore, operational costs are high due to the need for oxygenation and pumping to maintain water circulation and filtration. On the other hand, tank systems generally allow for

more intensive culture and as mentioned earlier, the food conversion rate is lower than for cage fish farming so less fish feed is required to obtain an equivalent volume of fish.

Tanks for the culture of Nile tilapia can be of different sizes and shapes as long as they allow for the effective removal of waste solids. Various shapes have been used to cultivate Nile tilapia (e.g. square, rectangular, round, oval, octagonal and "D-ended" or "racetrack" configurations), but the most common forms are circular and rectangular. The advantage of circular tanks is that they allow higher water velocities than other tank shapes and tend to be self-cleaning. However, rectangular tanks made of concrete have been widely used in Nile tilapia culture, as they are easy to construct. We suggest in this business case the use of rectangular tank units with 30 x 10 x 1 m dimensions, which at a final stocking density of 50 kg/m3 and a rate of 2 harvests per year, can reach 30 tons of fish per tank annually. For a total annual production of 300 tons, a total of 10 tanks would be necessary. Another option would be circular tanks with a diameter of 16m and a depth of 1m (total volume of 200 m3), which on the basis of 2 harvests per year and a similar final stocking density, could produce 20 tons of fish annually. To attain the objective of a total output of 300 tons per year, 15 of such circular tanks would be necessary. If well managed, higher stocking densities and therefore higher output can be achieved.

Additional costs related to tank-based aquaculture include the following:

- Land;
- Building, equipped with office space, storage area (for fish feed stocks) and cold room;
- Labour costs: the venture would require labour for feeding, water control, harvesting and marketing;
- Concession fees (to practise aquaculture, a concession contract is required);
- Utilities (electricity and water);
- General overheads & miscellaneous (e.g. health/veterinary costs).

Drawing on the experience of existing tank culture activities in Rwanda and other industry sources, Table 7 presents cost items and indicative costs for tank-based aquaculture of Nile tilapia and catfish in Rwanda.

Table . Costs associated with the tank culture of Nile tilapia and catfish

Item	Unit Cost (RWF)	Unit Cost (USD)
Equipment costs		
Land	6,000,000	8,690
Building & related equipment	2,200,000	3,186
Construction of 30 x 10 x 1 m concrete tank	2,485,000	3,600
Installation of water supply and other related equipment, e.g. aerators, diffusers, pumps (cost per tank)	870,000	1,260
Concession		
Concession flat fee	35,000	50.7
Cost of inputs		
Fish seed (per fingerling)	50	0.07
Fish feed (per kg)	500	0.72
Labour Rates/month		
Manager	2,000,000	2,896.5
Supervisor	400,000	506.9
Stocking, feeding and harvesting personnel	175,000	253.4
Security personnel	70,000	101.4
Utilities		
Electricity – per kwatts/hour (kwh)	131.2	0.19
Other Costs		
General Overheads (Admin Staff, transport, etc.)	2% of Turnover	

Miscellaneous (e.g. health/veterinary costs), per month	700,000	1,014

Like cage fish farming, as business grows additional investment in an ice making machine and a refrigerated vehicle for the commercialisation of products (i.e. to bring the products directly to markets) could be considered.

3.3.2 Pricing

Regarding the fishmeal product proposed to be manufactured, a price of 3,750 RWF per kg is considered. As we shall see in the next sections, this level of price allows the production to be profitable and is competitive with the price other fishmeal products available on the domestic market.

Regarding the fish species proposed to be cultivated through aquaculture, the current market prices are the following on the domestic market:

- Fresh Nile tilapia fetch prices ranging between 2,000 and 2,500 RWF per kg;
- Fresh catfish fetch prices ranging between 1,500 and 2,000 RWF per kg (but have the potential to fetch higher prices on export markets).

The price indications above will guide the pricing policy and indeed the unit price of the farmed fish produced in the context of the proposed aquaculture production.

4 MARKET CONSIDERATIONS

4.1 Market Analysis

Due to a lack of fish-eating tradition, Rwanda's fish consumption has historically been low and well below regional averages[11]. However, the domestic demand for fish has grown in recent years, as the nutritional benefits of fish become more apparent to the population. The domestic demand is however still largely un-met, in spite of significant imports. Fish traders confirm an under-supply to the markets, and that the demand is much higher than the supply.

Domestic fish consumption is expected to continue growing in the coming years and therefore the market is expected to grow further in size. According to the Master Plan for Fisheries and Fish Farming "with the projected 16 million people by 2020, the country will need 112,000 tons of fish annually if the population is to catch up with the average fish consumption in Sub Sahara Africa".

However, the potential market for the products proposed to be produced as part of this business case is not restricted to the domestic market but also includes significant export markets, in particular neighbouring DRC, which takes the bulk of the growing regional fish trade. Indeed, a sizable share of Rwanda's current aquaculture production is already exported to DRC (for example, about 60% of the output of the cage fish farming pilot project in Cyangugu is exported

[11] In 2006, Rwanda's fish consumption was only slightly above 1kg per person per year, rising to 1.89kg/year in 2011. This was still well below the levels observed in neighbouring countries: Burundi 3.6 kg/year; DRC 6.9 kg/year; Uganda 10kg/year and Tanzania 11.9 kg/year, with the Sub-Saharan Africa average being 6.6kg/year. However, consumption has increased steadily in recent years and is now estimated to be around 2.5kg per person per year.

to DRC through cross-border trade) and as mentioned earlier up to 80% of the imported dried *dagaa* is in fact re-exported to DRC through informal cross-border trade.

The market for fish products can be divided into two main segments:

- Table fish (large fish), such as Nile tilapia and catfish, which are generally sold fresh and are for human consumption;
- Small-sized fish such as *isambaza* from Lake Kivu, haplochromines, *dagaa* imported from Tanzania and Uganda, *ndagala* imported from Burundi, which are usually sold in dried from and can be used both for (i) human consumption and (ii) as ingredient in animal feed manufacture.

The table fish segment is largely dominated by Nile tilapia, which accounts for more than 90% of consumption on the domestic market. Catfish only accounts for a small share of the domestic consumption but lucrative market niches for catfish exist throughout the region, in particular in DRC. This segment is currently driven by high prices, with fresh Nile tilapia fetching prices from 2,000 to 2,500 RWF per kg (and Nile tilapia fillets fetching prices from 4,500 to 5,000 RWF per kg). Fresh catfish fetches a price between 1,500 and 2,500 RWF per kg on the domestic market but has the potential to fetch higher prices on export markets. Nile tilapia is generally sold fresh while catfish is often sold smoked.

The small-sized fish segment has experienced strong growth in recent years, as evidenced by the striking rise of dried fish imports since 2009.

Regarding the sub-segment of small dried fish for direct human consumption, the market growth (both domestic and regional) can be explained by factors such as the increased awareness on the nutritious value of small fishes, the declining catches of table fishes as well as the increase in population. Three main types of dried fish are commercialised at the domestic level in this sub-segment: the local *isambaza* from Lake Kivu, the imported *ndagala* from Burundi and the imported *dagaa* from Tanzania and Uganda. These 3 products fetch very different prices: as an example, on local markets dried *isambaza* is sold at a price ranging from 3,000 to 4,000 RWF/kg, while *ndagala* and *dagaa* fetch on average 5,500 and 2,000 RWF/kg respectively. Consumers generally prefer *isambaza* or *ndagala*, which are perceived to have a better taste and be of higher quality[12], but *dagaa* constitutes a cheaper alternative for low-income earners and thus captures a large market share.

Regarding the sub-segment corresponding to dried small fish for use in animal feed manufacture, the market growth is the direct result of an increase in animal husbandry (including fish farming) activities in Rwanda, which increased the demand for animal feed and in turn the demand for dried fish that can be used to produce fish meal. This sub-segment is largely dominated by dried *dagaa* imported from Tanzania and Uganda, because of to the low cost of the fish. *isambaza* and *ndagala* cannot compete with *dagaa* on this sub-segment, because manufacturing animal feed using *isambaza* or *ndagala* would be too costly.

Finally, it can be noted that while the market for dried fish is very large, on the other hand very little fishmeal (dried fish processed into to fish flour or powder) is currently available on the domestic market. The Kibuye fishing project on Lake Kivu is the only domestic producer of fishmeal: their product is made from *isambaza* and is for human consumption. As mentioned earlier, the product is well accepted and commands a good price, but this is a small-scale operation with limited output that accounts for a very small share of the potential demand. In

[12] As mentioned earlier, *isambaza* and *ndagala* are in fact the same fish species.

addition, small quantities of fishmeal aimed at human consumption are also being imported from Uganda and fetch a high price (sold at around 5,000 RWF/kg in Kigali shops).

4.2 Clients

For fishmeal production, the potential clients will include:

- **Animal feed producers**, as well as farmers who produce their own animal feed: in addition to the company PAFI presented in section 3.2.2, there are several other small-scale animal feed producers in Rwanda, mostly based in Kigali, which are producing feeds for animal husbandry (poultry and pigs). All these animal feed manufacturers are currently using imported dried *dagaa*, which, after grinding themselves the dried fish, they use as ingredient in their animal feed. The proposed haplochromines fishmeal production would allow these animal feed producers to source the fishmeal locally.
- **Direct consumers** (human consumption): produced under satisfactorily hygienic conditions, fishmeal is a fish protein concentrate that can be used as an additive or complement to foods. In particular, it can be mixed with staples such as rice, sorghum or maize meal to make complementary foods for young children.
- **Nutritional centres**: fish protein concentrates such as fishmeal can play an effective role in reducing protein deficiency for population suffering from malnutrition. As mentioned above, fish protein concentrates are in particular beneficial to growing children and can be used in nutritional centres to supplement diets of malnourished children.

Regarding Nile tilapia and catfish produced through aquaculture, potential clients will be **direct consumers** and **regional fish traders** who will distribute the fish to local markets across the country and in the region.

4.3 Competition

Competition for fishmeal production will come mainly from the imported dried *dagaa* from Lake Victoria. Although the two products differ in terms of value addition (fishmeal is processed dried fish and is therefore a step further in value addition), they will be competing against each other since as mentioned earlier a large share of the dried *dagaa* is bought particularly by animal feed manufacturers, with a view to grinding it and obtaining the fishmeal. Furthermore, as we have seen, dried *dagaa* is well established on the regional market. Competition from fishmeal products already being commercialised in Rwanda is expected to be limited because of the small quantities involved.

The competition in aquaculture production will come mainly from the Lake Victoria fish, in particular Nile tilapia, which are imported from Tanzania and Uganda, whether fresh or in dried form.

In this context, public initiatives and campaigns to promote the consumption of fish and fish products (e.g. fishmeal) from Rwanda, in particular within the framework of the Domestic Market Recapturing Strategy, would prove beneficial in assisting the domestic production to better compete against products imported from the region.

5 FINANCIAL & PROFITABILITY ANALYSIS

5.1 Profit Calculation of Fishmeal Production

5.1.1 Calculation of Revenues and Costs

Table 8 provides a profit calculation for one unit producing 300 tons of fishmeal per year. Costs are calculated as follows:

- The operating cost of producing 300 tons of fishmeal per year is 879 million RWF (about 1.27 million USD) [13];
- Investment costs, and hence capital costs, are relatively low. The estimated total investment costs are 72.87 million RWF (105,616 USD) and an annual depreciation of 20% for the equipment has been assumed. Taking into account the depreciation of equipment, capital cost for the first year amounts to 18.7 million RWF (27,152 USD).

With regard to revenues, the main assumptions are:

- Recovery (input/output) rate of 25%, i.e. 1,000 tons of raw material (fresh haplochromines) will allow for 250 tons of fishmeal to be sold;
- The sales price of fishmeal per kg is 3,750 RWF (5.43 USD).

Based on these assumptions, sales revenues per month will be 1,125 million RWF (1.63 million USD) per year. This translates into an annual profit of about 227.6 million RWF (327,593 USD), or a net profit margin on sales revenues of 20.2%.

Table : Costs and revenues associated with the production of 300 tons of fishmeal per annum

			Rwf			USD		
TOTAL COST PER YEAR	**Unit**	**Quantity**	**Unit cost**	**Subtotal**	**Total**	**Unit cost**	**Subtotal**	**Total**
A. Capital cost per year								
A1. Land & Building								
Land	unit	1	3.000.000	3.000.000		4.348	4.348	
Building	unit	1	2.200.000	2.200.000		3.188	3.188	
Total Investment Land and Building				**5.200.000**			**7.536**	
A2. Machines and equipment								
Packaged fishmeal production line FOB	unit	2	22.425.000	44.850.000		32.500	65.000	
Transportation, insurance, tax, handling of the above	%	50	44.850.000	22.425.000		65.000	32.500	
Other equipment (e.g. office equipment)	lump sum			400.000			580	
Total Investment machines and equipment				**67.675.000**			**98.080**	
Total Capital Investment (A1+A2)				**72.875.000**			**105.616**	
Cost of Land and Building (only for Year 1)					**5.200.000**			**7.536**
Depreciation of machines and equipment (cost per year)	% of investment cost			20%	**13.535.000**		20%	**19.616**
B. Other expenses per year								
Maintenance (10% of equipment cost)	%	10	67.675.000	6.767.500		98.079,71	9.808	
General overheads (2% of sales revenues)	%	2	1.125.000.000	22.500.000		1.630.434,78	32.609	
Sub-total					**29.267.500**			**42.417**
C. Direct production costs per year								
Raw materials	kg	1.200.000	600	720.000.000		0,87	1.044.000	
Labour costs:								
Manager	per month	12	2.000.000	24.000.000		2.898,55	34.783	
Supervisor	per month	12	400.000	4.800.000		579,71	6.957	
Mechanic x 2	per month	12	350.000	4.200.000		507,25	6.087	
Helpers/Packers x 4	per month	12	280.000	3.360.000		405,80	4.870	
Security	per month	12	70.000	840.000		101,45	1.217	
Packing material	per kg of product	300.000	150	45.000.000		0,22	66.000	
Electricity	per kWh	345.600	132	45.674.496		0,19	65.664	
Other utilities	per month	12	30.000	360.000		43,48	522	
Miscellaneous	per month	12	100.000	1.200.000		144,93	1.739	
Sub-total					**849.434.496**			**1.231.838**
TOTAL COSTS PER YEAR					**897.436.996**			**1.301.407**

REVENUES PER YEAR	**Unit**	**Quantity**	**Unit price**	**Subtotal**	**Total**	**Unit price**	**Subtotal**	**Total**
Sales per year	kgs	300.000	3.750	1.125.000.000		5,43	1.629.000	
TOTAL REVENUE					**1.125.000.000**			**1.629.000**

PROFIT PER YEAR (BEFORE TAX)	**227.563.004**	**327.593**
Profit margin on sales	20,2%	

[13] The operating cost is calculated here as the sum of direct production costs (B) and other expenses (C).

5.1.2 Working Capital Requirements

The absolute minimum working capital requirement would be for a month of operation, at a total of 73.2 million RWF (106,123 USD). However, depending on the collection, delivery and payment terms of both raw materials and final product, a safer assumption is for working capital to cover at least three months, i.e. 219.7 million RWF (318,370 thousand USD).

5.2 Profit Calculation of Cage Fish Farming

5.2.1 Calculation of Revenues and Costs

Table 9 provides a profit calculation for the production of 1,200 tons of Nile tilapia in cage fish farming (150 cages in total). Costs are calculated as follows:

- The operating cost of producing 1,200 tons of Nile tilapia per year is 1.37 million RWF (1.99 million USD).
- Investment costs, and hence capital costs, are relatively low, as the equipment required is relatively basic. The estimated total investment costs are 275.4 million RWF (399,153 USD) and an annual depreciation of 20% for the equipment has been assumed. Taking into account the depreciation of equipment, capital cost for the first year amounts to 58.95 million RWF (85,346 USD).

With regard to revenues, the main assumptions are:

- Each cage produces 4 tons of Nile tilapia at each harvest and the fish is harvested every 6 months: this means that each cage produces 8 tons of fish per year;
- The average food conversation ratio of 1.75;
- The sales price of Nile tilapia per kg is 2,250 RWF (3.26 USD).

Based on these assumptions, sales revenues will be 2.7 billion RWF (3.9 million USD) per year. This translates into an annual profit of 1.27 billion RWF (1.85 million USD), or a net profit margin on sales revenues of 47.0%.

Table : Costs and revenues associated with the production of 1,200 tons of Nile tilapia per annum in cage fish farming

			Rwf			USD		
Direct input costs per cage / per year	**Unit**	**Quantity**	**Unit cost**	**Subtotal**	**Total**	**Unit cost**	**Subtotal**	**Total**
INPUTS								
Raw materials								
Fish seed	fingerling	18.000	50	900.000		0,07	1.260	
Fish feed	kg	14.000	500	7.000.000		0,72	10.080	
Sub-total					**7.900.000**			**11.340**
DIRECT INPUT COST PER CAGE PER YEAR					**7.900.000**			**11.340**

TOTAL COST PER YEAR	**Unit**	**Quantity**	**Unit cost**	**Subtotal**	**Total**	**Unit cost**	**Subtotal**	**Total**
A. Capital cost per year								
A1. Land, Building & Concession								
Land	unit	1	3.000.000	3.000.000		4.348	4.348	
Building	unit	1	1.800.000	1.800.000		2.609	2.609	
Concession flat fee	unit	1	35.000	35.000		51	51	
Total Investment Land, Building & Concession				**4.835.000**			**7.007**	
A2. Equipment								
Cages (5 x 5 x 5 m)	unit	150	1.800.000	270.000.000		2.609	391.305	
Boat (pirogue)	unit	2	90.000	180.000		130	261	
Other equipment (e.g. office equipment)	lump sum			400.000			580	
Total Investment Equipment				**270.580.000**			**392.146**	
Total Capital Investment (A1+A2)				**275.415.000**			**399.153**	
Cost of Land, Building & Conc. (only for Year 1)					**4.835.000**			**7.007**
Depreciation of equipment (cost per year)	% of investment cost			20%	**54.116.000**		20%	**78.429**
B. Other expenses per year								
Bank charges (5% of raw materials costs)	%	5	1.185.000.000	59.250.000		1.701.000	85.050	
Maintenance (10% of capital investment)	%	10	275.415.000	27.541.500		399.153	39.915	
General overheads (2% of sales revenues)	%	2	2.700.000.000	54.000.000		3.913.043	78.261	
Sub-total					**140.791.500**			**203.226**
C. Direct production costs per year								
Raw materials								
Fish seeds	fingerling	2.700.000	50	135.000.000		0,07	189.000	
Fish feed	kg	2.100.000	500	1.050.000.000		0,72	1.512.000	
Labour costs:								
Manager	per month	12	2.000.000	24.000.000		2.899	34.783	
Supervisor	per month	12	400.000	4.800.000		580	6.957	
Stocking, feeding and harvesting x 3	per month	12	525.000	6.300.000		761	9.130	
Security x 3	per month	12	210.000	2.520.000		304	3.652	
Utilities	per month	12	60.000	720.000		87	1.044	
Miscellaneous (incl. health/veterinary costs)	per month	12	700.000	8.400.000		1.014	12.174	
Sub-total					**1.231.740.000**			**1.768.739**
TOTAL COSTS PER YEAR					**1.431.482.500**			**2.057.402**

REVENUES PER YEAR	**Unit**	**Quantity**	**Unit price**	**Subtotal**	**Total**	**Unit price**	**Subtotal**	**Total**
Sales per year	kgs	1.200.000	2.250	2.700.000.000		3,26	3.912.000	
TOTAL REVENUE					**2.700.000.000**			**3.912.000**

PROFIT PER YEAR (BEFORE TAX)	**1.268.517.500**	**1.854.598**
Profit margin on sales	47,0%	

5.2.2 Working Capital Requirements

Given that a production cycle has a duration of six months (fish is harvested from the cages every 6 months), the absolute minimum working capital requirement is 686.3 million RWF (995 thousand USD). However, taking into account the time for the harvested fish to be sold, a safer assumption is for working capital to cover at least seven months, i.e. 800.6 million RWF (1.16 million USD).

5.3 Profit Calculation of Tank Culture

5.3.1 Calculation of Revenues and Costs

Table 10 provides a profit calculation for the production of 300 tons of Nile tilapia in tanks (10 tanks in total). Costs are calculated as follows:

- The operating cost of producing 300 tons of Nile tilapia per year is 375.8 million RWF (540 thousand USD).

- The estimated total investment costs are 41.8 million RWF (60,558 USD) and an annual depreciation of 20% for the equipment has been assumed. Taking into account the depreciation of equipment, capital cost for the first year amounts to 14.6 million RWF (21,196 USD).

With regard to revenues, the main assumptions are:

- Each tank produces 15 tons of Nile tilapia at each harvest and the fish is harvested every 6 months: this means that each tank produces 30 tons of fish per year;
- The average food conversation ratio is 1.5;
- The sales price of Nile tilapia per kg is 2,250 RWF (3.26 USD).

Based on these assumptions, sales revenues will be 675 million RWF (978 thousand USD) per year. This translates into an annual profit of 284.5 million RWF (416 thousand USD), or a net profit margin on sales revenues of 42.2%.

Table : Costs and revenues associated with the production of 300 tons of Nile tilapia per annum in tank culture

			Rwf			USD		
Direct input costs per tank / per year	**Unit**	**Quantity**	**Unit cost**	**Subtotal**	**Total**	**Unit cost**	**Subtotal**	**Total**
INPUTS								
Raw materials								
Fish seeds	fingerling	75.000	50	3.750.000		0,07	5.250	
Fish feed	kg	45.000	500	22.500.000		0,72	32.400	
Sub-total					**22.500.000**			**32.400**
DIRECT INPUT COST PER CAGE PER YEAR					**22.500.000**			**32.400**

TOTAL COST PER YEAR	**Unit**	**Quantity**	**Unit cost**	**Subtotal**	**Total**	**Unit cost**	**Subtotal**	**Total**
A. Capital cost per year								
A1. Land, Building & Concession								
Land	unit	1	6.000.000	6.000.000		8.696	8.696	
Building	unit	1	1.800.000	1.800.000		2.609	2.609	
Concession flat fee	unit	1	35.000	35.000		51	51	
Total Investment Land, Building & Concession				**7.835.000**			**11.355**	
A2. Equipment								
Tank (dimension: 30 x 10 x 1 m)	unit	10	2.485.000	24.850.000		3.601	36.015	
Water supply and other related equipment per tank	unit	10	870.000	8.700.000		1.261	12.609	
Other equipment (e.g. office equipment)	lump sum			400.000			580	
Total Investment Equipment				**33.950.000**			**49.203**	
Total Capital Investment (A1+A2)				**41.785.000**			**60.558**	
Cost of Land, Building & Conc. (only for Year 1)					**7.835.000**			**11.355**
Depreciation of equipment (cost per year)	% of investment cost			20%	**6.790.000**		20%	**9.841**
B. Other expenses per year								
Bank charges (5% of raw materials costs)	%	5	262.500.000	13.125.000		376.500,00	18.825	
Maintenance (10% of capital investment)	%	10	33.950.000	3.395.000		49.202,90	4.920	
General overheads (2% of sales revenues)	%	2	675.000.000	13.500.000		978.260,87	19.565	
Sub-total					**30.020.000**			**43.311**
C. Direct production costs per year								
Raw materials								
Fish seeds	fingerling	750.000	50	37.500.000		0,07	52.500	
Fish feed	kg	450.000	500	225.000.000		0,72	324.000	
Labor costs:								
Manager	per month	12	2.000.000	24.000.000		2.899	34.783	
Supervisor	per month	12	400.000	4.800.000		580	6.957	
Stocking, feeding and harvesting x 2	per month	12	350.000	4.200.000		507	6.087	
Security x 2	per month	12	140.000	1.680.000		203	2.435	
Electricity	per kWh	300.000	132	39.648.000		0,19	57.000	
Other utilities	per month	12	50.000	600.000		72,46	870	
Miscellaneous (incl. health/veterinary costs)	per month	12	700.000	8.400.000		1.014	12.174	
Sub-total					**345.828.000**			**496.804**
TOTAL COSTS PER YEAR					**390.473.000**			**561.310**

REVENUES PER YEAR	**Unit**	**Quantity**	**Unit price**	**Subtotal**	**Total**	**Unit price**	**Subtotal**	**Total**
Sales per year	kgs	300.000	2.250	675.000.000		3,26	978.000	
TOTAL REVENUE					**675.000.000**			**978.000**

PROFIT PER YEAR (BEFORE TAX)					**284.527.000**			**416.690**
Profit margin on sales					42,2%			

5.3.2 Working Capital Requirements

Given that a production cycle has a duration of six months (fish is harvested from the tanks every 6 months), the absolute minimum working capital requirement is 188 million RWF (272 thousand USD). However, taking into account the time for the harvested fish to be sold, a safer assumption is for working capital to cover at least seven months, i.e. 219 million RWF (318 thousand USD).

5.4 Initial Investment Requirements

Based on the details outlined above, the initial investment capital required to initiate the whole project, i.e. for a fishmeal production unit and the cultivation of Nile tilapia in 150 cages and 10 tanks, can be presented as shown in Table 11.

Initial investment and working capital requirements for producing 300 tons of fishmeal per year are 423,986 USD. Initial investment and working capital requirements for the cultivation of 1,200 tons of Nile tilapia through cage fish farming and 300 tons of Nile tilapia through tank culture are 1.56 million USD and 378,304 USD respectively.

Taken together, the total investment cost of the project as proposed in this business case would be 2.36 million USD.

Table : Initial Investment Capital (USD)

	Fishmeal	Cage fish farming	Tank culture	Total
Fixed Assets/equipment	105.616	399.153	60.558	565.327
Working Capital *(3 months for fishmeal, 7 months for cage and tank culture)*	318.370	1.160.353	317.746	1.796.469
Total investment required	**423.986**	**1.559.506**	**378.304**	**2.361.796**

5.5 Financial Performance Analysis

5.5.1 Assumptions

1. It is proposed for the project to be financed fully by equity.

2. Financial analysis was carried out based on constant US dollar prices for project investment cost, operational cost and revenues, at an exchange rate of 690 RWF per USD.

3. Terminal values of equipment are assumed to be the net book value at the end of the analysis period, i.e. zero.

4. Working capital at the end of the period of analysis is assumed to be recoverable in full.

5. No replacement of equipment was provided for during the 6-year analysis period. However, a routine maintenance regime is assumed and corresponding maintenance costs have been considered.

6. Income tax of 30% will be paid fully during the year of assessment.

7. Sensitivity analyses have been prepared regarding fluctuations of the cost of raw materials and the sales price.

5.5.2 Pro-forma Financial Statements

Pro-forma financial statements for the three components (fishmeal production; cage fish farming; tank culture) have been prepared and are presented in Appendices III and IV, respectively.[14] Table 12 provides a summary.

The analysis indicates that the project, as well as each of the individual components/production units will be profitable each year, given the financial and operating assumptions stated above. Gross margin to sales percentage average will be 24.4% for fishmeal production, 54.8% for cage fish farming and 49.2% for tank culture, while net margins to sales will be 20.6%, 47.6% and 43.8%, respectively. Average annual net profit before tax is estimated at 2.62 million USD, of which about 70% are contributed by the cultivation of Nile tilapia in cages and the rest by the fishmeal production and the cultivation of Nile tilapia in tanks.

Table : Summary of key financial data

USD	Fishmeal production	Cage fish farming	Tank culture	Total
Sales revenues	1.629.000	3.912.000	978.000	6.519.000
Cost of goods sold	1.231.838	1.768.739	496.804	3.497.382
Gross profit	397.162	2.143.261	481.196	3.021.618
Expenses	62.033	281.655	53.151	396.839
Profit before tax	335.129	1.861.606	428.045	2.624.780
Tax	100.539	558.482	128.413	787.434
Profit after tax	234.591	1.303.124	299.631	1.837.346
Gross margin	24,4%	54,8%	49,2%	46,4%
Net margin	20,6%	47,6%	43,8%	40,3%
Cumulated profit (6 years)	1.418.230	7.873.731	1.799.928	11.091.890
FIRR	132%	111%	124%	

Cash flow projections indicate positive net cash flows during all years of operation, for all production units as well as cumulatively. FIRRs are satisfactory, at 132% for fishmeal production, 111% for cage fish farming and 124% for tank culture, under conservative assumptions.

5.5.3 Sensitivity Analysis

The project remains profitable under most simulations of reduction in selling price and increases in the cost of raw materials. For both variables, a 10% and 20% deviation from the base scenario has been applied. The results of this analysis are presented in Table 13.

[14] Note that there are small differences in numbers compared to previous sections due to rounding.

Table : Sensitivity Analysis Results

Scenario	Indicator	Fishmeal	Cage fish farming	Tank culture
Base scenario	FIRR	132%	111%	124%
	Av net margin (%)	20,6	47,6	43,8
	Av net profit after tax (USD)	234.591	1.303.124	299.631
10% reduction in sales price	FIRR	76%	89%	98%
	Av net margin (%)	12,1	42,4	37,8
	Av net profit after tax (USD)	124.622	1.043.925	232.897
20% reduction in sales price	FIRR	22%	67%	71%
	Av net margin (%)	1,4	35,4	30,3
	Av net profit after tax (USD)	12.873	775.562	165.806
10% increase in raw materials costs	FIRR	91%	94%	105%
	Av net margin (%)	14,3	43,4	39,8
	Av net profit after tax (USD)	163.292	1.187.265	272.315
20% increase in raw materials costs	FIRR	55%	80%	89%
	Av net margin (%)	7,9	38,8	35,7
	Av net profit after tax (USD)	90.212	1.062.242	244.643

The proposed fishmeal production is more vulnerable to external shocks than cage fish farming and tank culture. The fishmeal production is in particular affected by reduction in sales prices: indeed, a reduction of 20% of the sales price would render the fishmeal production barely profitable.

Regarding cage fish farming and tank culture, although increase in raw materials costs and reduction in sales prices of course tend to affect negatively profits, margins and FIRR, they remain largely profitable. Cage fish farming and tank culture are also more affected by the reduction in sales prices than by the increase in materials costs.

APPENDICES

I. REFERENCES

II. INTERVIEW LIST

IV. PROFORMA FINANCIAL STATEMENTS / FISHMEAL PRODUCTION

IV. PROFORMA FINANCIAL STATEMENTS / CAGE FISH FARMING

IV. PROFORMA FINANCIAL STATEMENTS / TANK CULTURE

APPENDIX I: REFERENCES

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APPENDIX II: INTERVIEW LIST

Name	Institution/Organization
Dr. Wilson RUTAGANIRA	Rwanda Agriculture Board, Coordinator of the Aquaculture and Fisheries Program
Théophile NIANDWI	FEFICOORWA (Federation of Fishery Cooperatives of Rwanda), Chairman of Federation
Jean Bosco KABAGAMBE	Ingege Fish Farm, Managing Director Rwanda Fish Farmers' Association
Bart GASANA	Rwanda Fish Industries (RWAFIL), Director
Frank KAVUTSE	Rwanda Fish Industries (RWAFIL), Production Manager
Vicent NZABAMWITA	SOPICAKI Ltd.
Roger SHAW	Lakeside Fish Farm, Director
Aury-Boris MFURANZIMA	Premier Animal Feed Industries (PAFI), Marketing Manager

APPENDIX III: PRO-FORMA FINANCIAL STATEMENTS FOR THE PRODUCTION OF FISHMEAL

BASE CASE

INCOME STATEMENT

			Year 1 (2016)	Year 2 (2017)	Year 3 (2018)	Year 4 (2019)	Year 5 (2020)	Year 6 (2020)
Capital investment								
Land & Building	7.536,24							
Equipment	98.079,71							
Total Capital Investment	**105.615,95**							
Revenue								
Price per kg of fishmeal (US$)			5,43	5,43	5,43	5,43	5,43	5,43
Quantity sold (kgs)			300.000,00	300.000,00	300.000,00	300.000,00	300.000,00	300.000,00
Gross Sales			1.629.000,00	1.629.000,00	1.629.000,00	1.629.000,00	1.629.000,00	1.629.000,00
Less: Sales Returns			-	-	-	-	-	-
Net Sales			**1.629.000,00**	**1.629.000,00**	**1.629.000,00**	**1.629.000,00**	**1.629.000,00**	**1.629.000,00**
Cost of Goods Sold								
Raw materials			1.044.000,00	1.044.000,00	1.044.000,00	1.044.000,00	1.044.000,00	1.044.000,00
Labour			53.913,12	53.913,12	53.913,12	53.913,12	53.913,12	53.913,12
Packing material			66.000,00	66.000,00	66.000,00	66.000,00	66.000,00	66.000,00
Electricity			65.664,00	65.664,00	65.664,00	65.664,00	65.664,00	65.664,00
Other utilities			521,76	521,76	521,76	521,76	521,76	521,76
Miscellaneous			1.739,16	1.739,16	1.739,16	1.739,16	1.739,16	1.739,16
Cost of Goods Sold			**1.231.838,04**	**1.231.838,04**	**1.231.838,04**	**1.231.838,04**	**1.231.838,04**	**1.231.838,04**
Gross Profit (Loss)			**397.161,96**	**397.161,96**	**397.161,96**	**397.161,96**	**397.161,96**	**397.161,96**
Expenses								
Depreciation Equipmen		20%	19.615,94	19.615,94	19.615,94	19.615,94	19.615,94	-
Maintenance		10%	10.561,60	10.561,60	10.561,60	10.561,60	10.561,60	10.561,60
General overheads		2%	32.580,00	32.580,00	32.580,00	32.580,00	32.580,00	32.580,00
Total Expenses			**62.757,54**	**62.757,54**	**62.757,54**	**62.757,54**	**62.757,54**	**43.141,60**
Profit Before Tax			**334.404,42**	**334.404,42**	**334.404,42**	**334.404,42**	**334.404,42**	**354.020,37**
Tax		30%	**100.321,33**	**100.321,33**	**100.321,33**	**100.321,33**	**100.321,33**	**106.206,11**
Profit After Tax (Net Profit)			**234.083,10**	**234.083,10**	**234.083,10**	**234.083,10**	**234.083,10**	**247.814,26**
Cumulative Net Profit			**234.083,10**	**468.166,19**	**702.249,29**	**936.332,38**	**1.170.415,48**	**1.418.229,74**
Gross Margin %			**24,38**	**24,38**	**24,38**	**24,38**	**24,38**	**24,38**
Net Margin %			**20,53**	**20,53**	**20,53**	**20,53**	**20,53**	**21,73**
Average Net Profit	**236.371,62**							

CASH FLOW PROJECTIONS

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cash Inflow							
Sale Receipts: Cash	0	1.629.000,00	1.629.000,00	1.629.000,00	1.629.000,00	1.629.000,00	1.629.000,00
Total Cash Inflow	**0**	**1.629.000,00**	**1.629.000,00**	**1.629.000,00**	**1.629.000,00**	**1.629.000,00**	**1.629.000,00**
Cash Outflow							
Land, Building, Equipment & Furnitu	105.615,95						
Stock (raw materials)	87.000,00						
Raw materials	0	1.044.000,00	1.044.000,00	1.044.000,00	1.044.000,00	1.044.000,00	1.044.000,00
Bags	0	53.913,12	53.913,12	53.913,12	53.913,12	53.913,12	53.913,12
Labour	0	66.000,00	66.000,00	66.000,00	66.000,00	66.000,00	66.000,00
Electricity	0	65.664,00	65.664,00	65.664,00	65.664,00	65.664,00	65.664,00
Other utilities	0	521,76	521,76	521,76	521,76	521,76	521,76
Miscellaneous	0	1.739,16	1.739,16	1.739,16	1.739,16	1.739,16	1.739,16
Maintenance	0	10.561,60	10.561,60	10.561,60	10.561,60	10.561,60	10.561,60
General overheads	0	32.580,00	32.580,00	32.580,00	32.580,00	32.580,00	32.580,00
Subtotal	*192.615,95*	*1.274.979,64*	*1.274.979,64*	*1.274.979,64*	*1.274.979,64*	*1.274.979,64*	*1.274.979,64*
Tax	*0*	*100.321,33*	*100.321,33*	*100.321,33*	*100.321,33*	*100.321,33*	*106.206,11*
Total Cash Outflow	***192.615,95***	**1.375.300,96**	**1.375.300,96**	**1.375.300,96**	**1.375.300,96**	**1.375.300,96**	**1.381.185,74**
Net Cash Flow	**(192.615,95)**	**253.699,04**	**253.699,04**	**253.699,04**	**253.699,04**	**253.699,04**	**247.814,26**
Cumulative Cash Flow	**-**	**253.699,04**	**507.398,08**	**761.097,11**	**1.014.796,15**	**1.268.495,19**	**1.516.309,45**

PRO FORMA BALANCE SHEET

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
ASSETS						
Machines, Equipment & Furniture (Net of Dep)	98.079,71	78.463,77	58.847,83	39.231,88	19.615,94	0,00
Working Capital	343.825,24	343.825,24	343.825,24	343.825,24	343.825,24	343.825,24
Bank	253.699,04	507.398,08	761.097,11	1.014.796,15	1.268.495,19	1.516.309,45
Total Assets	**695.603,99**	**929.687,08**	**1.163.770,18**	**1.397.853,28**	**1.631.936,37**	**1.860.134,69**
LIABILITIES						
Equity/Capital	441.904,95	441.904,95	441.904,95	441.904,95	441.904,95	441.904,95
Retained Earnings	234.083,10	468.166,19	702.249,29	936.332,38	1.170.415,48	1.418.229,74
Depreciation Account	19.615,94	19.615,94	19.615,94	19.615,94	19.615,94	0,00
Total Liabilities & Capital	**695.603,99**	**929.687,08**	**1.163.770,18**	**1.397.853,28**	**1.631.936,37**	**1.860.134,69**

FINANCIAL INTERNAL RATE OF RETURN (FIRR)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Net Cash Flow	(192.615,95)	253.699,04	253.699,04	253.699,04	253.699,04	253.699,04	247.814,26
Net Book Value of Fixed Assets	0	0	0	0	0	0	0
Recovery of Working Capital I	0	0	0	0	0	0	343.825,24
Recovery of Working Capital II	0	0	0	0	0	0	0
Cash Flow for FIRR	(192.615,95)	253.699,04	253.699,04	253.699,04	253.699,04	253.699,04	591.639,50

FIRR **132%**

APPENDIX IV: PRO-FORMA FINANCIAL STATEMENTS FOR CAGE FISH FARMING

BASE CASE

INCOME STATEMENT

			Year 1 (2016)	Year 2 (2017)	Year 3 (2018)	Year 4 (2019)	Year 5 (2020)	Year 6 (2020)
Capital investment								
Land, Building & Concession	7.007,25							
Equipment	392.145,57							
Total Capital Investment	**399.152,82**							
Revenue								
Price per kg (US$)			3,26	3,26	3,26	3,26	3,26	3,26
Quantity sold (kgs)			1.200.000,00	1.200.000,00	1.200.000,00	1.200.000,00	1.200.000,00	1.200.000,00
Gross Sales			3.912.000,00	3.912.000,00	3.912.000,00	3.912.000,00	3.912.000,00	3.912.000,00
Less: Sales Returns			-	-	-	-	-	-
Net Sales			**3.912.000,00**	**3.912.000,00**	**3.912.000,00**	**3.912.000,00**	**3.912.000,00**	**3.912.000,00**
Cost of Goods Sold								
Raw materials			1.701.000,00	1.701.000,00	1.701.000,00	1.701.000,00	1.701.000,00	1.701.000,00
Labour			54.521,76	54.521,76	54.521,76	54.521,76	54.521,76	54.521,76
Utilities			1.043,52	1.043,52	1.043,52	1.043,52	1.043,52	1.043,52
Misc. (incl. health/veterinary)			12.173,88	12.173,88	12.173,88	12.173,88	12.173,88	12.173,88
Cost of Goods Sold			**1.768.739,16**	**1.768.739,16**	**1.768.739,16**	**1.768.739,16**	**1.768.739,16**	**1.768.739,16**
Gross Profit (Loss)			**2.143.260,84**	**2.143.260,84**	**2.143.260,84**	**2.143.260,84**	**2.143.260,84**	**2.143.260,84**
Expenses								
Bank charges		5%	85.050,00	85.050,00	85.050,00	85.050,00	85.050,00	85.050,00
Depreciation Equipment		20%	78.429,11	78.429,11	78.429,11	78.429,11	78.429,11	-
Maintenance		10%	39.915,28	39.915,28	39.915,28	39.915,28	39.915,28	39.915,28
General overheads		2%	78.240,00	78.240,00	78.240,00	78.240,00	78.240,00	78.240,00
Total Expenses			**281.634,40**	**281.634,40**	**281.634,40**	**281.634,40**	**281.634,40**	**203.205,28**
Profit Before Tax			**1.861.626,44**	**1.861.626,44**	**1.861.626,44**	**1.861.626,44**	**1.861.626,44**	**1.940.055,56**
Tax		30%	**558.487,93**	**558.487,93**	**558.487,93**	**558.487,93**	**558.487,93**	**582.016,67**
Profit After Tax (Net Profit)			**1.303.138,51**	**1.303.138,51**	**1.303.138,51**	**1.303.138,51**	**1.303.138,51**	**1.358.038,89**
Cumulative Net Profit			**1.303.138,51**	**2.606.277,02**	**3.909.415,53**	**5.212.554,04**	**6.515.692,55**	**7.873.731,44**
Gross Margin %			**54,79**	**54,79**	**54,79**	**54,79**	**54,79**	**54,79**
Net Margin %			**47,59**	**47,59**	**47,59**	**47,59**	**47,59**	**49,59**
Average Net Profit	**1.312.288,57**							

CASH FLOW PROJECTIONS

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cash Inflow							
Sale Receipts: Cash	0	3.912.000,00	3.912.000,00	3.912.000,00	3.912.000,00	3.912.000,00	3.912.000,00
Total Cash Inflow	**0**	**3.912.000,00**	**3.912.000,00**	**3.912.000,00**	**3.912.000,00**	**3.912.000,00**	**3.912.000,00**
Cash Outflow							
Land, Building, Concession & Equipm	399.152,82						
Stock (raw materials)	850.500,00						
Raw materials	0	1.701.000,00	1.701.000,00	1.701.000,00	1.701.000,00	1.701.000,00	1.701.000,00
Labour	0	54.521,76	54.521,76	54.521,76	54.521,76	54.521,76	54.521,76
Utilities	0	1.043,52	1.043,52	1.043,52	1.043,52	1.043,52	1.043,52
Misc. (incl. health/veterinary)	0	12.173,88	12.173,88	12.173,88	12.173,88	12.173,88	12.173,88
Bank charges	0	85.050,00	85.050,00	85.050,00	85.050,00	85.050,00	85.050,00
Maintenance	0	39.915,28	39.915,28	39.915,28	39.915,28	39.915,28	39.915,28
General overheads	0	78.240,00	78.240,00	78.240,00	78.240,00	78.240,00	78.240,00
Subtotal	*1.249.652,82*	*1.971.944,44*	*1.971.944,44*	*1.971.944,44*	*1.971.944,44*	*1.971.944,44*	*1.971.944,44*
Tax	*0*	*558.487,93*	*558.487,93*	*558.487,93*	*558.487,93*	*558.487,93*	*582.016,67*
Total Cash Outflow	***1.249.652,82***	**2.530.432,38**	**2.530.432,38**	**2.530.432,38**	**2.530.432,38**	**2.530.432,38**	**2.553.961,11**
Net Cash Flow	**(1.249.652,82)**	**1.381.567,62**	**1.381.567,62**	**1.381.567,62**	**1.381.567,62**	**1.381.567,62**	**1.358.038,89**
Cumulative Cash Flow	**-**	**1.381.567,62**	**2.763.135,25**	**4.144.702,87**	**5.526.270,50**	**6.907.838,12**	**8.265.877,01**

PRO FORMA BALANCE SHEET

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
ASSETS						
Machines, Equipment & Furniture (Net of Dep)	392.145,57	313.716,46	235.287,34	156.858,23	78.429,11	0,00
Working Capital	1.265.216,19	1.265.216,19	1.265.216,19	1.265.216,19	1.265.216,19	1.265.216,19
Bank	1.381.567,62	2.763.135,25	4.144.702,87	5.526.270,50	6.907.838,12	8.265.877,01
Total Assets	**3.038.929,38**	**4.342.067,89**	**5.645.206,40**	**6.948.344,91**	**8.251.483,43**	**9.531.093,20**
LIABILITIES						
Equity/Capital	1.657.361,76	1.657.361,76	1.657.361,76	1.657.361,76	1.657.361,76	1.657.361,76
Retained Earnings	1.303.138,51	2.606.277,02	3.909.415,53	5.212.554,04	6.515.692,55	7.873.731,44
Depreciation Account	78.429,11	78.429,11	78.429,11	78.429,11	78.429,11	0,00
Total Liabilities & Capital	**3.038.929,38**	**4.342.067,89**	**5.645.206,40**	**6.948.344,91**	**8.251.483,43**	**9.531.093,20**

FINANCIAL INTERNAL RATE OF RETURN (FIRR)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Net Cash Flow	(1.249.652,82)	1.381.567,62	1.381.567,62	1.381.567,62	1.381.567,62	1.381.567,62	1.358.038,89
Net Book Value of Fixed Assets	0	0	0	0	0	0	0
Recovery of Working Capital I	0	0	0	0	0	0	1.265.216,19
Recovery of Working Capital II	0	0	0	0	0	0	0
Cash Flow for FIRR	(1.249.652,82)	1.381.567,62	1.381.567,62	1.381.567,62	1.381.567,62	1.381.567,62	2.623.255,08
FIRR	**111%**						

APPENDIX V: PRO-FORMA FINANCIAL STATEMENTS FOR TANK CULTURE

BASE CASE

INCOME STATEMENT

			Year 1 (2016)	Year 2 (2017)	Year 3 (2018)	Year 4 (2019)	Year 5 (2020)	Year 6 (2020)
Capital investment								
Land, Building & Concession	11.355,07							
Equipment	49.202,91							
Total Capital Investment	**60.557,98**							
Revenue								
Price per kg (US$)			3,26	3,26	3,26	3,26	3,26	3,26
Quantity sold (kgs)			300.000,00	300.000,00	300.000,00	300.000,00	300.000,00	300.000,00
Gross Sales			978.000,00	978.000,00	978.000,00	978.000,00	978.000,00	978.000,00
Less: Sales Returns			-	-	-	-	-	-
Net Sales			**978.000,00**	**978.000,00**	**978.000,00**	**978.000,00**	**978.000,00**	**978.000,00**
Cost of Goods Sold								
Raw materials			376.500,00	376.500,00	376.500,00	376.500,00	376.500,00	376.500,00
Labour			50.260,92	50.260,92	50.260,92	50.260,92	50.260,92	50.260,92
Electricity			57.000,00	57.000,00	57.000,00	57.000,00	57.000,00	57.000,00
Other Utilities			869,52	869,52	869,52	869,52	869,52	869,52
Misc. (incl. health/veterinary)			12.173,88	12.173,88	12.173,88	12.173,88	12.173,88	12.173,88
Cost of Goods Sold			**496.804,32**	**496.804,32**	**496.804,32**	**496.804,32**	**496.804,32**	**496.804,32**
Gross Profit (Loss)			**481.195,68**	**481.195,68**	**481.195,68**	**481.195,68**	**481.195,68**	**481.195,68**
Expenses								
Bank charges		5%	18.825,00	18.825,00	18.825,00	18.825,00	18.825,00	18.825,00
Depreciation Equipmen		20%	9.840,58	9.840,58	9.840,58	9.840,58	9.840,58	-
Maintenance		10%	6.055,80	6.055,80	6.055,80	6.055,80	6.055,80	6.055,80
General overheads		2%	19.560,00	19.560,00	19.560,00	19.560,00	19.560,00	19.560,00
Total Expenses			**54.281,38**	**54.281,38**	**54.281,38**	**54.281,38**	**54.281,38**	**44.440,80**
Profit Before Tax			**426.914,30**	**426.914,30**	**426.914,30**	**426.914,30**	**426.914,30**	**436.754,88**
Tax		30%	**128.074,29**	**128.074,29**	**128.074,29**	**128.074,29**	**128.074,29**	**131.026,46**
Profit After Tax (Net Profit)			**298.840,01**	**298.840,01**	**298.840,01**	**298.840,01**	**298.840,01**	**305.728,42**
Cumulative Net Profit			**298.840,01**	**597.680,02**	**896.520,03**	**1.195.360,04**	**1.494.200,05**	**1.799.928,47**
Gross Margin %			**49,20**	**49,20**	**49,20**	**49,20**	**49,20**	**49,20**
Net Margin %			**43,65**	**43,65**	**43,65**	**43,65**	**43,65**	**44,66**
Average Net Profit	**299.988,08**							

CASH FLOW PROJECTIONS

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cash Inflow							
Sale Receipts: Cash	0	978.000,00	978.000,00	978.000,00	978.000,00	978.000,00	978.000,00
Total Cash Inflow	**0**	**978.000,00**	**978.000,00**	**978.000,00**	**978.000,00**	**978.000,00**	**978.000,00**
Cash Outflow							
Land, Building, Concession & Equipm	60.557,98						
Stock (raw materials)	188.250,00						
Raw materials	0	376.500,00	376.500,00	376.500,00	376.500,00	376.500,00	376.500,00
Labour	0	50.260,92	50.260,92	50.260,92	50.260,92	50.260,92	50.260,92
Electricity	0	57.000,00	57.000,00	57.000,00	57.000,00	57.000,00	57.000,00
Other utilities	0	869,52	869,52	869,52	869,52	869,52	869,52
Misc. (incl. health/veterinary)	0	12.173,88	12.173,88	12.173,88	12.173,88	12.173,88	12.173,88
Maintenance	0	6.055,80	6.055,80	6.055,80	6.055,80	6.055,80	6.055,80
General overheads	0	19.560,00	19.560,00	19.560,00	19.560,00	19.560,00	19.560,00
Subtotal	*248.807,98*	*541.245,12*	*541.245,12*	*541.245,12*	*541.245,12*	*541.245,12*	*541.245,12*
Tax	*0*	*128.074,29*	*128.074,29*	*128.074,29*	*128.074,29*	*128.074,29*	*131.026,46*
Total Cash Outflow	***248.807,98***	**669.319,41**	**669.319,41**	**669.319,41**	**669.319,41**	**669.319,41**	**672.271,58**
Net Cash Flow	**(248.807,98)**	**308.680,59**	**308.680,59**	**308.680,59**	**308.680,59**	**308.680,59**	**305.728,42**
Cumulative Cash Flow	**-**	**308.680,59**	**617.361,18**	**926.041,78**	**1.234.722,37**	**1.543.402,96**	**1.849.131,38**

PRO FORMA BALANCE SHEET

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
ASSETS						
Machines, Equipment & Furniture (Net of Dep)	49.202,91	39.362,33	29.521,75	19.681,16	9.840,58	0,00
Working Capital	334.659,70	334.659,70	334.659,70	334.659,70	334.659,70	334.659,70
Bank	308.680,59	617.361,18	926.041,78	1.234.722,37	1.543.402,96	1.849.131,38
Total Assets	**692.543,21**	**991.383,22**	**1.290.223,23**	**1.589.063,24**	**1.887.903,25**	**2.183.791,08**
LIABILITIES						
Equity/Capital	383.862,61	383.862,61	383.862,61	383.862,61	383.862,61	383.862,61
Retained Earnings	298.840,01	597.680,02	896.520,03	1.195.360,04	1.494.200,05	1.799.928,47
Depreciation Account	9.840,58	9.840,58	9.840,58	9.840,58	9.840,58	0,00
Total Liabilities & Capital	**692.543,21**	**991.383,22**	**1.290.223,23**	**1.589.063,24**	**1.887.903,25**	**2.183.791,08**

FINANCIAL INTERNAL RATE OF RETURN (FIRR)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Net Cash Flow	(248.807,98)	308.680,59	308.680,59	308.680,59	308.680,59	308.680,59	305.728,42
Net Book Value of Fixed Assets	0	0	0	0	0	0	0
Recovery of Working Capital I	0	0	0	0	0	0	334.659,70
Recovery of Working Capital II	0	0	0	0	0	0	0
Cash Flow for FIRR	(248.807,98)	308.680,59	308.680,59	308.680,59	308.680,59	308.680,59	640.388,12
FIRR	**124%**						