Tilapia Aquaculture Business Model for Ethiopia: Feasibility Study

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Tilapia Aquaculture Business Model for Ethiopia: Feasibility Study

Consultant:
Abebe Ameha Mengistu Consultancy Service

Team of Experts:
Abebe Ameha Mengistu, PhD (Project Coordinator, Senior Fisheries Expert)
Sileshi Ashine, MSc (Aquaculture Economist)

Owner:
Addis Ababa Chamber of Commerce and Sectoral Associations Agri-business Support Facility Project

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PART I: INTRODUCTION

Culturing fish is a very old practice in Africa, although commercial production of fishes is still developing throughout the continent. Some species and strains of fishes are in particular suitable for commercial production. The Nile Tilapia (Oreochromis niloticus) is one of these very important fishes, introduced from Africa and the Middle East to several countries elsewhere in the world. Now it has become popular in commercial and subsistence aquaculture ventures. China and other Asian countries are famous for their bulk contribution to global aquaculture production of tilapia and other fishes. The sector incorporates not only rearing fish for harvest, but also hatcheries, feed processing, environmental issues, genetic and species diversity, post-harvest processing, economics, as well as improvements through research and knowledge transfer.

In Ethiopia, existing fish production is mainly based on capture fisheries from natural lakes and rivers; artificial reservoirs also contribute some amount. The capture fisheries, however, has never been able to satisfy the ever-increasing domestic demand, with prices for unprocessed and semi-processed fish products showing drastic increment in the past two decades. The biomass and potential yield of the natural waters cannot entertain significant increase in fishing efforts, with natural fish stocks depleting from time to time. The best alternative, and the only choice to get out of this gap in demand and supply, and the best option to ensure conservation of genetic and species diversity of fishes in Ethiopia appears to be transformation of Ethiopian fisheries into a mainly aquaculture-based production system.

A few individuals and private companies have tried (and are trying) to establish commercial level aquaculture in different parts of the country. None of these have been realized due to problems of financial, land provision, environmental safety or other issues. In line with this, preparation of a model feasibility study and business plan for commercial fish farming in Ethiopia became mandatory. The Agri-business Support Facility Project of the Addis Ababa Chamber of Commerce and Sectoral Associations took the initiative to establish an Aquaculture Platform to facilitate activities related to production, marketing and value chain analysis. Preparation of this feasibility study and business plan has been contracted to Abebe Ameha Mengistu Consultancy Service, and the document is meant to serve as a desktop reference material to be used by potential investors, the government and researchers.

In view of focusing on Addis Ababa as the major market outlet for farmed tilapia, two geographic areas, namely Shewa Robit and Wenji-Metehara, are proposed as suitable localities climatically, availability of water and land and for transportation. The local strains of Nile tilapia will be used to start the business until the best productive strain will be sorted out through action research. The level of management and design of aquaculture is proposed to be semi-intensive concrete ponds that initially require around 5 ha of land. Fingerlings will be at first obtained from existing local suppliers, until an intensive hatchery gets established. A ‘green water’ system fertilized with grasses and leaves will
be used to produce natural feed for the tilapia, with supplementary feed to be applied to enhance growth. Electrical aeration will provide additional dissolved oxygen to the system.

Several assumptions are taken into account to estimate productivity and levels of production per harvest. Nine ponds, each having a dimension of 50 m x 50 m x 1.2 m will be prepared as growth and fattening ponds. The stocking density is proposed to be 26 fingerlings/m², eventually to be thinned to 11.7 fishes/m² after two months. With 90-95% survival during a total of six months of rearing, the farmed tilapia are expected to attain an individual weight of 300 g. Fillets of Nile tilapia will be packed, labeled and marketed as a premium-to-high quality product. Whole fresh or gutted fish can also be sold upon request by the customers.

An estimated 100 tons of tilapia will be produced by the fish farm per year, with a productivity of about 44 tons/ha/harvest. The farm is expected to create jobs for at least 45 persons during its establishment. The investment and annual operating costs are estimated to be around ETB 8 million and ETB 2.6 million, respectively. The NPV for the aquaculture project at the end of the first ten years is about ETB 4.5 million, with the computed FIRR of the farm being 64%. In summary, the proposed commercial tilapia farm business appears highly profitable and feasible both technically and financially.
PART II: TECHNICAL FEASIBILITY OF THE PROPOSED COMMERCIAL TILAPIA AQUACULTURE

2.1 BACKGROUND OF THE PROJECT

Ethiopia has a rich resource of freshwater fishes in its natural lakes and rivers. So far, the major source of food fish for the domestic market are the traditional and small scale modern capture fisheries. The demand for and price of fish has increased significantly over the past two decades. Fish stocks in lakes and rivers are also getting depleted due to uncontrolled fishing. Increasing human population and the need for nutritional security and conservation of fish diversity in Ethiopia make it mandatory and timely to look for alternative ways of fish production. That is, the capture fishery from the natural waters has to be supplemented with culture fishery (aquaculture). To date, commercial aquaculture has not been effectively established in Ethiopia. One of the actions required to promote commercial aquaculture in Ethiopia is conducting research and preparation of a document on the feasibility of fish farming in Ethiopia.

2.1.1 INITIATION AND PURPOSE OF THE PROJECT

Under conditions where no commercial aquaculture has been established before, initiation and handling of such feasibility study requires a responsible institution that has access to and network with several relevant stakeholders. Accordingly, the current project was initiated and facilitated by the Agri-business Support Facility (ABSF) Project of the Addis Ababa Chamber of Commerce and Sectoral Associations (AACCSA). The purpose of this feasibility study of commercial tilapia aquaculture business model is to provide technical assistance to potential investors on aquaculture in Ethiopia. This is thought to lay the basis for commercial level aquaculture in Ethiopia which will contribute to food and nutritional security in the country, to conserve natural fish stocks, as well as to create job opportunities and contribute to the national income.

2.1.2 SCOPE

The project covers the feasibility study and business plan for commercial aquaculture of Oreochromis niloticus (Nile tilapia) in the central part of Ethiopia. The research covered relevant parts of the country in terms of fish production and market, while selection of appropriate sites for the intended aquaculture were specified to a geographic area covering a radius of about 250 km around the capital city Addis Ababa. To make the study as complete as possible, biological, geographic, environmental, social, legal, human resource, veterinary and economic issues are addressed.

2.1.3 APPROACH AND METHODS

Preparation of an aquaculture business model for Ethiopia at this time is challenging and
demanding, requiring thorough investigation of available information in the country and elsewhere. The study is difficult mainly because there is no previously established commercial level aquaculture in the country, and there are no research findings that recommend the best set of inputs (seeds, feed, locality, etc) to implement a pilot project. The benchmarks for the current study, therefore, are experiences of other African and Asian countries that have passed through processes similar to the present situation of Ethiopia in establishing commercial tilapia aquaculture from scratch.

To organize this document, at first desktop study of existing knowledge and experiences in Ethiopia, Africa and the world was performed. The potential, opportunities, challenges and risks of establishing the business were assessed. Following this, making decision on an appropriate tilapia aquaculture model was difficult, but was managed under some considerations. The decision was made carefully, as the model business plan should neither be overambitious, nor should it be economically and environmentally unsustainable.

Potential stakeholders and key informants were identified to get up-to-date information and practical suggestions. A good example here is the role of the Ministry of Agriculture as the core actor to develop Ethiopian aquaculture. Existing efforts in terms of research and establishing large-scale commercial aquaculture, hatchery, feed production, improving fish processing and marketing conditions were assessed in Addis Ababa, Ziway, Hawassa, Arba Minch, Bahir Dar and Shewa Robit.

Data on the biology (taxonomy, breeding, feeding, growth, mortality/survival), geography (soil, landscape, climate) and potential productivity of the selected species of tilapia were used as inputs to organize the business plan. In addition, layout of the aquaculture facility, legal, market and other considerations were put together to enrich the model.

Although benchmarking and adaptation of experiences from other countries has been considered, the proposed commercial tilapia aquaculture is prepared to reflect the ideas and recommendations of the team of experts involved in the study. Activities were performed following the work plan and the final adjustments indicated in the inception report. The processes and outcomes indicated in this business model will be subject to further update and modification pending on valued comments of other experts, the client and the potential investors.
2.2 PROSPECTS FOR FISH PRODUCTION, CONSUMPTION AND TRADE

A set of essential inputs are needed to establish and run a commercial fish farm. The main inputs are land, water, capital goods, fingerlings/seed, feed, capital, labor, services (research, extension, finance, etc) and technical and business know-how. Currently, the lack of seed and feed as well as skills in the field is crucial. What follows is assessment of availability and accessibility of these set of resources and inputs.

2.2.1 SUITABLE GEOGRAPHIC AREAS AND CLIMATIC CONDITIONS

Two localities are suggested to be candidates to pilot the proposed commercial tilapia aquaculture around the major market, Addis Ababa (Fig. 1). These are:

i. Vast plain around the town of Shewa Robit, located 220 km north-east of Addis Ababa at 10°00’N, 39°54’E and situated at an altitude of 1280 m a.s.l.; and

ii. The flat lands between Wenji (8°27’N, 39°17’E, 1584 m a.s.l.) and Metehara (8°54’N, 39°55’E, 947 m a.s.l.), through which the Awash River runs in the Rift Valley; this locality is about 150 km south-east of Addis Ababa.
Both localities (Shewa Robit and Wenji area) are lowland to mid-altitude areas with relatively warm climates as compared to the adjacent highlands. These localities are selected based on the basic and minimum conditions that have to be fulfilled to establish commercial aquaculture in tropical areas.

The choice of suitable geographic areas for the intended commercial tilapia aquaculture is mainly based on year-round availability of water, land for investment, access to electricity and feeder roads, soil type and topography, suitable natural climatic conditions for growth and reproduction of Nile Tilapia and proximity to major market.

### 2.2.2 MANPOWER REQUIREMENTS

The technical and entrepreneurial skills in Ethiopian aquaculture are yet to be developed at all levels. More capacity will be needed to carry out action research to address the biological and technological challenges facing aquaculture in Ethiopia. Developing the business orientation of the research and extension services of the government institutions and the entrepreneurial attitude and skills of the business community will be critical. This calls for capacity building intervention in aquaculture biology, technology, business planning and management.

The proposed enterprise’s management structure is given below in Fig. 2. The firm will have a total of 45 staff members including 4 management personnel, 7 technical experts and 34 other workers.

The two technical team leaders who are supposed to manage the primary fish production and processing units should have adequate knowledge and skills in their respective responsibilities. As it will be difficult to find well trained personnel in the country, they
should be able to get tailored trainings. Other workers in these two units should also be provided with relevant skill trainings on feeding and caring for fish in captivity and in fish processing and safety matters. The number of workers in the facility can be increased with future expansion programs and operation of the project at full capacity.

2.2.3 QUALITY AND STANDARDS FOR MARKETED FISH

The concern for public safety and product quality has become stringent in recent times. Therefore, the farm will adopt and adhere to existing national and international food standards. Nationally, fish products for human consumption shall comply with the Food, Medicine and Health Care Administration and Control Proclamation (No. 661/2009), and the 2014 Draft Fish Product Quality Control Regulation. The ISO ratings and the HACCP are also compulsory standard frameworks to comply with. Internationally, the US Department of Agriculture and the Food and Drug Administration, ISO ratings, HACCP, the EU inspectorate, and the South African Bureau of Standards are common food standards to comply with, especially during export. Most important is the tool prepared to assist with compliance to the International Standards for Responsible Tilapia Aquaculture (WWF, 2011).

Fig. 2. Organogram of the proposed tilapia farm with a minimum staff allocation.
2.2.4 FISH PROCESSING AND DISTRIBUTION

Fish processing is a value addition process to raw fish. Tilapia fillet will be the principal product of the proposed farm. Fish processing involves a series of tasks such as: receiving, sorting, filleting, weighing and packaging, eco-labeling and cold storing.

**Filleting:** The raw fish will be processed to make fillets. Fillet yield of individual fishes depends on the species, sex, size, and its structural anatomy. Of commercially farmed species tilapia (Oreochromis sp.) has a low fillet yield of 30 to 35% as compared to >38% for the catfish species Ictalurus punctatis (Borderías and Sánchez-Alonso, 2011). Filleting should take place while the fish is fresh. This has many advantages including providing a very fresh product without gaping, allows shipping the product to markets earlier, prolongs product shelf life as well as creating convenience for fish food preparation. Filleting can be done manually for the first phase until the need arises to use filleting machine for bulk processing in the second phase. Still the former method will be preferred given the abundantly available and affordable labor in the country.

**Packaging:** Packaging is generally dictated by the demands of the buyer and consumers. Taking this into account, the farm will produce 1-kg plastic packed frozen and/or chilled fillet. It will be a convenient and affordable size. Upon demand, the fillets can be packed as 0.5, 5 or 10 kg bags.

**Eco-labeling:** Sustainable harvesting and processing standards are increasingly recognized through eco-labelling. The farm will develop its own standard eco-label to provide buyers and consumers the trust and confidence on the product as well as to promote the visibility of the farm.

**Distribution of final product:** Using its refrigerated truck the firm will transport and distribute the final product to predetermined whole seller(s). The main roads that stretch from Addis Ababa to Shewa Robit, or from Addis Ababa to Nazareth are currently the most convenient paths.

The farm will have a retail outlet in Shewa Robit town, or in Nazareth, to provide product access to local consumers and people in transit.

**Cold chain:** Recognizing that fish is a highly perishable food product, the fish processing, distribution and marketing functions shall be in place and use the required cold chain facilities and apply the standard operating practices. Elements of the cold chains are chilled processing environment, deep freezer, refrigerated truck, and ice making machine. Though specific temperature threshold is species-dependent, the temperature must be lower than 17 °C to avoid gaping in fillets.
2.2 THE CHOICE OF APPROPRIATE COMMERCIAL AQUACULTURE SYSTEM

Different types of commercial aquaculture can be suggested for Ethiopia, each type having its own advantages and disadvantages in terms of investment capital, productivity, operational requirements, management, and environmental suitability. As commercial aquaculture is non-existent in Ethiopia, the choice of these systems requires careful consideration of sustainability both economically and environmentally. Economic sustainability requires production of good quality fish in large amounts, and this is usually achieved along with some level of damage to biodiversity and the environment. The commercial tilapia aquaculture suggested as a starter for Ethiopia, should therefore be one that balances economic and environmental sustainability. The capacity of the potential investor, the availability of basic inputs and other factors also need be considered to suggest a possible choice.

In line with this, for Ethiopia, two types of commercial aquaculture systems (intensive and semi-intensive) can be suggested along with one mode of deployment, land-based set up. The system should be land-based to avoid direct disturbance on the natural water body (lake or river). In particular, the problem of escape of fishes from the aquaculture system, and pollution from fertilizers and sinking feed can be effectively controlled in a separate facility. This document presents the semi-intensive system as the currently best option for the potential investor.

2.2.1 SEMI-INTENSIVE TILAPIA AQUACULTURE

A semi-intensive tilapia aquaculture in land-based concrete or earthen ponds appears ideal as a model to start commercial tilapia farm in Ethiopia. It is appropriate to think of a model that is feasible both economically and environmentally. Most of the inputs required for this system do not need sophisticated technology, or very expensive equipment as an intensive system does. In the proposed semi-intensive tilapia farm, the ponds will be fertilized to enhance growth of phytoplankton and zooplankton that will serve as natural feed for the fish. Supplementary meal and formulated feed such as floating pellets will be added in accordance with the size (weight) and the density of stocked fish. Experience in Asian and African countries that had histories of challenge in establishing tilapia aquaculture decades ago, indicates that semi-intensive aquaculture is the dominant type of management system. Tilapia aquaculture in mainland China, Egypt, Zambia and Kenya are few of the very good examples for this.

2.2.2 LAYOUT OF THE TILAPIA FARM

The proposed fish farm will have administrative, research, fish processing and cold- storage, waste treatment, and pond areas (Fig. 9). The total area required during the beginning stage of the tilapia farm project is 3 ha (30,000 m2), with an additional 2 ha (20,000 m2) considered for expansion in a few years (Table 1).
Administrative and public area: The administrative area includes offices, stores, garage, washing and restrooms. The public section will have social area with café, children’s playground, health area, shop and exhibition sections. This compound will have an area of 2,500 m².

Research area: Here four small ponds (each having 100 m²) and laboratory facilities will be placed to conduct experimental research on the reproduction, growth and productivity of farm fish, as well as water quality, fish health and environmental studies. In addition, a fisheries and aquatic sciences library, will be set in this area. The area allocated for these facilities is 1,000 m².

Fish processing and cold-storage area: This includes shed for gutting, cleaning and packing fresh whole fish, as well as a cold store room to keep products until transported to the market. The area for this post-harvest facility will be 1,500 m².

Waste treatment area: In this area, byproducts of gutted fish, left-over feed and other biological wastes will be treated for recycled use. In addition waste water will be drained to agricultural land. The area for this compound will be 600 m².

Grow-out ponds: The grow-out ponds at the initial stage of the project comprise a total of nine equal sized (50 m x 50 m x 1.5 m) ponds: three growth ponds and six fattening ponds. Growth ponds will be used to keep newly arriving fingerlings for quality check (sex, diseases, etc) and to acclimatize them to the new pond conditions. Here the fingerlings are expected to increase in length. Fattening ponds will be used for thinning of the densely stocked fishes in the growth ponds, and to allow the fish gain mass as fast as possible. Harvest will be conducted from the fattening ponds. The total land area to be occupied by the whole pond compound is 28,900 m² (nearly 3 ha) including ponds, canals, reservoir and dykes. The actual area to be occupied by water in the nine ponds is 22,500 m², with a depth of 1.2 m. The ponds will be arranged in such a way that input and drainage of water to and from the ponds will be facilitated by gravity and when needed, with little pumping effort.
Fig. 3. Generalized layout of ponds and other facilities in the tilapia aquaculture farm. The source of water for the ponds will be adjacent to the water reservoir, the ponds and waste treatment areas (note that proportion or relative size of the components is not presented to the scale).

Table 1. Tilapia aquaculture land use plan in the proposed tilapia aquaculture system.

<table>
<thead>
<tr>
<th>Land use plan</th>
<th>Total (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish growing pond (3, unit area 2,500 m²)</td>
<td>7,500</td>
</tr>
<tr>
<td>Fish fattening pond (6, unit area 2,500 m²)</td>
<td>15,000</td>
</tr>
<tr>
<td>Dykes, canals and passages between ponds</td>
<td>400</td>
</tr>
<tr>
<td>Fish processing, office/store, etc</td>
<td>7,500</td>
</tr>
<tr>
<td>Reserved for expansion in 2nd phase</td>
<td>20,000</td>
</tr>
<tr>
<td>Total farm land (~5 ha):</td>
<td>50,400</td>
</tr>
</tbody>
</table>
2.2.3 STRAINS OF NILE TILAPIA

Under conditions where no commercial aquaculture has been established before, it is difficult to precisely decide on the strain of tilapia that performs the best in Ethiopia. Lessons from other countries that started aquaculture from scratch indicate that the process of identifying the best farm fish and developing the fish farm require continued research along with the production process. In China, development of commercial aquaculture became a success story after hybrids of different species of tilapia were tested and proved good in hatcheries and grow-out facilities. In Zambia, several years of research has helped to identify the species that best suits the tilapia farm at Kafue Fisheries, and later led to the idea of introducing Genetically Improved Farm Tilapia (GIFT) strains.

To balance sustainability in terms of production and environmental safety, the issue of introducing hybrid or genetically improved strains, or of exotic species of tilapia, is controversial. It is obvious that GIFT strains showed fast growth rate as compared to local strains of tilapia (Ansah et al., 2014). However, it is also recommended to improve management practices and infrastructure to increase the yield and profitability of local strains instead of introducing genetically improved strains (Ansah et al 2014). Escapes of the exotic strains from the aquaculture ponds into natural water systems can be a major problem posing threat on indigenous species of tilapia and other fishes. However, the high productivity of these strains in commercial aquaculture has been proven elsewhere.

For the proposed commercial tilapia aquaculture in Ethiopia, a good option will be to use local strains of Nile Tilapia that exhibit best growth performance and are tolerant to a wide range of environmental conditions. In the meantime, research can be done to test the growth and culture conditions of hybrid tilapia, for instance a mix of (XX) female indigenous Oreochromis niloticus and (YY) male exotic tilapia. The hybrids are expected to be all-male (XY), and this is one of the major aspects to ensure faster growth of the farmed tilapia. However, the productivity of the hybrid can’t be guaranteed without experimentation. Experiences in other countries have shown that hybrids of female indigenous O. niloticus with YY male tilapia as good candidates for commercial aquaculture. Regarding environmental safety, escape of these fish from the aquaculture facility into natural water systems can be controlled using a combination of methods indicated in the environmental issues section below.

2.2.4 ENVIRONMENTAL ISSUES AND WASTE TREATMENT

The intended aquaculture system is proposed to be feasible not only economically, but also environmentally. The major sources of disturbance on the environment from commercial aquaculture appear to be escape of exotic fish strains (species) from the ponds into natural water systems, and pollution of natural waters from inorganic nutrients and formulated feed that settle on the bottom of the pond. Damages on the environment from these sources can be avoided or minimized by establishing the aquaculture facility as a separate pond system isolated from the river or lake, by preparing secure safety bar-
riers, by ensuring total fish removal from ponds during final harvest, and/or by draining the pond water into agricultural land instead of returning it directly back into the river or lake.

Byproduct from filleting will be recycled to animal/fish feed. Until the farm develops its in-house capacity to prepare fish meal, the byproduct will be dried up and supplied to feed processing factories. If catchment area conservation is incorporated with the aquaculture project, this can enhance the biodiversity of the surrounding area.

2.4 TILAPIA PRODUCTION AND PROCESSING

2.4.1 FINGERLINGS

Currently, production of fingerlings of tilapia to supply for commercial level aquaculture is non-existent in Ethiopia. However, existing, newly established and planned hatcheries will have the potential to supply good quality fingerlings for grow-out systems. The quality of the fingerlings has to meet the standards required for good performance in the grow-out ponds. Quality seed production has to be the core objective of the separate hatcheries to be established in Ethiopia.

Stocking density of the fingerlings in the growth ponds is suggested to be set at 32 fingerlings per m². This figure is adopted referring to experience of Kafue Fisheries Limited (30 fishes/m²) in Zambia (Flynn, 2010). The average weight of individual fingerlings during the initial stocking has to be at least 27 g. After two months, the fingerlings are expected to attain an average size of 180 g, and the stock will be split into two (thinning) and restocked in fattening ponds; at this stage, it is assumed that 90% of the initial stock will survive. It is also assumed that 95% of the tilapia stocked in the fattening ponds can survive until the time of harvest, where individuals are expected to reach an average size of 350 g.

2.4.2 FERTILIZATION OF PONDS, FEED AND FEEDING

For the currently proposed tilapia farm, feed will be made available to the fingerlings and grown tilapia in two different ways. The first is natural feed in the form of phyto- and zooplankton. Growth of plankton in the ponds will be enhanced by creating ‘green water’ ponds through addition of grasses and leaves and optionally chemical fertilizers. Animal droppings from poultry, pig or other farms can also be used to fertilize the ponds. The second is supplementary feed that can be made available from different sources. Wheat or rice bran is good source of energy and moderate protein. Leaves of Sesbania and Leucaena (NOT SEEDS which are toxic) are good sources of vitamins and proteins, and serve as good fertilizers. Cakes made of soy, sunflower, sesame and cottonseed are excellent sources of protein and energy. Other sources of food such as insects and finely chopped body parts of dead fish can also be used. The supplementary feed can be prepared in the form of floating pellets to give the fish enough time to feed before the pellets sink to the
bottom.

2.4.3 AERATION
With increased stocking density and high level of solutes and impurities in the pond water, the level of dissolved oxygen (DO2) will be lowered to some extent, causing suffocation and death to the fish. Moreover, in a ‘green water’ aquaculture that uses grasses and leaves to fertilize the ponds, large amount of DO2 is consumed by phytoplankton and algae at night. Availability of sufficient amount of DO2 ensures relatively high growth and productivity of the farmed fish. The ponds will have still waters that cannot mix atmospheric oxygen into the water. Sufficient amount of oxygen can be dissolved into the pond water by the use of electric paddle wheel aerators. The aerators will have to be used mainly at night when uptake of DO2 by photosynthetic organisms takes place. Daytime aeration also is required in cases of high level of phytoplankton productivity and increased water temperature. One paddle wheel aerator will be used per pond.

2.4.4 VETERINARY SERVICES
The ‘green water’ system is generally reported to have little risk of diseases for the fish (Flynn, 2010). During and after stocking is performed, the health of the fingerlings and the adult fish will be examined using direct observation and samples of fish and water at periodic intervals. In the growth ponds, the fingerlings will be quarantined to avoid introduction of bacterial, fungal or helminthic diseases into the ponds. If manageable level of prevalence of diseases is observed, appropriate treatment of the ponds will be conducted. The grow-out ponds also will be examined and treated for any prospectively occurring diseases. This will be done periodically on monthly intervals. Water quality analysis will have to be performed every two weeks to prevent potential damage due to pollution of the ponds.

2.4.5 PREDATION
Predation of fish in open air aquaculture systems is expected to occur by piscivorous birds (e.g., cormorants, pelicans), large reptiles (e.g., Nile monitor), or small mammals (e.g., freshwater otter). To control these predators non-harmful techniques will be used, including specially designed fences around the pond area, mechanical deterrents and watchmen. Some unavoidable predation of the farmed fish will be considered in computing the survival rate of the final harvest from the grow-out ponds.

2.4.6 STOCKING DENSITY AND GROWTH PERFORMANCE OF STOCKED TILAPIA
Under good growth conditions, tilapia of 20 to 40 g can be stocked in grow-out ponds, and under good temperature regimes, the males can reach a weight of over 200 g in 3 to 4 months, and over 400 g in 5 to 6 months. However, this may not be achieved under
stressful conditions such as shortage of good quality feed, sub-optimal water temperature or absence of aerators. Further gain of size (weight) can be achieved if the fish are reared for 8 months or more. The above growth performance goes with stocking density ranging between 2 and 7 fish/m² (Popma and Massre, 1999).

The proposed tilapia aquaculture is expected to use a ‘green water’ system with additional formulated feed. Aerators will be used to improve performance of the fish. Accordingly, the stocking density of 27 g fingerlings in the growth ponds is planned to be 26 fingerlings/m². Assuming 90% survival (that is 23.4 fish/m²) after two months, and subsequent thinning by dividing fishes of a growth pond into two fattening ponds (that is 11.7 fish/m²), individual fishes are expected to reach 300 g in four months of fattening (total of six months in grow-out pond).

### 2.4.7 PRODUCTION CYCLE

The proposed tilapia aquaculture system is intended to produce good quality fish and supply the market continuously throughout the year. This requires proper designing and timing of the initial stocking in the growth ponds and subsequent thinning transfer into the fattening ponds, harvest, cleaning of ponds, fish processing storage and market (Fig. 4).

![Diagram of tilapia production cycle](image.png)

*Fig. 4. Pattern of transfer of fingerlings and grown tilapia in the ponds.*
Fingerlings will be introduced into one of three growth ponds every two months, and kept in each pond for two months to grow in length. These will be split into two (thinning) and transferred into the fattening ponds having similar sizes as that of the growth ponds. Transfer (thinning) from growth to fattening ponds will accordingly be performed every two months. The fish are fed in the fattening ponds for four months, and harvested (Table 2).

Table 2: Production cycle of semi-intensive commercial tilapia aquaculture showing repeated processes of thirteen batches of stocking and nine rounds of harvest over 24 months period. G = Growth; F = Fattening; T = Thinning Transfer; B = Batch or round; H = Harvest.

<table>
<thead>
<tr>
<th>Month</th>
<th>G Pond 1</th>
<th>G Pond 2</th>
<th>G Pond 3</th>
<th>F Pond 1</th>
<th>F Pond 2</th>
<th>F Pond 3</th>
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Harvesting and processing of fishes belonging to the same batch (round) in two fattening ponds will take place for two months. Immediately after total harvest from a pond, the pond will be prepared for the next round of stocking. In the meantime, the next batch from two other ponds will be ready for harvest. The production cycle goes on this way to ensure year round stocking, production, processing and supply of tilapia.

### 2.4.8 TYPE OF PRODUCT

The major type product that will be prepared for market will be fillets. Upon request
by customers, gutted tilapia can be prepared. For the gutted products, the abdominal contents and the gills will be removed, and blood and other dirt will be cleaned with tap water. Clean gutted fish will be packed in fish boxes and made ready for market. Some of the fish will be filleted and packed in plastic bags to prepare fillet products of 1.0 kg. However, packaging can also be done, up on demand, in 0.5, 5.0 and 10.0 kg capacity bags. All byproducts of gutting and filleting will be sun-dried and further processed (recycled) to prepare feed for other animal farms such as poultry.

2.4.9 TILAPIA PRODUCTIVITY OF THE PONDS

The average size of an individual farmed tilapia during harvest after six months of feeding in the grow-out ponds is expected to be 300 g. By associating this value with the number (six) and size (2,500 m²) of individual fattening ponds, 50.02 t of tilapia can be harvested from the facility during the first year, and 100.04 t per annum in the second year and onwards. That is, the productivity of the system is expected to be 44.46 t/ha/harvest. After a few years, research findings will have to be applied to improve this initial level of production, thereby scaling up the management level to the intensive system.

2.5 CONTRIBUTION OF THE PROPOSED TILAPIA FARM

The proposed commercial tilapia aquaculture will have a lot of contributions to local communities, the broader society, the government, researchers, and the nation at large. The following are the core benefits to be obtained from the proposed business.

Employment and Job Opportunities: At the initial stage of its operation, the facility will create job opportunities for a total of 45 skilled, semi-skilled and unskilled personnel. In addition, the potential wholesaler and retailers will benefit from the new business. Indirectly, suppliers of fish feed and fingerlings will have a secure business as they get regular receiver(s) of their products.

Nutritional Security: Fish meat is reputed for its high nutritional content, containing proteins, vitamins, minerals and fat in proportions that are healthy for humans. Children, pregnant women, patients, and different members of the society have poor access to fish meat, especially in the case of communities living in areas very far from lakes and rivers.

Research, Training and Knowledge Transfer: The purpose of any commercial level aquaculture facility should incorporate some level of research as a component. In the case of Ethiopia, the amount of highly skilled manpower in aquaculture is scanty to none. As a result, the sector has been ignored, and fruitful training has never been given to small-scale fish farmers, or for potential investors. University graduates obtain good theoretical lessons at different institutions of the country, but this has not been supplemented with matching job opportunities and practical experiences. The level of research also is too low to bring about a breakthrough in the country’s history of aquaculture. These points are key to urge the proposed and other aquaculture projects to incorporate research, training and knowledge transfer in their development (production) programs.
ration with universities (especially to train graduate students) and research centers can strengthen efforts of the permanent researchers of the aquaculture facility.

**Preservation of Genetic Resources:** As large-scale production of fishes for human consumption exploits natural fish stocks, populations of locally endemic and threatened species of fishes and other aquatic organism also become vulnerable. In Lake Tana, for instance, the African large barbs (Labeobarbus spp.) are locally endemic, and the effect of any disturbance of the system through overfishing, introduction of exotic species or by pollution is difficult to predict. Alternatively, production systems such as aquaculture can avoid or minimize risks of threatening natural fish stocks while ensuring supply for the market. Maintaining ecological balance and conservation of genetic and species diversity in inland waters can be enabled by promoting aquaculture systems.

**Contribution to the National Income:** The role of aquaculture as a lucrative business both to the investor and the government is obvious. As a viable business area, commercial aquaculture brings about considerable amount of income to countries through taxation and by generating foreign currency.

### 2.6 RISKS, CHALLENGES AND REMEDIES

Different types of risks and challenges are expected during establishment and operation of the project. Most of these challenges are common to aquaculture systems in general, whereas a few appear specific to the case of Ethiopia.

**Construction:** Sandy soils and land having a lot of boulders on and/or under the surface could be a challenge during construction as this requires a lot of investment to construct concrete ponds. This can be remedied either by selecting suitable sites or by using low-cost construction alternatives.

**Flooding:** As the aquaculture facility will be established close to where a major river or lake is found, large amount of rainfall may result in over-flooding that can flood the ponds. This is dangerous as it can cause physical damage on the facility, introduce diseases and unwanted chemicals or organisms into the pond, and can allow escape of farmed fish into natural water bodies. This has to be remedied by constructing the walls of the ponds higher and/or using dykes that are raised high enough to block flood.

**Predation:** Different types of predators of tilapia can inhabit the pond when they discover the new habitat and availability of potential prey - fishes. These predators include piscivorous animals such as pelicans, cormorants, Nile monitor, snakes, freshwater otters and invertebrates such as freshwater crabs. Mechanical techniques such as fences, trenches, scarecrow, etc and watchmen can be used to deter some of the predators. Poisoning or other ways of mass killing of the predators is not advised.

**Market:** Some months or days of the year may not be good marketing seasons due to religious norms. These are major fasting seasons of the Ethiopian Orthodox Tewahido Church, and feasting days during and after major religious holidays. During fasting sea-
sons, many followers of the Orthodox Christianity do not consume meat and other animal products; and during religious holidays, beef, mutton and chicken are traditionally consumed. If this might cause problem on the market, either products can be shipped to alternative markets elsewhere, or stored in cold rooms for supply during peak seasons of demand.

**Budget:** The project may encounter financial problems due to the large amount of capital required to establish the aquaculture facility (e.g., construction) and for operational costs (e.g., supplementary feed that require at least one-half of the total operational cost). If the potential investor cannot afford to cover the investment and operational costs, the government and other organizations are expected to avail money in the form of credit or as a subsidy during the first few years.

**Highly skilled manpower:** It is obvious that Ethiopia does not have aquaculture specialists with practical experience in large-scale aquaculture development activities. Management and technical team members of the facility may have to obtain training either abroad, or by bringing senior experts from other countries that have long-time experience.

**Productivity and diseases:** The proposed tilapia farm will be established under conditions where there is no practically operating commercial level tilapia farm in Ethiopia. This by itself can result in associated problems of low level of productivity and frequent occurrence of diseases. This could be attributed to choice of appropriate strain of tilapia, stocking density, limnological parameters, climate, feed type and feeding mechanism, and other aspects. These problems will be corrected through continued research and documentation starting from establishment of the facility. Diseases, especially new and unexpected ones, will have to be better controlled through prevention mechanisms such as hygiene and regular follow up, and when traced, by treating the infected ponds.

**PART III: BUSINESS FEASIBILITY OF THE PROPOSED COMMERCIAL TILAPIA AQUACULTURE**

**3.1 SOCIO-ECONOMIC, LEGAL, INSTITUTIONAL AND POLICY GROUNDS**

**3.1.1 THE ROLE OF FISHERIES IN GLOBAL ECONOMY**

**Fish utilization:** The share of global fish production destined for direct human consumption has increased from 71% in the 1980s to over 86% in 2012. The balance was destined for the manufacturing of fishmeal and fish oil. About 35% of world fishmeal production was obtained from fish residues in the same year (FAO, 2014).

Again, 46% of the food fish production was utilized in the form of live, fresh or chilled fish. These product forms in developing countries as a whole accounted for 54%. Despite
this, the share of frozen products has increased to 24% in developing and to a record high
of 55% in developed countries. Interestingly, developing countries have been increasing-
ly adding value to their fish products. The export demand for frozen fish by developed
countries has been increased over time as the principal input to their food manufactur-
ing industries.

**Fish trade:** Fish remains among the most traded food commodities worldwide. In 2012,
about 200 countries reported exports of fish products. Over one-third (37%) of all fish
production valued at USD 129.2 billion was exported, and almost an equal value (USD
129.5 billion) of fish imported; each grown by 0.3%, China is the largest exporter and
became the world’s third-largest importing country of fish products since 2011, next to
U.S.A. and Japan. The European Union is also the largest market for imported fish prod-
ucts.

The important change in global fish trade pattern is that share of fish export by devel-
oping countries has increased to over 60% in volume and 54% in value of the world fish
exports in 2012. Africa as a whole is a net exporter of fish products.

The EU’s dependence on import will continue rising due to the unmet (58%) fish demand
in the region. The U.S.A. has been overtaking Japan’s leading role in the world’s import.
EU remains an important fish export destination for many developing countries; it con-
stituted 46% of the global fish import. Import remains the backbone of its processing
industry. Its top preferred fish product is frozen fillet (63.7%).

**Fish Consumption:** The nutritional value of fish is high. A 150 g of fish provides 50 to 60%
of an adult’s daily protein requirements. In 2010, fish accounted for 16.7% of the global
population’s intake of animal protein and 6.5% of all protein consumed.

Global per capita fish consumption increased from an average of 9.9 kg in the 1960s,
17.6 kg in 2007 to 19.2 kg in 2012. The growth was however highly skewed; Japan, China,
EU and U.S.A. become the lead fish consuming countries with respective per capita fish
consumption of 57 kg, 31 kg, 23 kg, and 24 kg. China will continue its strong growth in
fish consumption while Japan will experience a long-term steady
decline in fish consumption and imports as meat increasingly replaces fish.

Annual per capita fish consumption in developing regions was also significantly increased
from 5.2 kg in 1961 to 17.8 kg in 2010. A sizeable and growing share of fish consumed
in developed countries consists of imports, owing to steady demand and declining do-
mestic fishery production. In developing countries, fish consumption is largely driven by
supply.

The impressive growth in fish consumption is fuelled by a combination of population
growth, rising income and urbanization, and facilitated by the strong expansion of fish
production and trade, and more efficient distribution channels. Overall, taking the rapid
population growth as a single factor, the global demand for food fish will grow substan-
tially up by 30% between 2010 and 2030. If harvested the capture fishery at MSY and the
increased harvest is likely to be consumed within the region rather than exported, there will be 13% higher fish consumption by 2030 in SSA. Consumption will be even higher if the endangered fish stocks are recovered and efficiency of post-harvest handling improved.

**Fish price:** Fish prices are influenced by demand and supply forces, as well as by the costs of operation and prices of alternative commodities (e.g. meat, chicken and fishmeal). According to FAO (2014), the aggregate fish Price Index has generally increased markedly and reached a record high in 2013.

Employment: Fishery and aquaculture are the main sources of livelihood for 10 to 12% of the world’s population. In 2012, about 58.3 million people (37% as full time occupation) were engaged in the primary production of capture fisheries and aquaculture. This livelihood opportunity was realized in Asia by 84% and more than 10% in Africa. In addition, substantial numbers of people are engaged in support services.

### 3.1.2 ECONOMIC OVERVIEW OF ETHIOPIA

The agriculture sector is still playing a dominant role in the country’s economy. Currently, aquaculture accounts for nearly 46% of GDP, 73% of employment, and nearly 80% of foreign export earnings. A more market-oriented production, large-scale value addition and agro-industrialization are expected to be more robust in the coming years (ATA, 2014).

The diverse agro-ecologies, each with its own growth potential as well as the attractive investment and business environment provide the country with comparative advantages over other countries. For the last two decades, the Ethiopian Government has been undertaking a series of reforms for broad macroeconomic stability, development of a free market economy and improving investment and business climates.

**Fish Processing and Utilization**

Fish utilization in Ethiopia takes place in various forms - fresh, frozen, dried, salted dry and smoked. Usually fresh fish are destined to local markets while frozen fish are moved to national markets - major cities and towns. Fish processing practices widely vary across fish handlers. Fish handled by the informal operators and destined for local consumption are usually in gutted and filleted forms but processed ashore under poor hygiene conditions. FPME and some larger private firms better handle the fish along the fish value chain. Dominantly, FPME handles processed and frozen fish to domestic market. It has a number of processing plants, cold chain facilities and retailing shops.

**Fish Marketing**

Fish marketing involves the process and functions of procuring, storing, transporting, distributing, pricing and retailing fish. In Ethiopia, fish market operators/traders are basically grouped into two broad categories - formal and informal operators. The formal
operators are those licensed by the concerned government authority upon fulfillment of minimum entry requirements and conditions. They are relatively better equipped with cold chains and supply their products to major cities and towns. They vertically integrate the fish value chain. The FPME, private fish traders and some fishery cooperatives are under this category. The informal fish trades are those operating without license and dominantly operate at local level. The traditional fish market can better be understood by way of market and product segmentation.

### Market and Product Segmentation

Market segmentation is a selection of consumer groups who are most sympathetic to a product; it is done on the bases of demographic variables, income, occupation, education, household status, life-style, product use patterns and product benefits (Oxfam, 2005). Further, product segmentation could be made by grouping or clustering fish species and products taking their similar forces of demand and supply. Accordingly, Ethiopia’s fish market could be segmented into three (Table 3): low to high value local fish market, high to premium value national fish market, and premium value export fish market.

Table 3. Proposed indicative fish segmentation by species, product, value and market.

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<tr>
<th>Fish species</th>
<th>Processing</th>
<th>Product</th>
<th>Value</th>
<th>Dominant market</th>
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<td>Nile perch</td>
<td>Slice</td>
<td>Fresh/frozen</td>
<td>Premium value</td>
<td>National, Export</td>
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<tr>
<td>Nile tilapia</td>
<td>Fillet</td>
<td>Fresh/Frozen</td>
<td>Premium to high value</td>
<td>National, Export</td>
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<tr>
<td>African catfish</td>
<td>Fillet &amp; gut</td>
<td>Fresh/Frozen</td>
<td>High value</td>
<td>Local, National</td>
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<tr>
<td>Large barb</td>
<td>Fillet</td>
<td>Dried</td>
<td>Low</td>
<td>Local</td>
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<td></td>
<td>Gut</td>
<td>Salted</td>
<td>Low</td>
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**Low to high value local market:** This market is essentially the spot of primary fish market at and around the landing site. The transaction dominantly takes place between individual fishermen and local buyers (hotels, restaurants and catering centers). The fish has undergone minimal processing (sorting and gutting or filleting) ashore under poor hygienic conditions. Almost all of the fish is handled fresh. The market for this segment is entirely unorganized. However, the demand in this market is generally stable. Fish prices are negotiated and determined by local buyers and fishermen every day. The fish species in this market comprise from low to high value species.

**High to premium value national market:** National markets are the bigger fish markets situated in the country’s metropolitan city - Addis Ababa and other big towns. The value chain of this segment is more organized. The major operators are formal traders with
cold chains and retailing shops. They usually make forward contracts with fishermen’s cooperatives. They usually prefer handling high to premium value species such as tilapia and Nile perch. Many of them process, transport, distribute and sell fish using their own processing plants, cold chains and retail shops. The purchasing power of the end buyers is higher than that in local market and thus demands for such products are high. Demands in this market are affected by season.

**Premium value export market:** Export market is the international fish market with a different set of norms and practices as compared to the national and local fish markets. The quality and safety concern are the highest for this market. The export market products are the premium category product such as frozen Nile perch slice and Tilapia fillet, which fetch premium prices. The number of sellers in this market is very limited.

This segregation of fish market and product into distinct segments provides insight to compare the value chain, keeping into focus the product and market characteristics and find out uniqueness and competitiveness. As it is a common feature in developing countries, fish handling, distribution, and marketing are identified as problems for fish utilization in Ethiopia. Appropriate infrastructure and know-how for fish processing, storage and distribution are still deficient, and quality control of fish products going to the domestic market is less stringent.

Consumers’ preferences for fish species and products greatly vary. Preference is mainly influenced by factors such as knowledge about species and taste, availability and supply, price/affordability, convenience to the intended fish diet/menu as well as culture. Nile perch and Nile tilapia are the most popular species in the market and are preferred by all market segments; but, because of their expensive price, they are largely destined to national markets and to a limited extent to export markets.

**Fish Trade**

The country’s international trade in fisheries products is limited to small exports of mostly frozen fillets of tilapia and Nile perch slice to neighboring countries such as Sudan and Middle East countries like Qatar, Dubai and Saudi Arabia and imports of small volumes of frozen and canned fish from different countries.

In the period 2006 - 2010, Ethiopia exported a total of 505 tons (USD 390,000) and imported a total of 483 tons (USD 1,122,000) of fish products for human consumption. The country was a net exporter of 22 tons of fish. In value terms, it was a net importer incurring a trade deficit of USD 733,000 or 65% (Fig. 5 and 6). This is not a surprise when looked at the 55% overall country’s trade deficit in the period 2010-2013 (BoFED, 2006).
Generally, it appears that the country was incurring significant hard currency for import which is not good. The fish (export and import) trade practice not only involved very small deals but also highly erratic. FPME has stopped exporting fish due to shortage of fish since 2010 (Rothuis, et al, 2013).

Fish Consumption

Fish per caput consumption (whole fresh equivalent) in Ethiopia was 194 g in the period 1997 - 2007. It has grown to 419 g in 2013 (Fig. 7). By any standard, this level of fish consumption is significantly low when compared with the average consumption rate of 17.8 kg for developing regions and 19 kg for the world.
Religion and culture have important influence on magnitude and patterns of fish consumption. Followers of the Ethiopian Orthodox Tewahido Church are reserved from consuming animal products, including fish, during fasting seasons that sum up to 189 days (or 51.8%) in a year. The Ethiopian Orthodox Christians constituted 44% of the total population in 2007 (CSA, 2009). In practice, however, some members (unknown proportion) of the Orthodox Christians are reluctant to eat fish during these fasting days. More understanding of the religious influence calls for fish marketing research.

Price of Fish

Fish prices have been increased consistently over the past years, but at varied degree across species and product forms. Nile Perch slice is the most prestigious and expensive of all. It is destined for consumption at major cities and towns. There exist a number of fish shops from big to small size. Supermarkets retail fish products along other animal products such as beef, chicken and egg.

In 2011, actual fish prices per kilogram widely varied across fish species/products from ETB 18.00 to 100.00. Nile perch slice fetched ETB 100.00/kg followed by tilapia fillet (ETB 60.00/kg), catfish and carp fillet (ETB 31.00/kg) and tilapia gutted (ETB 23.00/kg). The least price is for filleted large barbs (ETB 18.00/kg) (Fig. 8 and 9).

In the period 2002-2011, average consumer fish price has increased by 20% with the range of 17% to 25% across species. The growth in fish price has increased exponentially since then. For example, Nile perch slice in the cosmopolitan city has increased to about ETB 200/kg and tilapia fillet to ETB 90/kg in 2014.

Socio-economics
The importance of the fishery industry for food and nutrition security, employment and as source of income is significant particularly in developing countries with poverty. In Ethiopia, contributions to the GDP and government revenue are important though small.

Food and Nutrition Security

Fishery is an important source of high value animal protein; an essential part of the diets for thousands of poor people who reside closer to the fishing areas, thus meeting their food and nutrition security. In those places and communities annual per caput fish consumption is well above 10 kg per year. This makes clear how far supply affects consumption.
Employment and Income

Fishery is also highly important in creating job and income opportunities for those who lack or are inadequately supported by alternative livelihoods. In 2010, a total of 14,630 people were engaged in fishing operation. Out of these, 55% were part-timers, 27% full-timers, 16% occasional fishers and 2% fish farmers. In addition, over 20,000 people were engaged in other fishery value chain functions (MoA, 2014).

Both the part-time and occasional fishers are opportunistic in nature, intending to maximize their short term gain regardless of the long term benefits. Such kind of behavior is found jeopardizing the health and state of the renewable fish stocks.

Value Addition to GDPs

Unlike other developing countries the national and sectoral economic contributions of the fishery industry in Ethiopia remains far limited because of its subsistence nature (Fig. 10).

![Graph](image)

Fig. 10. Annual value added by Ethiopian capture fishery and aquaculture at current price (‘000 ETB).

The value added by the capture fishery and aquaculture industry to Ethiopia's economy remains low. Its contribution to national, agricultural and livestock GDPs was 0.08%, 0.2% and 0.87%, respectively. With respect to trade, as mentioned before, the fish trade balance was negative by 65%.

3.1.3 ETHIOPIA'S NATIONAL POLICY, LEGAL AND INSTITUTIONAL REVIEW

In Ethiopia, the diversity of agricultural products and the increasing demand for food (fish) products in different forms offers large-scale investment opportunities for food processing. Therefore, the Government, through its various policies and laws facilitated the incentive structures needed to promote both domestic and foreign investments in, among others, agri-business, capture fishery and aquaculture and in food processing.
Further, Ethiopia’s top priorities for investment opportunities in agriculture are identified to include fishing and fish farming, agribusiness, and food processing. The 2nd Growth and Transformation Plan (2015-2020) also sets priority for developing aquaculture through encouraging private investment while providing public sector supports to developing model farms and promote higher education and training in the field (Hussein Abegaz, 2014).

Ethiopia has considerable investment advantages over other competing countries. These include political and social stability, fast growing economy, abundant and suitable natural resources (land, water and climate), strong guarantee and protection, abundant and affordable labor, large size domestic market with strategic location and access to export destinations, improved economic infrastructure, competitive incentive package, and of course, one-door administrative services.

There exist various policies and laws that encouraged both domestic and foreign investments and business across a wide range of the economy. Federal and regional institutions which, in one way or another, influence the country’s fisheries development include the Ministry of Agriculture, Ministry of Water, Energy and Irrigation, Ministry of Environment and Forests, Ethiopian Investment Commission, Ministry of Trade, Revenue and Customs Authority, etc. There also exist research, higher education and support institutions and partners which are important to the fishery and aquaculture sector in terms of generating/providing researched and evidenced solutions, trained personnel, as well as facilitating and supporting through advocacy and funding to the industry.

The aquaculture business model or business plan envisaged here below is a generic one for the sector. Each investor will have to adapt it to its own context, need and capacity. Guided by this, developing and using a business plan at firm level will be crucial.

### 3.1.4 INSTITUTIONAL AND BUSINESS SETTING OF THE PROPOSED BUSINESS

#### Goals

The following three goals are foreseen to achieve by the model tilapia aquaculture

a. Maximizing profit for the business in harmony with environmental safety,

b. Contributing to socio-economic development of the country, and

c. Serving as knowledge hub in commercial tilapia aquaculture

#### Market Analysis for Farmed Tilapia

The market analysis centrally looks at fish demand and supply forces and the important factors that influence their interactions. Demand factor include population, income, socio-culture, product quality and safety, price as well as product substitution. Availability and sustainability of fish stocks, availability of infrastructure and essential inputs as well
as factor costs and price are key determinants of supply.

   a. Market and Product Segmentation

The classification and explanation for fish market and product segmentations are already provided in the review part of this document. The appropriate market for the farmed tilapia fillet (product segment) is the high value national market that comprises of the major cities and towns of the country, and their average to high income consumers.

The farmed tilapia fish and its filleted product will be uniquely characterized by: preferred species, uniform size, consistent supply, multiuse filleted product, conveniently packed, safely handled, eco-friendly, traceable, and fair price. Therefore, given the past trends and future demands, the segmented species and product for the farm are Nile Tilapia and its 1-kg plastic pack fillet in chilled and or frozen forms. These market and product segmentations provide competitive edge of the model farm.

   b. Demand Forecast

Successful fish marketing requires offering a fish product tailored to meet the particular need of a segmented consumer group. As partly indicated above, the segmented high value national market is characterized by better income and educated people with increased urban life style and health concerns, as well as fast expanding urbanization, and hotel and tourism. The price of fish product remains relatively lower than its substitute animal products (beef and chicken). All these are positive forces to increase demand for high value food such as fish of premium standard.

In order to forecast demand for fish for this market, an important, yet conservative, assumption is made regarding an average annual per caput fish consumption for the coming 10 years, which is 1.5 kg/year. The high value fish national market is also identified and considered 13 major cities and towns of the country. Fig. 11 and 12 below illustrate the projected population and fish demand by the targeted market.

The 13 fast-growing major cities and towns of Ethiopia constitute a total population of 7.4 million in 2015, which will increase to 10.9 million in 2025, 17.13 million in 2035, and 39.7 million in 2050. Only 25% of this target population is assumed to bear effective demand for the farmed fish. Despite the importance of other towns the cosmopolitan city Addis Ababa representing 58% of the target population, will be the prime market for the farmed fish.
Fig. 11. Forecasted annual change in population and fish demand in 13 major cities and towns of Ethiopia.

Fig. 12. Target population in the 13 major cities and town of Ethiopia.

Based on the considerations and the above illustrations, growth of the targeted urban population will double from 18% to 36% between 2015 and 2050. In the same period, the fish demand by this population will increase by more than seven-fold, from 8,000 ton in 2015, to 16,314 ton in 2025 and to 59,495 ton by 2050. This provides considerable fish market potential for the flourishing aquaculture industry. Projection on growth of targeted population and the respective annual fish demand is provided in Table 5 below.

c. Supply Forecast

The sector review also clearly identified the critical and growing gap in fish supply both nationally and globally.

The prospect for increasing fish supply in Ethiopia from all species in general and tilapia in particular from the capture fisheries will be far limited. The open access nature of the resource coupled with the low institutional capacity to enforce the fisheries management law is among the key constraints. The propensity to increase future fish supply under exploited fish stocks of major rivers is also very limited. Increasing import is/will not be commendable as well. Therefore, the only thrust of bringing additional fish supply to the growing demand is aquaculture.
The proposed tilapia aquaculture is part of this effort and will, on the average, supply 136.5 tons/yr whole fresh equivalent for ten years. The farm will bring additional farmed fish supply of 68 tons by expanding the farm by three ponds at any time. The potential capacity of the farm will then be to produce and supply 205 tons/year.

d. Price Segmentation

Price goes along with product type, quality and convenience. In 2014, price of tilapia fillet in the national market - largely in Addis Ababa - was about ETB 80/kg against ETB 60/kg in 2011 (Fig. 11 above). Price has increased by one-third in three years period and will continue to rise. This is an important opportunity for the high quality farmed tilapia fillet which is assumed to receive at least a 10% premium price over the wild, poorly handled and erratically supplied tilapia fillet. This will be affordable by the targeted enlightened and better income consumers. In the current business model analysis a price of ETB 90/kg of high quality tilapia fillet is considered, with annual increment of 5% in subsequent years.
Table 4. Target population for tilapia market in the 13 major cities and towns of Ethiopia ('000) (Source: Computed from www.Worldometers.info and the UN’s Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2012 Revision.)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Total AA and 12 Major towns</td>
<td>5,335</td>
<td>6,296</td>
<td>7,429</td>
<td>8,915</td>
<td>10,876</td>
<td>13,486</td>
<td>17,127</td>
<td>22,094</td>
<td>29,164</td>
<td>39,664</td>
</tr>
<tr>
<td>Addis Ababa</td>
<td>3,104</td>
<td>3,662</td>
<td>4,322</td>
<td>5,186</td>
<td>6,327</td>
<td>7,845</td>
<td>9,963</td>
<td>12,853</td>
<td>16,966</td>
<td>23,073</td>
</tr>
<tr>
<td>Other 12 major towns</td>
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<td>2,633</td>
<td>3,107</td>
<td>3,729</td>
<td>4,549</td>
<td>5,641</td>
<td>7,164</td>
<td>9,241</td>
<td>12,199</td>
<td>16,590</td>
</tr>
<tr>
<td>Mekelle</td>
<td>287</td>
<td>338</td>
<td>399</td>
<td>479</td>
<td>584</td>
<td>724</td>
<td>920</td>
<td>1,187</td>
<td>1,567</td>
<td>2,131</td>
</tr>
<tr>
<td>Nazareth</td>
<td>283</td>
<td>334</td>
<td>394</td>
<td>473</td>
<td>577</td>
<td>715</td>
<td>908</td>
<td>1,172</td>
<td>1,547</td>
<td>2,104</td>
</tr>
<tr>
<td>Dire Dawa</td>
<td>269</td>
<td>318</td>
<td>375</td>
<td>450</td>
<td>549</td>
<td>680</td>
<td>864</td>
<td>1,114</td>
<td>1,471</td>
<td>2,001</td>
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<tr>
<td>Gondar</td>
<td>265</td>
<td>313</td>
<td>369</td>
<td>443</td>
<td>540</td>
<td>670</td>
<td>851</td>
<td>1,097</td>
<td>1,449</td>
<td>1,970</td>
</tr>
<tr>
<td>Hawassa</td>
<td>226</td>
<td>266</td>
<td>314</td>
<td>377</td>
<td>460</td>
<td>571</td>
<td>725</td>
<td>935</td>
<td>1,234</td>
<td>1,678</td>
</tr>
<tr>
<td>Bahir Dar</td>
<td>199</td>
<td>235</td>
<td>277</td>
<td>332</td>
<td>405</td>
<td>503</td>
<td>639</td>
<td>824</td>
<td>1,087</td>
<td>1,479</td>
</tr>
<tr>
<td>Jimma</td>
<td>155</td>
<td>183</td>
<td>216</td>
<td>260</td>
<td>317</td>
<td>393</td>
<td>499</td>
<td>644</td>
<td>849</td>
<td>1,155</td>
</tr>
<tr>
<td>Desse</td>
<td>154</td>
<td>181</td>
<td>214</td>
<td>257</td>
<td>313</td>
<td>389</td>
<td>493</td>
<td>636</td>
<td>840</td>
<td>1,143</td>
</tr>
<tr>
<td>Jigjiga</td>
<td>153</td>
<td>180</td>
<td>213</td>
<td>255</td>
<td>311</td>
<td>386</td>
<td>490</td>
<td>632</td>
<td>835</td>
<td>1,135</td>
</tr>
<tr>
<td>Debre Zeit</td>
<td>128</td>
<td>152</td>
<td>179</td>
<td>215</td>
<td>262</td>
<td>325</td>
<td>412</td>
<td>532</td>
<td>702</td>
<td>955</td>
</tr>
<tr>
<td>Kombolcha</td>
<td>75</td>
<td>89</td>
<td>105</td>
<td>125</td>
<td>153</td>
<td>190</td>
<td>241</td>
<td>311</td>
<td>411</td>
<td>558</td>
</tr>
<tr>
<td>Modjo</td>
<td>38</td>
<td>45</td>
<td>53</td>
<td>63</td>
<td>77</td>
<td>96</td>
<td>122</td>
<td>157</td>
<td>208</td>
<td>282</td>
</tr>
</tbody>
</table>

| Per caput fish fillet demand forecast (ton/yr) | 8,003 | 9,443 | 11,143 | 13,372 | 16,314 | 20,229 | 25,691 | 33,141 | 43,747 | 59,495 |

**e. Competition**

There seems to exist competition against the proposed farmed tilapia and its fillet product from other wild fish species and products, imported (canned) fish products and substitute animal products (beef, mutton and chicken). As said before, additional fish production from existing capture fishery is limited, particularly from the most preferred and high value Nile perch and tilapia stocks. Fish import will continue but it will be in small quantity and unable to influence the domestic price. The competition from substitute animal products will not be as such strong. In terms of nutrition, fish protein is of higher quality than other animal products. In terms of cost, fish remains relatively cheap. Therefore, fish will be preferred to those products. The analyses lead to the conclusion that competition exists but unable to influence fish price and demand.

The positive change in income further expands the demand for fish. On the contrary, demand for fish will shrink during the 182 fasting days/year of the Orthodox Christians. The magnitudes of their influence are not currently known thus not consid-
In sum, the current annual per caput fish consumption (below 250 kg) for the past decades was, more than other factors, constrained by short, low quality and inconsistent supply of fish. This leaves significant opportunity for fish farming. The market, species and product segmentations described above provide the competitive edge for the aquaculture value chain operators. There is, therefore, a strong need to unleash the current and potential fish market opportunities efficiently and effectively.

3.1.6 VALUE CHAIN FOR FARmed TILAPIA FIlLETS

Commercial aquaculture - fish farming as a business - requires a new value chain and investment to deliver specific types of fish products to specific market segment. The fish farm is designed to integrate and operate the production, processing and distribution functions of the value chain while the upstream function (supply of inputs and services) and the downstream functions (wholesaling and retailing) of the chain will be operated by other business firms through backward and forward contracting (Fig. 13). The potential wholesaler(s) will distribute the products to different retailers and caterers - fish shops, supermarkets, hotels, restaurants, households - so that the product will reach target consumers. The farm will be the lead-firm in the value chain and is responsible for coordinating the chain functions and actors to ensure growth and competitiveness at each firm’s level and throughout the whole chain.

Fig. 13. Value chain for the proposed farmed tilapia fillet.

3.2 FINANCIAL ANALYSIS

Fish farming is not for everyone; it is certainly not for the “weekend farmer”. Fish are living animals that require daily attention and patience. The purpose of any business is not only to generate, but also to maximize profit. Therefore, before starting any business activity all possible costs involved in that activity should be taken into account. If the to-
tal farm revenue from sales generated for the period is greater than the costs, it means profits are generated for that given period.

The most fundamental types of financial records and analyses that the aquaculture enterprise should make and maintain are:

- **Assumptions**: sets standards, quantities and costs on major inputs and services
- **Benefits**: provides sources and amount of revenue and other benefits
- **Cost breakdown**: details out investment and operation costs
- **Income statement**: shows profitability status of the business
- **Cash flow**: shows the movement of cash into (inflows) and out of (outflows) the business.
- **Balance sheet**: shows the financial status at the end of each year.
- **Profitability**: shows financial indicators - NPV and FIRR - that measure the profitability of the project
- **Sensitivity Analysis**: reveals any vulnerability and a planning component to develop strategies for minimizing risk.

### 3.2.1 KEY PARAMETERS AND ASSUMPTIONS

Annex 2 provides a set of the proposed fish farm’s performance parameters and assumptions. These assumptions are derived from the technical analysis section of this document, and provide the bases for analysis of the profitability of the farm.

The major assumptions are:

- **Total farm land will be 5 ha, of which 3 ha for use in 1st phase and 2 ha in 2nd phase for expansion**;
- **Grow-out pond size will be 2,500 m2 (50 m x 50 m x 1.2 m), and there will be 3 growth and 6 fattening ponds**;
- **There will be a total of 9 grow-out ponds with total water area of 22,500 m2 and holding capacity of 27,000 m3**.
- **Stocking density of fingerlings into growth pond at 26/m2 and grown fish into fattening pond at 11.7/m2**;
- **Average weight of individual fingerlings stocked to growth pond is 27 g, restocked to fattening pond is 180 g and fish weight at harvest is 300 g**;
- **Growth rate of fingerlings in growth ponds is 2.5 g/day, and of grown tilapia in fattening ponds is 1.4 g/day**;
- **Supplementary feed applied at 2.5 g/fingerling/day (=162.5 kg/pond/day) for growth**
pond, and 5 g/fish/day (=146.25 kg/pond/day) for fattening pond;

- Survival rate of fingerlings in growth pond at 90% and of fish in fattening pond at 95%;
- Productivity of the tilapia aquaculture system at farm level is 44.46 ton/ha/harvest;
- Fillet product with a conversion ratio of 30% from whole fresh; and
- Price of major product is ETB 90/kg of tilapia fillet at year 1.

3.2.2 COST BREAKDOWN

Two categories of investment costs are identified: infrastructure and equipment. Table 6 provides the investment cost breakdown.

Investment Cost

The infrastructure component consists of buildings and related structures. These specifically include land acquisition, pond construction, fences and office/store/cleaning shed construction. The estimated total value of these assets is ETB 5,702,500. The equipment component consists of generator, vehicle, deep freezers, ice-making machine, refrigerated truck, laboratory and office equipment and others. Their estimated initial total cost is ETB 2,292,500. Therefore, the total investment cost of the farm is estimated at ETB 7,995,000.

Investment Financing and Debt Servicing

The total investment cost amounting to ETB 7,995,000 will be financed through raising owner’s equity (30%) and bank loan (70%). A 10.5% cost of capital per year and a loan period of 5 years are assumed. Table 7 below provides the debt servicing schedule.

Operating Costs

Yearly, operating costs are composed of variable and fixed costs. Variable costs are cost factors that are likely to change over the operation period. These are basically, fingerlings, feed, water, and labor. The mean annual cost of these inputs over the 10-year period is ETB 775,566 (Table 7).

The other set of costs amount to ETB 1,784,200, which consists of ETB 843,328 for selling, general and administrative expenses, ETB 366,492 for annual depreciation, ETB 173,534 for interest payment and ETB 400,848 for profit tax (Table 7).

3.2.3 REVENUE

Based on the production and price assumption drawn above the farmed tilapia production will be 50.02 tons in the first year followed by 100.04 tons in subsequent years.
One-kg plastic bag tilapia fillet is a packaging standard. An initial price of ETB 80/kg which will grow by 5% per year is assumed. By the 10th year of the farm, the price of fillet is assumed to increase to ETB 124/kg, which will remain fairly competitive.

The farm will then earn average sales revenue of ETB 3.79 million per year (Table 8). Of this, the tilapia fillets will contribute ETB 3.26 million, dried byproducts of fish will bring the farm with average additional revenue of ETB 0.115 million per year, and ETB 0.41 million is the residual value of assets. At the end of the 10th year, the total residual value of the assets of the farm will be worth ETB 4.125 million.
Table 5. Initial investment capital and depreciation (ETB) for the proposed tilapia farm.

<table>
<thead>
<tr>
<th>Cost category and item</th>
<th>Eco-Life</th>
<th>Unit</th>
<th>Qty</th>
<th>Unit Cost or price</th>
<th>Total cost</th>
<th>Annual depreciation</th>
<th>Book value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. INVESTMENT CAPITAL</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>1.1 Infrastructure</strong></td>
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</tr>
<tr>
<td>Land Lease</td>
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<td>375,000</td>
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<td></td>
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<tr>
<td>Grow-out ponds (2,500 m² each)</td>
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<td>#pond</td>
<td>9</td>
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<td>4,050,000</td>
<td>162,000</td>
<td>2,430,000</td>
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<td>8,000</td>
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<td>450,000</td>
<td>18,000</td>
<td>270,000</td>
<td>450,000</td>
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<tr>
<td>Water storage (10,000 m³) &amp; supply system with PVC lining</td>
<td>25</td>
<td>set</td>
<td>1</td>
<td>75,000</td>
<td>75,000</td>
<td>3,000</td>
<td>45,000</td>
<td>75,000</td>
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<tr>
<td>Fence (2000 m length around 5 ha)</td>
<td>15</td>
<td>m</td>
<td>2000</td>
<td>20</td>
<td>40,000</td>
<td>2,667</td>
<td>13,333</td>
<td>40,000</td>
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<td>Fish processing shade (20 m x 15 m)</td>
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<td>m²</td>
<td>350</td>
<td>750</td>
<td>262,500</td>
<td>10,500</td>
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<tr>
<td>Office/store (20 m x 20 m)</td>
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<td>10,000</td>
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<td></td>
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<td>214,167</td>
<td>3,185,833</td>
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<tr>
<td>Generator and solar power</td>
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<td>120,000</td>
<td>8,000</td>
<td>40,000</td>
<td>120,000</td>
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<tr>
<td>Vehicle - pickup double cabin</td>
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<td>pcs</td>
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<td>450,000</td>
<td>450,000</td>
<td>22,500</td>
<td>225,000</td>
<td>450,000</td>
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<tr>
<td>Deep freezer (m2)</td>
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<td>pcs</td>
<td>5</td>
<td>15,000</td>
<td>75,000</td>
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<td>25,000</td>
<td>75,000</td>
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<td>Ice making machine</td>
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<td>45,000</td>
<td>3,000</td>
<td>15,000</td>
<td>45,000</td>
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<td>Refrigerated truck</td>
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<td>850,000</td>
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<td>Filleting table - marble</td>
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<td>pcs</td>
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<td>3,500</td>
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<td>5,250</td>
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<td>Cart</td>
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<td>pcs</td>
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<td>3,000</td>
<td>3,000</td>
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<td>1,000</td>
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<tr>
<td>Weighing scales (large and small)</td>
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<td>pcs</td>
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<td>250</td>
<td>7,500</td>
<td>15,000</td>
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<td>25,000</td>
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<tr>
<td>Aerator (paddle wheel)</td>
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<td>set</td>
<td>10</td>
<td>7,000</td>
<td>70,000</td>
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</tr>
<tr>
<td>Hand tools</td>
<td>5</td>
<td>set</td>
<td>5</td>
<td>2,500</td>
<td>12,500</td>
<td>2,500</td>
<td></td>
<td>25,000</td>
</tr>
<tr>
<td>Office machine: 2 computers, 1 printer, 1 fax-machine, 3 phones</td>
<td>15</td>
<td>set</td>
<td>10</td>
<td>35,000</td>
<td>350,000</td>
<td>23,333</td>
<td>116,667</td>
<td>350,000</td>
</tr>
<tr>
<td>Fishing gear: 2 seine &amp; 4 scoop nets</td>
<td>5</td>
<td>set</td>
<td>3</td>
<td>5,000</td>
<td>15,000</td>
<td>3,000</td>
<td></td>
<td>30,000</td>
</tr>
<tr>
<td>Furniture</td>
<td>15</td>
<td>set</td>
<td>10</td>
<td>25,000</td>
<td>250,000</td>
<td>16,667</td>
<td>83,333</td>
<td>250,000</td>
</tr>
<tr>
<td><strong>Sub-total 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,292,500</td>
<td>152,325</td>
<td>939,250</td>
<td>2,327,500</td>
</tr>
<tr>
<td><strong>Total Capital</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7,995,000</td>
<td>366,492</td>
<td>4,125,083</td>
<td>7,655,000</td>
</tr>
</tbody>
</table>
### 3.2.4 PROFITABILITY ANALYSIS

**A. Net Cash Flow**

Profit is the first concern of investors and business operators. Profit measures the viability of the enterprise and allows for business expansion. It is the incremental cash flow or net income derived from the investment.

The net cash flow is the income statement showing the annual profits or losses of the business. The current results show that during the first years, the net cash flow is negative because of the initial investment. In the years that follow it incrementally becomes positive over the planning horizon. For the investment period, the average annual profit to the enterprise is calculated to ETB 1,229,867. The detail for net income computation is given in Table 8 below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Installment of Principal</th>
<th>Annual Interest Payment</th>
<th>Debt Serving</th>
<th>Loan Outstanding End of Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5,596,500</td>
<td>10.5%</td>
<td>P + I</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1,119,300</td>
<td>587,633</td>
<td>1,706,933</td>
<td>4,477,200</td>
</tr>
<tr>
<td>2</td>
<td>1,119,300</td>
<td>470,106</td>
<td>1,589,406</td>
<td>3,357,900</td>
</tr>
<tr>
<td>3</td>
<td>1,119,300</td>
<td>352,580</td>
<td>1,471,880</td>
<td>2,238,600</td>
</tr>
<tr>
<td>4</td>
<td>1,119,300</td>
<td>235,053</td>
<td>1,354,353</td>
<td>1,119,300</td>
</tr>
<tr>
<td>5</td>
<td>1,119,300</td>
<td>117,527</td>
<td>1,236,827</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>5,596,500</td>
<td>1,762,898</td>
<td>7,359,398</td>
<td></td>
</tr>
</tbody>
</table>
Table 7. Income Statement for the proposed semi-intensive tilapia aquaculture business model over 10-years period.

<table>
<thead>
<tr>
<th>B. Net Present Value (NPV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The NPV is the most straightforward discounted measure of incremental income of the agricultural investment projects, in this case tilapia aquaculture. It is the sum of the present worth of the net income generated over the investment period. It indicates how much value an investment adds to the firm.</td>
</tr>
<tr>
<td>Discounted at 10.5%, the NPV for the aquaculture project at the end of the first ten years is ETB 4,463,687. The decision criteria is accepting investment projects that have the discounted NPV of zero or greater. In that case, the tilapia aquaculture is super attractive.</td>
</tr>
</tbody>
</table>
C. Financial Internal Rate of Return (FIRR)

Another way measuring the profitability of the tilapia aquaculture is the (financial) discounted rate that brings the net present value to zero. It is the maximum interest rate the farm could pay for the resources used if the farm is to recover its investment and operating costs, and still breakeven. It shows the returns of the capital investment over the life of the investment.

The computed FIRR for the farm is 64%. This rate is highly attractive. The normal criteria for accepting the FIRR is when it is equal to or greater than the opportunity cost of capital invested.

D. Payback Period

It is the length of time over the investment period where the cumulative net operating income generated covers the total amount of capital investment. The payback period is found to be 5.8 years for the total capital invested. This means that it is to be expected that recovery of the initial investment will take that length of period.

3.2.5 SENSITIVITY ANALYSIS

It assesses the vulnerability of the net income of the enterprise in response to changes (10% fall or rise in the value of major factors such as fish production, fish sale price, and production cost (seed, feed, labor)). Early knowledge on these factors and the degree of influence will allow the enterprise to plan and take measures to minimize, and if possible, to eliminate associated risks and their unintended impact on the health of the business.

As illustrated in Fig. 14 and 15 below, the vulnerability of the farm profitability is more sensitive to changes in farm productivity and product price than direct variable costs. Managing the fish production practice will therefore be a critical success factor for the farm.
Fig. 14. Sensitivity of profitability ratio (in absolute numbers) against 10% rise and fall in key revenue and cost determinants.

Fig. 15. Sensitivity of profitability ratio (in terms of changes) against 10% rise and fall in key revenue and cost determinants.

The cost shares of the three important variables - seed, feed and labor are 21%, 33% and 43%, respectively. However, the labor cost will gradually be reduced as the farm efficiency improves over time.
3.2.6 ECONOMIC SIGNIFICANCE OF THE INVESTMENT

The local and national economic importance of the proposed aquaculture activity can be viewed from three dimensions - protein supply, employment creation and value addition to the economy.

- The farm will bring additional supply of 95.04 tons of premium quality fish to the society per year. This will help improve the diets of about 91,000 consumers at an average per caput consumption of 1.5 kg/yr.
- The farm will also provide job opportunity to 45 persons who will be earning better monthly income, and thus improve the livelihoods of their families.
- The farm will serve as a knowledge hub for the aquaculture industry. The country will benefit from the positive externalities of the farm by way of technology and knowledge transfer to the expanding industry.
- The farm will pay taxes to the government. This amounts on average to ETB 400,000/yr.

3.2.7 MANAGING RISK AND UNCERTAINING

Aquaculture is a high risk business. It is risky not only because of the biological processes it involves (or survival of large numbers of organism in captivity), but also because of its dependence on other essential factors including cost-incurring inputs such as fingerlings, feed and human skills.

Tilapia farmers can reduce their risks by varying degrees, yet few can be entirely eliminated. Thus, they have the option to absorb these risks themselves or to divert them. An important option is to ensure the welfare of the fish. There is also an agricultural insurance scheme in Ethiopia provided by some private banks (e.g. Nyala Insurance). It is a satisfactory and reliable means of sharing risks. The merit of the scheme is that, it boosts the confidence of lending institutions to make loans available to farmers.

Large-scale commercial aquaculture requires considerable amount of investment and operational cost. Construction of ponds, re-circulating systems and other components of aquaculture facility, as well as inputs of seed (fingerlings), formulated feed, transportation and manpower require considerable amount of financial input. Under conditions where there is no commercial fish farming practice – which is the case of Ethiopia – potential investors need motivation and support to implement economically feasible aquaculture. Support can be obtained from the government or non-governmental organizations. Development banks can provide financial support through credit programs. Agribusiness facilitators and other stakeholders can mediate these processes, as the potential investor may not have adequate information on the availability and mechanism of funding.
Some Aquaculture Risk Management Strategies

a. Adherence to this business plan and further adaptation to suit the interest of each individual firm.

b. Creating and maintaining a closer alignment with professional associations, research centers and universities for technical advice and support.

c. Adherence to and compliance with laws, regulations, technical standards and code of practices to meet social and environmental accountabilities

REFERENCES


**Proclamations, Guidelines and Strategies**


FMHCAA (2009). Food, Medicine and Health Care Administration and Control Proclama-
nation (No. 661/2009), Food, Medicine and Health Care Administration Authority (FMH-CAA), Addis Ababa, Ethiopia.


ANNEX

Key parameters and assumptions considered to establish the proposed commercial tilapia aquaculture in Ethiopia.

<table>
<thead>
<tr>
<th>Performance Variable</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Land and pond dimensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total area leased or rented</td>
<td>ha</td>
<td>5.0</td>
</tr>
<tr>
<td>Land area allocated for first phase</td>
<td>ha</td>
<td>3.0</td>
</tr>
<tr>
<td>Land area reserved for 2nd phase or expansion</td>
<td>ha</td>
<td>2.0</td>
</tr>
<tr>
<td>Total number of grow-out ponds</td>
<td>number</td>
<td>9.0</td>
</tr>
<tr>
<td>Number of growth ponds</td>
<td>number</td>
<td>3.0</td>
</tr>
<tr>
<td>Number of fattening ponds</td>
<td>number</td>
<td>6.0</td>
</tr>
<tr>
<td>Dimension of grow-out ponds 50mx50mX1.2m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water area of single grow-out pond</td>
<td>m2</td>
<td>2,500</td>
</tr>
<tr>
<td>Total water area of 9 ponds</td>
<td>m2</td>
<td>22,500</td>
</tr>
<tr>
<td>Total volume of water in (#9) grow-out ponds</td>
<td>m3</td>
<td>27,000</td>
</tr>
<tr>
<td><strong>2. Stocking density of fingerlings in growth ponds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stocking density of tilapia fingerlings in growth ponds</td>
<td>fingerlings/m2</td>
<td>26</td>
</tr>
<tr>
<td>Number of fingerlings stocked per growth pond</td>
<td>fingerlings/pond</td>
<td>65,000</td>
</tr>
<tr>
<td>Average weight of fingerlings stocked in growth ponds</td>
<td>kg</td>
<td>0.027</td>
</tr>
<tr>
<td>Total weight of fingerlings stocked per growth pond</td>
<td>kg</td>
<td>1,755</td>
</tr>
<tr>
<td><strong>3. Stocking density of tilapia in fattening ponds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stocking density of tilapia in fattening ponds</td>
<td>fish/m2</td>
<td>11.7</td>
</tr>
<tr>
<td>Number of grown tilapia stocked per fattening pond</td>
<td>fish/pond</td>
<td>29,250</td>
</tr>
<tr>
<td>Average weight of grown tilapia stocked in fattening ponds</td>
<td>kg</td>
<td>0.18</td>
</tr>
<tr>
<td>Total weight of grown tilapia stocked per fattening pond</td>
<td>kg</td>
<td>5,265</td>
</tr>
<tr>
<td><strong>4. Time period</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days rearing fingerlings in growth ponds</td>
<td>Day</td>
<td>60.0</td>
</tr>
<tr>
<td>Days rearing grown tilapia in fattening ponds</td>
<td>Day</td>
<td>120.0</td>
</tr>
<tr>
<td>Total days rear tilapia until harvest</td>
<td>Day</td>
<td>180.0</td>
</tr>
<tr>
<td>Days required to harvest and clean two ponds</td>
<td>Day</td>
<td>60.0</td>
</tr>
<tr>
<td><strong>5. Supplementary feed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>6. Growth rate of fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth rate of fingerlings in growth pond</td>
<td>g/day</td>
<td>2.5</td>
</tr>
<tr>
<td>Growth rate of grown tilapia in fattening pond</td>
<td>g/day</td>
<td>1.0</td>
</tr>
<tr>
<td>7. Survival of fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival of fingerlings in growth ponds</td>
<td>%</td>
<td>90.0</td>
</tr>
<tr>
<td>Survival of grown tilapia in fattening ponds</td>
<td>%</td>
<td>95.0</td>
</tr>
<tr>
<td>8. Harvest (production) and productivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of ponds to be harvested per batch/round</td>
<td>number</td>
<td>2.0</td>
</tr>
<tr>
<td>Average weight of individual tilapia to be harvested, after fattening</td>
<td>kg</td>
<td>0.3</td>
</tr>
<tr>
<td>Total number of tilapia individuals to be harvested per pond</td>
<td>number of fish</td>
<td>27,787.5</td>
</tr>
<tr>
<td>Total weight of tilapia to be harvested per pond</td>
<td>kg</td>
<td>8,336</td>
</tr>
<tr>
<td>Total weight of tilapia to be harvested per batch</td>
<td>kg</td>
<td>16,673</td>
</tr>
<tr>
<td>Total weight of tilapia to be harvested during the first year (3 batches)</td>
<td>kg</td>
<td>50,018</td>
</tr>
<tr>
<td>Total weight of tilapia to be harvested during the second year and beyond (6 batches)</td>
<td>kg</td>
<td>100,035</td>
</tr>
<tr>
<td>Productivity of the tilapia aquaculture system at farm level</td>
<td>ton/ha/harvest</td>
<td>44.46</td>
</tr>
</tbody>
</table>
Addis Ababa Chamber of Commerce and Sectoral Associations

Tel +251 115 518055
Fax +251 115 511479
E-mail: info@addischamber.com
website: www.addischamber.com