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Preliminary Design & Detailed Technical & Financial Feasibility Study for proposed AquaPark site in – Apac, UGANDA

FINAL REPORT

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(Short term expert)

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Under the coordination of

Context

Tamás Bardócz as Principal Consultant of the **AquaBioTech Group**, is the selected expert working on the tasks described in the terms of reference (ToR) Preliminary Design & Detailed Technical & Financial Feasibility Study for proposed AquaPark site in – Apac, Uganda. After the Short-Term Expert (STE) mission commenced 29th January 2019 and the Inception Report described the necessary information and methods for the feasibility study implementation.

The Validation Report provides a draft of the planned feasibility study highlighting the data and source on the key inputs for the financial and technical analysis. The report will be discussed on a meeting and if it is required modifications on the feasibility study objectives and outputs can be achieved.

Project Number: UGA 01 / 17 – Ug

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List of Acronyms & Abbreviations

ACF	Agricultural Credit Facility
AfDB	African Development Bank
AquaPark	Aquaculture Park
CAPEX	Capital Expenditures
DAIMWAP	Department of Agricultural Infrastructure, Mechanization and Water for Agricultural Production
DAMD	Department of Aquaculture Management & Development
DiFR	Directorate of Fisheries Resources
DSIP	Agriculture Sector Development Strategy and Investment Plan
EU	European Union
EUD	European Union Delegation in Uganda
EDF	European Development Fund
ESIA	Environmental Social Impact Assessment
FAO	United Nations Food and Agricultural Organisation
FCR	Feed Conversion Ratio
g	grams
HDPE	high density polyethylene
IRR	Internal Rate of Return (Financial Internal Rate of Return)
Kg	Kilogrammes
l	litres
MAIFF	Ministry of Agriculture, Animal Industry and Fisheries
$mg. L^{-1}$	Milligrams per litre
MoFPED	Ministry of Finance, Planning & Economic Development
MTTI	Ministry of Tourism, Trade & Industry
MWE	Ministry of Water & Environment
NaFIRRI	National Fisheries Resources Research Institute
NARO	National Agricultural Research Organization
NPV	Net Present Value
OPEX	Operational Expenditures
P	Phosphorous
PAT	Profit After Tax
PESCA	Promoting Environmentally Sustainable Commercial Aquaculture in Uganda project
PO	Producer Organizations
PPP	Public Private Partnership
PVC	Polyvinyl chloride
RAS	Recirculated Aquaculture System
ROA	Return on Assets
STTA	Short Term Technical Assistance
t	Metric tonnes (1,000 Kg)
TiLV	Tilapia Lake Virus

TORs	Terms of Reference
UGX	Ugandan Shillings
UIA	Uganda Investment Authority
USA	United States of America
USD	United States Dollars
UWA	Uganda Wildlife Authority
WACC	Weighted Average Cost of Capital

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1. Executive summary

Background

The Project Promoting Environmentally Sustainable Commercial Aquaculture (PESCA) in Uganda, which is funded by the European Union under the 11th EDF, emphasizes that the future commercial aquaculture sub-sector will be dominated by and operated by the private sector with profit and return on investment as the driving catalyst for this to happen.

This study for the Preliminary Design & Detailed Feasibility is being conducted for the proposed land-based AquaPark in Apac. It is implemented through a consultant hired through the TA contract with the Agrotec SpA consortium and is intended to develop the principles and concept proposed by a previous study by Poseidon (2013), a consulting company. It is also intended to look in more detail at what the reality on the ground at a proposed site is, which has been designated for the land-based AquaPark. The aim of this current feasibility study, therefore, is to define and propose the aquaculture production technologies and analyse the financial feasibility of the operation under a public-private partnership (PPP) style arrangement for the Apac AquaPark.

Site suitability and carrying capacity

An area along the Victoria Nile river, between Apac and Masindi Port, was previously identified as the designated location for the land based AquaPark. The procedure of the land choice and purchase was through MAAIF and will purchase and gain land title for approximately 200 ha of land (200 ha was recommended from the Poseidon 2013 study). Considering the concept of the Poseidon study that the production of the land based AquaPark should use pond technology to produce large quantities of tilapia and African catfish, a **preliminary site suitability survey** regarding the possibilities of freshwater pond aquaculture was carried out by NaFIRRI (2019), under the PESCA project. In order to integrate the results of this survey the consultant also visited the site and met with local stakeholders.

This study is therefore focused on the 200 ha of land being purchased and lays out a plan for its usage. This has resulted in a phased approach to the land development with the initial analysis based on the assessment from NaFIRRI that reports that only certain parts of the designated area are suitable for pond-based aquaculture (approximately 54 Ha), due to the various soil and topographic characteristics, as well as rocky surfaces encountered. Other areas of the total land (200 ha) are more suited to other forms of production unit and associated production facilities, which are indicated in this report under a suggested phased development plan.

The results of **a water survey,** undertaken as part of the site suitability survey, showed that the physical and chemical characteristics of the adjacent Victoria Nile river are also suitable for aquaculture production, but the water would have to be pumped to the upper areas where the land is suitable for pond and concrete raceway aquaculture facilities. Pumping generally increases operating costs for such fish farm operations, so this is an important consideration.

According to these results the study suggests the 1st phase developments of the AquaPark, where the most suitable areas can be used to start the aquaculture production. It is expected that the 1st phase investments will increase the aquaculture development potential of the region and a 2nd phase development can be started to increase production and ensure service infrastructure for the enlarged production.

The assumptions and models of this study are based on the preliminary site suitability and topographic data available to the consultant and suggest that further detailed site survey, as a prerequisite of the engineering design, will need a more complex and detailed soil survey and topographic survey and thus should be included in the Design requirements.

Proposed technologies

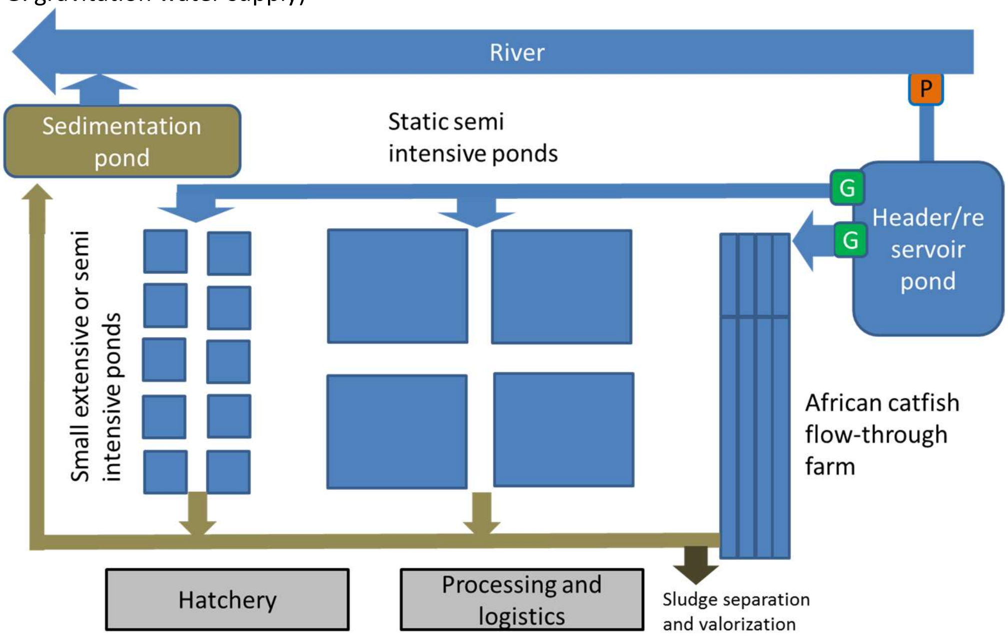
The primary goal of the AquaParks in Uganda to provide examples (pilots) that will be a model for environmental, economic and social sustainability of aquaculture development and expand fish production by attracting serious investors to the sub-sector in the future. To achieve this complex goal, the production framework of the AquaPark must integrate fish farmers with small, medium and large production capacity, while also must have an economic scale to ensure the financial viability of the project. Considering the suitable land availability and bearing in mind an ecosystem-based management approach to aquaculture, the consultant suggested the following production technologies to be integrated in the AquaPark and operated by different fish farmers:

1. To ensure the required economic scale the AquaPark needs an intensive production unit where large quantities of fish can be produced and able to supply the required volumes and standard quality for the markets. Considering all parameters, it is suggested that the majority of the AquaPark production should be an intensive flow-through system producing yearly 1,500 tonnes of African catfish with 1.5 kg or larger market size. The water supply of the flow through system is planned by pumping the water from the river to a water reservoir pond. The team managing this farm must include skilled aquaculture experts who also will operate a multispecies hatchery with an annual minimum capacity of 3 million African catfish and 2 million tilapia fingerlings. With this capacity the hatchery will be able to supply all producers of the AquaPark and can contribute to the stable supply of high-quality fingerlings in the region. The proposed land allocation for the 3,300 m^3 concrete raceway system, water reservoir pond, hatchery, feed store and other buildings is 6 ha.
2. The preliminary site survey results indicated that an approximately 34 ha relatively flat area with a moderate slope can be suitable for the construction of 30 earthen ponds (without liners) with 1 ha surface and 1.5 m water depth each. This area is next to the intensive unit and the ponds will be filled up from the central water reservoir. It is suggested, that the final engineering design should allow the use of the discharge water of the intensive unit in the ponds to contribute to the Nitrogen and Phosphorus fertilisation. The 1 ha ponds will apply the semi-intensive technology for tilapia production by using formulated fish feed and the natural production of the ponds. Dosing the proper amount of chemical and organic fertilisers to the ponds and the optional use of nutrient rich effluent water from the intensive unit will increase the natural production of the ponds and considerably reduce the feed costs. The production model of the study calculates with 15 t/ha production, but this can be increased in the future to 20 t/ha as the medium scale farmers become more experienced.
3. Local small-scale fish farmers also will be integrated in the AquaPark to manage smaller 0.2 ha ponds by using extensive technologies with less feed costs. It is estimated that an area of 12 ha of the designated land with moderate slope, could accommodate 50 barrage type ponds. These extensive fishponds will also be supplied from the central water reservoir pond and optionally can use the discharged nutrient and organic material rich effluent water of the intensive unit. Small-scale farmers can decide according to their knowledge and resources how many ponds they want to manage and how intensive technology will they use. The study production model calculates with 3 t/ha fish yield, which assumes very limited use of formulated feed and regular fertilisation of the pond water.

The **Combined Intensive Extensive (CIE)** aquaculture systems are the latest development direction in the aquaculture technology, which is suggested as an optional technology. Several studies and research results have shown that the biosecurity risk is very low if the combined systems produce different species, while the reuse of the valuable nutrients make the whole system more sustainable. Through applying this nutrient and water reuse model in the aquaculture park, the most effective use of natural resources can be achieved while also minimising the environmental impacts of the fish production. This model also can help to introduce new, affordable small-scale farming technologies.

The introduction of these production technologies will be considered as the first stage of the Apac AquaPark development and in the next stages the remaining land area can be used for other land based production technologies (lined pond systems, Recirculating Aquaculture Systems, etc.) or other aquaculture related activities like fish processing, fish feed production, aquaculture research and training station.

Figure 1 Simplified visual presentation of the proposed AquaPark technologies in the first phase (P: pumping; G: gravitation water supply)



Management Model for the AquaParks

The previous study "Feasibility Study to Design, Cost and Operationalize Model Commercial Aquaculture Parks in Uganda" prepared by Poseidon Aquatic Resources Management Ltd. (2013), has provided a concept regarding an Aquaculture Parks (AquaParks) approach to sector development. The study developed the concept and provided initial outlines and assessments of two AquaPark sites and potential management models based on a PPP approach. An initial concept level financial feasibility was also undertaken using various assumptions regarding structures, layouts, production levels and fish prices for the AquaParks, based on tilapia and Africa catfish production. This study outlined 3 possible business models for the AquaParks:

- Aquaculture Park concept (AquaPark/Co-operative model)
- Nucleus estate concept
- Farmer cluster concept

Investigating all models and researching the possibilities for the application of these management models for the land based AquaPark in Apac, the consultant suggests considerable simplification of the models because of the following issues:

- The complicated management and ownership structure of the suggested co-operative type model is not attractive for large-scale investors.
- The proposed high level of co-operation of farmers can be built only by applying a bottom-up approach, when all participants clearly understand the need for the cooperation. The expected new medium and small-scale farmers of the AquaPark will not be aware of this need.
- The size and the number of the producers in the planned AquaPark is not necessarily required to maintain a company only for managing the common activities.

Bearing these in mind, the consultant suggests a simplified version of the “nucleus model” where the largest producer in the current stage of the AquaPark will also act as a management company or developer of the AquaPark. In the case of the Apac AquaPark it is suggested, that the different stakeholders will have the following functions:

- The government provide the land for the AquaPark and ensures the access of the AquaPark to main infrastructure such as roads and electricity. The farmers using the Aquapark will pay a rental fee to the government who can regulate the operation of the AquaPark through the contracts and the licensing of the farms.
- With the financial support of the PESCA project the investor company of the intensive African catfish farm will manage the construction of all production facilities including the catfish farm, hatchery, pumping station, water reservoir and sedimentation pond as well as all production ponds. The large grower also will invest their own money as working capital to operate the intensive farm and the hatchery. This company also will provide the water, fingerling and feed for the small and medium-sized farmers.
- The medium and small growers will invest only working capital and will pay for the products and services to the large grower with a define commission fee to cover the costs of the company. The small and medium farmers also will sell their products to the large farmer but depending on their agreements they will be also be able to arrange their sales directly.

There are other options within this implementation and management model depending on the required own financial contribution from the different fish farmers and their involvement in the construction of the production facilities. According to the interviews with potential large-scale investors they are willing to invest their money in production facilities where they have control over the design and construction works. Their involvement in the design and construction phase therefore would be essential.

Business model and financial assessment

Carrying out a detailed feasibility analysis for operating the proposed AquaPark, a financial model was developed to be able to assess the financial viability of the whole project and the different sized aquaculture producers. In this model the available grant component *was not* included to see clearly how feasible the project would be without the grant. Similarly, it was assumed that all production infrastructure investments are financed by the large, nucleus investor to get a picture at the whole project level with regards to the capital costs, operating costs, financial performance indicators (such as ROI, NPV and IRR), as well as a detailed sensitivity analysis for key performance factors (KPI).

Detailed investment, revenue and costing analysis were developed for each of the business entities and comprehensive financial models developed to inform business decision making and planning. The emphasis was put on realistic assumptions and KPIs feeding the financial assessment.

In terms of budget available through the current project programme estimate (MAOPE), it was indicated that the cost of such an operation established through this study should not be limited by the MAOPE budgets, but should outline what is required to put a professional and up to date production operation on the ground (as it is to be used as a model for future investment). Extra funds required, if any, would be assumed from other sources.

The financial model was developed according to a biology/technology model for both species and all the three technologies. Operational costs and capital costs (CAPEX) were calculated by using the following methods:

- Collection of local data in Uganda where it was possible during field missions or from available literature
- Estimations based on the consultant's and company's experience
- Industry standards and scientific literature data

The sensitivity analyses were carried out for the large grower and medium grower only because the financial performance of the small farmers will vary within a very wide range depending on the intensity of their production. The key variables for the sensitivity analysis show that the key factors driving the financial viability of all fish farming operations are ***the feed price*, *the feed conversion ratio (FCR),*** **and** ***the fish selling price*.** The proposed production technologies also enable considerable changes in the intensity of the production where the key variable is *maximum harvest density* of the tanks or ponds. In this report the base case values for each key variable were conservative:

Intensity of production: 200kg/m^3 was suggested as maximum grow-out tank biomass, but according to the industry standards this can go up to 300 kg/m^3 if the growing market will justify an increased production. The calculated 15t/ha yearly production of the semi-intensive ponds is a realistic base case, because to reach the possible 20t/ha yield needs 5-8 years of experience with this technology.

Feed prices: Tilapia feeds are widely used in Uganda and the imported feed price, delivered to Mombasa, Kenya was validated as 2,775,000 UGX / t. African catfish farmers recently use tilapia feed if they use any but the protein content of this is too low for high intensity production. Because good quality catfish feeds with high protein content are not present in the country, the consultant contacted various feed suppliers and based on their estimated offers calculated the possible price delivered to Mombasa. This estimated average is 1050 USD/tons for the grow-out feed costs could be reduced if a local animal feed producer could manufacture at least the 5mm final grow-out feed according to a locally developed recipe.

Fish prices: Tilapia has a well-established market and on farm price around 8000 UGX/kg which price also was used in the financial model, but there is a realistic possibility to sell the 500g high quality fish in small quantity on a higher price. According to the preliminary market observations the African catfish above 1 kg has a 10,000-11,000 UGX/kg market size. Considering that the African catfish has a similar flesh quality like Tilapia, but the filleting yield of catfish is 10-15% more than Tilapia, the available farm gate price could be around 9000 UGX/kg. Because of the limited information on the recent African catfish market in Northern- Uganda the financial model uses the 8,000 UGX/kg farm gate price for African catfish which price can bear the costs of the wholesaler for processing or exports.

Table 1 Summary of financial performances of the three types of fish producers in the nucleus business model

		Small Grower	Medium Grower	Large Grower
Production capacity	**tons/year**	**24**	**443**	**1,526**
Cost of production	UGX/kg	**9,494**	**9,874**	**11,140**
Capex	UGX	61,236,895	2,460,592,228	16,625,362,906
Normalized Financial performances (15 years average)				
Yearly Average revenue	**UGX / year**	**324,867,649**	**6,108,171,174**	**25,856,261,060**
Operating profit	%	30.3%	26.4%	20.6%
Net Income	UGX / year	72,319,103	1,204,834,803	4,597,685,199
Net Income	%	21.0%	17.9%	16.0%
ROA	%	28.3%	22%	16%
Current Ratio		13.86	33.98	11.72
Weighted Average Cost of Capital	**%**	**14.5%**	**14.5%**	**14.5%**
IRR	%	42%	25%	22%
NPV	UGX	221,981,431	2,716,804,338	10,218,140,171
Exit price	UGX	133,672,462	5,359,049,294	36,291,082,211
Break-even point (production / year)	tons/year	7.2	204.9	720.3
Undiscounted Payback period	years	3.81	6.10	6.20
Discounted Payback period	years	4.76	9.26	11.13

The results of the financial models show that even the moderate density and low fish price assumed in the model can ensure a good Profit After Taxes (PAT/Net income) for the large-scale farming company. The largest investment costs of the AquaPark development are:

- Construction of the intensive flow-through African catfish farm.
- Building of large, large 1 ha ponds with 30 ha total water surface.
- Building small, 0.2 ha ponds with 10 ha total surface area.

The challenge for the implementation of the pilot AquaPark project is that potential medium and small-scale farmers do not have the capital and knowledge to implement such a scale of fishpond construction. There are 2 main options for the implementation of the pond construction:

Option A: The large-scale investor who also will operate the AquaPark infrastructure will build all elements of the AquaPark including the fishponds. In this case the PESCA project will provide 100% financial support for the construction.

Option B: The small and large ponds, as well as the water supply channels, will be built by the PESCA project and the companies or persons who will operate these ponds will be recruited by the project.

To be able to investigate the financial feasibility of the whole AquaPark project, the financial model has the following assumptions:

1. Large scale investor will build all the production and service infrastructure of the AquaPark.
2. The financial support/grant was not included in the model to evaluate the project as a financial investment.

The results show that the AquaPark project is financially feasible hence, a good return on investment.

The consultant suggests, that considering pilot projects should not be evaluated purely on a financial basis. The socio-economic impact assessment should be carried out.

Way forward

The feasibility studies will only make suggestions, and based on the financial models, decisions will be needed on the followings:

- Details of the granting mechanism of the project: funding rate, eligible costs, eligible beneficiary
- Detailed business and management structures for the AquaPark must be decided
- These details of the granting mechanism and the required AquaPark business structure must be clearly communicated to the potential investors.
- It is suggested that potential large-scale investors should be involved in the engineering phase of the project.
- The study suggests the required technologies and infrastructure investments to be designed at the engineering phase.
- The land based AquaPark needs much more engineering design and site survey (soil, topography) work, this should be considered in the preparation of the engineering ToR of this AquaPark.

2. Background & scope

2.1. Background

Fish is one of the priority commodities that MAAIF has identified within the Agriculture Sector Development Strategy and Investment Plan (DSIP) 2010/11 – 2014/15, and preliminary discussions on the new Agriculture Sector Support Plan 2015/16 – 2020/21 confirm that fish will continue to be a priority commodity for the Government of Uganda. Alongside this recognition, aquaculture is seen by the Government as a vital sub-sector, aiming to improve livelihoods, provide jobs and improve food and nutrition security for its people.

It is also recognised that as a commercial industry aquaculture remains underdeveloped, albeit with significant potential for development into a viable sector in Uganda. This is also interpolated to indicate that the sub-sector could produce critical volumes of fish to fill the growing gap in national fish supply, as wild fish catches continue to decline, the national population grows and the demand for raw material for fish value addition continues.

The role of imported fish, which also has a valuable contribution to the overall food and nutrition security requirement for the country, will continue, although trends in imports of certain species can have a negative effect on farmed fish species if not carefully controlled. Tilapia imported very cheaply to the region, including Uganda, is deemed to be having a key negative effect on business investment for farming fish in the region, as price competition is significant and therefore it increases perceived risks for investment in the aquaculture sector. Trade limitations on cheaper tilapia imports, primarily from Asia, are being implemented, but still this fish is entering the regional markets, including reportedly Uganda. African catfish production does not have the import price pressure yet, because this species is produced in a much lower volume in the world aquaculture and mainly consumed in the producer countries.

Generally, countries tend to export high value products and import more affordable products, thus satisfying the need for foreign currency, whilst maintaining a focus on national food and nutrition security; a balance has to be struck with national production and imported food, to cater for the various layers and segmentation of markets, which are determined mainly by the willingness and ability to pay, as well as geographical location and access to suitable supplies in local markets. Cheaper imports of tilapia have a place, where a population seeking fish, but unable to afford locally produced fish, will benefit. Post-harvest losses from fisheries is also significant and means quality and volume that could be available fails to reach markets for human consumption. As a source of protein, reducing these loses has huge potential to feed the growing populations.

Within the context of the Project Promoting Environmentally Sustainable Commercial Aquaculture (PESCA) in Uganda, which is funded by the European Union under the 11th EDF, it is recognised and captured in the various project documents, that Uganda has great potential for developing aquaculture beyond small volume production models into larger commercial scale production operations using both cages and land-based systems for tilapia (cages) and catfish and tilapia (land-based ponds). A small number of small-scale commercial level farms are beginning to emerge in Uganda and also surrounding countries, not least Kenya, Rwanda and DR Congo, which are taking advantage of lake waters and various sites for pond production. At this stage, most of these commercial enterprises remain relatively small in relation to what is envisaged in the coming years; the largest producer in Uganda at this time is approaching 1,000 Mt per year production.

PESCA emphasises and recognises that the future commercial aquaculture sub-sector will be dominated by and operated by the private sector with profit and return on investment as the driving catalyst for this to happen. In conjunction with this, value chain development throughout, which has core inputs (seed, feed, capital), production (fish grow-out) and marketing (post-harvest, distribution, logistics) components, together with the critical support mechanisms from the government side, where legal frameworks, policies and regulatory structures will need to be established, promoted and well-enforced to support the value chains as they expand. The various value chain activities that will emerge as either private sector or government led are part of the process that the Project hopes to address, with again, emphasis on having private sector recognise the potential for various core value chain inputs.

In general, global markets for fish and fishery products are expanding, representing a growing potential source of foreign currency earnings for many developing countries such as Uganda. Generally, noticeable trends include:

- There is a rise in share of total trade from developing countries with the principle markets being the EU, USA and Japan; these markets have been the modern focus for fish exports from many countries, as they are deemed to have a large population and are willing to pay higher prices for fish. With this focus, continued and increasing competition in these markets, means that these traditional international markets are becoming less profitable and attractive as a key market focus.
- Production of food fish from aquaculture on a global scale is now over-taking production from capture fisheries, indicating a significant shift in supply;
- There is a significant increase in regional trade in developing countries, which has been attributed to the increasing costs of exporting to the more distant, more sophisticated markets (such as EU/USA/Japan), in terms of transport costs but importantly the costs associated with compliance with import standards and legislation in those markets. A shift to regional markets is beginning to be an easier option for many up-and-coming suppliers of fish and competition regionally is less daunting as it is still in a less developed marketing system and rules are easier to comply with. Shorter distances make management and distribution less complicated as well, although in many instances on the continent of Africa, international road transportation systems in particular is still a major cost barrier, and this coupled with long and arduous border procedures remain a negative in the profit equation.
- African catfish is an emerging species of the world aquaculture and has a very high potential in Africa. Extensive and semi-intensive farming creates a continuous but small market for this species in the land locked areas which can be further developed. Recently Nigeria is the world largest African catfish producer where the production has been increasing from 10,000 tonnes to 170,000 tonnes in the last 20 years due to increasing local consumption.
- Competitively, Tilapia, as with a few other farmed fish species (salmon, prawn) is a global commodity. A commodity level market must compete on consistency of supply and importantly on price. To join such a marketing system, farmed fish must align several factors if price competitiveness is to be achieved.
- Cost reduction is a key component of such a competitive market environment, which with fish farming means growing fish to market size as fast as possible for the least cost. This entails breed selection processes to ensure faster growing fish are used for production.
- Feed costs, as a large percentage of overall costs, are critical and quality and feed conversion ratios must be superior. These factors together with superior operational efficiencies, technology and economies of scale during production and distribution allow entry into such markets. Volume production and low margins dictate success in these commodity-based production systems.

At this time, Uganda is not part of this system as it lacks most of the factors described above. A constraint at this early stage in commercial fish farming is the availability of locally produced, good quality fish feed mixes for growth stages of fish, which has forced most serious players to seek feed from outside the country.

Whilst these trends are not new news, it does remind us that as Uganda starts to develop a commercial sector, national and regional markets are a more realistic starting point than the more distant global markets, and with a diverse national/ regional customer base, focused attention to market segmentation (based on price), value addition where appropriate to differentiate with existing capture fisheries, which still have a hold on the market in terms of price and consumer preference. These key demand dynamics and supply realities must come together.

Regionally Uganda is surrounded by substantial population that extends from Sudan to South Africa and is certainly worthy of consideration for fish marketing and sales strategy development. Within this on the West is DR Congo, with an insatiable demand for fish products from the whole region and will be perhaps the most significant buyer of fish for years to come. Within reach is a wider region that includes the Middle East, where consumers and standards of living are pushing fish prices higher and certainly have shown interest in products from the Great Lakes region in East Africa and a high unsatisfied demand due to lack of local sources of fish. Generally, in the region a developing middle class is showing its beginnings as a potential market for better quality products, not least food products, thus offering potential for a higher paying customers and value addition strategies targeting such buyers.

A benefit that has come from previous success, and more recent failure is the well-documented case of Nile Perch in the region, particularly from Lake Victoria. Exports of Nile perch fillets to Europe provided significant revenue to Uganda, as well as Kenya and Tanzania, and for a while was a great success for the region, but competition from Asian fish in Europe (notably pangasius) has slowed this success to a point now when many factories are closing or operating at very low capacity and profit levels; without new options these factories (fish processing plants) will surely be out of business. The legacy of the now dwindling Nile perch processing industry is however a well-established processing knowledge and infrastructure (landing sites, processing facilities, transportation, laboratories and certification systems) that meets the higher standards from Europe and other markets; this is now under-utilised through a lack of fish and markets for fish to utilise this capacity. Potential clearly exists to merge this former processing industry with a burgeoning fish farming sector.

Uganda is in transition between a capture fishery, with significant international exports from Nile perch and local food production from Tilapia and others, and now potential for fish farming to take over that position. Whilst efforts to revitalise capture fisheries are ongoing and may show some success, the real future will be fish farming; this statement is made with the proviso that market demand, fish price, ability to pay and physical availability/ access will have the same impact as they have always had and approaches to marketing will dominate how production, sourcing of inputs, and their management is organised, if businesses are to be profitable and the sector is to grow.

Aquaculture Parks

The previous study "Feasibility Study to Design, Cost and Operationalize Model Commercial Aquaculture Parks in Uganda" prepared by Poseidon Aquatic Resources Management Ltd. (2013), available for reference as part of this consultancy, has provided a concept regarding an Aquaculture Parks (AquaParks) approach to sector development. The study developed the concept and provided initial outlines and assessments of two AquaPark sites and potential management models based on a PPP approach. An initial concept level financial feasibility was also undertaken using various assumptions regarding structures, layouts, production levels and fish prices for the AquaParks, based on tilapia and Africa catfish production. In the recent state of the project the planned AquaParks are to be in Kalangala District at Mwena landing site; water-based (cages for tilapia), and in Apac District; land-based (ponds for catfish and tilapia). These are to be then operated under a PPP style arrangement with Government of Uganda, together with a core technical operators and other sub-operators focused more on production. This AquaParks concept is currently being developed and this study in particular is looking at the preliminary design and technical/ financial feasibility for the land based AquaPark in Apac. The AquaParks will focus on demonstrating production techniques that are modern, have professional management and with a community perspective and strategy for growth of production. Through these *pilot* fish farming models, the Project hopes to stimulate further interest in commercial fish farming from serious investors, who might follow a similar AquaPark model to produce fish at a commercial scale in Uganda.

Objectives of this assignment

Within the context of the information provided above, a Detailed Feasibility Report, including preliminary design is the key objective of this particular contract. It is a key stage in the preparation for final detailed designs for the AquaPark in Apac District and will inform the process of procurement for actual construction of buildings and equipment critical to its operations. The Feasibility Study is to be a robust and defensible document that will be carefully reviewed and approved before the next stages can commence.

This assignment has included missions to Uganda for site visits and data collection, and has worked in tandem with site survey studies, including preliminary site suitability survey and topographic survey. This report provides details of all activities undertaken, analysis and results, and presents the preliminary design, technical and financial analysis. This Feasibility Study is the step before commencing the detailed engineering design and equipment specification for the AquaPark in Apac; once it is approved, the detailed engineering will proceed.

Annex 5 presents the Terms of Reference (TORs) for this work.

2.2. Objectives of the AquaParks in the Uganda context

2.2.1. The concept of AquaParks

Commercial aquaculture is quite a recent industry in the country, and sourcing quality feed at reasonable price is one of the biggest challenges that one can face when launching a fish farming activity. The same apply for seeds, with limited suppliers of good quality fingerlings. On the market side, access to fair price is equally challenging due to the intermediate traders who tend to maximize their margins by pushing the fish farmers' prices down. Hence, such business activity can look challenging to step into for small-scale farmers or new entrants in the sector.

Producer Organizations (PO) can provide the opportunity to overcome these challenges. The primary intention of such organizations is to improve competitiveness of their members by providing services or inputs at competitive pricing thanks to the economies of scale they generate by gathering farmers together in the value chain. The increased bargaining power allows to negotiate prices with suppliers on one side, and with customers on the other side.

There are various forms of PO possible, such as the association, the cooperative, the company, or a combination of these by having a nucleus investor in large scale production and integrating the medium and small-scale farmers. Small scale farmers will benefit from the PO at the condition that they can meet the requirements and foresee an increased profitability. It can also benefit non-members of the community by generating workforce requirements and generating new services requirements. Following the previous feasibility study undergone in 2013 (Poseidon,2013) and recommending the establishment of a cooperative-like business model to operate the AquaPark. This study outlined two basic concepts for the structure of the AquaParks:

- In the **co-operative model** all farmers within the aquapark have share in the dedicated management company of the park which does not do any production but manage and operate the common activities of the farmers. The most important common activities are for example feed purchase, fingerling purchase and common marketing and sales of the products. To cover the costs of the management company it charges fees on the input materials sold to the farmers and also on the fish products.
- The **nucleus model** idea is based on one or more larger producers with enough financial and technological capacity to integrate the production of smaller farmers. The medium- and small-scale farmers own or rent pond areas and are supported by the large farmer or management company.
- The Poseidon 2013 study also outlined a third model, where the farmers working in the same geographical area establish a **cluster** on voluntary base and arrange some support activities of the farming together.

From the discussions with various stakeholders in Uganda during the site visits it was clear that any type of AquaPark development **will need private investors** to finance the working capital and partly the CAPEX investments of the large-scale aquaculture production.

The previous feasibility study about the cage-based tilapia production AquaPark in Mwena and the discussions with potential investors showed that instead of the cooperative type AquaPark the **Nucleus model could work better**, where the large-scale producer integrates and help the production of smaller scale farmers.

The nucleus integrator as a business or organization that is owned by and operated by a for profit company receiving grants for the investment from the state and the integration activities carried out by the company are regulated in a Public-Private Partnership agreement. The integrator approach intends to improve the skills, efficiency, and competitiveness of its members by acting as an intermediary on their behalf in the value chain. The main economic and sustainability benefits are:

- lower costs through economies of scale
- increased access to input and output markets and services
- increased bargaining power
- increased confidence and influence

In the case of the AquaPark, the integrator would provide business-oriented services as listed below:

- <u>Input supply</u>: procure feed at more competitive prices thanks to bulk orders directly from suppliers without passing by local traders and produce fingerlings directly onsite that are sold at production cost plus a small commission (lower than from private hatcheries).

- Production services: supply of equipment (holding tanks, harvesting nets, fish crane etc.) and extension services (trainings)
- Coordinating production: support farmers with production management
- Marketing strategies: research on market trends, opportunities, negotiation
- Processing services: provide facilities and manpower for processing fish prior to sales (sorting, washing, chilling and packing)
- Quality control: monitoring quality of fish ready for sales
- Credibility: legal entity selling fish

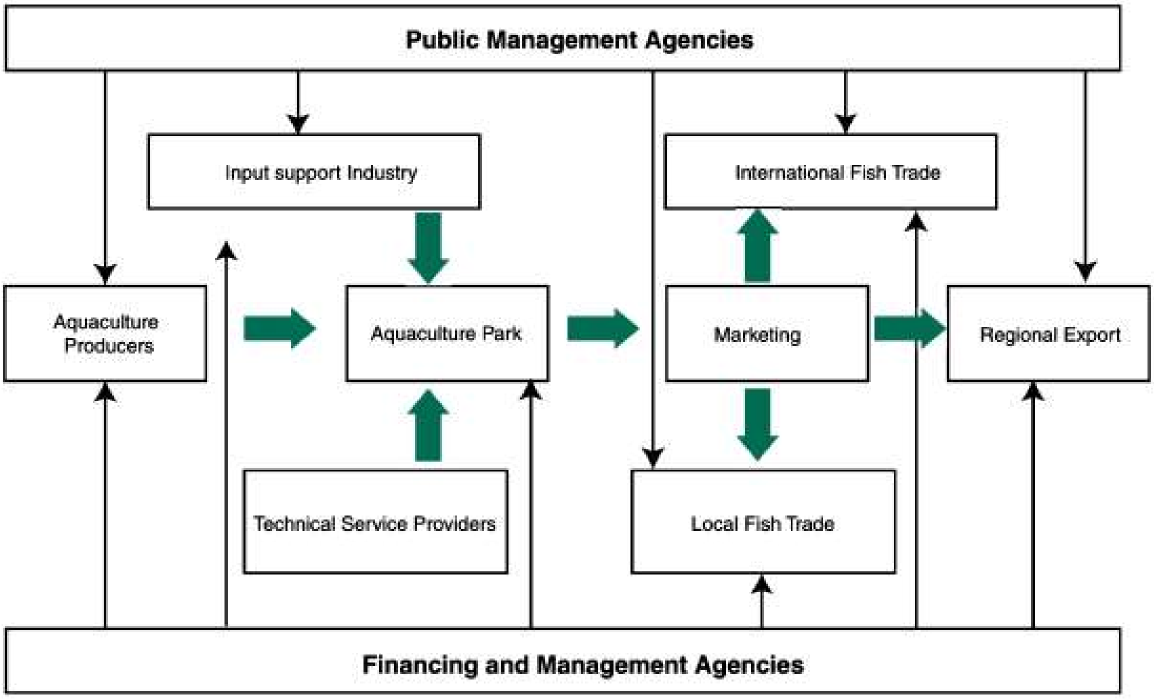
Other services that the integrator could provide in the future:

- financial services by providing inputs of credit basis or providing loans
- Retailing: detailed sales at higher prices than bulk sales.
- Trading: buying and selling fish from non-members
- Social services

2.2.2. Objectives of the AquaParks in Uganda

The National Investment Policy for Aquaculture Parks in Uganda (MAIFF, 2012) sets specific policy objectives along with strategies and recommendations for its effective implementation. It clearly targets the development of commercial AquaParks and intends to attract and enhance their development. The concept of the Aquaculture Park value chain developed by MAIFF is presented in Figure 2.

Figure 2 The concept of AquaParks value chain (MAIFF, 2012).



The nucleus AquaPark model can be integrated in this structure where in the Public Private Partnership (PPP) where the main private partner of the public is the large-scale producer company. The public sector can regulate the operation of the AquaPark through an agreement with this company with a special emphasis on the following issues:

- The transparency of the AquaPark management must be ensured.

- The services and fees charged by the company for the medium and small producers has to be regulated in the agreement.
- The guidance and support provided for the medium and small producers by the management company and by the public sector must be clearly described in the agreement.

2.3. Recommendation for land based AquaPark concept

2.3.1. General management

In early 2019 a preliminary site assessment was carried out to survey the possibilities for pond construction in the proposed land based AquaPark area. However, a more detailed soil characteristic survey will be needed for the engineering design of the AquaPark these results shows already that not the whole area of the park is suitable for pond construction. The consultant visited the site and suggested to include an intensive production unit in the AquaPark preliminary design to ensure the 2500-3000 tons production volume which can make the large infrastructure and technology investments economically feasible. The proposed AquaPark structure will include the following producers:

- Intensive African catfish flow-through farm producing 1500-3000 tonnes of African catfish in flow through system.
- Semi-intensive pond production of tilapia in 1 ha static water ponds.
- Small scale extensive pond production of tilapia in 0.2 ha static water ponds

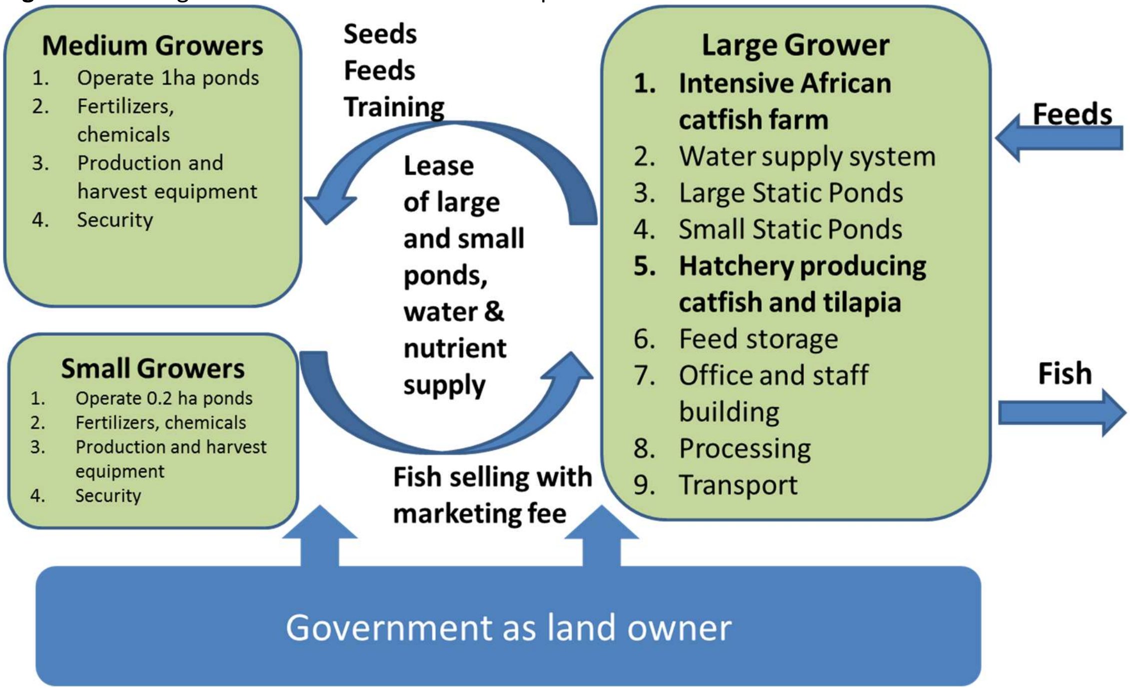
This structure was agreed by the participants of the inception report meeting on 11th February 2019, Entebbe.

It was also agreed, that to operate the intensive and semi-intensive units the AquaPark needs investors to finance the production costs.

Considering, that the designated 200 ha area is not everywhere ideal for pond construction, intensive aquaculture has to be applied. To exploit the excellent biological characteristics of the African catfish a tank based intensive flow-through technology is suggested (using much higher production/m^3 as the PARM study suggested) as the main part of the production (see the whole production plan in the relevant chapter).

The management and business plan model of the AquaPark should be simplified to remain attractive for the potential investors. To encourage the development of large-scale professional aquaculture in Uganda the AquaParks can be useful tool to facilitate private investments in the aquaculture. To achieve this goal the PPP model must be designed to support the large-scale production investment to make the production profitable while it also has to ensure that smaller farmers also will benefit from the investment. The PPP investments also must support the overall development of aquaculture activities in the region.

Figure 3 Working method of the nucleus based AquaPark model



2.3.2. Integration of out-growers

In the suggested concept, the large scale producer as the AquaPark nucleus company will integrate the following out-growers:

a) Medium and small scale producers operating fish ponds within the AquaPark territory
b) Medium and small scale producers operating fish ponds in the region, outside of the AquaPark.

The main difference between the 2 groups that the base of the integrated production within the AquaPark will be detailed in the operational agreement between the government and the large scale producer, while other farmers can be involved through bilateral agreements.

The farmers for operating the large and small ponds will be selected through a transparent mechanism coordinated by the MAAIF and involving local and regional decision making bodies. The involvement of farmers outside of the AquaPark will be based on an application procedure where the large producer will have the right to make the decision.

The AquaPark PPP operational agreement between the nucleus company (Private) and the government (Public) should detail the followings:

- Feed supply framework mechanism for out-growers by the nucleus company (price calculation methods, quality assurance, logistic framework etc.)
- Fingerling supply framework mechanism for out-growers by the nucleus company (price calculation methods, quality assurance, logistic framework etc.)
- Services in marketing of the aquaculture products by the nucleus company (compulsory volumes, price calculation method, quality assurance etc.)
- Technical advice and support services provided by the nucleus company for different out-growers
- Training and research services for out-growers provided by the government in cooperation with the nucleus company

2.4. Regulatory framework

A number of laws, regulations and policies have been developed to stimulate and support the development of aquaculture activities - and Aquaculture Parks in particular - in Uganda.

The key institutions and authorities involved in the coordination and implementation of the Aquaculture Parks policies and monitoring of their activities are:

- The National Planning Authority of the Ministry of Finance, Planning and Economic Development;
- The Ministry of Agriculture, Animal Industry and Fisheries through the Directorate of Fisheries Resources;
- The Directorate of Water Resources within the Ministry of Water and Environment (MWE);
- The Ministry of Lands and Urban Development;
- The Ministry of Tourism, Trade and Industry (MTTI);
- The National Environment Management Authority (NEMA);
- Uganda Investment Authority (UIA);
- Uganda Wildlife Authority (UWA).

Isyagi summarized the principle policies and regulations governing the development of Aquaculture Parks (Isyagi, 2017) and these summaries are presented in Annex 3. The key regulations to be followed for the establishment of any fish farming activities in Uganda are (NaFIRRI, 2018):

- The Fish Act, 2000
- Fish and Aquaculture Rules, 2003
- Water Act, 1997
- The National Environment Management Act, 1995.

All permits and licensing required for aquaculture activities are presented in the Fish and Aquaculture Rules, 2003.

3. Intensive tank culture: African catfish & pond production: Tilapia

3.1. African catfish: biological characteristics and farming procedures

African catfish *(Clarias gariepinus*) is a subtropical fish with a growth temperature range of 8°C to 35°C. The species is found in most African inland freshwater bodies with a pH of 6.5 to 8.0. It is a bottom dwelling fish but only reported to occupy up to a depth of 80 m. Clarias gariepinus has been reported to grow to 90 cm in length, weighing a maximum of 60 kg and living up 8 years with first maturity attained at 30 cm.

The growth of the catfish is directly linked to the optimum temperature. At a temperature between 25-30 °C growth is at an optimum.

Clarias gariepinus has been popular in African and Ugandan aquaculture in particular, mainly due to its wide tolerance to environmental conditions. It can survive low oxygen levels (less than 3 mg/l) as a result of the presence of an accessory breathing organ for capturing atmosphere oxygen (after the size of 3-4 cm). It is a bottom feeder but occasionally feeds at the water surface and requires high protein feed. The overall production characteristics of the African catfish are summarised in the Table 2.

Table 2 Summary of the culture parameters of African catfish

Reproduction	Hormone induction with various natural or synthetized products in all year. Male doesn't produce huge quantities of sperm, so it is needed to extract the gonad
Eggs production	Hatch on artificial support such as mosquito nets in flow though systems and in fish hatching jars. Eggs extracted from the female by striping the abdomen
Water Quality	Very resistant after the fingerlings stage when the air breathing cauliflower-like structures are developed. (3 weeks after hatching, 2.5-3 cm) Can survive in extreme conditions (sub optimal).
Diet	Predator; need high protein. Need more animal source protein. 44% crude protein in fry feed, 45-40% crude protein in juvenile and on-growing feed.
FCR: Kg of feed needed to produce 1 KG fish	1.1-1.3 for the on-growing, below 1 for the fingerlings
Culture cycle	Highly depend on the temperature, at 24-26°C can reach 1500g in 8 months
Sexual dimorphism	Male and Female are fast growing together, both sexes have similar growth rate, no need for sex reversal.
Market price in Uganda	10,000-11,000 UGX, larger fish are preferred.

The main farming technologies for African catfish are:

- Intensive production in flow-through systems using concrete tanks or ponds
- Semi intensive culture in ponds by using locally available feeds and natural production
- Extensive production in ponds, often in polyculture with other species

African catfish is an ideal raw material for fish processing because it has a very high dressed carcass and fileting yield especially compared to Tilapia as the following figures shows:

	Tilapia	African catfish
Dressed carcass	51.0%	60.0%
Filets	25.4%	46.0%

However, the planned AquaPark facilities will enable all the above-mentioned production methods, this feasibility study focusing on the development of a tank-based flow through production of the African catfish. This is the technology which very efficiently exploits the biological characteristics and potential of the species and can ensure the required economic feasibility of the investment.

3.2. Nile tilapia: biological characteristics and farming procedures

Tilapia is the common name for tropical freshwater fish of the Cichlidae family presenting very interesting characteristics for production. Tilapias have been farmed under extensive, semi-intensive and intensive conditions on every continent and are now the second largest group of fish farmed after carps. Out of all tilapia species, Nile tilapia, *Oreochromis niloticus,* is the most widely farmed. Its growth performances and adaptability to various farming environment have made it a target species for most of the aquaculture project developments in tropical areas in the last 30 years, for both artisanal and commercial interest.

Nile tilapia can adapt to temperature ranging from 12°C to close to 40°C, though optimum for farming is in the range of 26°C to 32°C. Below 24°C, reproduction will stop. The production cycle is easily reproduced in captivity allowing for large production of fingerlings at regular interval. Fingerling production takes about 8 weeks from eggs to 1.5-2g fingerlings. The Brooders are mixed at a male to female ratio of 1:2 to 1:3 either in hapas in ponds or in tanks, and eggs are collected at regular intervals depending on the water temperature (optimum at 28°C). Eggs are incubated for a period of 5-8 days in artificial incubators with constant water exchange ensuring the best hatching rates. After the incubation period, the fish are transferred to rearing units (hapas in ponds, directly in ponds, or in tanks) for a period of approximately 7 weeks. Feeding is undertaken on a daily basis using commercial feeds to optimise growth and regular grading will ensure homogeneity of the batches.

From 1.5 to 2g, the fingerlings are ready to be transferred for pre-growing (juvenile) phase and later to the on-growing phase to reach market size.

Depending on the farming technology selected (cage, ponds, tanks), the level of intensification (supply of artificial feeds, artificial aeration and water exchange…), and most importantly the water quality parameters (temperature, oxygen, ammonia), the production cycle from 2g to 400g ranges from 5 to 8 months or more.

Table 1: ranges for optimal water quality and environmental parameters for culture of tilapia *O. niloticus*

Description		**Criteria**
Optimal Average temperature	°C	28-30
Optimal Average Salinity	‰	0
Optimal Dissolved Oxygen	mg/l	5-7.5 (minimum 4)
Optimal Dissolved Oxygen	%	70-100
Optimal Average pH		6.8-8
Maximum Ammonia NH_3	mg/l	0.1
Maximum TAN -NH3/NH4+ (pH dependent)	mg/l	2
Maximum NO_3- -N	mg/l	300
Maximum NO2-	mg/l	0.1

Maximum CO2	mg/l	40
Calcium hardness	mg/l	50-100
Chloride	mg/l	100-300
Alkalinity	mg/l	100-250

This feasibility study focusing on the development of a pond based AquaPark, only the relevant pond farming technologies are described below.

3.3. Proposed Farming technologies in Apac

3.3.1. Production of African catfish in intensive flow-through system

African catfish is considered as one of the species with a high potential for the aquaculture development in Africa. The unique characteristics of the species like the very low Feed Conversion Ratio and the ability to take up oxygen from the air paired with excellent flesh quality and good processing yield makes this fish ideal for intensive production. To exploit the high biologic potential of the species the farming technology must ensure the ideal conditions for the growth.

The flow-through technology in concrete tanks can ensure:

- High production density: some farms use 300kg/m^3 stocking density for larger size groups.
- Optimal water quality: However, the fish is quite tolerant for poor water quality parameters, high ammonia and large amounts of suspended solids can increase the stress.
- Controlled production: The whole production cycle and all elements of the technology can be controlled. For example, feeding levels can be corrected according to the biomass calculations. Frequent grading of the fish is also required especially up to the size of 200g.

In the project we suggest starting with a lower production density, around 150 kg/m3 and raise the production by increasing the maximum stocking density up to 300 kg/ m^3.

3.3.2. SWOT analysis of African catfish production in flow-through system

<table>
<tr><th colspan="2">SWOT</th><th>Management, Mitigation, Exploitation</th></tr>
<tr><td rowspan="8">Strengths</td><td>Large, concentrated production</td><td rowspan="4">Through Public Private Partnership (PPP) in the aquaculture development African catfish can be one of the main species of the aquaculture development in Uganda. Can be promoted as safe and predictable investment for private investors.</td></tr>
<tr><td>Simple, efficient production infrastructure which can be built close to the market</td></tr>
<tr><td>Good examples, success stories in other African countries</td></tr>
<tr><td>The species does not have known highly contagious disease</td></tr>
<tr><td>Excellent meat quality</td><td rowspan="2">Generic marketing campaigns by government and farmers association to raise consumer awareness in Uganda for the benefits of the species.</td></tr>
<tr><td>High processing yield</td></tr>
<tr><td>The fish is known and popular in Northern - Uganda</td><td>Brand development for farmed African catfish by producer companies to increase markets.</td></tr>
<tr><td>Easy to transport and store alive</td><td>Development of alternative distribution channels without cold chain by involving small scale fish farmers as selling points.</td></tr>
</table>

Weaknesses	High investment costs	Financial support mechanisms for investors can facilitate aquaculture development
	The market value chain is not fully developed in the region	In parallel with increasing production, producers and governmental bodies have to work together to improve value chain.
	African catfish feed is not available at the moment in Uganda	Actions are needed to organize local feed production at least for the on-growing feed.
	Production technology is not widely used in Uganda	Technology research projects and trainings should be carried out by NaFIRRI.
	Market competition with wild catch	Identify and communication the benefits of aquaculture products
	Environmental impacts of intensive aquaculture	The impacts can be minimised by appropriate water treatment technologies and through reuse of nutrient rich effluents.
Opportunities	Increasing population in Uganda	Development of national programs to improve access for people to aquaculture products (logistic, support, information).
	Development of new processed products	Value added products to increase new and traditional markets like ready to cook products.
	Export markets for processed products	Development national strategy how the existing EU approved fish processing capacities can be better utilised.
Threats	Increase of feed prices because of the dependency on imported feed	Discussions with national and international feed producers should be started to establish a high-quality fish feed mill in Uganda.
	New, emerging diseases	Research and training programs on biosecurity in aquaculture can reduce the risks and the impacts.
	Increased import of Pangasius products from Asia	Developing a strong brand for African catfish produced in Uganda.

3.3.3. Tilapia production in large static ponds

Production of Nile tilapia (Oreochromis niloticus) in semi-intensive earthen ponds is the most important farming system in many countries (Egypt, Israel, Thailand, China), but it is not widely used in Uganda.

In this technology the fish yield is resulted from:

- Natural production yield: the phyto- and zooplankton biomass of the ponds is boosted by using fertilisers and a part of the fish dietary requirements is covered by this natural feed. The ratio of the natural production yield largely depends on the stocking density and the fertilization of the ponds and can reach the 50% of the total fish biomass yield in semi-intensive ponds.
- Feed yield: The utilisation of the natural food and the availability of this will decrease as the fish grow and the larger fish will need supplementary feeding by using formulated feed. Studies shows (Edwards et al. 2000.), that the most economical method to start the feeding when the fish reach the 100-150g size and rear them up to 450-500g.

Using this method, the length of the production period to reach the 500g market size varies between 236-328 days and the available yield/cycle is around 14 t/ha. Extrapolated for the whole year or using more intensive feeding and aeration of the ponds the yield can be 20 t/ha.

3.3.4. SWOT analysis of Nile tilapia production in large static ponds

SWOT		Management, Mitigation, Exploitation
Strengths	The technology is well known and proven in the world	Beside cage culture, semi intensive pond production of tilapia can contribute to the increase of the fish production in Uganda. The optimal market size can be larger than in cage production and pond produced tilapia can target specific national markets.
	Ponds can be operated with minimal working capital	
	Better use of the competitive advantages and environmental resources of the country in aquaculture	
	The technology is less dependent on the formulated feed quality and feed prices	Can be promoted as attractive investment opportunity for medium scale investors where the required working capital depends on the intensity of farming technology.
	Application of the most modern water monitoring and water treatment technologies can boost the production and reduce costs	
	Tilapia has already large markets in Uganda. Tilapia products are well known everywhere in the country.	Strengthening the image of locally farmed tilapia. Research on the nutritional values of pond farmed tilapia.
	Pond farming is labour intensive technology, can create jobs in rural areas	Long term aquaculture employment and training strategy for Uganda should identify the best locations for pond farming.
	Relatively low environmental impact	Static water ponds do not discharge organic material and nutrients in the environment. National strategies should encourage the increase of pond production.
Weaknesses	High investment costs compared to the available production volume results low NPV	Financial mechanisms to support pond constructions have to be developed.
	Earth ponds without liners require specific soil characteristic	Detailed soil survey of potential pond aquaculture areas.
	High competition with imported Tilapia products	Labelling of fresh locally produced tilapia. Production of at least 500 g market size could be an advantage on the market.
	Market competition with wild catch	Identify and communication the benefits of aquaculture products
	Maintain optimal water quality and productivity balance require specific experience and knowledge	Technology research projects and trainings should be carried out by NaFIRRI.
	Production technology is not widely used in Uganda	

Opportunities	Increasing population in Uganda	Development of national programs to improve access for people to aquaculture products (logistic, support, information).
	Development of new processed products	Value added products to increase new and traditional markets like for example ready to cook products.
	Increased tilapia production will reduce the feed costs	The ambitious plans for increased cage production will facilitate the establishment of local fish feed mills and distribution centres.
Threats	Tilapia Lake Harvest Virus is an emerging disease in the world	By using the appropriate biosecurity measures static pond systems disease outbreaks can be prevented. Because the prevention is much more difficult in cage systems a regional disease outbreak will increase the importance of pond farming.
	Increased import of Tilapia products from Asia	Awareness raising for fresh, locally produced tilapia. Compulsory labelling of imported, thawed products.

3.3.5. Tilapia production in small ponds

Small scale production of African catfish and tilapia in 200-500 m^2 earth ponds is a widely applied technology in many districts of Northern-Uganda region. The main problems of the farmers are:

- The production is very dependent on the rainy season when the water level of the swamps starts to raise to fill up the ponds or the rain provides enough water to fill up the ponds. The production season starts in April and finish in November-December.
- The farmers do not have the money to buy good quality feed and seed for the production and because of the very limited demand there are not available throughout the whole year.
- Because the water management of the ponds is not ideal, the farmers cannot exploit the natural production yield of the ponds.

In the proposed AquaPark 2000 m^2 ponds are suggested to build covering 10ha area. This size is large enough to effectively use the natural production of the pond but still can be managed by families with limited resources. (no need for heavy machines, household by products can be used as feed etc.). Because these ponds will have a clean water supply from the water reservoir and also have the option to use the nutrient rich effluent water of the intensive farm, the water quality can be managed by the farmer. These ponds will be suitable either for extensive production or for a semi intensive production of catfish and tilapia. The small-scale farmers will be able to purchase fish feed, high quality, monosex fingerlings and manure throughout the whole year from the AquaPark company and from the larger producers. They can decide about the applied technology and ratio of the stocked species according to their resources and knowledge.

The financial model calculated with 3 tonnes/ha average production volume for these ponds which assume a low-level semi intensive production where complementary feeding by using pellet feed is applied.

3.3.6. SWOT analysis of Nile tilapia production in small static ponds

SWOT		Management, Mitigation, Exploitation
Strengths	Similar technology is used already in Uganda, there is a high interest for small scale aquaculture production	Promote small scale fish farming as an activity to provide income for the rural families. Socio-economic research has to be carried out to survey the potential number of small-scale farmers managing small ponds in the AquaParks.
	Ponds can be operated with minimal working capital	
	Extensive technology is not dependent on external inputs like machines, feed, electricity	
	Small ponds can be managed by families providing good income	
	Small ponds can provide opportunities for various aquaculture technologies from extensive to intensive production	AquaPark pond design has to ensure the application of various technologies.
	Regularly harvested small volumes of fish can be easily sold on the local markets	AquaPark agreements shall allow for small scale farmers to sell their products up to a certain volume.
	Zero discharge extensive and semi-intensive technology is able to clean effluents of intensive aquaculture production	Small scale farming can be combined with large scale intensive aquaculture production where large producers provide fingerlings, know-how, feed while small farmers can treat the effluents of the intensive farm.
Weaknesses	Potential small-scale farmers does not have the capital to build ponds	Financial mechanisms to support pond constructions have to be developed.
	Earth ponds without liners require specific soil and topographic characteristic.	Detailed soil survey of potential pond aquaculture areas.
	Efficient extensive and semi intensive technologies are not widely known.	Specific trainings about extensive technologies have to be developed and on-site trainings should be provided.
	Market competition with wild catch.	Identify and communication the benefits of aquaculture products.
	Low profitability of small-scale production.	Successful small-scale farmers should be supported by the government to increase their production and grow.
Opportunities	Low input technologies can provide cheaper, affordable fish in rural areas	The small-scale farming can contribute to food security and healthy diet of poor people.
	Small scale aquaculture is the best way to train people for fish production	Pilot AquaPark activities should include on site training and demonstration.
	Construction of a number of ponds sharing dykes and supply channels reduce the relative investment costs	Small scale ponds have to be included in the AquaPark design
	Using nutrient rich effluent water from intensive fish farms can further reduce the production costs	The possibilities of Combined Intensive Extensive systems in Uganda should be further researched.
Threats	Disease outbreaks can cause massive losses	Biosecurity measures has to be developed for the whole AquaPark and all producers have to apply them
	Increased import of Tilapia products from Asia can reach the markets of the small farmers	Awareness raising for fresh, locally produced tilapia. Compulsory labelling of imported, thawed products.
	Investing in large number of small ponds is not attractive for investors	The construction of small ponds should be 100% financed by the PESCA project.

3.4. Supporting functions to production

The development of the land based AquaPark requires auxiliary functions and activities to support production, facilitate operations and reduce the production costs of fish farmers by grouping the efforts. These include the following:

- Office building, staff quarters and training centre
- Hatchery producing African catfish and Tilapia fingerlings
- Pumping station with pumps
- Water reservoir to ensure continuous water supply
- Sedimentation pond collecting all discharged water of the AquaPark
- Supply and discharge water channels
- Feedstore
- Workshop for servicing and maintenance of various equipment
- Processing facility to sort/process/package the harvested fish
- Ice machine and ice storage

3.5. Environmental impact

However, the concept of the land based AquaPark is to treat in constructed wetland and reuse the discharged water and nutrients of the intensive African catfish farm, it still will have an impact on the environment. In this study the environmental carrying capacity of the project will be assessed but an Environmental Social Impact Assessment (ESIA) must be developed for the selected site in order to assess the quality of the environment prior to starting farming operations. The operating AquaPark will need frequent monitoring must be implemented in order to assess and evaluate environmental changes due to any possible pollution coming from the intensive and semi intensive aquaculture activities. The content and approach to the ESAI is mandated by NEMA in Uganda and must use appropriately certified individuals to conduct the study. This leads to approval prior to establishing the farm.

A series of measure can be implemented preventively to minimize the impact of cage farming on the environment, including alternating farming sites to allow natural remediation of the lake bottom over a period of time. This remains difficult and expensive to implement as it requires moorings readily available at different sites.

The ESIA for the proposed land based AquaPark in Apac district needs to be developed and submitted for approval to the National Environment Management Authority. This is currently being undertaken separately from this Feasibility Study.

3.6. Diseases

3.6.1. Diseases of African catfish

African catfish is known as fish species with a very high resistance to diseases and water quality. If African catfish does develop a disease, almost always the reason for the disease is related to environmental or management problems of the farming. While the disease in African catfish must be treated properly, but in the meantime work on solving the cause of the problem in a structural way. The tanks must be cleaned and disinfected regularly by using formalin or other antibacterial disinfection solution. The most important diseases are listed in Table 3 using data from literature (Gertjan De Graaf and Johannes Janssen 1996., Viveen et al. 1986) and personal interviews with catfish farmers in Hungary.

Table 3 Summary of the main disease affecting African catfish farming**.**

DISEASE	AGENT	TYPE	SYMPTOMS	TREATMENT
Bacterial infections	*Aeromonas, Pseudomonas species*	Bacteria	Mainly on fingerlings and fry, an oedema ventral from the cardiac cavity which can cause heavy mortalities (up to 90%)	Prevention by keeping clean stress-free environment. Short or long bath treatment using various antibiotics, Neomycin or Florfenicol in 50mg/L concentration. Antibiotics in the feed 100 mg active ingredient/fish biomass kg for 10 days
Bacterial infections	*Fexibacter, Myxobacteria*	Bacteria	Mainly on fingerlings and small juveniles, fish remain in vertical position at the surface, white spots on the skin particularly around the mouth and on the fins.	Proper hatchery management reduces the risk of myxobacteria and infected fish can be treated with a Furaltadone-bath at a dose of 50 ppm for one hour. Alternatively, Florfenicol added to the feed in 5g/10kg fish biomass.
Fungal diseases	*Saprolegnia*	Fungus	Mainly infect the eggs but also adult fish can be infected. Cotton-like growths on the eggs and on the skin of the fish especially on skin injuries.	0.25 mg/L formalin bath for 10-15 min or hydrogen peroxide-based products in the recommended dose. **Note**: the use of malachite green is strictly forbidden in aquaculture.
Parasitical diseases	*Trichodina*	Protozoan parasite	Mostly occurs on fingerlings and juveniles. White mucoid film on the skin and gills, bloody areas on the skin	Regular, accurate cleaning of the tank's surface, 2.5 ml/100l formalin solution. Formalin bath in 10-20 ml/100l for 20-25 min. NaCl 3% solution bath for 1-3 min
Parasitical diseases	*Costia*	Protozoan parasite	Relatively low mortality of the fingerlings, fish swim in vertical position at the surface.	Regular, accurate cleaning of the tank's surface, 2.5 ml/100l formalin solution. Formalin bath in 10-20 ml/100l for 20-25 min. NaCl 3% solution bath for 1-3 min
Parasitical diseases	*Ichthioptirius*	Protozoan parasite	White dots on the skin and the barbels.	Prevention by higher exchange rate of water. Formalin bath in 10-20 ml/100l for 20-25 min. NaCl 3% solution bath for 1-3 min
Monogenetic trematodes	Dactylogyrus spp.; Gyrodactylus spp.	Protozoan parasite	Occurs on body surface, fins or gills	$KMnO_4$, $CuSO_4$ or formalin treatments, NaCl 3% solution bath for 2-4 min
Ruptured intestine syndrome	Unknown	Unknown	Lethargic behaviour; swollen abdomen; discoloured abdominal skin; reddish anal area; rupture of the abdominal wall at the final stage	Provide sufficient balanced and well conserved diet.

DISEASE	AGENT	TYPE	SYMPTOMS	TREATMENT
Crack head disease	The cause of this disease is not fully understood	Unknown	"Crack head" disease is an obvious catfish disease reported from intensive pond rearing and hatcheries up to present in Africa. slightly distended abdomen due to septicaemia and haemorrhage. This disease can be detected in an early stage, affected fish show a reddish lateral line on the skull, between the two air chambers, parallel to the skull plate joints	Adverse water quality due to overfeeding and Vitamin C deficiency are believed to be the main factor causing "crack head" disease. Feeding should be substantially reduced, more vitamin C (ascorbic acid) must be added to the feed.

3.6.2. Diseases of Tilapia

Tilapia are often reported as fish that are highly resistant to poor water quality and diseases, but this characteristic seems to fade as several cases of mass mortalities have been observed in commercial operations around the world and linked with disease infestation. In recent years, the most virulent disease affecting tilapia farming are streptococcosis and Tilapia Lake Virus disease also called TiLV.

Vaccines have been developed to prevent infections from *Streptococcus* (Brudeseth, 2013) and mass vaccination is now implemented in commercial operations, but it is still expensive making it difficult to implement for small-scale farmers. Table 4 below presents a summary of the main diseases affecting tilapia farming.

Table 4 Summary of the main disease affecting tilapia farming. Source FAO 2005, OIE 2018.

DISEASE	AGENT	TYPE	SYMPTOMS	TREATMENT
Tilapia Like Virus (TiLV)	*Orthomyxo-like virus*	Virus	Inflammation of eyes and brain, liver damage, red skin. Mortality reaching 80-100% of infected fish.	No treatment has been found yet. Recommendations from OIE and FAO are to restrict movements of tilapia from farms and countries which are known to be infected with TiLV.
Motile Aeromonas Septicaemia (MAS)	*Aeromonas hydrophila* & related species	Bacteria	Loss of equilibrium; lethargic swimming; gasping at surface; haemorrhaged or inflamed fins & skin; bulging eyes; opaque corneas; swollen abdomen containing cloudy or bloody fluid; chronic with low daily mortality	$KMnO_4$ at 2-4 mg/litre indefinite immersion or 4-10 mg/litre for 1 hour; antibiotics (need 'extra-label use permit' in the USA), e.g. Terramycin® in feed at 50 mg/kg fish/d for 12-14 d, 21 d withdrawal
Vibriosis	*Vibrio anguillarum* & other species	Bacteria	Same as MAS; caused by stress & poor water quality	Antibiotic in feed
Columnaris	*Flaviobacterium columnare*	Bacteria	Frayed fins &/or irregular whitish to grey patches on skin &/or fins; pale, necrotic lesions on gills	$KMnO_4$ as with MAS; indefinite immersion with $CuSO_4$ at 0.5-3 mg/litre, depending on alkalinity

DISEASE	AGENT	TYPE	SYMPTOMS	TREATMENT
Edwardsiellosis	*Edwardsiella tarda*	Bacteria	Few external symptoms; bloody fluid in body cavity; pale, mottled liver; swollen, dark red spleen; swollen, soft kidney	Antibiotic in feed
Streptococcosis	*Streptococcus iniae* & *Enterococcus sp.*	Bacteria	Lethargic, erratic swimming; dark skin pigmentation; exophthalmia with opacity & haemorrhage in eye; abdominal distension; diffused haemorrhaging in operculum, around mouth, anus & base of fins; enlarged, nearly black spleen; high mortality.	Antibiotic in feed, e.g. Erythromycin at 50 mg/kg fish/d for 12 d (requires 'extra-label use' permit in the USA), or vaccination by injection
Saprolegniosis	*Saprolegnia parasitica*	Fungus	Lethargic swimming; white, grey or brown colonies that resemble tufts of cotton; open lesions in muscle	$KMnO_4$ or $CuSO_4$treatments; use 1 mg/litre of $CuSO_4$ for every 100 mg/litre alkalinity up to 3.0 mg/litre $CuSO_4$; formalin at 25 mg/litre indefinite immersion or 150 mg/litre for 1 h
Ciliates	*Ichtyophtirius multifiliis; Trichodina* and others	Protozoan parasite	Occurs on gills or skin	$KMnO_4$, $CuSO_4$ or formalin treatments
Monogenetic trematodes	*Dactylogyrus* spp.; *Gyrodactylus* spp.	Protozoan parasite	Occurs on body surface, fins or gills	$KMnO_4$, $CuSO_4$ or formalin treatments

4. Site suitability and carrying capacity

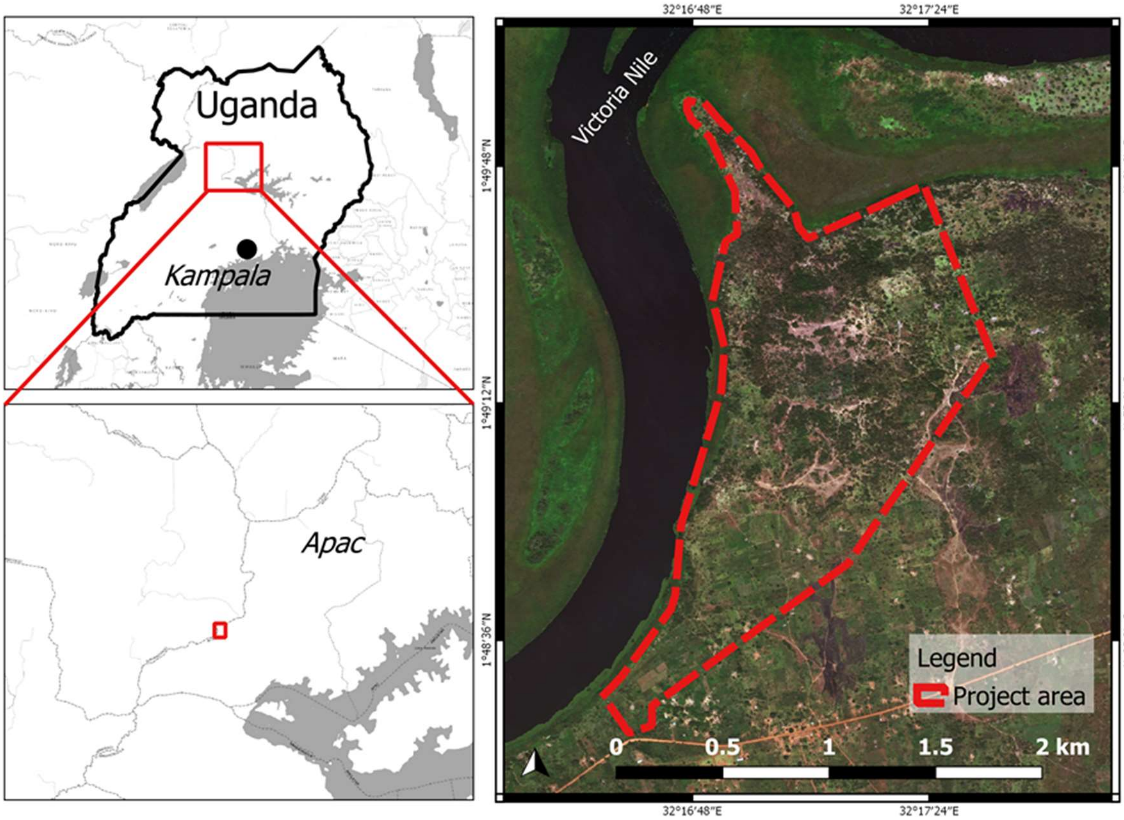
4.1. Site selection criteria

Following the approval of the Onekgwok and Tarogali in Apac district for establishment of the land-based Aquaculture Parks (APs) in Uganda by MAAIF under the Promotion of Environmentally Sustainable Commercial Aquaculture (PESCA) project, and area along the Victoria Nile river was designated for the planned aquaculture production. The preliminary site suitability survey of the area (Figure 4) was carried out by the NaFIRRI (NaFIRRI 2019 report) team to asses primarily the following critical questions:

- the physic-chemical characteristics of the waters accessible in the proposed land for aquaculture production.
- To investigate the soil characteristics of the area to decide if it is generally suitable for pond construction or not.

A topographic survey of the area also was carried out after the preliminary survey, but the results of this were only available as PDF summary file at the time of the recent draft preparation.

Figure 4 Map of the different sites that were visited during the survey to assess site suitability for land based and lake-based Aquaculture Parks at Onekgwok and Tarogali in Apac District



Water availability and water quality

The planned produced species, African catfish and Nile tilapia does not have specific needs for the water quality but the water temperature has an impact on the production characteristics of the planned farms. The main water source of the whole AquaPark will be the Viktoria Nile river forming the longest border of the designated AquaPark area. NaFIRRI data (Table 5) shows that the physical and chemical water quality parameters of all sampling points were appropriate for African catfish and tilapia aquaculture.

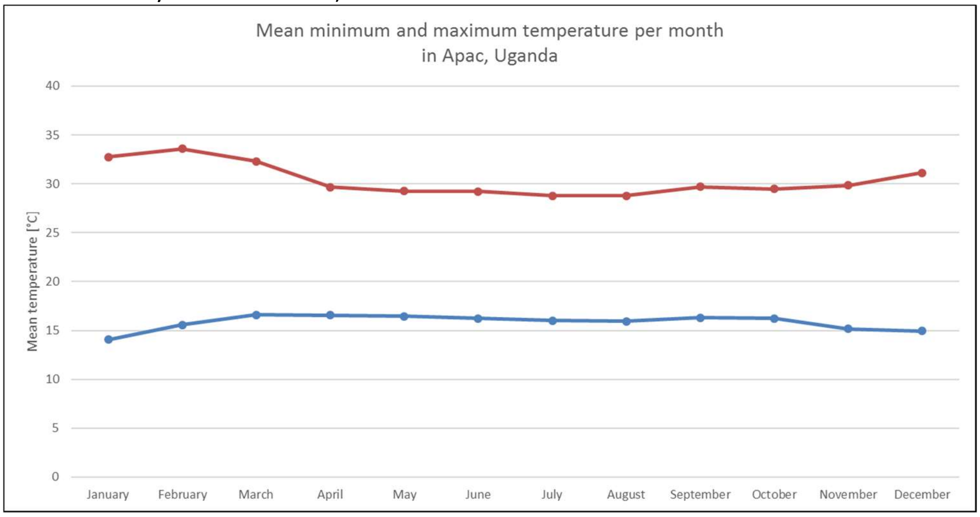
Table 5 Physical criteria; mean(X) ± SD of the selected physical parameters that were considered in the assessment of site suitability. (NaFIRRI 2019)

Site	**Site**	**TD**	**SD**	**FR**	**pH**	**Cond**	**DO**	**Temp**
Land based/River fed		**(m)**	**(m)**	**(m/s)**	**(-)**	**(µS/cm)**	**(mg/L)**	**(˚C)**
R. Nile (Onekgwok)	A	1.2	0.4	96	7.2±0.2	92.9±0.1	7.0±0.0	24.8±0.0
	B	8.6	1.2	114	6.9±1.1	127.0±0.1	7.9±0.1	26.3±0.0
	C	8.1	1.3	169	6.7±0.6	123.0±0.3	5.8±0.5	26.3±0.0
	D	3.2	0.4	86.5	7.0±1.1	120.3±0.1	7.7±0.8	26.3±0.0
R. Nile (Tarogali)	A	3.36	1.6	328	6.2±1.2	142.8±0.1	6.5±0.0	24.1±0.0
	b	7.55	1.45	123	7.2±0.4	222.7±6.7	7.6±0.6	25.9±0.5
	c	3.11	1.5	260.5	7.7±0.3	140.9±0.2	5.9±0.1	24.3±0.0
	d	2.11	0.81	89.5	7.67±0.5	134.9±0.5	6.1±0.5	25.1±0.3
Recommended range		**> 5**	**0.6**	**(9 -15)**	**6.5 – 9.5**	**100 – 2,000**	**> 5**	**24 - 30**
Acceptable range		>5	0.4-1.2		**5.5 - 10**	**30 - 5000**	**>2**	**22 - 35**

The water temperature data of the possible water extraction points shows values in a range of 24-26 °C which can already provide good culture conditions for both species. Taking into account that the water will be pumped from the river to a water reservoir and in the ponds, the final water temperature will be defined by the average yearly temperatures of the area. Considering the available air temperature data, it is estimated that the average culture water temperature for the flow-through African catfish farm will be a little bit higher than the river temperature reaching the 25-26°C.

The water temperature of the shallow 1.5 m deep ponds will go up to 28-30 °C which is still favourable for Tilapia production, but with high densities the oxygen level can be low especially during the morning hours.

Figure 5 Average monthly minimum and maximum temperature in Apac, Uganda (data source: provided by NaFIRRI; based on the years 2008-2018)



The dissolved oxygen levels (DO) of all sampling site were sufficient for Tilapia and African catfish production, but this parameter is highly affected by the day period. However, the exact time of the sampling is not known, it is assumed that the measured 5.8-7.9 mg/L DO level at the water supply side of the farms will ensure the required oxygen level if the appropriate farming practices are applied.

Chemical parameters presented in the NaFIRRI report for all considered chemical parameters Nitrite-Nitrogen (NO2-N), Nitrate-Nitrogen (NO3-N), Total Ammonia-Nitrogen (NH3-N), Soluble Reactive Phosphorous (SRP) and Total Suspended Solids (TSS) in all the sampled sites were found to be much below the recommended range for aquaculture.

Soil and topographic data

The starting point of the aquaculture park development in the Apac district was to develop pond-based production systems to produce tilapia and African catfish. Unfortunately, the suitability of the land characteristics for pond construction was not surveyed before designating the area for a pond based aquapark. These field investigations to determine surface and sub-surface soil conditions at the site should be made as early as possible as they may reveal soil conditions undesirable for pond construction.

For engineering purposes, the techniques used for soil investigations vary from relatively simple visual inspection to detailed sub-surface exploration and laboratory tests. Visual inspection of the site is an essential preliminary step to provide data on sub-surface soils, a test pit measuring 0.80×1.50 m with a depth of 1.50 to 2.0 m, depending on the land form and the elevation of the water table, should be dug in each hectare of the site. Digging of a test pit permits visual examination of soil and also makes it possible to obtain disturbed and undisturbed samples of soils encountered in the different layers below ground level.

Soils have characteristics that can easily be determined by sight and feel. Visual examinations are employed in place of precise laboratory tests to define the basic soil properties. A sandy clay to clayey loam is the best type of soil both for pond construction and growing natural foods at the pond bottom. Areas with a layer of organic soil over 0.60 m in thickness are unsuitable for any kind of fish pond, because it would be difficult to maintain water levels in the ponds due to high seepage; also, it would be necessary to transport suitable soils for dike construction to the site, and this will be costly. Big surface stones or rock outcrops may make an area unsuitable for anything except lined ponds or concrete raceways.

NaFIRRI team carried out a very limited site suitability research and collected soil samples at a depth of 15cm from the surface. Physical observations for colour, texture, stickiness, and odour were carried out in the field. The collected soil samples were sent to the laboratory for further detailed analysis. In the laboratory, the collected soil samples were analysed for dry consistency, plasticity (wet soils), plastic limit (toughness on thread), percent organic matter content, cation exchange (CEC), pH (-), conductivity, Nitrates, Phosphorous and Bi-carbonate concentrations.

However, the samples were only taken from the top layers of the soils, together with the general topographic end environmental data can give a preliminary idea about the site suitability for pond construction.

The recently available data from the rating of soil properties and area characteristics (NaFIRRI 2019) shows the designated land area is not everywhere suitable for pond construction. According to the preliminary study and site visit discussions the soils in the Onekgwok are seems the most suitable option for establishment of earthen pond aquaculture establishment. Because of the rocky, stony and silty nature of the soils at Tarogali, ponds would be expensive to construct and would require liners to hold water.

Concrete tanks can be built in the areas where earthen pond construction is not possible, but it has to be taken into consideration, that in these areas the building of water supply channels without watertight covering is also a limitation for the project.

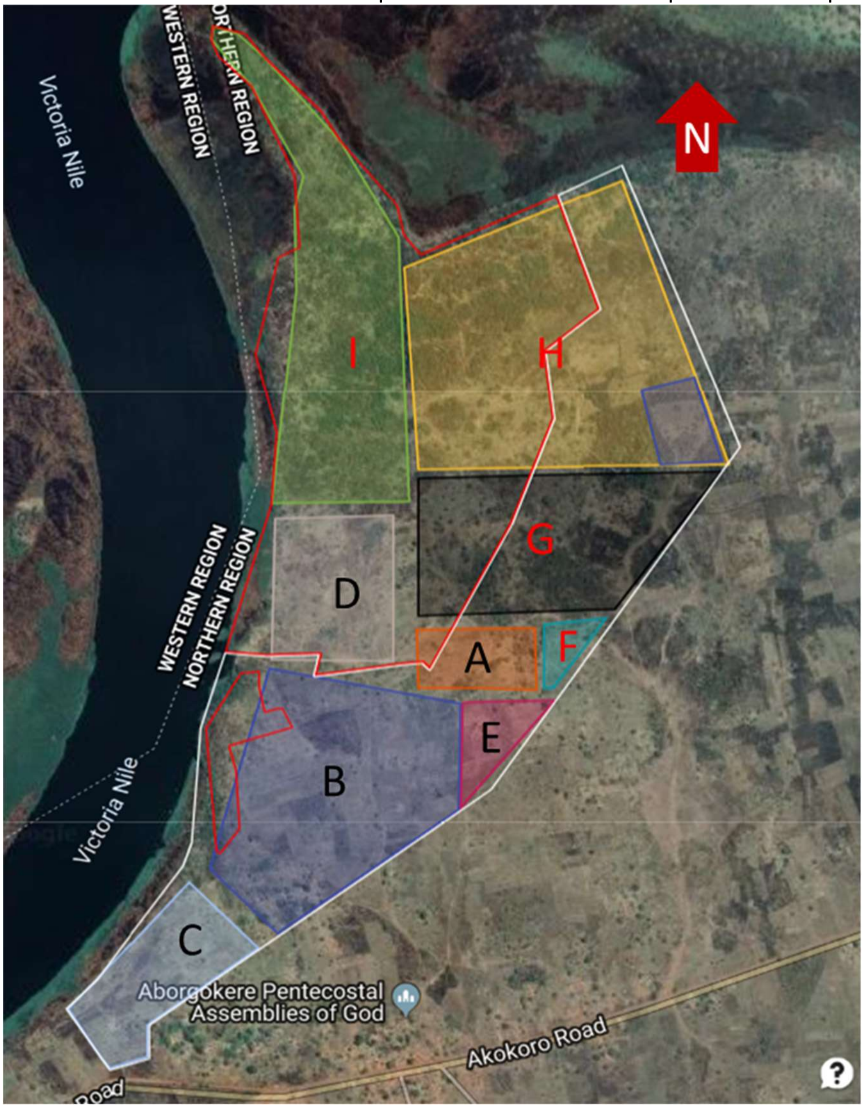
According to the land elevation model, developed from the data of the land topographic survey the proposed areas of Onekgwok and Tarogali are on the upper bank of the Nile in Apac district and therefore less susceptible to flooding. During the site visit, the consultant also collected GPS data about the elevation estimation and a topographic model input data also were received from the MAAIF (Appendix 4) and incorporated in a land elevation model. According to these data the elevation between the river water level (1030 m) and the highest points of the area suitable for a water reservoir construction (1048m) is 18m which will be the base of the calculation of the pumping requirements.

The final, detailed site survey, before the design and engineering of the ponds will need a more complex and detailed soil survey and topographic survey to provide the required data what the pond engineers require. The best if this work is carried out by the same company which will prepare the engineering design for the ponds.

4.2. Proposed, preliminary location for the aquaculture technologies

The area between Apac and Masindi Port was identified in this study as a potential location of the land based AquaPark and the process of the land purchase by the government to ensure approximately 200 ha (Figure 1.) for the AquaPark has started. The preliminary site suitability assessment from NaFIRRI found that the whole proposed area is NOT suitable for pond-based aquaculture due to the rocky surface, soil and topographic characteristics. The area most appropriate for pond construction was visited by the consultant to identify the potential areas for the suggested technologies.

Figure 6 Proposed areas for the first and second phase of the land-based AquaPark development



Based on the results of preliminary site suitability report the areas of the different aquaculture activities were identified and a phased implementation of the AquaPark was proposed. In Phase 1 the pilot AquaPark will be developed within the framework of the PESCA project. Using the results and the experience in AquaPark management in Phase 2 the AquaPark will reach it's final size by hosting more aquaculture and fish farming related activities.

Figure 6 shows the designated AquaPark areas (outer red and white line marks the whole area) and a possible allocation of various activities.

Phase 1. Pilot project

A: 6ha for intensive African catfish concrete tanks, multispecies hatchery, water reservoir (with liner), Offices, workshop, feed store

B: 35ha large static tilapia ponds with aeration

C: 11 ha area small 0.2 ha static ponds with water supply

D: area for 3 ha sedimentation pond and constructed wetland for water treatment

E: 4 ha community pond for animals and irrigation (optional, not included in the financial model)

Phase 2 suggested developments

F: Area for future Solar Panel park to provide energy for the AquaPark

G: Aquaculture service infrastructure area: processing plant, feed mill, logistic centre

H: Lined fishponds (52 ha) to produce 20 t/ha African catfish in semi intensive static water ponds. The area includes 3 ha water reservoir to provide fresh water supply.

I: Irrigated agricultural land to reuse nutrients and produce crops for fish feed production or for human consumption

Detailed description of the areas and their use in the relevant chapter. Outline design of the ponds and the infrastructure is in Annex 2. The final number and detailed design of the ponds and the buildings will be defined in the engineering phase of the project. In this study we described the ideal use of the available land and technologies, but the number and size of the ponds depends on the results of the detailed site surveys (soil, geology etc.) in the engineering phase.

4.3. Carrying Capacity

To develop an ecosystem-based management approach for aquaculture to strengthen the implementation of the FAO Code of Conduct for Responsible Fisheries, the FAO proposed an ecosystem approach to aquaculture (EAA), defined as a strategy for the integration of aquaculture within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems. Carrying capacity is a major component of EAA, which helps set the upper limits of aquaculture production given the environmental limits and social acceptability of aquaculture, thus avoiding "unacceptable change" to both the natural ecosystem and the social functions and structures. In general terms, carrying capacity for any sector can be defined as the level of resource use both by humans and animals that can be sustained over the long-term by the natural regenerative power of the environment (Ross et al. 2013).

The Aquaculture Park development in Apac must follow the principles of EAA, to ensure the long-term environmental, economic and social sustainability of land-based aquaculture investments. The main aspects of carrying capacity assessments follow the 4 main categories:

Physical carrying capacity is based on the suitability for development of a given activity, considering the physical factors of the environment and the farming system.

Production carrying capacity estimates the maximum aquaculture production and is typically considered at the farm scale.

Ecological carrying capacity is defined as the magnitude of aquaculture production that can be supported without leading to significant changes to ecological processes, services, species, populations or communities in the environment.

Social carrying capacity has been defined as the amount of aquaculture that can be developed without adverse social impacts.

In this study the physical carrying capacity is discussed in the site selection criteria while the production carrying capacity aspects are evaluated in the production systems and preliminary design chapters. In this chapter the focus is on the ecological/environmental carrying capacity and social carrying capacity.

4.3.1. Environmental impacts and ecological carrying capacity of the Apac, AquaPark

The main environmental impact of intensive African catfish production in flow through system in the planned area is the high amount of discharged water from the system. The discharge of a flow through system will contain all waste material from the fish farming activity:

- Fish faeces and uneaten feed is rich on carbon and organic material and has a very high Biological Oxygen (BOD). The amount of fish faeces highly depends on the feed quality and lower quality feed will result higher amount of wastes. In case of the predatory fish like the African catfish the amount of faeces and uneaten feed is about 25% of the dry weight of the feed administered to the fish (Pillay 2008.)
- However, the faeces also contain 40% of total Phosphorus (P) and 10% of total Nitrogen (N) discharge, the 90% of N and 60% of P leave the system dissolved in the water.
- The chemicals and medical products used in the feed and in the culture-water also will be fully discharged from the flow-through system.

According to the production model total volume of the flow-through tanks will be 3300 m^3 and the maximum water exchange rate will be 2 times per a day. This means that the highest volume of discharged water will be 6600m^3 waste water containing the suspended solids mainly from faeces and uneaten feed and dissolved P and N. The amount of the daily faeces and uneaten feed will be:

	Daily amount of feed		**Amount of faeces and uneaten feed**	
Nursery	544	kg/day	136	kg/day
Grow out	8,244	kg/day	2,061	kg/day

The nutrient discharge of the intensive flow-through system was calculated by using the data on environmental impacts provided by the Aller Aqua CLARIA Float grow-out feeds and the results are summarised in the Table 6.

Table 6 The calculated Nitrogen (N) and Phosphorus (P) discharge of an intensive African catfish flow-through farm in a 240 days cycle

Fish size	**Feed**	**FCR**	**Biomass kg**	**N in faeces(kg)**	**N in water(kg)**	**P in faeces(kg)**	**P in water(kg)**
10-50g fish	2mm	1	36,057	209	1,395	191	292
50-150	3mm	1.1	103,020	422	4,668	600	967
150-500	4mm	1.2	336,667	1,519	15,703	1,892	3,025
500-1500	5mm	1.3	1,000,000	4,444	48,926	5,414	8,584
Total discharge				6,594	70,691	8,097	12,867

The proposed preliminary design of the Apac AquaPark suggests two possible solutions for the reduction of the environmental impact of the discharge:

- Separate the thick sludge of fish faeces and uneaten feed from the relatively clean up-flow of the discharge water.
- Remove the nutrients from the effluent water before discharging it in the river.

To achieve this goal a sludge separation unit will be built after the flow through raceways and will include a smaller sedimentation pond and filtration system to remove the large part of suspended organic wastes. The remaining suspended solids can settle and trapped in the final sedimentation pond while 80% of the dissolved P and N is also trapped in the mud (Gal et al. 2009) and nutrients will be taken up by the algae and water plants of the pond. The pond sediment and the water plants should be regularly removed and can be used as soil improving materials and fertilizers for agricultural production. The suggested size of the sedimentation pond is 3 ha with a 2m maximum depth but also with shallow 20-50 cm deep areas with macro-phyton vegetation. This size and structure enable a 9 days retention time which assuming an average 3.6 m/h settling velocity for the suspended solids and larger waste particles of the discharged water can remove all formulated waste from the effluent. This type of pond also will work as constructed wetland to decompose organic material and remove the dissolved nutrients from the water. Extensive stocking of tilapia (50kg/ha) can support these processes.

Around the 3-ha sedimentation pond a 13-ha area should be designated for further ponds and constructed wetlands. This area will be enough to treat the effluent water of the future increased production and even the expected expansion of the AquaPark with more intensive aquaculture units.

The proposed AquaPark technology also provide an option for a combined intensive-extensive system (CIE) to reuse the dissolved nutrients of from the discharged production water. As a production system operated in a close interaction of the intensive and extensive production units. The key element of the proper operation is the treatment capacity of the extensive unit. Results proved (Edwards et al.2000, Gal et al. 2009) that combination of intensive aquaculture with extensive fishponds enhances the nutrient utilisation efficiency and fish production in IES.

According to the data of Edwards et al. and practical experiences to grow tilapia only by using natural production of the ponds needs the use of urea and phosphate fertilizers above the 28-36 kg DM/day/ha chicken manure. To reach 8-11 t/ha/year natural yield the recommended N supplement is 4 kg/day/ha and 1-2 kg/day/ha Phosphor. This gives a minimum requirement of directly available, dissolved N and P for the AquaPark ponds as summarised in the Table 7.

Table 7 Calculated supplementary N and P needs of the pond technologies in the AquaPark

			Sup. N requirement	Sup. P requirement
Large ponds	30	ha	43,800	10,950
Small ponds	10	ha	14,600	3,650
Total			**58,400**	**14,600**

The results show, that using the effluent water and sludge from the intensive African catfish farm the supplementary N and P needs of the extensive and semi intensive production can be ensured. This will reduce the production costs of the small and medium size farmers and considerably reduce the environmental impact of the intensive flow-through unit.

The static pond production technologies will have a minimal environmental impact because as a result of static water technology, most of the nutrients not used by the fish will be deposited in the mud

(Edwards et al. 2000) The production water from the ponds will be discharged at the end of the production period when all added nutrients and fish feed will be converted into fish growth.

4.3.2. Social acceptance of aquaculture

The local society was involved in the preparation of the AquaPark from the beginning and participated in the designation of the area. During the site visit of the consultant on 6-8th February 2019 2 different stakeholder meeting was organised:

- Meeting with the local authority representatives in Apac and Apac district.
- Meeting with the representatives of the village communities around the AquaPark.

Above this the consultant also met with local fish farmers in the region. The local communities and the fish farmers were very positive and has high expectations for the project. Many people on the meetings expressed their interest to start a small-scale fish farming activity in the aquapark. Farmers in the region were interested in the fingerling and feed supply of the AquaPark and asked that the training activities should be available for other farmers as well not only for the AquaPark farmers.

The only concern from the local community was that the AquaPark area will cut their villages off from the animal drinking site what they use now. As a solution and to further increase the social acceptance of the aquaculture the preliminary design suggests building a “community pond” between the village and the AquaPark to ensure for the animals’ easy access to the water. This pond will be regularly filled up from the central water reservoir of the AquaPark.

The social services of the AquaPark can be further improved if the planned borehole supplying the hatchery also will be accessible for the local communities to provide drinking water for them.

The main social impact of the planned AquaPark will be a considerable positive impact on the employment and income generation for the rural areas.

The number of jobs created in Phase 1 pilot aquaculture park development is calculated in the Table 8 according to the financial model.

Table 8 Expected impact on local employment

Aquaculture producer	Number of companies	Expected total employment
Large scale intensive African catfish farm also managing the AquaPark services	1	43
Semi intensive pond farming of tilapia	1 or 2	17-34
Small scale extensive-semi intensive tilapia ponds	50 person or family	50

5. Production systems and preliminary design

5.1. Summary of production models

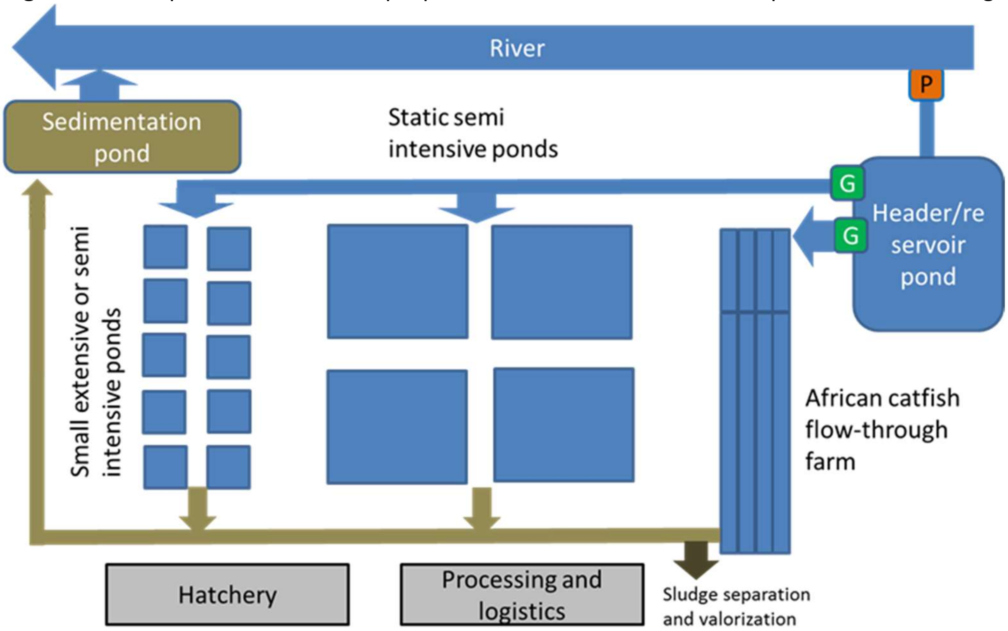
During the mission in Uganda, the consultant visited a number of farms and conducted interviews with the farms' owners or employees to assess their production performances and discuss their challenges.

Based on the environmental data collected and reported, industry standards and data collected from the farmers, the production model suggested for the AquaPark is based on three production technologies:

1. The core production unit should be an intensive flow-through system producing 1,000 tonnes of African catfish with 1.5 kg or more market size. This intensive unit will provide the main part of the fish production of the AquaPark.
2. In the area next to the intensive unit ponds will be built and supplied with water from the central water reservoir with the possibility to use the nutrient rich discharge water of the intensive unit to fertilise the ponds. The 1 ha ponds will apply the semi-intensive technology for tilapia production using animal manure and fertilisers to increase natural production of the ponds and reduce the FCR of the fish feed.
3. Local small-scale fish farmers will be integrated by the AquaPark to manage smaller 0.1 - 0.25 ha ponds by using extensive technologies with less feed costs. These extensive fish ponds will also have the possibility to use discharged nutrient and organic material rich effluent water of the intensive unit and can apply various fish feeding methods.

Through applying this nutrient and water reuse model combining intensive, semi intensive and extensive production systems within the aquaculture park, the most effective use of natural resources can be achieved while also minimise the environmental impacts of the fish production. This model helps to introduce new, affordable small-scale farming technologies.

Figure 7 Visual presentation of the proposed combination of various aquaculture technologies



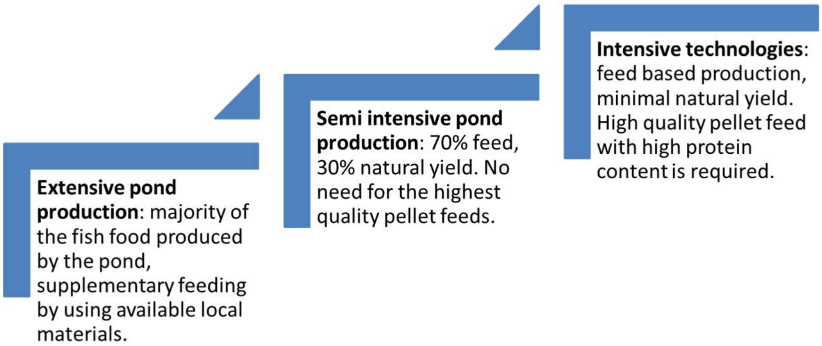


Figure 7 describes the visual presentation of the proposed combination of various aquaculture technologies, where the lower steps represents less input demand while the main water flow will be from the higher to the lower steps. The water supply is by pumping from the river (P) to a central water reservoir from where the clean water is supplied by gravity (G) to the ponds and tanks.

A set of assumptions have been taken to develop the production model and design of the pilot AquaPark, which are then used to feed in the financial analysis. These production assumptions, presented in Table 9, summarising the production model the 3 different technology and 3 different farmers.

Table 9 Summary of the proposed aquaculture technologies for the first phase of the AquaPark

Key parameters	**Intensive African catfish production**	**Semi intensive tilapia production**	**Extensive or semi intensive small ponds**
Technology	3,300 m^3 concrete raceway and tank system with flow through water, 1.2-1.3 grow out FCR, 8 months prod. cycle	30 ponds with 1 ha surface and 1.5 depth Static water but possibility for clean water supply. All male monosex fingerlings. 8 months production period.	0.1-0.25 ha ponds, 1.5 m depth Static water but possibility for clean water supply. All male monosex fingerlings. 12 months production period.
Product	1.5 kg African catfish	500 g Tilapia	400 g tilapia
Production carrying capacity	200 kg/m^3	15 t/ha/cycle	3 t/ha
Feed	High quality imported feed from Aller Aqua (Zambia) or Coppens CP 45-40%	Locally available good quality tilapia feeds	Mainly natural production with some supplementary feeding.
Fertilisation	No	Intensive farm effluents and poultry manure	Intensive farm effluents, poultry manure, green compost
Yield	1,000 tonnes/cycle; about 1500 tonnes/year	15 t/ha/year	2.4 t/ha

5.2. Suitability for expansion of the production systems

5.2.1. Potential increase of production within the planned facilities of Phase 1

The available maximum density in African catfish flow-through systems is 300 kg fish/m3 in the on-growing stage, but in the production model we calculated with 200 kg/m3 maximum capacity. Increasing the maximum production density to 250-300 kg/m^3 the planned facility can produce approximately 1000 tons more African catfish. This increase of production certainly will require a full processing facility to be able to constantly sell the production through an improved value chain. It is also a possibility to increase the African catfish density and use some of the flow-through intensive tanks for tilapia production if the market needs more tilapia. However, the maximum stocking density of tilapia in this system should not be more than 40 kg/m^3 and the water exchange rate should be higher than for African catfish, lower feed prices and increased Tilapia prices can make this type of expansion economically feasible.

The planned maximum biomass of the large static tilapia ponds, the production model is 15 t/ha which is lower that the available maximum 20 t/ha production. The lower production density was applied to achieve an increased use of the natural production and reduce feed based FCR. With more experience in pond management and in case of lower feed prices or increased Tilapia prices, pond tilapia farmers can increase their production with 5 t/ha/year resulting 60 t more tilapia production on the 30-ha area.

5.2.2. Increase of AquaPark activities in Phase 2

The Phase 1 of the proposed AquaPark development will develop economically feasible, sustainable aquaculture production technologies and will not use the whole area of the allocated roughly 200 ha.

After the Phase 1 pilot AquaPark development in the PESCA project and the development of the African catfish value chain, the production of the AquaPark can be further increased by using the land where lined ponds can be built. According to the preliminary site suitability survey and topographic data, a 52 ha area is suitable (Figure 6) for this purpose where 150 lined ponds with 0.3 ha pond water surface can be built. These ponds are ideal for static water intensive production of African catfish where 20 t/ha yearly production can be achieved without aeration, resulting a total production of 900 tons/year. The ponds will be served by a 4 ha water reservoir to ensure clean water supply if it is needed during the production period. The water reservoir will be filled up from the pumping station built in the Phase 1.

Together with the increased production of the Phase 1. Production unit, the total production of the AquaPark will reach the 3000 tonnes. This volume of production will require high level of fish secondary processing (packed products with longer shelf-life) and distribute the products in the whole country and on regional export markets. The fish processing and packaging plant can be built in the area where the surface is rocky and not suitable for pond construction. A 26.5 ha area was allocated as the “service industry” area of the AquaPark where fish feed factory and a logistic centre also can be developed in the future. The planned production of the AquaPark will be large enough to build a smaller fish feed factory in the AquaPark, but the supply of the whole region also will need capacities.

The increased energy needs of the AquaPark will require more use of solar energy therefore a 2-ha area for a solar panel park was allocated for the Phase 2 developments.

Because the final AquaPark production will produce large amount of sediments and organic wastes which are excellent material for soil improvement, some areas of the allocated land should be used for agricultural production. The Phase2 developments will include a 37-ha area for production of irrigated and non-irrigated crops to be used as fish feed material and for human consumption. Local communities also can be involved in the use of the agriculture area and this could further increase the social acceptance of the AquaPark. Using the effluents and waste products if the aquaculture units in agriculture will allow a nearly zero discharge aquaculture production in Apac.

5.3. Intensive African catfish production model - large-scale operator

5.3.1. Business model

The construction of the production facilities of the AquaPark and the operation of the common activities like hatchery production, feed purchase and marketing of products require an experienced aquaculture investor with strong financial background. This investor will be the main PPP partner of the governmental body and will provide services for the medium and small farmers in the AquaPark. The yearly 1500 tonnes intensive production of African catfish and the financial model results of this activity can be attractive for large scale national and international investors.

5.3.2. African catfish production plan

The key parameters of the planned African catfish production model are presented in the Table 10. These parameters assume the exchange of the water 2 times a day in the production tanks and the use of high-quality formulated feed. The model based on data from various literature, personal communication of intensive African catfish farmers and the personal experience of the consultant.

Table 10 240 days cycle production plan for the intensive, flow-through technology of African catfish by large farmer

Fish size	Granulate/Pellet size	FCR	Days	Phase	Mortality rate	Number of fish (thousands)	Biomass (kg)
Eggs to larvae	-	-	3	Hatchery		1,663	
0-0.3 g	Artemia	-	14		25%	1,330	399
0.3-0.5*	0GR	0.6	7		20%	1,109	554
0.5-1.0	1GR	0.7	7		10%	1,008	1,008
1.0 -3.0	2GR	0.8	12	Nursery	10%	916	2,749
3.0-6.0	3GR	0.9	11		10%	833	4,998
6.0 -10	3GR	0.9	10		10%	757	7,572
10-50g fish	2mm	1	25		5%	721	36,057
50-150	3mm	1.1	22	On-growing	5%	687	103,020
150-500	4mm	1.2	40		2%	673	336,667
500-1500	5mm	1.3	90		1%	667	1,000,000

The suggested production technology is the flow-through technology in concrete raceways. Because the raceways can be sectioned according to the needs of the batches, this infrastructure can ensure a high level of flexibility of the farmer to use the farm capacities on the most efficient way.

The planned production technology will ensure the continuous supply of the markets with 29 tonnes of fish every week.

The farm will have nursery and on-growing raceways with a total 3300m^3 capacity:

Raceways	Nursery	On-growing
Length	4	25
Width	2	5
Depth	1.5	1.5
Volume m3	12	180
Number	5	18
Total capacity m3	**60**	**3240**

The 18 large concrete tanks should be built in 2 separated unit of 9 tanks as presented in the Annex 2 drawings. The suggested maximum production density of the On-growing raceways is 200 kg fish/m^3 which later can be raised up to 300 kg fish/m^3 as the farm management and staff will be more experienced and familiar with the species.

Having the estimated 26^{o}C average culture water temperature, the fish will reach the market size in 8 months resulting a 1500 tonnes yearly production. Using the same infrastructure but increasing the production density the yearly production can reach the 2000-2500 tonnes.

The water source of the flow-through system will be a water reservoir which will be filled up from the Victoria Nile by pumping.

Picture 1 Photo of a concrete raceway African catfish farm in Hungary. Source Tamás Bardócz

The effluent water of the raceways will be treated in 2 steps:

1. Sludge separation: The large particles of uneaten feed and faeces will be separated already by the tank dual drain system and collected in a 400 m^2 pre-sedimentation pond. The sludge will be continuously removed by pumping and used to fertilise agricultural land.
2. The overflow of the sedimentation pond and the relatively clean water from the tanks will be filtrated by a drum filter (80-100-micron mesh size) from where the sludge will go to the pre-sedimentation pond. The treated water will be collected in the 3-ha final sedimentation pond area where the remaining suspended solids and the N and P nutrients will be removed from the water by algae, macro-vegetation and fish.The pre-treated effluent water of the system can be used to fertilise the semi intensive and extensive ponds of the AquaPark.

5.3.3. Pumping station and water reservoir

The pumping station will provide the water supply for the water reservoir which will ensure the continuous water supply of the flow-through unit. The static pond systems also will receive their fill-up water supply from the water reservoir and if they need clean water supply to quickly improve the water quality this also will be provided by gravity from the water reservoir.

To fulfil these requirements the water storage capacity of the water reservoir pond should be the double of the flow-through system capacity. The 0,33 ha, 2m deep reservoir should be at a location from where the whole amount of the water can be drained by gravity.

The available pumping capacity should be 300m^3/hour pumped to 25 m head height (18 m pumping height + 7 m head loss because of the pipe line) from the river. This will require 4 electric pumps with 150m^3/hour capacity each.

5.3.4. Hatchery operations

In the nucleus AquaPark model the large-scale African catfish farmer will provide a number of services and support functions for the medium and small farmers within the AquaPark. One of the most important service will be to operate a multi-species hatchery providing African catfish (*C. gariepinus*) and high quality, sex reversed tilapia (*O. niloticus*) fingerlings for the medium and small-scale farmers.

The total capacity of the hatchery will be designed for the maximum expected production of the flow-through farm (3000 t/year) and the 1 ha tilapia ponds (600 t/year) with an output of 3 million catfish fingerling and 2 million tilapia fingerlings as a minimum capacity.

The hatchery is expected to produce catfish on a monthly basis with a one-month tank-based pre-nursing period in the hatchery. The small sized catfish larvae will be fed with hatched Artemia nauplii on the first 14 days and mixed with granulates in the next 5 days. This technology can provide the highest quality fingerlings for the intensive production while the calculated cost of Artemia is only 45 UGX/fry.

African catfish broodstock will be regularly selected from the on-growing unit and one section of the growing tanks will be used for holding the broodstock.

Tilapia fry will be produced on weekly basis hatched in the hatchery building and then transferred to hapas in hatchery ponds. The hatchery ponds can be built as next to the hatchery or 2-4 from the planned small ponds can be used for this purpose. The 1 g fingerlings will then be sold to the medium scale and small farmers to rear them in their ponds. Eggs will be collected on a weekly basis from the breeders, stocked in hatching jars to hatch for a 5 - 7 days period, then stocked in the hapas rearing units for sex reversal for 21 days and nursery rearing units for another 10 days to reach 1 g.

In order to keep the production costs of the small and medium farmers low the recommended hatchery output size of tilapia fingerling is 1 g. This fingerling can be further nursed up to 5g in hapas placed in selected post-nursing ponds operated by the farmers.

The hatchery should have rearing facilities for tilapia broodstock, egg incubation, sex reversal and nursery. Choice of ponds or tanks systems should be made to best suit the site, expected production capacity and operations. The capacity of the facility should cover for an increase in production of the AquaPark over time.

Table 11 Calculation of the required area for the hatchery based on the monthly outputs of 1g African catfish and Tilapia fingerlings

Annual production	African catfish		Tilapia	
	1500 t/year	**3000 t/year**	**450 t/year**	**600 t/year**
Fingerling monthly production	138,577	277,153	155,633	194,321
Incubation and Artemia m2	50	100	50	100
Tank requirement for larval rearing m3	4	6	5	7
Tank requirement for pre-nursing m3	22	44		
Required area for RAS technology m2	5.20	10.00	1.00	1.40
Total hatchery area needed m2 (+50% handling area)	122	**240**	84	**163**
Hapas in pond area up to 1g m2	-	-	450	950
Hapas m2 for broodstock	-	-	3,000	5,000

The recommended hatchery building should be 500 m^2 (total hatchery area needed for the maximum capacity for both species in Table 11) which will include the RAS technology area (biofilter, drum filter) and will be able to produce African catfish and Nile tilapia together. The planned capacity of the RAS hatchery will be in the range of 5-7 million 1-5g fingerling depending on the intensity of the rearing technology. This yearly fingerling production of this hatchery will be enough for continuous supply of other small farmers in the region with high quality African catfish and tilapia fingerlings until the AquaPark reach the larger capacity.

However, African catfish is not particularly sensitive for lower water temperatures (25-26^{o}C is ideal 21-22^{o}C is still good with longer incubation times), because of the tilapia, water heating must be included for the egg incubation unit to ensure water temperature is sustained between 26°C and 30°C all year long.

For the egg incubation unit to function the water entering the system will require a high level of water treatment to produce clear, filtered water. The detailed design of the inlet water treatment should be based on the water characteristics as shown in the water quality requirements in table 1 and the water characteristics required for rearing eggs and fingerlings of tilapia.

5.3.5. Feed store

In the nucleus AquaPark model the large-scale African Catfish producer will purchase and store tilapia feed also for the medium and small-scale producers and sell them with a commission rate to cover the expenses of storage and handling. Taking into account the future role of the AquaPark when it also will serve as fingerling and feed supplier of the small fish farms in the whole region, an extra feed storage capacity of 250 t/year tilapia and catfish feed is included in the feed requirement (Table 12).

Table 12 Calculation of the required feed storage capacity

Yearly feed requirements (tonnes)	Nucleus farmer	Medium farmers	Small farmers	Extra capacity	Total
Tilapia Juvenile	-	37		50	87
Tilapia On-growing	-	522	22	200	744
Catfish Juvenile	59			50	109
Catfish On-growing	1,874			200	2,074
Total	**1,933**	**559**	**22**	**500**	**3,014**

The shelf life of catfish and tilapia feeds in Uganda should be considered as 6 months, but in the storage capacity calculation, better to calculate with monthly shipment of feed having a reserve for one month in the storage capacity. According to the calculation presented in Table 12 the average monthly feed requirement of the AquaPark farms and other feed buyers is 251 tonnes. Having a one-month reserve storage capacity the feed store should be able to store 502 tonnes dry fish feed in 25 kg bags at any given time. Calculating with the usual 0.65 x 0.45 x 0.13m compressed bag size which can be packed in 20 layers up to 2.6 m height and maintain 15% of the floor for forklift driveway, the required **feed store area is 346 m^2**.

The store should be of metal frame design and suitable high roofing (approximately 3 m), be waterproof, have a concrete floor with a 1% slope, include ventilation and air extraction and be pest-proof. Lighting and ventilation to meet the room requirements and safety legislation will also be installed.

The location of any infrastructure requirements such as wall partitions, electrical distribution boards and drains if required should be specified in the designs.

Internal staff areas, for seating, guarding, storage of handling equipment and other small items, record keeping being included in the design.

5.3.6. Workshop and storage area

It is envisaged that the workshop facility should have an area of minimum 250 m^2 to store outboards engines needing servicing or repair, as well as any other equipment needing maintenance.

The room will be closed and have a roof at standard heights.

The location of any infrastructure requirements such as wall partitions, electrical distribution boards and drains if required should be specified in the designs. Lighting and ventilation to meet the room requirements and safety legislation will also be installed.

5.3.7. Fuel Store

Fuel for the emergency generator, tractors, forklift and trucks should be bought in large quantities and stored on the farm. The fuel store should have an area of minimum 40 m^2 to store fuel drums and engine oil drums, full ones on one side and empty ones on the other. The store will consist of a concrete platform with fencing, and a double door access to allow easy discharge of full drums. It will have a roof at standard heights.

5.3.8. Offices

The office block can be separated part of the hatchery or feed storage building and will be used mainly by the large grower. New office furniture needs to be provided to accommodate for the administration staff of the nucleus company, as well as the management team of the medium and small farmers. The calculated Office area is based on the standard requirements of 8m^2/office worker and for the planned 12 management, marketing and admin staff the required building is at least 96 m^2 This building should also include a 50 m^2 area is to be established for staff rest, canteen, lunch breaks, etc. with areas for preparing food. The area should have a simple structure, covered for shade from the sun/ rain and areas for seats, tables, etc.

5.3.9. Post-harvest processing facility

After harvesting the concrete tanks and ponds the fish will be stored in boxes with ice and transported on ice to the processing facility or other wholesale buyers. At the early stage of the AquaPark development the processing should only involve sorting to remove the deformed fish and excessively small fish, weighing and putting the fish on ice in crates. This area should be an isolated building or container with a capacity to store the harvest of 2 days at least.

In the future, it is advised to develop more detailed sorting by sizes.

5.3.10. Ice machine and ice store

Assuming that each kg of fish needs the same amount of ice for package (whole fish on ice), the maximum weekly requirement of ice will be 60-70 t for tilapia and catfish transports.

5.3.11. Power supply

The power supply of the AquaPark will have the following main pillars:

- Supply from the national grid along the road towards Apac.
- Diesel generators for emergency case or in case of high energy need peaks.
- Optionally Solar Panels also can be used to reduce energy costs.

Table 13 Calculation of the energy requirement of the land based AquaPark farms

Use	Daily use hours	kW/hour	Daily kW	Yearly kW	Data source
Pumping to flow-through	24	29.00	696	254,040	Supplier data
Aerators in flow-through	12	18.75	225	82,125	Supplier data
Aerators on the ponds	12	45	540	197,100	Supplier data
Hatchery and borehole	24	12.50	300	109,500	AquaBioTech design data
Offices	8	0.6	4.8	1,752	AquaBioTech design data
Ice machine			372	135,900	Geneglace, 1:1 fish/ice ratio
Total energy needs			**2,138**	**780,417**	**kW/year**

An adequate space with concrete platform and fencing needs to be established to accommodate for the backup power generator. The power back-up is necessary to ensure the ice store and cold-storage would remain powered in case of power-cut.

5.3.12. Option for the use of photovoltaic (PV) system to reduce energy costs

Aquaculture in Africa is an ideal candidate for the exploitation of solar energy possibilities. Most of the energy consuming activities of the AquaPark can be done during the daylight by using solar energy and this energy can be stored in the product of the activity. These main activities are:

- Pumping the water in the water reservoir from the river and then store the water in the reservoir for night supply of the flow-through system. This will need to increase the pumping and water storage capacity. The pumping capacity should be 600 m^3/hour and the area of the 2 m deep water reservoir pond should be 0.66 ha.

- Ice production and store the ice in a properly isolated container.
- Aeration of the ponds and the flow-through tanks: the majority of the aeration can be done during the daylight period ensuring a high DO level for the night hours. Aeration will be also needed in the semi intensive ponds just before sunrise when the DO level is the lowest.

Having this energy uptake patterns a PV system with minimal battery needs can be designed while the 60-80% of the electricity needs can be provided. Depending on the design of the pumps and ice machine a PV system between 300 kWp and 420 kWp can be installed, depending on how much the design of the loads is optimized for solar. 1 kWp of solar covers roughly 6 m². That means the space needed is between 1800 m² and 2500 m². System costs can not directly be specified without detailed system design but according to Equator Solar Systems Ltd. (Uganda) they will roughly range between 350,000 € and 450,000 € excl. VAT.

In addition, it is recommended to install a small 1-phase solar system for uninterrupted emergency power supply. The purpose is to bridge short power cuts and supply during this time important appliances like the office, control units etc. for the time until the generator is started. For this a battery system with lithium batteries should be installed which is integrated into the big system, hence they have a common central control system. Lithium batteries are strongly recommended due to the fact that they are more expensive than common lead acid batteries but are much more robust and have a much longer lifetime. This emergency system could be in the size of 10 kWp PV capacity and a lithium battery with 10 kWh battery capacity costing about 35,000 € excl. VAT

It is estimated that including the solar power supply system will increase the CAPEX costs with 2,052,312,480 UGX while assuming 70% contribution to the energy needs will reduce the total electricity costs of the AquaPark (including all producers) with 330,342,712 UGX every year.

5.3.13. Fencing

The fencing of the intensive African catfish farm and the storage areas is required with a strong fence.

5.3.14. Human resources

The human resources of the nucleus, large scale producer will ensure the operation of the hatchery (3 technician), the African catfish farm and the common activities of the AquaPark members like purchasing and storage feed and marketing of fish. The human resources of the nucleus AquaPark company are planned from the first full year of production as follows:

Administration	8
Marketing	4
Production / Operations	31
TOTAL	**43**

5.4. Medium-scale operator

5.4.1. Business model

This investment option provide possibility for investors in the region to start a lucrative aquaculture business by producing Nile tilapia in ponds. The operation of the planned pond farms needs trained fish farmers and experienced business managers. The number of medium scale farmers depends on the final implementation plan of the AquaPark, but in the financial model we assumed one farmer or company operating 30 static water tilapia ponds, with an average surface area of 1 ha. In the current financial model, the farmer(s) will rent the pond area from the government/public directly while pay for the services (water, electricity, feed, fingerlings) bought from the large/nucleus grower managing the AquaPark.

5.4.2. Production plan

The production model of the 1 ha static ponds is the well-known technology applied in Asia and Egypt which also use the natural production of the ponds and use formulated feed to complete the diet. The ponds will buy the sex reversed 1 g fingerlings from the hatchery operated by the nucleus farmer who also will sell the tilapia feed for the pond farmers. The fingerlings will be reared up to 5 grams in hapas or in the smaller ponds of the AquaPark and stocked in the large ponds at the size of 5g (
Table 14).

Table 14 Summary of the planned production model of the 1 ha static ponds

Fish size	FCR feed	Nat. prod	FCR with Nat. prod.		Days	Mortality rate	Number of fish (1000)	Biomass (kg)	Fish (g)
Freshly hatched larvae to swim up fry				Hatchery	4	0	1,571	79	0.05
0-0.5g (Sex reversal)					21	20%	1,309	655	0.5
0.5-1.0	0.9	20%	0.72		10	15%	1,138	1,138	1
1.0-5.0	1.1	20%	0.88	Nursery	20	10%	1,035	5,174	5
5.0-20	1.5	40%	0.9	Ponds	70	10%	941	18,816	20
20-250	1.5	30%	1.05		130	5%	896	223,994	250
250 -500	1.6	25%	1.2		110	5%	853	426,656	500

In this technology the length of the culture period and the contribution of the natural food production to the FCR highly depend on the skills and experience of the farmers. This complex technology needs the proper handling of the fish and the right management of the water quality to result high yield with the relatively low FCR. In the basic production model of the AquaPark about 15 tonnes/ha production was planned where the farmers can reach 500g average market size in 1 year. This technology will enable to maximise the natural production yield while also produce high quality, larger fish with a comparative advantage on the market.

The planned 1 ha ponds will be built on a relatively flat area enabling a paddy-pond structure where the neighbouring ponds share the dikes. The crest of the dykes between the ponds should be at least 2 m wide. The perimeter dykes will have at least 3m dike crest ensuring the access to the ponds with small trucks and tractors.

Figure 8 Suggested pond type and arrangement for the medium scale farmers to create 1 ha ponds in the flat area. (Source: FAO Training Series: Simple methods for aquaculture CD-ROM)

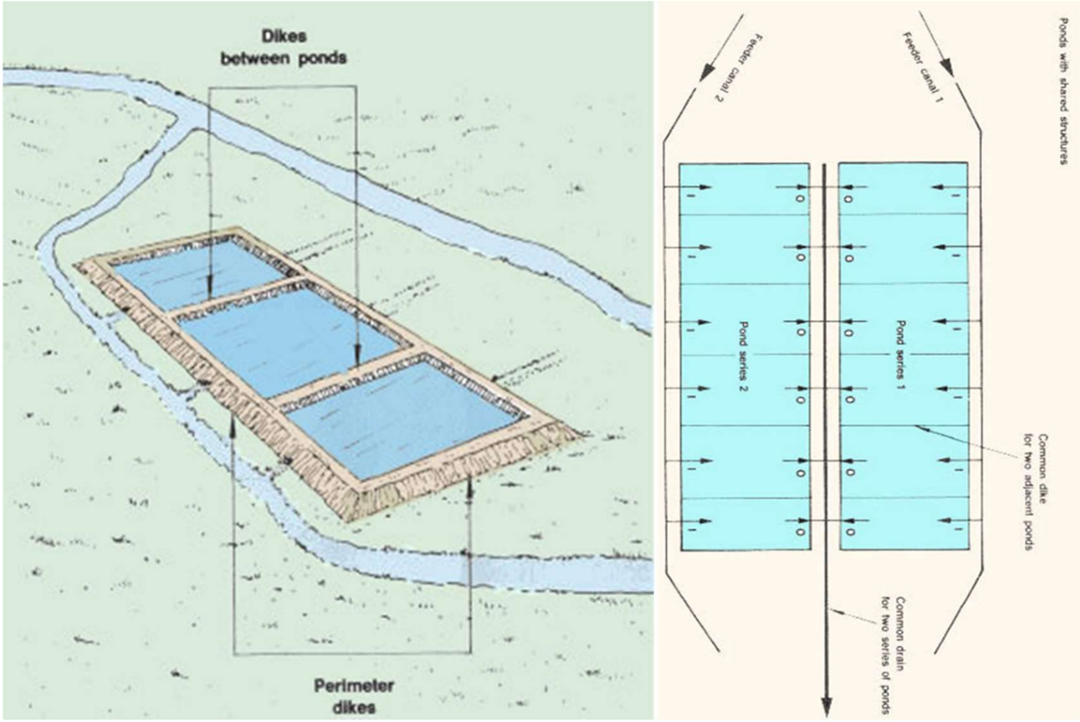
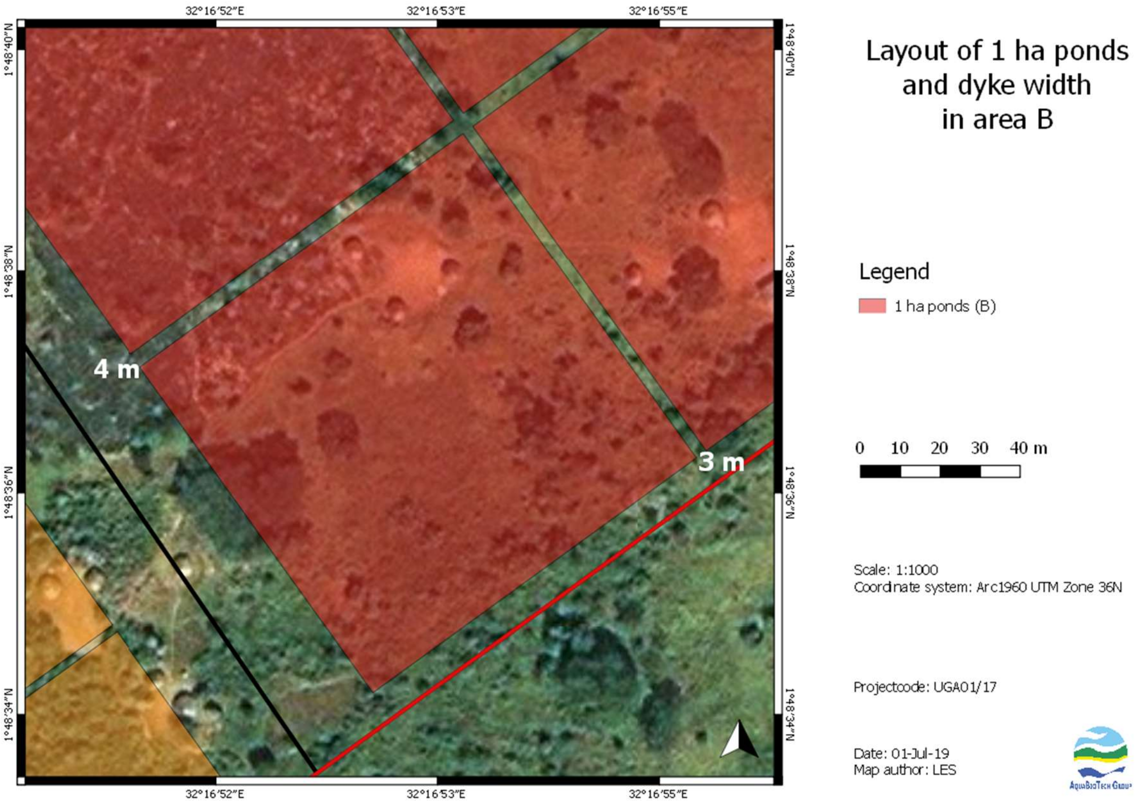


Figure 9 Detailed view of the 1 ha pond design with dyke top widths



5.4.3. Operational equipment and infrastructure

The medium-scale farmer will own and use the following equipment to operate the ponds:

- 1 paddle wheel aerator for each pond (30).
- 6 small boats which can be moved amongst the ponds to carry out manuring, feeding and harvesting.
- 1 small tractor with trailer to transport fertilisers, feed
- 1 small truck

5.4.4. Human resources

The staff will focus purely on production operations including fingerlings transfer, grading, manuring, feeding, harvesting, and maintenance of the ponds. Security guards also will be needed. Assuming that the whole 30ha pond area will be operated by one company, the human resources needs will be the follows:

Manager	1
Administration	1
Production / Operations	9
Security guards	6
TOTAL	**17**

5.5. Small-scale operator

5.5.1. Business model

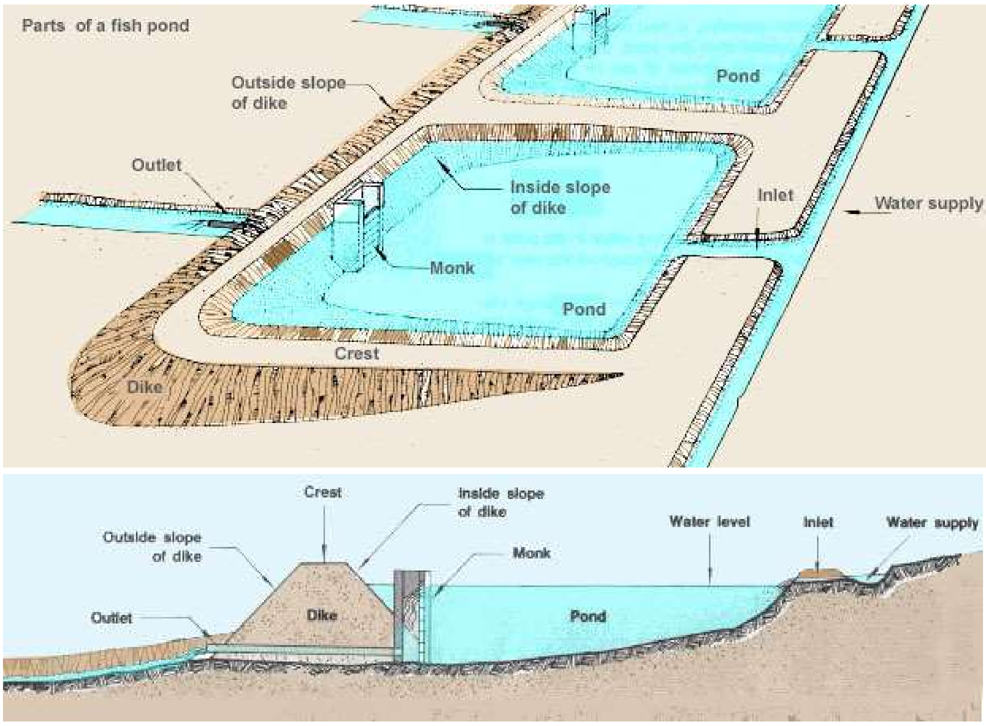
The planned small pond unit of the AquaPark will be developed to support small aquaculture businesses in the Apac district. The aim of this element of the project is to support the economic development of the region by starting new aquaculture family businesses providing a good income for the poor rural livelihoods. The small ponds can be operated separately by families or persons, but the broader goal of the AquaPark project is to encourage the establishment of co-operatives of the small farmers where they can do a part of the farming activities together. Like for example common guarding, harvesting, pond maintenance, buying equipment together etc. The small farmers integrated in the AquaPark will need only minimal investment costs to start the activities and their support mechanisms by the nucleus grower should be regulated in the PPP agreement.

5.5.2. Production plan

The production model for the small-scale farmers is flexible and depends on the resources and commitment of the farmers. The suggested pond types are contour ponds which can be built on the sloped area close to the river. The farmers can use only natural fertilisers or also use supplementary feed from the large grower. The fish can be raised up to 250g by mainly using the enhanced natural production of the ponds and using formulated feed after this size. In the financial model we calculated with 400g final size of the fish which can be reached in 1 year.

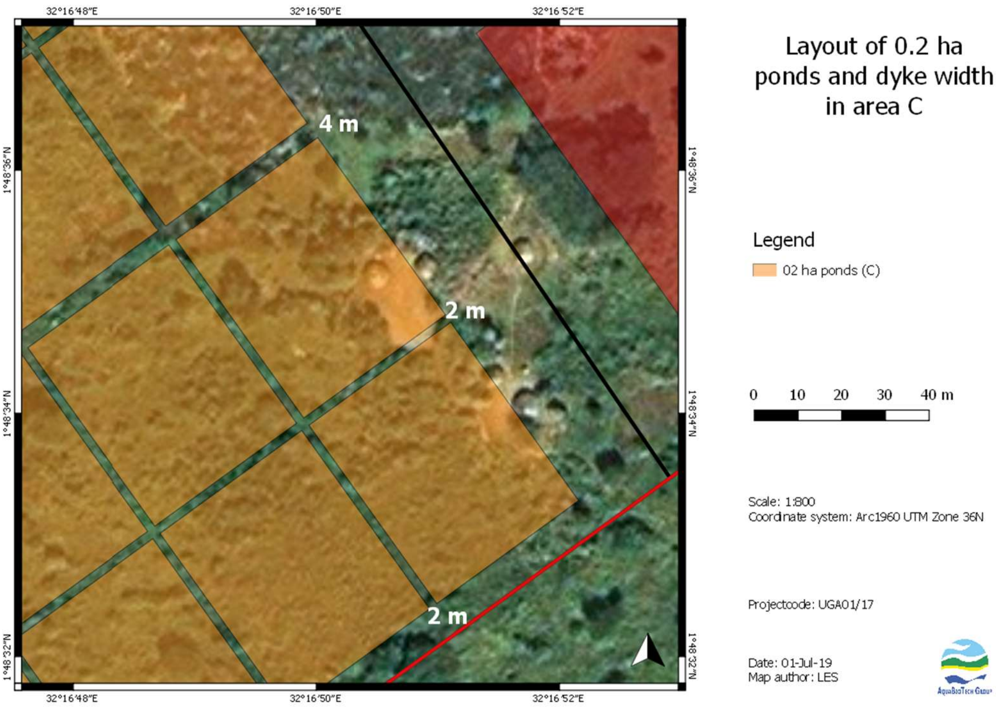
Each small farm is planned to rent 2-3 small ponds operated by an individual or by a family without human resource costs.

Figure 10 Suggested contour pond type for the small-scale farmers to create 0.2 ha ponds (Source: FAO Training Series: Simple methods for aquaculture CD-ROM)



The estimated average production of the small ponds is 2.3 tonnes per hectare which assumes regular manuring and treatment of ponds and will also need supplemental feeding of fish with formulated feed. The production of the ponds can be higher or lower depending the financial capacity of the small farmers to buy good quality feed from the nucleus farmer.

Figure 11 Detailed view of the 0.2 ha pond design with dyke top widths



6. Financial study

6.1. Financial framework for the AquaPark development

Fish farming as a commercial activity is a capital-intensive business due to the level of investment required to launch the activity and the long start-up period requiring a substantial amount of capital to finance operations prior to first incomes are generated. Hence, prior to launching such activity, it is important to assess its financial viability and funding requirements.

Financial analysis of investments starting large scale aquaculture production in a region where this activity was not present before, also needs to incorporate some special aspects when evaluating economic feasibility of the project. Such aspects are for example:

- In intensive fish production, feed costs are usually above 60% of the total variable costs, but these prices cannot be predicted based only the actual prices of the region. The prices for large volumes of fish feed will be lower if the suppliers can rely on a massive, continuous need for their product. Aquaculture development also will encourage feed producers to establish feed production facilities in the region or to reduce their shipping costs to further reduce the feed prices.
- By improving the aquaculture investment criteria (feed, seed, water, knowledge) these large-scale investments make next fish farming projects easier and generate more feasible investments in aquaculture.
- Green field investments in aquaculture usually happen in remote areas where the necessary service infrastructure is often missing.

On the other hand, the growing consumer interest for fish increase the demand in all countries which is often supplied through imports from the successful aquaculture producer countries. The well organised fish import structure is often the biggest barrier for new farmers to enter to the market with their locally produced fish.

These issues were recognised in all countries where aquaculture industry has a great potential to develop and boost the local economy. Establishing aquaculture parks to help new farmers to overcome the obstacles they must face is a widely used approach by many countries. Investigating the different aquaculture parks, three main level of Public and Private Partnership can be described:

1. The government designate an area for aquaculture production and develop the service infrastructure like roads, electricity and water supply for the area. The licensing of the aquaculture in the designated areas are also often simplified.
2. The farmers get direct financial public support to build the production infrastructure if they do their activities within the designated area.
3. The state supports the start of the production of the new farmers on various ways like reduced VAT on products and reduced tax on imported fish feed in the first years, financial support for training of the workers, etc.

The above-mentioned support and management measures are planned to be applied in the pilot AquaPark project pursued in Apac district to set the basis for further similar land-based fish farming development in Uganda. This feasibility study assesses the financial viability of different sizes of operators under an integrator-like management and operational structure, called nucleus Aquapark model. The purpose of the nucleus model is to provide economies of scale to all farmers by supporting a large-scale aquaculture investment also integrating medium and small-scale farmers. The financial analysis has therefore been developed around a business model where the nucleus, large scale investor provides services and farm inputs to the medium and small-scale operators. The financial assessment is based on a set of inputs for the below categories:

- Biological model and production plan (Outlined in the study)
- Market data
- Capital expenditures (CapEx)
- Operational expenditures (OpEx)

As described earlier in the report, the biological model is very different for all type of operators and is based on a set of data and realistic assumptions based on the company experience of the AquaBioTech and discussions with various stakeholders of the Apac land based AquaPark project.

A set of Excel spreadsheets have been developed for each of the three (3) business operators (large nucleus– medium – small scale operators) and include the following:

- revenue workings
- operating workings
- manpower
- CapEx
- Income statement
- Cashflow
- Balance sheet
- Analysis and ratios

6.2. Key assumptions

6.2.1. Business model of the AquaPark Phase 1 developments

The previous study "Feasibility Study to Design, Cost and Operationalize Model Commercial Aquaculture Parks in Uganda" prepared by Poseidon Aquatic Resources Management Ltd. (2013), has provided a concept regarding an Aquaculture Parks (AquaParks) approach to sector development. The study developed the concept and provided initial outlines and assessments of two AquaPark sites and potential management models based on a PPP approach. An initial concept level financial feasibility was also undertaken using various assumptions regarding structures, layouts, production levels and fish prices for the AquaParks, based on tilapia and Africa Catfish production. This study outlined 2 possible main business models for the AquaParks in Uganda:

- In the co-operative model all farmers within the aquapark have share in the management company of the park which manage and operate the common activities of the farmers like feed purchase, fingerling purchase or production and centralised sales of the products.
- The so called nucleus model ensure more independency for the farmers and the nucleus large farm consist of a common water supply system including the central pumping station; hatcheries for the production of seed stock; possibly a feed mill; processing, packing and

marketing facilities as well as a corps of extension technicians which are operated by a developer. The "plasma" consists of the grow-out ponds with an average size of 0.5 ha which are to be distributed to individual growers who qualify under the program.

Evaluating both models and researching the possibilities for the application of these management models for the land based AquaPark in Apac, the consultant suggests considerable simplification of the models because of the following issues:

- The complicated management and ownership structure of the earlier proposed models is not attractive for large scale investors.
- The proposed high level of co-operation of farmers can be built only by applying a bottom up approach when all participants clearly understand the need for the cooperation. The expected new medium and small-scale farmers of the AquaPark will not be aware of this need.
- The size and the number of the producers in the planned AquaPark is not necessary require maintaining a company only for managing the common activities.

Bearing these in mind, the consultant suggests a simplified version of the “nucleus model” where the largest producer in the recent stage of the AquaPark will also act as a management company or developer of the AquaPark. In the case of the Apac AquaPark it is suggested, that the different stakeholders will have the following functions:

- The government provide the land for the AquaPark and ensure the access of the aquapark to the main infrastructure like road and electricity. The farmers using the Aquapark will pay renting fee for the government who can regulate the operation of the AquaPark through the contracts and the licensing of the farms.
- With the financial support of the PESCA project the investor company of the intensive African catfish farm will manage the construction of all production facilities including the catfish farm, hatchery, pumping station, water reservoir and sedimentation pond as well as all production ponds. Large grower also will invest own money as working capital to operate the intensive farm and the hatchery. This company also will provide the water, fingerling and feed for the small and medium sized farmers.
- The medium and small growers will invest only working capital and will pay for the products and services to the large grower with a certain commission fee to cover the costs of the company. The small and medium farmers also will sell their products to the large farmer but depending on their agreements they will be also allowed to arrange their sales directly.

There are other options within this implementation and management model depending on the required ow financial contribution from the different fish farmers and their involvement in the construction of the production facilities. One other option can be that the government design and build all production facilities. According to the interviews with potential large-scale investors they are willing to invest their money in production facilities where they have control over the design and construction works. They involvement in the design and construction phase therefore would be essential.

In the developed business models, it is assumed that the large-scale investor (nucleus) holds the following functions to support all farmers registered within the AquaPark:

- licencing and permits (provided by the PESCA project),
- production and supply of quality fingerlings,
- procurement and supply of quality feed,

- water supply for the ponds,
- providing post-harvest processing infrastructure,
- marketing and sales of fish.

Above these services the large-scale producer also will support the medium and small-scale farmers with technical trainings and aquaculture consultancy and will charge commissions on the main supplies. The assumptions taken in the 2012 feasibility study with regards to commissions charged by the AquaPark Cooperative to the farmers for the above support were applied similarly for the nucleus model in the current financial assessment and are presented in Table 15.

Table 15 Assumptions on commissions charged by the Aquapark cooperative to the farmers.

Fingerlings supply	10% of production cost
Feed supply	3% of delivered feed cost
Lease on infrastructures and ponds	All operators pay directly
Marketing fee	5% of revenue (fish sales)

The final business model of the AquaPark and the cooperation amongst the members should be clarified based on the results of the financial feasibility study and some changes in the commissions might create a clearer and financially balanced cooperation. Because the small and medium scale farmers will use the freshwater supply infrastructure of the large farmer, the cost of the water pumping also should be included in the financial model. This can be higher marketing fee or a specifically calculated contribution to the pumping costs and maintenance of the supply channels and water reservoirs.

The financial model investigates all business model without the financial support (grant) of the CAPEX but includes the following support from the government and PESCA project in the PPP framework:

- Road and electricity infrastructure is provided by the government/project until the gates of the AquaPark.
- All licenses are ensured by the project for each farmer to start their activity.

This approach enables to evaluate the project purely based on the financial performance of the farming activities and the government can design the final methods of the granting mechanism according to the outputs of the model.

6.2.2. Biological assumptions

The details of the different production plans are presented in the relevant chapter. The main biological assumptions with the largest impact on the financials for the nursery and on-growing period are summarised in the Table 16 These assumptions are based on the detailed production model and improvement of the FCR was calculated in the financial model as the farmers become more experienced.

Table 16 Biological assumptions used for the technical and financial analysis

		Intensive African catfish	Semi-intensive tilapia	Extensive tilapia
density	kg/m3	200	0.98	0.16
Culture period	Day	240	365	365
stocking size	Grams	1	1	1
harvest size	Grams	1500	500	400
On-growing Survival	%	92%	82%	69%
On-growing FCR (with natural prod.)		1.3 - 1.2	1.28 - 1.22	1.2
Natural production/yield rate	%	0	25 - 20%	30 - 40%

6.2.3. Exchange rates

The financial analysis is developed in Ugandan Shillings (UGX). When cost estimation of prices used in the financial analysis are based on United States dollars (USD), or for quick comparison against international standards, the following USD to UGX exchange rate has been used:

USD	1
UGX	3,700

6.2.4. Operational costs

Operational costs include all main inputs to the farms. Some inputs are procured by the operators themselves, and some are sourced through the nucleus company. In the latter case, the commissions charged by the nucleus company are included in the farmers' operational costs. The list of operational costs with assumptions and rational behind them is available in Table 17 for the farmers (operators). The major operational cost for each farmer is the costs of fish feed. Tilapia feeds are widely used in Uganda and the imported feed price, delivered to Mombasa, Kenya was validated as 2,775,000 UGX / t. African catfish farmers recently use tilapia feed if they use any but the protein content of this is too low for high intensity production. Because good quality catfish feeds with high protein content are not present in the country, the consultant contacted various feed suppliers and based on their estimated offers calculated the possible price delivered to Mombasa. This estimated 1100 USD/tons for the grow-out feed costs could be reduced if a local animal feed producer could manufacture at least the 5mm grow-out feed according to a locally developed recipe. The regional transport costs of the feeds to Apac was estimated as 5000 USD.

6.2.5. Market assumptions

The Eastern Africa region is projected to realize increased fish consumption from 4.80 kg in 2013 to 5.49 kg by 2022. Rising population growth and income levels imply that the region will need 2.49 million tonnes of fish to fill the demand–supply gaps (Obiero et al. 2019). Because of the discrepancies in the import and re-export as well as wild catch and aquaculture statistics it is difficult to calculate the fish consumption data of Uganda. Some publications use the 12.5-15 kg/capita/year values but the 4.85 kg/year/capita estimation of Mapfumo (2019.) is more realistic.

While tilapia markets are relatively well known and prices well established and high consumption was recorded in the central region (Mapfumo 2019)(farm gate price between 6000-9000 UGX/kg, Market price in the range of 10000-14000 UGX/kg), there are only very limited information available about African catfish. However the preliminary market surveys in this study show, that African catfish is popular in Northern Uganda and consumption is similar to Tilapia, the focused survey and development of the markets of this fish must be a part of the AquaPark development. The potential and servicable markets can be calculated as follows:

Northern Uganda population (2014 census)	7,188,132
Northern Uganda Households	1,349,162
African catfish consumption model	1 kg/month/household
Potential Available Market (PAM)	16,190 t/year
Served Addressable Market 20% (SAM)	3,238 t/year
Servicable and Obtainable Market (SOM)	1000-2000 t/year

According to the national household survey in 2016/17 the average household size is larger in Northern-Uganda (5.3) than the country average (4.7). The 1kg African catfish production per month in a household would result 2.25kg/year/capita African catfish consumption which is only the 46% of the estimated yearly average.

According to Mapfumo (2019.) there are considerable regional and international export possibilities for aquaculture products from Uganda. In terms of African catfish the largest recent market of the species is in Nigeria, where the average price is 2.3 USD/kg. Kenya also represent a potential market for the African catfish where the market price is around 2.9 USD/kg (El-Sayed 2017). Considering the excellent processing yields of African catfish (46% filleting yield) it has a great potential for export to international markets. The European Union (EU) is by far the world's biggest importer of fish, seafood and aquaculture products. Import rules for these products are harmonised, meaning that the same rules apply in all EU countries. The largest African catfish producer and supplier of the EU is Hungary (4000 t/year) where the fish is produced by using geothermic water sources. The farm gate price of whole African catfish is 2.1 USD/kg while the fillet without skin market price is 8.9 USD/kg. (www.aki.gov.hu)

6.2.6. Product forms and sales prices of the AquaPark

There are considerable differences in the fish products and prices in Uganda. While in the area of the Lake Victoria, Tilapia is the most preferred and highly priced fish, in Northern Uganda African catfish is very popular and has a same or higher market value than Tilapia. However African catfish is farmed and caught in Northern Uganda there are no available market studies about the recent situation. In our study we must rely on the limited marker research of the field visit when the consultant met local stakeholders, catfish farmers and visited fish markets. According to these data the preferred market size of the catfish is at least 1 kg, but larger fish can have a higher per kilogram price. The recent market price of the Africa catfish is 10,000 – 12,000 UGX /kg depending on the size of the fish. The market is dominated by the fresh catch from the lakes and the river areas and farmers also sell their product on this price directly from the farms.

Tilapia has a well-established market and on farm price around 8000 UGX/kg which price also was used in the financial model, but there is a realistic possibility to sell the 500g high quality fish in small quantity on a higher price. Because the pond culture of tilapia will result a wider range of size categories the model uses different prices depending on the size of the fish from 6000-9000 UGX/kg. According to the preliminary market observations the African catfish above 1 kg has a 10,000-11,000 UGX/kg market size. Considering that the African catfish has a similar flesh quality like Tilapia, but the filleting yield of catfish is 10-15% more than Tilapia, the available farm gate price could be around 9000 UGX/kg. Because of the limited information on the recent African catfish market in Northern-Uganda the financial model uses the 8,000 UGX/kg farm gate price for African catfish which price also can bear the costs of the wholesaler for processing or exports.

Considering the growing population and markets in Uganda, the financial model calculates with a 2% increase on all fish prices above the inflation.

6.2.7. Cost of sales

Cost of sales is calculated based on the commission taken by the nucleus, large grower for the marketing of the fish supplied by the farmers. It is set at 5% of the total revenues of the farmer.

6.2.8. Income tax

The corporate income tax was set at 30% without minimum income limit according to the current legislation in Uganda.

6.2.9. Exit price (exit point)

In order to assess the success of each investment (small – medium – large – AquaPark company) using the NPV and IRR methods, it is necessary to estimate the value the projects at the end of the assessment period. This value, called exit price or exit point, is dependent on a large number of factors and on the strategy of the investors.

Considering that the farmers have a long-term plan and do not intend to sell their farms, a simple assumption was taken and the exit point for each investment was calculated as 218.3% of the initial investment injected into each business entity (small – medium – large investor company).

6.2.10. Inflation

Considering the recent, historic and predicted inflation data of Bank of Uganda and other websites, an inflation rate of 5% was included from year 2 onward for all operational expenses for the 15 years period of the assessment.

The sale price of fish was equally inflated by 5% to compensate for the increase in operational costs.

6.2.11. Cost of debt and WACC

Cost of debt

It was assumed that while capital expenditures for the infrastructure and development of the pilot AquaPark facilities will be funded by the EU, through the MAAIF/PESCA grant, the farm operators will be providing the working capital and provision for contingencies required to launch and sustain their operations during the first 12 months of activity.

The cost of debt (interest rate) assumes that the Agricultural Credit Facility (ACF) would be sought for loans contracted for projects engaged in agriculture or agro-processing, offering a better interest rate of 15% instead of the generally offered 23% for commercial loans (*https://ugbusiness.com › Data*). Assuming a high-case rate, 23% is used in the WACC calculation. The investment requirements were assumed to be financed by 40% debt and 60% equity.

Weighted average cost of capital (WACC)

With a cost of equity capital estimated at 13% based on the Risk and Return on Uganda's stock exchange (*https://mpra.ub.uni-muenchen.de/6407/1/MPRA_paper_6407.pdf*), and the cost of debt assumed at 23%, the WACC is calculated at 14.5%.

Particulars	Return	Capital Structure	Ref:	
Average Market Return (Cost of Equity) (%)	**13%**	60%	https://mpra.ub.uni-muenchen.de/6407/1/MPRA_paper_6407.pdf	Risk and Return on Uganda's stock exchange
Cost of Debt (%)	23%	40%	https://ugbusiness.com › Data	**Commercial bank interest rates and charges as at 1 January, 2019**
Tax rate	30%			
WACC	**14.5%**			

Table 17 Description of the operational costs to be assumed by the Operator. The same cost assumptions have been used for all three types of operators.

Cost to	Item	Cost Assumption	Unit	Comments	Rational
Operator	Fingerlings	A. catfish: 150 Tilapia: 100	UGX/ pcs	production cost per 1-2g fingerlings	assumption based on field data collection
Operator	Fingerlings – Nucleus charge	10%		% of fingerlings production cost charged by the Nucleus for the production and supply of fingerlings	assumption
Operator	On-growing Feed	A. catfish: 3,885,000 Tilapia: 2,775,000	UGX / ton	cost of imported feed delivered to Mombasa, Kenya	assumption based on field data collection, and consultation with feed producers
Operator	Feed shipment	18,500,000	UGX / container	cost of shipping one 24 MT feed container from Mombasa to Apac, Uganda	assumption based on field data collection
Operator	Feed - Nucleus charge	3%		commission charged by the Nucleus on cost of feed purchased and delivered	assumption
Nucleus	Pumping costs	29	kW/hour	300 m^3/hour water pumped to 25m head, 0.1 kW/m^3	Calculation based on pump data
Operator	On farm and off farm transport vehicles	60 – 450	litre/month	range of fuel consumption based on vehicle or boat and usage. Detailed in the excel file	assumption based on experience and industry standards
Operator	Fuel costs – Diesel	3,800	UGX / litre		assumption based on field data collection
Operator	Fuel costs – Petrol	4,000	UGX / litre		assumption based on field data collection
Operator	Engine Oil	15,000	UGX / litre		assumption based on field data collection
Nucleus	Ice – Harvest	90	kW/tonnes	1 kg of ice used for 1 kg of fish harvested. cost of ice production is part of the electricity cost assumption	it relies purely on pumping water and operating the ice machine
Operator	Electricity	604.7	UGX / kW	ERA 2019, Medium industrial consumers average in Apac	Overall budget is assumed at this stage
Nucleus	Generator	6.5	litres / hour	average fuel consumption at full capacity	assumption based on experience
Nucleus	Generator	3	hours run-time /day	average forecasted	assumption

6.3. Capital expenditure

A summary of the capital expenditure for the four business entities is presented in Table 18, with a breakdown of the infrastructure & buildings and production systems while the calculation method for the main CAPEX costs is detailed in Table 19.

Based on the assumption that the AquaPark nucleus will not own the land but will build the pond infrastructure, land lease and infrastructure lease will be separated. All operators will directly pay the land renting fee to state as landowner, while the medium and small-scale operators will pay for the use of the infrastructure to the nucleus company which will bear the production infrastructure CAPEX.

Similarly, the AquaPark nucleus company will bear the CAPEX for the infrastructure and buildings, which include the infrastructure of the water supply for the ponds.

Working capital covers the total operating costs for the first 12 months of activity of the farmers and provision for contingency was set at 15%.

The base scenario was developed without the solar system while a financial scenario by using the solar system with an additional investment of 2,023,425,600 UGX.

For the small grower the working capital estimation comes mainly from the feed and seed costs which can be further reduced by providing these inputs by the government to start the activities.

Table 18 CAPEX analysis for the small - medium - large growers: main elements of the investment costs

		Small Grower	Medium Grower	Large Grower
Final production capacity	tons	24	443	1,526
Infrastructure & Buildings	UGX			**8,870,649,420**
Hatchery	UGX			647,500,000
Intensive flow-through farm	UGX			1,798,200,000
Large static ponds	UGX			1,332,000,000
Small-static ponds	UGX			740,000,000
Vehicles	UGX		**400,000,000**	**790,000,000**
Operations Equipment	UGX		**167,980,000**	**111,000,000**
Office Equipment & Furniture	UGX			**64,528,000**
Working Capital	UGX	55,669,904	1,534,665,416	4,686,643,141
Provision for Contingencies	UGX	5,566,990	320,946,812	2,181,397,884
Grand Total	UGX	**61,236,895**	**2,460,592,228**	**16,788,578,446**
Financed by:	USD	16,551	665,025	4,537,454
Grant	UGX			
Equity	UGX	36,742,137	1,476,355,337	10,073,147,067
Debt	UGX	24,494,758	984,236,891	6,715,431,378
Grant	USD			
Equity	USD	9,930	399,015	2,722,472
Debt	USD	6,620	266,010	1,814,981

Table 19 Details of the infrastructure and buildings CAPEX estimations

CAPEX costs		Estimated value	Estimation method
Flow-through farm 3,300 m3	UGX	1,798,200,000	Based on previous projects, the estimated costs of the concrete raceway construction is 150 USD/m3 what also includes the draining and water supply structures
1 ha earth ponds with total 30 ha area	UGX	1,332,000,000	Based on literature data from Uganda and estimation of the earth works 12,000 USD/ha
50 small ponds with 0.2 ha each	UGX	740,000,000	7,400 UGX/m2 Literature data from Uganda
Water reservoir 0.33 ha lined pond	UGX	36,630,000	3 USD/m2 including the pond liner
Sedimentation pond 3 ha earth pond	UGX	133,200,000	Based on literature data from Uganda and estimation of the earth works 12,000 USD/ha
Channels, water supply, infrastructure		3,030,022,500	Estimated value, 75% of the production infrastructure costs.
Pumps, pumping station and pipework	UGX	110,585,640	6 pumps with 150m3/hour capacity + 60M UGX for pumping station and pipework
Office, workshop, fuel store, staff area building		161,320,000	436m2 total building area calculating with 100 USD/m2
Hatchery (including RAS technology)	UGX	647,500,000	5 million/year capacity, calculated with 35,000 USD/1 million capacity.
Feed store	UGX	128,020,000	346m2 total building area calculating with 100 USD/m2

6.4. Operational expenditure

The financial model for the Apac AquaPark was developed for the first year when the facilities can operate with 50% capacity and for the following 15 years (1+15 years). Inflation correction (5%) was included in the calculation and the financial results were calculated as an average of the 16 years of operation.

Table 20 below compares the cost of production per size of operators and informs on the cost centres share of revenue.

Because the AquaPark will select the broodstock and implement a breeding program the costs of this are included in the other costs (fingerling, manpower etc.) of the large grower/nucleus company this cost item is not included in the analysis. Considering that the small farmers will operate the small ponds as family or personal business, salary costs were not calculated for them. From the analysis, it appears, as expected, that feed is the main cost centre representing between 63% and 48.5% of the revenues generated. The feed costs share is lower for the pond tilapia culture than in tilapia cage production because of the use of the natural production of the ponds. The feed costs share of the African catfish production is according to the industry standards for flow-through intensive production.

Table 20 Cost of production and cost centres share of revenue in the 1+15 years assessment period

		Small Grower	Medium Grower	Large Grower
Production capacity		**24**	**443**	**1,526**
Cost of production	UGX/kg	9,505	9,874	11,140
Cost centres of revenues				
Fingerlings		4.41%	4.97%	1.37%
Feed		48.51%	51.00%	63.06%
Production Equipment		3.59%	0.59%	0.06%
Electricity		4.72%	2.04%	1.65%
Manpower		0.00%	4.60%	2.96%
Fuel & Lubricants		0.00%	0.51%	0.36%
Lease on infrastructures		2.35%	0.38%	0.02%
Permits & Licenses		0.00%	0.00%	0.00%
Maintenance Costs		0.15%	0.94%	2.74%
Total Cost		**63.73%**	**65.02%**	**73.54%**
Movement in Inventory		-0.51%	-0.43%	-0.69%
Cost of Goods Sold		**63.22%**	**64.60%**	**72.85%**

Comparing the small and medium versus large operations, the above results demonstrate the economies of scale generated by larger operations. With a higher production capacity, the variable costs, capital requirements and capital expenditures are diluted resulting in lower production costs. However, it appears that the increase in production between the small and medium operators doesn't result in economies of scale. This is the result of the increase cost of manpower required to undertake activities of the farm.

Table 21 Cost structures (normalized averages over the 15 years assessment period).

Cost structure	Small Grower	Medium Grower	Large Grower
Fingerlings	5.6%	6.0%	2.9%
Feed	61.4%	61.7%	74.4%
Production Equipment	4.5%	0.7%	0.1%
Electricity	6.0%	2.5%	2.2%
Manpower	0.0%	5.6%	3.5%
Fuel & Lubricants	0.0%	0.6%	0.4%
Lease on infrastructures	3.0%	0.5%	0.0%
Permits & Licenses	0.0%	0.0%	0.0%
Maintenance Costs	0.2%	1.1%	3.4%
General expenses and Administration	0.4%	2.3%	2.0%
Sales & Marketing	6.4%	6.1%	2.7%
Insurance	0.0%	0.0%	0.0%
Depreciation & Amortization	0.2%	2.5%	3.1%
Interest	0.5%	0.9%	1.5%
Tax	11.9%	9.6%	3.8%
TOTAL	100.0%	100.0%	100.0%

6.5. Financial results

6.5.1. Profitability measures

Net farm income

Net farm income, also called Profit After Tax (PAT) measures the return to the operator's equity or capital. It is calculated from deducting all the expenses required to operate the business to the total revenue.

$$Net\ income\ = Total\ revenue - total\ expenses$$

Rate of return on assets

The rate of Return on Assets (ROA) measures the profits obtained from the use of all capital (debt and equity) invested in the business by comparing the profits to the value of the assets of the business.

$$ROA = \frac{Adjusted\ net\ farm\ income}{Current\ assets}$$

$$Adjusted\ net\ farm\ income\ = Net\ farm\ income\ + interest\ expense$$

Current ratio

Current ratio informs of a company's liquidity by comparing the value of current farm assets against the value of current farm liabilities. The formula is:

$$Current\ ratio = \frac{Current\ farm\ assets}{Current\ farm\ liabilities}$$

current farm assets: those that will generate or will be able to generate saleable products in the near future

current farm liabilities: upcoming financial obligations

Net Present Value NPV

The NPV is a method for valuation of the business done using the income approach (discounted cashflow approach). The NPV is the difference between the present value of cash inflows and the present value of cash outflows over a period. It analyses the profitability of a projected investment of project.

A positive NPV indicates that the investment is profitable as the projected earnings generated exceeds the anticipated costs, while a negative NPV indicates that the project will results in net loss.

The NPV is calculated using the built-in excel formula.

Payback period

The payback method calculates how long it will take to repay the original investment, with the limitation that it doesn't account for the time value of money.

The payback period is calculated

Internal Rate of Return (IRR)

The IRR is a discount rate that makes the NPV of all cash flows from the project equal to zero. To indicate the profitability of a project, the IRR needs to be positive and higher than the cost of investment (WACC).

The IRR is calculated using the built-in excel formula.

6.5.2. Comparison of financial performances

The results presented in Table 22 demonstrate that based on the set of assumptions taken in this base case scenario, the project is profitable for all the three sizes of operators with positive NPVs and IRR higher than the WACC. The undiscounted payback period for large farmer is 6.2 years and 11 years discounted payback time.

Table 22 Financial performances of the 3 entities considered in the nucleus business model. The data are the 15 years full capacity production average results of the base model

		Small Grower	Medium Grower	Large Grower
Production capacity	**tons/year**	**24**	**443**	**1,526**
Cost of production	UGX/kg	**9,494**	**9,874**	**11,140**
Capex	UGX	61,236,895	2,460,592,228	16,625,362,906
Normalized Financial performances (15 years average)				
Yearly Average revenue	**UGX / year**	**324,867,649**	**6,108,171,174**	**25,856,261,060**
Operating profit	%	30.3%	26.4%	20.6%
Net Income	UGX / year	72,319,103	1,204,834,803	4,597,685,199
Net Income	%	21.0%	17.9%	16.0%
ROA	%	28.3%	22%	16%
Current Ratio		13.86	33.98	11.72
Weighted Average Cost of Capital	**%**	14.5%	14.5%	14.5%
IRR	%	42%	25%	22%
NPV	UGX	221,981,431	2,716,804,338	10,218,140,171
Exit price	UGX	133,672,462	5,359,049,294	36,291,082,211
Break-even point (production / year)	tons/year	7.2	204.9	720.3
Undiscounted Payback period	years	3.81	6.10	6.20
Discounted Payback period	years	4.76	9.26	11.13

The results of the financial models show that even the moderate density and low fish price assumed in the model can ensure a good Profit After Taxes (PAT/Net income) for the large-scale farming company. Because the large, production infrastructure costs (including the pond construction) are included in the financial figures of this "nucleus" AquaPark company these numbers also show the financial feasibility of the whole AquaPark project. Integrating the grants for the CAPEX costs the picture would be much different and will show an even higher positive NPV and good return of investment costs. The consultant suggests, that considering pilot projects should not be evaluated purely on a financial basis.

As the results of the financial analysis shows the whole project using semi intensive and extensive technology can achieve a high profitability from fishing activities. In the financial model the analysis was done for the theoretical case when all the 1 ha ponds are operated by one company and all the small pond are also rented by one organisation. Because the small farmer model assumes that all the farm work will be done by the farmers and their families in this model their income comes from the PAT/Net income. If the 50 small ponds will be operated by 6 families the farm can ensure a 1,000,000 UGX/month average income for them. The financial performance of the medium sized farms also will enable for 2-3 larger companies to share the work and the profit, but also can be operated by one larger company with the required strong financial background.

6.5.3 Sensitivity analysis

A sensitivity analysis was undertaken to assess the outcome of variations of a set of key operating and financial variables on net profitability (Net Profit margin in %) of the different operators. The results are presented in tables respectively for the large – medium and small-scale operators.

The sensitivity analyse were carried out for all the 3 type of farmers, but it has to be considered, that the financial performance of the small farmers will vary with a very wide range depending the intensity of their production. The key variables for the sensitivity show that the key variables driving the financial viability of all fish farming operations are the feed price, the feed conversion ratio (FCR), and the fish price. The proposed production technologies also enable considerable changes in the intensity of the production where the key variable is maximum harvest density of the tanks or ponds.

In this report, the base case value for each key variable was conservative and impact on the profitability of 25% increase or reduction of the following key parameters were investigated.

Feed prices: Tilapia feeds are widely used in Uganda and the imported feed price, delivered to Mombasa, Kenya was validated as 2,775,000 UGX / ton. African catfish farmers recently use tilapia feed if they use any but the protein content of this is too low for high intensity production. Because good quality catfish feeds with high protein content are not present in the country, the consultant contacted various feed suppliers and based on their estimated offers calculated the possible price delivered to Mombasa. This estimated 1,050 USD/tons for the grow-out feed costs can be reduced if the feed suppliers are involved as long term partners in the AquaPark development. The increase of feed prices because of the fluctuating fish meal prices has a low risk because the African catfish feeds usually use alternative protein sources. The main reason of a higher feed price can be the increase of the import costs because of changing taxes or transport costs.

Fish prices: Tilapia has a well-established market and on farm price around 8,000 UGX/kg and in the financial model 7630 UGX average selling price was used for the various size of tilapia harvested from the ponds. There is a realistic possibility to sell the 500g high quality fish in small quantity on a higher price. According to the preliminary market observations the African catfish above 1 kg has a 10,000-11,000 UGX/kg market size. Considering that the African catfish has a similar flesh quality like Tilapia, but the filleting yield of catfish is 10-15% more than Tilapia, the available farm gate price could be 25% higher. Because of the limited information on the recent African catfish market in Northern- Uganda the financial model uses the 8,000 UGX/kg farm gate price for African catfish which price can bear the costs of the wholesaler for processing or exports. The population growth and the increasing popularity of fish paired with the reduction of the imports can result a considerable increase in the fish prices. The decrease of the tilapia prices can be caused by the growing import of tilapia products from China. The African catfish does not have any competitive product on the market at the moment, but the Pangasius production in Asia and the import of this fish can be competitor of the catfish products.

Feed Conversion Ratio (FCR): As expected, one of the key variables that largely drive the profitability of each farmers' operations is the Feed Conversion Ratio (FCR). The feed being the largest cost-centre of the operations (over 50% of the revenues), a substantial reduction in FCR and feed cost will significantly reduce costs and increase profitability. FCR can be reduced in the semi-intensive and extensive systems by developing the technology and use even more natural production of the ponds. Improvement of the FCR was already included in the model, if the starting FCR can be reduced up to its 92%. The 1.3 starting FCR for the intensive production of the African catfish also can be further reduced by local breeding of the fish or using selected strains with high quality genetic material. The increase of the FCR can be caused by lower quality feed, sub-optimal production environment (temperature, DO, disease).

Intensity of production: The production capacity of the intensive and pond units can be enlarged without developing new production infrastructure. For the flow-through intensive African catfish farm 200kg/m^3 was suggested as maximum grow-out tank biomass, but according to the industry standards this can go up to 300 kg/m^3. The calculated 15t/ha average yearly production of the semi-intensive ponds is a realistic base case, because to reach the possible 20t/ha yield needs 5-8 years of experience with this technology. The intensity of production depends highly on the knowledge and experience of the farmer. If the nucleus flow through farm can find an experienced African catfish farmer, the production density can be 25% higher from the beginning.

The marketing fee paid to the nucleus company: In the proposed AquaPark model the large African catfish grower company also manage the services for the small and medium farmers and get paid for these services in form of commissions. The marketing fee is paid by the small and medium farmers after the fish they produce and sell through the large nucleus company. Because all the investment and infrastructure maintenance will be done by the large company, the small and medium company can be highly profitable. To make the large-scale investment more attractive for investors 25% increase of the marketing fee is possible. If the goal is to encourage more medium and small-scale farmers to start the farming activity in the AquaPark the marketing fee can be limited in the PPP agreement on 25% less level. In this case the large investor should be compensated with a higher amount of investment grant for the CAPEX.

Equity part of the CAPEX: It is expected in the base case scenario that all farmers will contribute with 60% equity to the CAPEX costs. 25% change of this can modify the profitability through the higher or lower interest costs. Because the small farmers do not have any CAPEX in the planned AquaPark and investment of the medium sized farmers is limited to the production equipment, the profitability of these farmers is not very much affected by this variable.

Fish price appears to be the key variable that has the biggest impact on financial performances of each farmer. The unlikely 25% reduction of the African catfish on farm price would result that this business produce losses (Table 23) while the other 2 farm type remain profitable even by selling fish on the reduced price in the first year.

FCR also have large impact on the profitability, but while 25% reduction of this biologically determined key parameter is unlikely for both farmed species, the increase is possible due to poor farming practices. The results of the sensitivity analysis show that even in this case, all the three-farm type remain profitable based on the 15 full production year average.

Increasing the production volume by stocking and harvesting higher fish density in the tanks and ponds is a realistic option for each farm type. The 25% of the maximum density of the production tanks of the flow-through African catfish farm (Table 23) could increase the profitability but still remain below the 300 kg/m^3 suggested maximum density. However, the production volume should be increased only when the markets and distribution channels are already established.

The 25% increase of the marketing fee charged by the large company does not change dramatically the financial results of the small and medium scale producers (Table 24, Table 25). To make the large-scale investment more attractive for investors, this fee can be raised or modified to a fixed price solution where the large-scale farmer can apply higher margin rate on the fish bought from the medium and small-scale farmers.

Table 23 Sensitivity analysis for the large-scale operator producing African catfish. Net profitability is the average normalized profitability over 15 years

Large scale - grower - AquaPark model		base case	Net profitability	-25%	Net profitability	25% more	Net profitability
1. Grow-out feed cost	UGX/t	3,885,000	16.0%	2,913,750	31.2%	4,856,250	7.2%
2. Catfish price	UGX/kg	8,000	16.0%	6,000	-4.7%	10,000	26.8%
3. FCR in the first year		1.3	16.0%	0.975	25.9%	1.625	5.5%
4. Maximum Density Grow out	kg/m^3	200	16.0%	150	12.6%	250	18.2%
5. Marketing Fee to Nucleus company	%	5%	16.0%	3.8%	15.8%	6.30%	16.2%
6. Equity part of CAPEX	%	60%	16.0%	45.0%	15.6%	75.00%	16.4%

Table 24 Sensitivity analysis for the medium-scale operator producing Nile tilapia in semi-intensive ponds. Net profitability is the average normalized profitability over 15 years.

Medium scale - grower - AquaPark model		base case	Net profitability	-25%	Net profitability	25% more	Net profitability
1. Grow-out feed cost	UGX/t	2,775,000	17.9%	2,081,250	24.9%	3,468,750	10.8%
2. Tilapia price	UGX/kg	7630	17.9%	5723	0.29%	9538	27.6%
3. FCR		1.28	17.9%	0.96	26.8%	1.6	8.9%
4. Maximum Density Grow out	kg/m^2	1.5	17.9%	1.125	13.7%	1.875	20.5%
5. Marketing Fee to Nucleus company	%	5%	17.9%	3.8%	18.8%	6.30%	17.0%
6. Equity part of CAPEX	%	60%	17.9%	45.0%	17.7%	75.00%	18.1%

Table 25 Sensitivity analysis for the small-scale operator producing Nile tilapia in small extensive ponds. Net profitability is the average normalized profitability over 15 years.

Large scale - grower - AquaPark model		base case	Net profitability	-25%	Net profitability	25% more	Net profitability
1. Grow-out feed cost	UGX/t	2,775,000	21.0%	2,081,250	27.7%	3,468,750	14.2%
2. Average tilapia price	UGX/t	7630	21.0%	5723	5.5%	9000	30.1%
3. FCR		1.20	21.0%	0.9	29.6%	1.5	12.4%
4. Maximum Density Grow out	kg/m^2	0.24	21.0%	0.18	18.5%	0.30	22.5%
5. Marketing Fee to Nucleus company	%	5%	21.0%	3.8%	21.8%	6.30%	20.1%
6. Equity part of CAPEX	%	60%	21.0%	45.0%	21.0%	75.00%	21.0%

7. Conclusions

This Preliminary Design & Detailed Feasibility Study conducted for the proposed land based AquaPark development project in Apac was intended to follow the principles and concept developed by the previous report prepared by Poseidon and submitted in final form in early 2013. Additionally, through direction provided from field missions, a stakeholder meetings and discussions with the EUD in Kampala, various assumptions have been made regarding basic expectations of the project; production volumes, cost and revenue parameters and management set-up (core operator and out-growers).

In terms of budget available through the current project programme estimate (MAOPE), it was indicated that the cost of such an operation established through this study, should not be limited by the MAOPE budgets, but to outline what is required to put a professional and up to date production operation on the ground (as it is to be used as a model for future investment). Extra funds required, if any, would be assumed from other sources. The total investment costs of the large-scale African catfish production were estimated more than 4 million USD which also includes the construction of the small and large ponds as well as the working capital of the catfish farming in the first year of production.

The results of the financial models show that even the moderate density and low fish price assumed in the model can ensure a good Profit After Taxes (PAT/Net income) for the large-scale farming company. Because the large, production infrastructure costs (including the pond construction) are included in the financial figures of the “nucleus” AquaPark company these numbers also indicates the financial feasibility of the whole AquaPark project. Since the planned grants were not included in the financial calculations, evaluating the figures purely according to the return of the investments the whole AquaPark project would not be feasible for the large, nucleus farm investor. This is realistic because the AquaPark is a pilot action where the nucleus farmer also will provide services for the small and medium scale farmers making their business profitable. To fully compensate the large-scale farmers for these services and encourage the large-scale investment in the project a granting mechanism must be developed.

Integrating the grants for the CAPEX costs in the financial evaluation would be much different and will show a positive NPV and good return of investment costs. The consultant suggests, that considering pilot projects should not be evaluated purely on a financial basis.

This is also well demonstrated in the financial model of the medium and small farmers which indicates a fair average yearly PAT and higher IRR for their relatively low investment costs. These successful businesses however would not be viable without the services of the large-scale investor, because they investment costs and operating costs (water, feed, fingerling supply) would be much higher.

Due to the assumptions used for the base case scenario and the careful analysis that has ensued, it can be seen from this report that the intended pilot phase of the land based AquaPark in Apac is feasible and financially viable for the operators.

The planned land purchase of the government will ensure around 200 ha area for the AquaPark from which this first phase development will use only 50 ha. It is advised that after the 1st year of the operating farms the results of the first phase development must be evaluated and a new project should be initiated to create a master plan for the whole available area.

Way forward

It is suggested that the Project now reviews in detail the results of this study and that possible scenarios are envisaged as to a way forward, keeping the overall project objectives in mind and in the context of potential changes during the project period related to the key success factors identified. The outputs of the Project are all focused on these key success factors, so we can expect improvement as a result. Based on the financial model, decisions will be needed on the followings:

- Details of the granting mechanism of the project: funding rate, eligible costs, eligible beneficiary
- Detailed business and management model for the AquaParks must be decided
- The details of the granting mechanism and the required AquaPark business model must be clearly communicated to the potential investors.
- Potential large-scale investors should be involved in the engineering phase of the projects.
- The studies will suggest the required technology and infrastructure investments required to design in the engineering phase.
- The land based AquaPark needs much more engineering design and site survey (soil, topography) work, this should be considered in the preparation of the engineering ToR of this AquaPark.

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Annex 1 Income statements and balance sheets

Income statement for the large-scale operator

Income Statement (UGX)		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Revenue	UGX	4,149,270,174	15,772,164,856	16,835,525,640	17,934,515,568	19,146,393,776	20,441,241,716	21,803,353,684	23,280,680,111	24,859,361,131	26,492,032,771	28,292,251,536	30,216,250,055	32,243,879,396	34,440,359,926	36,788,148,829	39,297,756,911
	USD	1,121,424	4,262,747	4,550,142	4,847,166	5,174,701	5,524,660	5,892,798	6,292,076	6,718,746	7,160,009	7,646,554	8,166,554	8,714,562	9,308,205	9,942,743	10,621,015
Cost		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fingerlings CATFISH		230,353,439	241,871,111	253,964,666	266,662,900	279,996,045	293,995,847	308,695,639	324,130,421	340,336,942	357,353,790	375,221,479	393,982,553	413,681,681	434,365,765	456,084,053	478,888,255
Fingerlings TILAPIA		186,576,975	195,905,824	205,701,115	215,986,171	226,785,480	238,124,754	250,030,991	262,532,541	275,659,168	289,442,126	303,914,233	319,109,944	335,065,442	351,818,714	369,409,649	387,880,132
Broodstock		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feed CATFISH		4,520,398,787	9,413,288,654	9,679,392,020	10,055,967,061	10,446,001,126	10,873,509,889	11,292,862,756	11,857,505,894	12,450,381,189	13,072,900,248	13,726,545,261	14,412,872,524	15,133,516,150	15,890,191,957	16,684,701,555	17,518,936,633
Feed TILAPIA		1,060,070,502	2,212,996,629	2,323,646,461	2,403,861,477	2,524,054,551	2,650,257,279	2,761,951,816	2,900,049,407	3,045,051,877	3,144,505,084	3,301,730,338	3,466,816,855	3,612,259,149	3,792,872,106	3,982,515,711	4,181,641,497
Production Consummables		10,740,000	11,277,000	11,840,850	12,432,893	13,054,537	13,707,264	14,392,627	15,112,259	15,867,871	16,661,265	17,494,328	18,369,045	19,287,497	20,251,872	21,264,465	22,327,689
Harvest		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity		270,617,951	328,036,516	344,438,341	361,660,258	379,743,271	398,730,435	418,666,957	439,600,304	461,580,320	484,659,336	508,892,302	534,336,918	561,053,763	589,106,452	618,561,774	649,489,863
Manpower		475,705,724	521,356,702	547,424,537	574,795,764	603,535,552	633,712,329	665,397,946	698,667,843	733,601,235	770,281,297	808,795,362	849,235,130	891,696,886	936,281,731	983,095,817	1,032,250,608
Fuel - Generator		27,046,500	28,398,825	29,818,766	31,309,705	32,875,190	34,518,949	36,244,897	38,057,142	39,959,999	41,957,999	44,055,899	46,258,693	48,571,628	51,000,210	53,550,220	56,227,731
Fuel - Vehicle & boats		29,640,000	31,122,000	32,678,100	34,312,005	36,027,605	37,828,986	39,720,435	41,706,457	43,791,779	45,981,368	48,280,437	50,694,459	53,229,182	55,890,641	58,685,173	61,619,431
Oil		2,925,000	3,071,250	3,224,813	3,386,053	3,555,356	3,733,124	3,919,780	4,115,769	4,321,557	4,537,635	4,764,517	5,002,743	5,252,880	5,515,524	5,791,300	6,080,865
Lease on infrastructures		3,000,000	3,150,000	3,307,500	3,472,875	3,646,519	3,828,845	4,020,287	4,221,301	4,432,366	4,653,985	4,886,684	5,131,018	5,387,569	5,656,947	5,939,795	6,236,785
Permits & Licenses		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintenance Costs		-	-	9,839,151	253,276,508	265,940,333	381,935,054	520,522,591	708,850,532	744,293,058	1,018,169,066	1,186,326,535	1,245,642,862	1,307,925,005	1,373,321,255	1,441,987,318	1,514,086,684
Total Cost		6,817,074,878	12,990,474,511	13,445,276,320	14,217,123,669	14,815,215,565	15,563,882,753	16,316,426,722	17,294,549,869	18,159,277,362	19,251,103,198	20,330,907,374	21,347,452,742	22,386,926,831	23,506,273,172	24,681,586,831	25,915,666,172
Movement in Inventory		- 4,323,266,276	386,245,299	- 117,277,798	- 194,869,972	- 147,603,989	- 188,788,858	- 189,975,191	- 251,626,225	- 220,845,602	- 282,924,811	- 279,803,469	- 262,717,605	- 278,121,017	- 309,061,583	- 324,514,662	- 340,740,395
Cost of Goods Sold		2,493,808,602	13,376,719,809	13,327,998,523	14,022,253,697	14,667,611,575	15,375,093,895	16,126,451,530	17,042,923,644	17,938,431,760	18,968,178,387	20,051,103,905	21,084,735,137	22,108,805,814	23,197,211,590	24,357,072,169	25,574,925,778
Gross Profit		1,655,461,572	2,395,445,047	3,507,527,117	3,912,261,870	4,478,782,200	5,066,147,821	5,676,902,153	6,237,756,468	6,920,929,371	7,523,854,384	8,241,147,631	9,131,514,918	10,135,073,582	11,243,148,337	12,431,076,660	13,722,831,133
General expenses and Administration		225,563,337	295,166,963	307,978,091	324,372,831	339,463,830	356,516,086	374,085,388	394,412,676	414,133,310	436,678,595	459,685,015	482,669,265	506,523,743	531,849,930	558,442,427	586,364,548
Sales & Marketing		110,305,357	319,333,137	385,722,490	410,152,887	436,963,580	465,562,324	495,641,438	528,166,685	562,867,959	598,805,429	638,258,043	680,358,664	724,712,934	772,634,312	823,781,446	878,374,531
Insurance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other income		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBITDA		1,319,592,877	1,780,944,948	2,813,826,536	3,177,736,152	3,702,354,790	4,244,069,411	4,807,175,327	5,315,177,107	5,943,928,102	6,488,370,360	7,143,204,574	7,968,486,988	8,903,836,905	9,938,664,094	11,048,852,787	12,258,092,054
Depreciation & Amortization		630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186	630,903,186
EBIT (Operating Profit, Operating Income)		688,689,691	1,150,041,762	2,182,923,350	2,546,832,966	3,071,451,604	3,613,166,225	4,176,272,141	4,684,273,921	5,313,024,916	5,857,467,174	6,512,301,387	7,337,583,802	8,272,933,719	9,307,760,908	10,417,949,601	11,627,188,868
Interest		332,507,258	665,014,516	631,763,790	565,262,339	498,760,887	432,259,436	365,757,984	299,256,532	232,755,081	166,253,629	99,752,177	33,250,726	-	-	-	-
PBT		356,182,433	485,027,246	1,551,159,559	1,981,570,627	2,572,690,717	3,180,906,789	3,810,514,157	4,385,017,389	5,080,269,836	5,691,213,545	6,412,549,210	7,304,333,076	8,272,933,719	9,307,760,908	10,417,949,601	11,627,188,868
Tax		106,854,730	63,303,696	337,812,196	415,814,936	525,475,212	629,396,927	727,676,892	804,573,153	897,598,155	965,188,042	1,045,365,387	1,146,988,338	1,247,701,230	1,342,764,187	1,435,684,895	1,530,464,018
PAT (Net Income)		249,327,703	421,723,550	1,213,347,363	1,565,755,691	2,047,215,505	2,551,509,863	3,082,837,265	3,580,444,236	4,182,671,681	4,726,025,504	5,367,183,823	6,157,344,738	7,025,232,489	7,964,996,721	8,982,264,706	10,096,724,850
Legal Reserve		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Available for Dividends		249,327,703	421,723,550	1,213,347,363	1,565,755,691	2,047,215,505	2,551,509,863	3,082,837,265	3,580,444,236	4,182,671,681	4,726,025,504	5,367,183,823	6,157,344,738	7,025,232,489	7,964,996,721	8,982,264,706	10,096,724,850
Dividends		-	-	606,673,682	782,877,846	1,023,607,752	1,275,754,931	1,541,418,632	1,790,222,118	2,091,335,840	2,363,012,752	2,683,591,911	3,078,672,369	3,512,616,244	3,982,498,361	4,491,132,353	5,048,362,425
Retained Earnings		249,327,703	421,723,550	606,673,682	782,877,846	1,023,607,752	1,275,754,931	1,541,418,632	1,790,222,118	2,091,335,840	2,363,012,752	2,683,591,911	3,078,672,369	3,512,616,244	3,982,498,361	4,491,132,353	5,048,362,425

AquaBioTech Group

Agrotec spa

Balance sheet for the large-scale operator

Balance Sheet (UGX)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Assets																
PPE	11,449,743,135	10,818,839,949	10,366,424,763	9,735,521,576	9,104,618,390	8,652,203,204	8,021,300,018	7,390,396,832	6,937,981,646	10,151,907,361	9,521,004,175	9,068,588,989	8,437,685,803	7,806,782,616	7,354,367,430	6,723,464,244
Cash & bank	1,661,988,723	5,584,347,423	5,898,524,948	6,515,860,999	7,406,911,670	8,342,812,703	9,721,997,742	11,306,875,988	13,035,840,388	11,326,727,208	13,785,155,349	16,472,062,457	20,422,897,097	24,819,238,130	29,534,872,129	34,974,828,524
Account receivable	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biological asset	4,323,266,276	3,937,020,977	4,054,298,775	4,249,168,747	4,396,772,736	4,585,561,594	4,775,536,786	5,027,163,011	5,248,008,613	5,530,933,424	5,810,736,893	6,073,454,498	6,351,575,515	6,660,637,098	6,985,151,760	7,325,892,155
Total Assets	**17,434,998,134**	**20,340,208,349**	**20,319,248,485**	**20,500,551,323**	**20,908,302,797**	**21,580,577,501**	**22,518,834,546**	**23,724,435,831**	**25,221,830,648**	**27,009,567,993**	**29,116,896,417**	**31,614,105,943**	**35,212,158,414**	**39,286,657,844**	**43,874,391,320**	**49,024,184,923**
Equity & Liabilities																
Equity	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744	9,975,217,744
Retained Earnings	249,327,703	671,051,253	1,277,724,935	2,060,602,780	3,084,210,533	4,359,965,464	5,901,384,096	7,691,606,214	9,782,942,054	12,145,954,806	14,829,546,718	17,908,219,087	21,420,835,331	25,403,333,692	29,894,466,045	34,942,828,470
Legal reserves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shareholder Equity	**10,224,545,447**	**10,646,268,997**	**11,252,942,678**	**12,035,820,524**	**13,059,428,276**	**14,335,183,208**	**15,876,601,840**	**17,666,823,958**	**19,758,159,798**	**22,121,172,550**	**24,804,764,461**	**27,883,436,830**	**31,396,053,075**	**35,378,551,435**	**39,869,683,788**	**44,918,046,213**
Amended Equity	10,224,545,447	10,646,268,997	11,252,942,678	12,035,820,524	13,059,428,276	14,335,183,208	15,876,601,840	17,666,823,958	19,758,159,798	22,121,172,550	24,804,764,461	27,883,436,830	31,396,053,075	35,378,551,435	39,869,683,788	44,918,046,213
Debt	6,650,145,162	6,650,145,162	5,985,130,646	5,320,116,130	4,655,101,614	3,990,087,097	3,325,072,581	2,660,058,065	1,995,043,549	1,330,029,032	665,014,516	-	-	-	-	-
Account payables	560,307,524	1,067,710,234	1,105,091,204	1,168,530,713	1,217,688,951	1,279,223,240	1,341,076,169	1,421,469,852	1,492,543,345	1,582,282,455	1,671,033,483	1,754,585,157	1,840,021,383	1,932,022,453	2,028,623,575	2,130,054,754
Total liabilities & Equities	**17,434,998,134**	**18,364,124,393**	**18,343,164,529**	**18,524,467,366**	**18,932,218,841**	**19,604,493,545**	**20,542,750,590**	**21,748,351,875**	**23,245,746,692**	**25,033,484,037**	**27,140,812,460**	**29,638,021,987**	**33,236,074,458**	**37,310,573,888**	**41,898,307,363**	**47,048,100,967**

Income statement for the Medium-scale operator

Income Statement (UGX)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Revenue	776,995,088	3,618,094,520	3,874,979,231	4,150,102,757	4,444,760,052	4,760,338,016	5,098,322,015	5,460,302,878	5,847,984,383	6,263,191,274	6,707,877,854	7,184,137,182	7,694,210,922	8,240,499,897	8,825,575,390	9,452,191,243
Cost																
Fingerlings	195,849,446	205,641,918	215,924,014	226,720,215	238,056,226	249,959,037	262,456,989	275,579,838	289,358,830	303,826,772	319,018,111	334,969,016	351,717,467	369,303,340	387,768,507	407,156,933
Broodstock	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feed	1,040,016,196	2,171,130,895	2,279,687,439	2,356,121,320	2,473,927,386	2,597,623,755	2,705,761,741	2,841,049,828	2,983,102,319	3,078,978,618	3,232,927,549	3,394,573,927	3,535,165,359	3,711,923,627	3,897,519,809	4,092,395,799
Production Equipment	24,000,000	24,570,000	25,467,750	26,741,138	28,078,194	29,482,104	30,956,209	32,504,020	34,129,221	35,835,682	37,627,466	39,508,839	41,484,281	43,558,495	45,736,420	48,023,241
Harvest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity	68,229,458	84,375,767	88,594,556	93,024,284	97,675,498	102,559,273	107,687,236	113,071,598	118,725,178	124,661,437	130,894,509	137,439,234	144,311,196	151,526,756	159,103,093	167,058,248
Manpower	181,550,316	190,627,832	200,159,223	210,167,185	220,675,544	231,709,321	243,294,787	255,459,526	268,232,503	281,644,128	295,726,334	310,512,651	326,038,283	342,340,198	359,457,208	377,430,068
Fuel - Generator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel - Vehicle	9,120,000	19,152,000	20,109,600	21,115,080	22,170,834	23,279,376	24,443,344	25,665,512	26,948,787	28,296,227	29,711,038	31,196,590	32,756,419	34,394,240	36,113,952	37,919,650
Oil	900,000	1,890,000	1,984,500	2,083,725	2,187,911	2,297,307	2,412,172	2,532,781	2,659,420	2,792,391	2,932,010	3,078,611	3,232,541	3,394,168	3,563,877	3,742,071
Lease on infrastructures	15,000,000	15,750,000	16,537,500	17,364,375	18,232,594	19,144,223	20,101,435	21,106,506	22,161,832	23,269,923	24,433,419	25,655,090	26,937,845	28,284,737	29,698,974	31,183,923
Permits & Licenses	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintenance Costs	-	-	11,299,523	43,828,035	46,019,437	71,813,608	75,404,288	109,373,557	114,842,235	120,584,347	33,389,082	35,058,536	36,811,463	38,652,036	40,584,638	42,613,870
Total Cost	1,534,665,416	2,713,138,412	2,859,764,105	2,997,165,355	3,147,023,623	3,327,868,003	3,472,518,202	3,676,343,166	3,860,160,325	3,999,889,524	4,106,659,518	4,311,992,494	4,498,454,855	4,723,377,598	4,959,546,478	5,207,523,802
Movement in Inventory	-967,443,925	150,062,429	-39,345,770	-35,580,206	-39,005,811	-47,461,555	-37,690,310	-53,799,931	-48,425,988	-36,520,655	-8,322,292	-54,446,944	-49,393,469	-59,900,113	-63,025,693	-66,307,552
Cost of Goods Sold	567,221,491	2,863,200,841	2,820,418,336	2,961,585,149	3,108,017,812	3,280,406,448	3,434,827,892	3,622,543,235	3,811,734,336	3,963,368,869	4,098,337,226	4,257,545,551	4,449,061,387	4,663,477,485	4,896,520,785	5,141,216,250
Gross Profit	209,773,597	754,893,679	1,054,560,896	1,188,517,607	1,336,742,240	1,479,931,568	1,663,494,124	1,837,759,643	2,036,250,047	2,299,822,405	2,609,540,628	2,926,591,631	3,245,149,535	3,577,022,412	3,929,054,605	4,310,974,993
General expenses and Administration	68,670,215	77,612,424	81,547,890	85,597,349	89,877,217	94,488,544	99,104,255	104,210,463	109,420,986	114,625,641	119,890,801	125,885,341	132,033,921	138,635,618	145,567,398	152,845,768
Sales & Marketing	38,849,754	180,904,726	193,748,962	207,505,138	222,238,003	238,016,901	254,916,101	273,015,144	292,399,219	313,159,564	335,393,893	359,206,859	384,710,546	412,024,995	441,278,770	472,609,562
Insurance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other income	37,000,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBITDA	139,253,628	496,376,529	779,264,045	895,415,120	1,024,627,021	1,147,426,124	1,309,473,768	1,460,534,037	1,634,429,842	1,872,037,200	2,154,255,935	2,441,499,432	2,728,405,068	3,026,361,800	3,342,208,437	3,685,519,662
Depreciation & Amortization	139,866,348	139,866,348	139,866,348	139,866,348	139,866,348	139,866,348	139,866,348	139,866,348	139,866,348	139,866,348	68,326,667	68,326,667	68,326,667	68,326,667	68,326,667	68,326,667
EBIT (Operating Profit, Operating Income)	-612,720	356,510,181	639,397,697	755,548,772	884,760,673	1,007,559,776	1,169,607,420	1,320,667,689	1,494,563,494	1,732,170,852	2,085,929,268	2,373,172,765	2,660,078,401	2,958,035,133	3,273,881,770	3,617,192,996
Interest	48,360,845	96,721,689	91,885,605	82,213,436	72,541,267	62,869,098	53,196,929	43,524,760	33,852,591	24,180,422	14,508,253	4,836,084	-4,836,084	-14,508,253	-24,180,422	-33,852,591
PBT	-48,973,565	259,788,492	547,512,092	673,335,337	812,219,406	944,690,678	1,116,410,491	1,277,142,928	1,460,710,902	1,707,990,430	2,071,421,014	2,368,336,680	2,664,914,486	2,972,543,387	3,298,062,193	3,651,045,587
Tax	-	77,936,548	164,253,628	202,000,601	243,665,822	283,407,203	334,923,147	383,142,879	438,213,271	512,397,129	621,426,304	710,501,004	799,474,346	891,763,016	989,418,658	1,095,313,676
PAT (Net Income)	-48,973,565	181,851,944	383,258,464	471,334,736	568,553,584	661,283,475	781,487,344	894,000,050	1,022,497,632	1,195,593,301	1,449,994,710	1,657,835,676	1,865,440,140	2,080,780,371	2,308,643,535	2,555,731,911
Legal Reserve	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Available for Dividends	-48,973,565	181,851,944	383,258,464	471,334,736	568,553,584	661,283,475	781,487,344	894,000,050	1,022,497,632	1,195,593,301	1,449,994,710	1,657,835,676	1,865,440,140	2,080,780,371	2,308,643,535	2,555,731,911
Dividends	-	90,925,972.11	191,629,232	235,667,368	284,276,792	330,641,737	390,743,672	447,000,025	511,248,816	597,796,651	724,997,355	828,917,838	932,720,070	1,040,390,185	1,154,321,767	1,277,865,955
Retained Earnings	-48,973,565	90,925,972	191,629,232	235,667,368	284,276,792	330,641,737	390,743,672	447,000,025	511,248,816	597,796,651	724,997,355	828,917,838	932,720,070	1,040,390,185	1,154,321,767	1,277,865,955

Balance sheet for the Medium-scale operator

Balance Sheet (UGX)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Assets																
PPE	780,510,464	640,644,117	705,757,769	565,891,421	426,025,073	491,138,725	351,272,377	211,406,029	276,519,681	136,653,333	68,326,667	204,980,000	136,653,333	68,326,667	204,980,000	136,653,333
Cash & bank	746,511,158	1,223,708,701	1,224,249,136	1,476,879,884	1,775,770,116	1,910,188,152	2,316,536,304	2,767,946,668	3,082,407,088	3,696,728,808	4,392,252,738	4,948,745,367	5,817,574,493	6,786,780,018	7,662,787,685	8,865,060,038
Account receivable	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biological Asset	967,843,525	817,781,096	857,106,886	892,647,132	931,612,983	979,034,578	1,016,684,928	1,070,444,899	1,118,830,927	1,155,311,623	1,163,593,955	1,218,000,938	1,267,354,447	1,327,214,600	1,390,200,333	1,456,467,924
Total Assets	**2,494,865,147**	**2,682,133,913**	**2,787,113,790**	**2,935,418,436**	**3,133,408,171**	**3,380,361,455**	**3,684,493,609**	**4,049,797,596**	**4,477,757,696**	**4,988,693,763**	**5,624,173,359**	**6,371,726,305**	**7,221,582,274**	**8,182,321,285**	**9,257,968,018**	**10,458,181,296**
Equity & Liabilities																
Equity	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337	1,473,025,337
Retained Earnings	-86,313,965	4,094,007	195,224,147	430,437,228	714,311,535	1,044,602,586	1,435,047,372	1,881,800,311	2,392,853,841	2,990,507,005	3,715,412,674	4,544,290,626	5,477,022,610	6,517,476,510	7,671,913,791	8,949,947,060
Legal reserves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shareholder Equity	**1,386,711,372**	**1,477,119,344**	**1,668,249,484**	**1,903,462,565**	**2,187,336,872**	**2,517,627,923**	**2,908,072,709**	**3,354,825,648**	**3,865,879,178**	**4,463,532,342**	**5,188,438,011**	**6,017,315,963**	**6,950,047,947**	**7,990,501,847**	**9,144,939,128**	**10,422,972,397**
Amended Equity	1,386,711,372	1,477,119,344	1,668,249,484	1,903,462,565	2,187,336,872	2,517,627,923	2,908,072,709	3,354,825,648	3,865,879,178	4,463,532,342	5,188,438,011	6,017,315,963	6,950,047,947	7,990,501,847	9,144,939,128	10,422,972,397
Debt	982,016,891	982,016,891	883,815,202	785,613,513	687,411,824	589,210,135	491,008,446	392,806,757	294,605,067	196,403,378	98,201,689	-	-98,201,689	-196,403,378	-294,605,067	-392,806,757
Account payables	126,136,884	222,997,678	235,049,105	246,342,358	258,659,476	273,523,398	285,412,455	302,165,192	317,273,451	328,758,043	337,533,659	354,410,342	369,736,015	388,222,816	407,633,957	428,015,655
Total liabilities & Equities	**2,494,865,147**	**2,682,133,913**	**2,787,113,790**	**2,935,418,436**	**3,133,408,171**	**3,380,361,455**	**3,684,493,609**	**4,049,797,596**	**4,477,757,696**	**4,988,693,763**	**5,624,173,359**	**6,371,726,305**	**7,221,582,274**	**8,182,321,285**	**9,257,968,018**	**10,458,181,296**

Income statement for the Small-scale operator

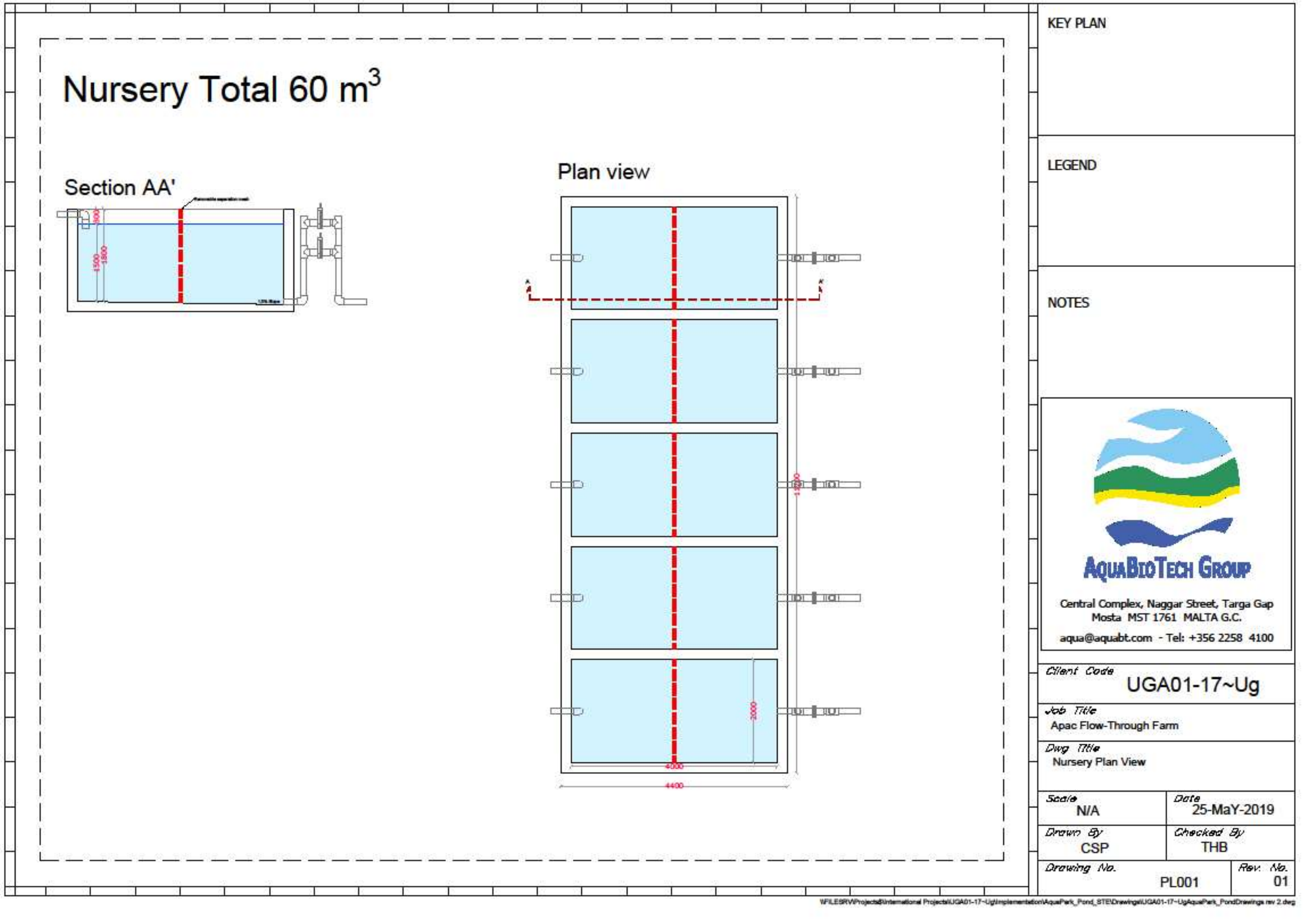
Income Statement (UGX)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Revenue	41,325,065	192,431,061	206,093,667	220,726,317	236,397,885	253,182,135	271,158,067	290,410,290	311,029,420	333,112,509	356,763,497	382,093,706	409,222,359	438,277,146	469,394,824	502,721,856
Cost																
Fingerlings	9,385,227	9,854,488	10,347,212	10,864,573	11,407,802	11,978,192	12,577,101	13,205,957	13,866,254	14,559,567	15,287,545	16,051,923	16,854,519	17,697,245	18,582,107	19,511,212
Broodstock	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feed	51,856,421	108,255,633	113,668,415	119,856,002	125,848,802	132,141,242	139,048,630	146,001,061	153,301,114	159,861,618	167,854,698	176,247,433	185,461,564	194,734,642	204,471,374	214,694,943
Production Equipment	7,850,000	8,032,500	8,434,125	8,855,831	9,298,623	9,763,554	10,251,732	10,764,318	11,302,534	11,867,661	12,461,044	13,084,096	13,738,301	14,425,216	15,146,477	15,903,801
Harvest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity	9,413,209	10,561,181	11,089,240	11,643,702	12,225,887	12,837,182	13,479,041	14,152,993	14,860,642	15,603,674	16,383,858	17,203,051	18,063,204	18,966,364	19,914,682	20,910,416
Manpower	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel - Generator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel - Vehicle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lease on infrastructures	5,000,000	5,250,000	5,512,500	5,788,125	6,077,531	6,381,408	6,700,478	7,035,502	7,387,277	7,756,641	8,144,473	8,551,697	8,979,282	9,428,246	9,899,658	10,394,641
Permits & Licenses	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintenance Costs	-	-	-	193,335	203,001	355,252	373,015	626,665	657,998	690,898	725,443	761,715	799,801	839,791	881,781	925,870
Total Cost	83,504,857	141,953,803	149,051,493	157,201,568	165,061,646	173,456,830	182,429,997	191,786,496	201,375,821	210,340,059	220,857,062	231,899,916	243,896,670	256,091,503	268,896,079	282,340,883
Movement in Inventory	- 46,280,062	6,949,230	- 1,892,890	- 2,145,387	- 2,066,696	- 2,211,897	- 2,368,733	- 2,472,750	- 2,535,927	- 2,366,310	- 2,637,344	- 2,930,342	- 3,189,183	- 3,242,932	- 3,408,386	- 3,582,112
Cost of Goods Sold	37,224,795	148,903,033	147,158,602	155,056,181	162,994,950	171,244,932	180,061,264	189,313,746	198,839,893	207,973,749	218,219,718	228,969,573	240,707,486	252,848,571	265,487,693	278,758,771
Gross Profit	4,100,269	43,528,029	58,935,064	65,670,136	73,402,936	81,937,203	91,096,803	101,096,544	112,189,527	125,138,760	138,543,779	153,124,132	168,514,872	185,428,575	203,907,131	223,963,085
General expenses and Administration	417,524	709,769	745,257	786,008	825,308	867,284	912,150	958,932	1,006,879	1,051,700	1,104,285	1,159,500	1,219,483	1,280,458	1,344,480	1,411,704
Sales & Marketing	2,066,253	9,621,553	10,304,683	11,036,316	11,819,894	12,659,107	13,557,903	14,520,514	15,551,471	16,655,625	17,838,175	19,104,685	20,461,118	21,913,857	23,469,741	25,136,093
Insurance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other income	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBITDA	1,616,492	33,196,707	47,885,123	53,847,812	60,757,733	68,410,812	76,626,750	85,617,097	95,631,177	107,431,434	119,601,319	132,859,948	146,834,271	162,234,260	179,092,909	197,415,288
Depreciation & Amortization	556,699	556,699	556,699	556,699	556,699	556,699	556,699	556,699	556,699	556,699	-	-	-	-	-	-
EBIT (Operating Profit, Operating Income)	1,059,793	32,640,007	47,328,424	53,291,113	60,201,034	67,854,113	76,070,051	85,060,398	95,074,478	106,874,735	119,601,319	132,859,948	146,834,271	162,234,260	179,092,909	197,415,288
Interest	1,224,738	2,449,476	2,327,002	2,082,054	1,837,107	1,592,159	1,347,212	1,102,264	857,317	612,369	367,421	122,474	- 122,474	- 367,421	- 612,369	- 857,317
PBT	- 164,945	30,190,532	45,001,422	51,209,059	58,363,927	66,261,954	74,722,839	83,958,134	94,217,161	106,262,366	119,233,898	132,737,474	146,956,745	162,601,681	179,705,278	198,272,604
Tax	-	9,057,159	13,500,427	15,362,718	17,509,178	19,878,586	22,416,852	25,187,440	28,265,148	31,878,710	35,770,169	39,821,242	44,087,023	48,780,504	53,911,583	59,481,781
PAT Net Income	- 164,945	21,133,372	31,500,996	35,846,341	40,854,749	46,383,368	52,305,988	58,770,694	65,952,013	74,383,656	83,463,728	92,916,232	102,869,721	113,821,177	125,793,695	138,790,823
Legal Reserve	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Available for Dividends	- 164,945	21,133,372	31,500,996	35,846,341	40,854,749	46,383,368	52,305,988	58,770,694	65,952,013	74,383,656	83,463,728	92,916,232	102,869,721	113,821,177	125,793,695	138,790,823
Dividends	-	10,566,686.08	15,750,498	17,923,171	20,427,375	23,191,684	26,152,994	29,385,347	32,976,006	37,191,828	41,731,864	46,458,116	51,434,861	56,910,589	62,896,847	69,395,412
Retained Earnings	- 164,945	10,566,686	15,750,498	17,923,171	20,427,375	23,191,684	26,152,994	29,385,347	32,976,006	37,191,828	41,731,864	46,458,116	51,434,861	56,910,589	62,896,847	69,395,412

Balance sheet for the Small-scale operator

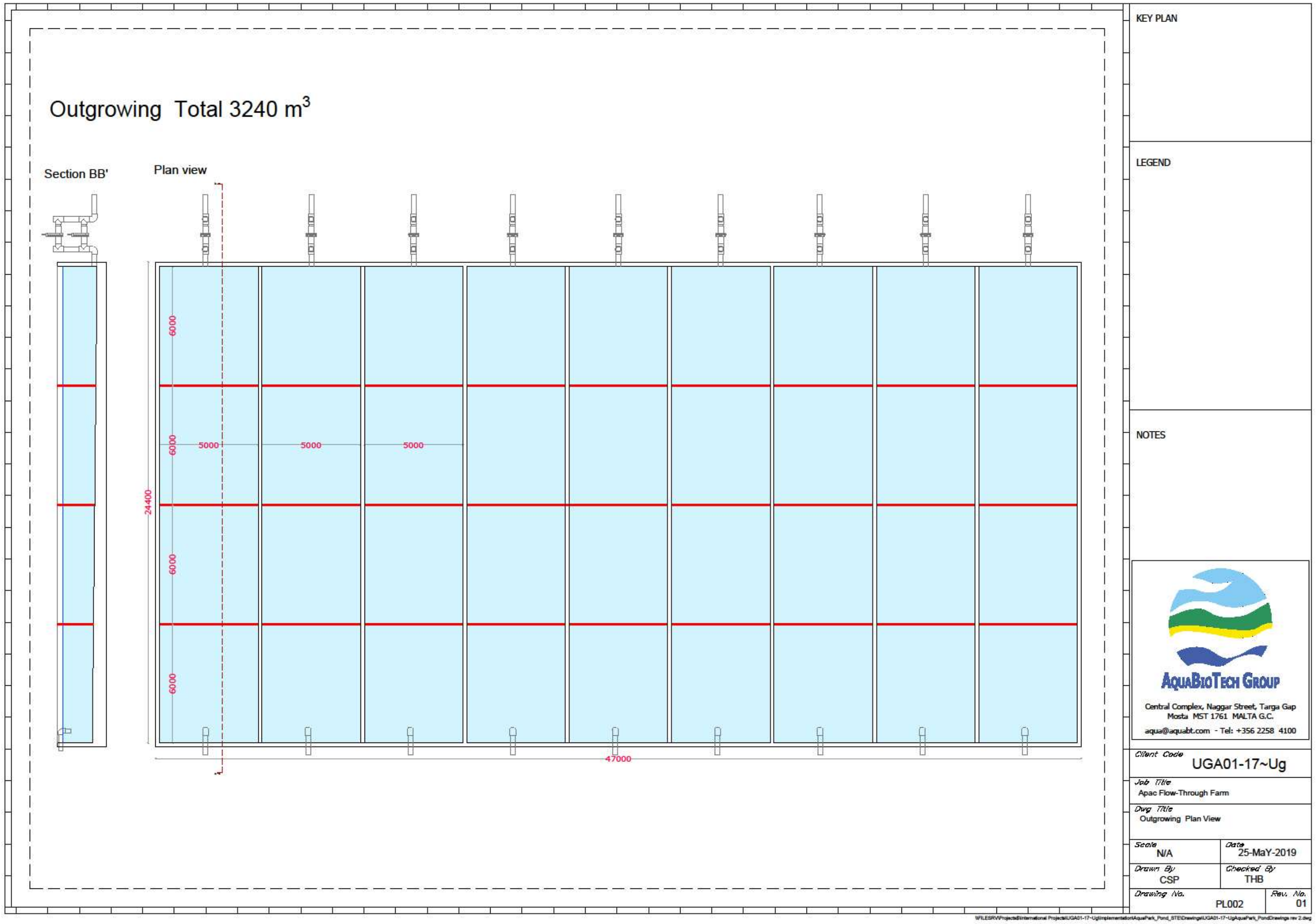
Balance Sheet (UGX)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Assets																
PPE	5,010,291	4,453,592	3,896,893	3,340,194	2,783,495	2,226,796	1,670,097	1,113,398	556,699	-	-	-	-	-	-	-
Cash & bank	16,645,010	39,521,648	52,069,851	66,624,727	83,738,662	103,515,687	126,144,691	151,933,539	181,269,005	214,938,532	252,447,988	294,433,917	341,216,153	393,436,649	451,528,065	515,996,942
Account receivable	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Biological Asset	46,280,062	39,330,832	41,223,722	43,369,109	45,435,805	47,647,702	50,016,435	52,489,186	55,025,113	57,391,423	60,028,768	62,959,110	66,148,293	69,391,226	72,799,611	76,381,723
Total Assets	**67,935,363**	**83,306,072**	**97,190,466**	**113,334,030**	**131,957,962**	**153,390,185**	**177,831,224**	**205,536,122**	**236,850,817**	**272,329,956**	**312,476,755**	**357,393,027**	**407,364,447**	**462,827,874**	**524,327,677**	**592,378,665**
Equity & Liabilities																
Equity	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137	36,742,137
Retained Earnings	-164,945	10,401,741	26,152,239	44,075,410	64,502,784	87,694,468	113,847,462	143,232,809	176,208,815	213,400,643	255,132,507	301,590,623	353,025,484	409,936,072	472,832,920	542,228,331
Legal reserves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shareholder Equity	**36,577,192**	**47,143,878**	**62,894,376**	**80,817,547**	**101,244,921**	**124,436,605**	**150,589,599**	**179,974,946**	**212,950,952**	**250,142,780**	**291,874,644**	**338,332,760**	**389,767,621**	**446,678,209**	**509,575,057**	**578,970,468**
Amended Equity	36,577,192	47,143,878	62,894,376	80,817,547	101,244,921	124,436,605	150,589,599	179,974,946	212,950,952	250,142,780	291,874,644	338,332,760	389,767,621	446,678,209	509,575,057	578,970,468
Debt	24,494,758	24,494,758	22,045,282	19,595,806	17,146,331	14,696,855	12,247,379	9,797,903	7,348,427	4,898,952	2,449,476	-	-2,449,476	-4,898,952	-7,348,427	-9,797,903
Account payables	6,863,413	11,667,436	12,250,808	12,920,677	13,566,711	14,256,726	14,994,246	15,763,274	16,551,437	17,288,224	18,152,635	19,060,267	20,046,302	21,048,617	22,101,048	23,206,100
Total liabilities & Equities	**67,935,363**	**83,306,072**	**97,190,466**	**113,334,030**	**131,957,962**	**153,390,185**	**177,831,224**	**205,536,122**	**236,850,817**	**272,329,956**	**312,476,755**	**357,393,027**	**407,364,447**	**462,827,874**	**524,327,677**	**592,378,665**

Annex 2 – Drawings

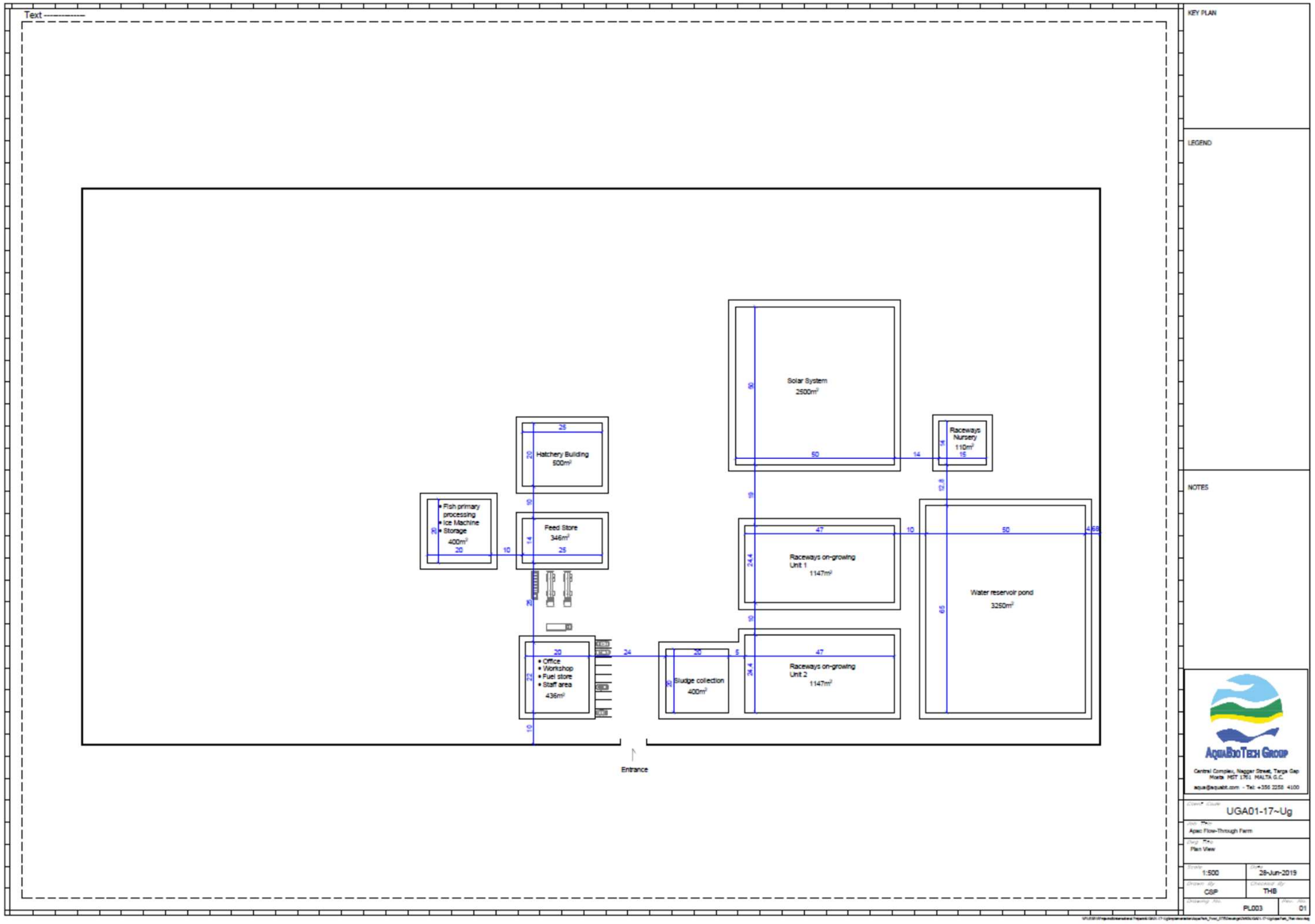
Annex 2/A Section and plan view of the African catfish flow-through nursery tanks



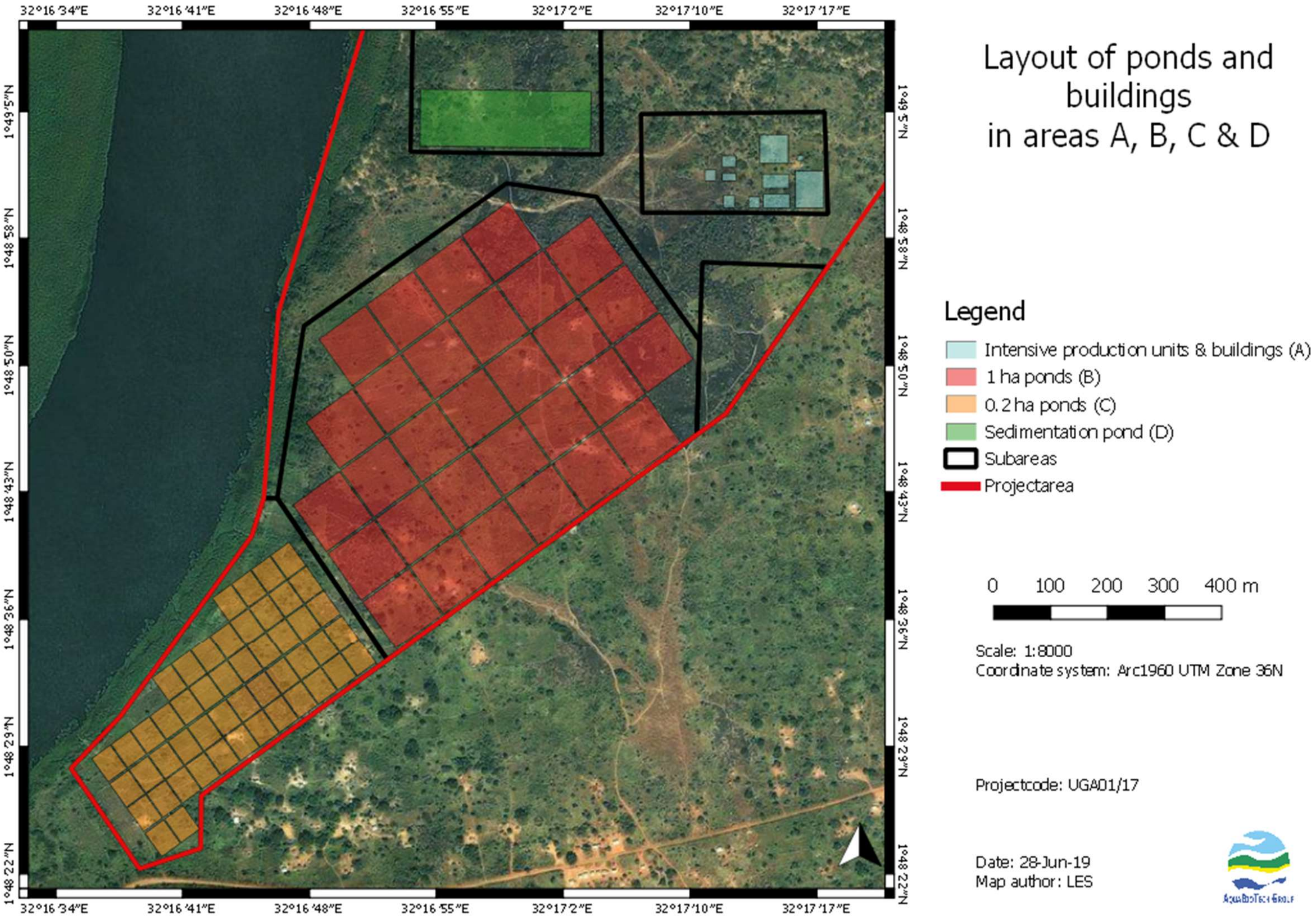
Section and plan view of the African catfish flow-through grow-out tanks, Unit 1



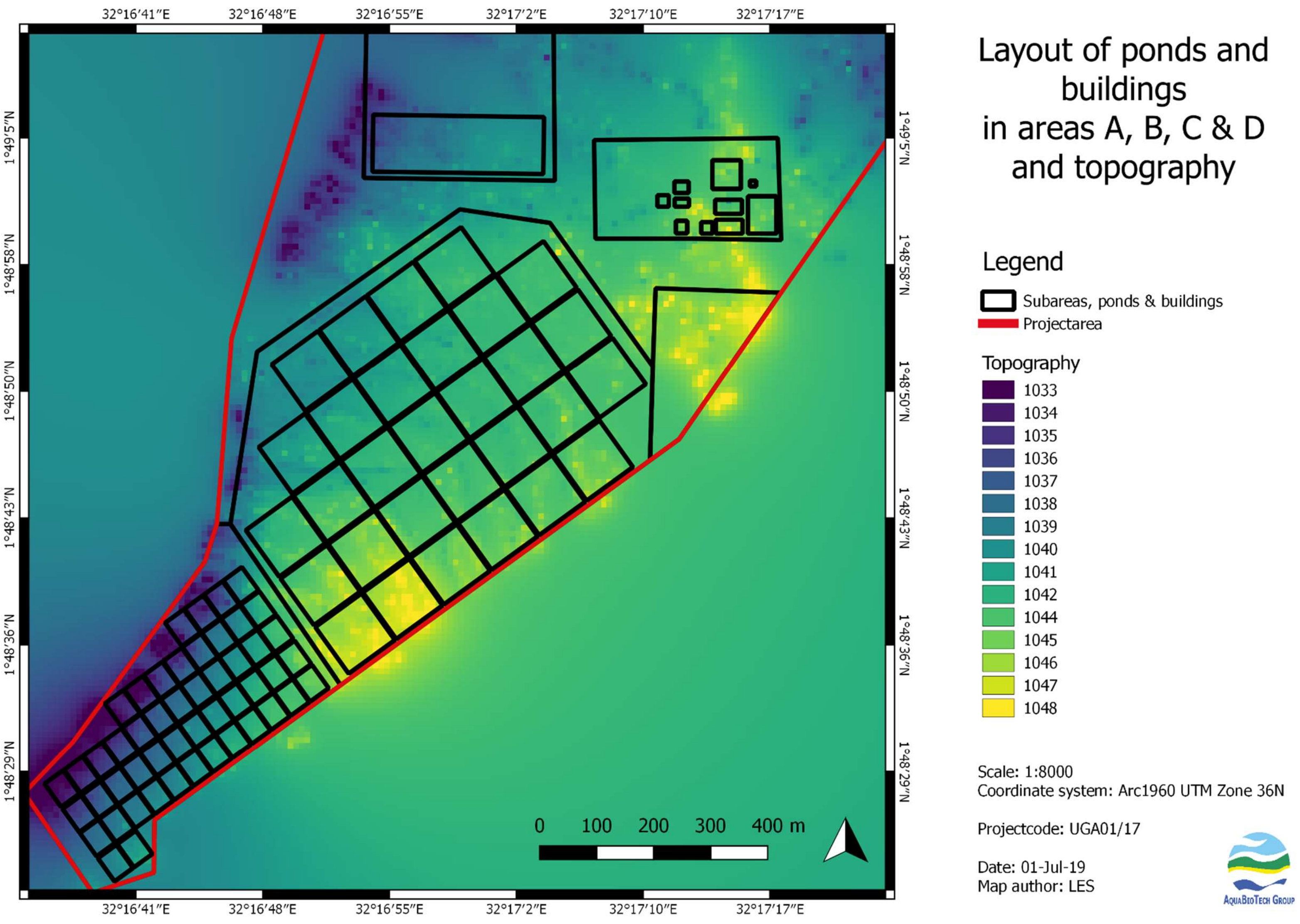
Annex 2/B Plan view design of the large scale African catfish farm and AquaPark management area



Annex 2/C Satellite view outline design of ponds and buildings of the Phase 1 development



Annex 2/D Topographic model view and outline design of ponds and buildings of the Phase 1 development



Annex 3 – Summary of the principle policies and regulations governing the development of AquaParks in Uganda.

Adapted from Isyagi, N. 2017. Aquaculture Parks in Uganda.

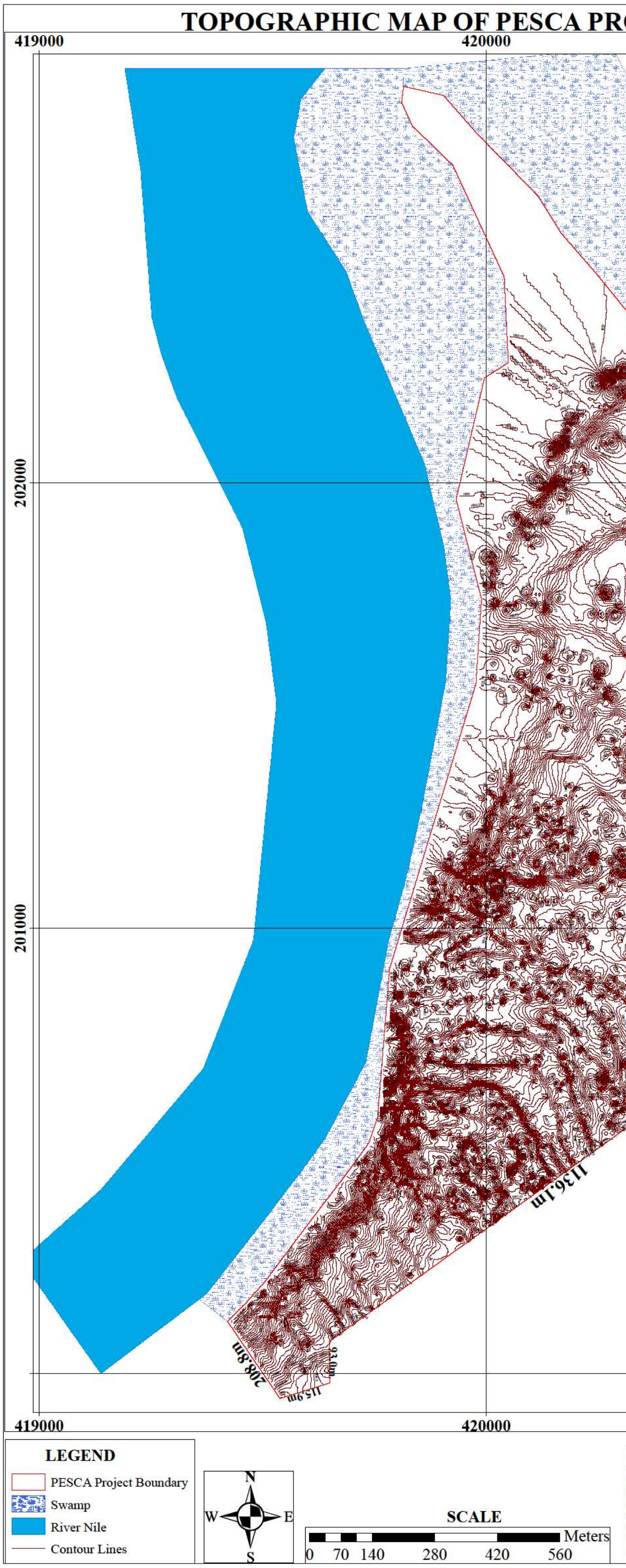
Policy	Overall Goals
The National Fisheries Policy, 2004	To ensure increased and sustainable fish production and utilization by properly managing capture fisheries, promoting aquaculture and reducing post-harvest losses.
The National Aquaculture Parks Investment Policy, 2012	To create a competitive, market-oriented and environmentally responsible aquaculture industry.
The National Water Policy, 1999	To attain an integrated and sound water resources management regime that balances economic, ecological and health priorities. This includes water for agricultural production, under which water for aquaculture use falls.
The National Policy for Water for Agricultural Production, 2011 (draft)	The provision of water for increased agricultural production and productivity through coordinated interventions targeting water for crops, livestock and aquaculture. The need for this policy was realized based on the fact that the quantity and quality of water resources available to boost and sustain agriculture were receding due to an array of factors that included poor watershed management, inadequate water, harnessing capacity and rational use of water resources.
The National Agricultural Policy, 2013	To promote food, nutrition security and household incomes through coordinated interventions that focus on enhancing productivity and value addition, providing employment opportunities, and promoting domestic and international trade.
The National Environment Management Policy, 1994	This provides the overall policy framework to ensure sustainable social and economic development in the country that maintains or enhances environmental quality and resource productivity without compromising ability of present and future generations to meet their needs.
The National Policy for the Conservation and Management Wetland Resources, 1995	To ensure the protection and sustainable use of wetland resources so as to maintain their ecosystem function to include long-term interests of future generations.
The National Trade Policy, 2007	To develop and nurture private sector competitiveness, to support the productive sectors of the economy to trade at both domestic and international levels, with the ultimate objective of creating wealth, employment, enhancing social welfare and transforming Uganda from a poor peasant society into a modern and prosperous society.

The Uganda National Land Policy, 2013	To ensure efficient, equitable and optimal use as well as management of land resources for poverty reduction, wealth creation and overall socioeconomic development. The sustainable exploitation of land resources while safeguarding environmental sustainability is stressed.
Science and Technology Policy, 2009	To strengthen national capability to generate, transfer and apply scientific knowledge, skills and technologies that ensure sustainable utilization of natural resources for the realization of Uganda's development objectives.
The Uganda Food and Nutrition Policy, 2003	To ensure food security and adequate nutrition for all the people in Uganda.
The Public-Private Partnership Framework Policy, 2010	To enable the public and private sectors to work together to improve public service delivery through private sector access to public infrastructure and related services.

Law	Content
The Constitution of Uganda, 1995	The main legislative body of the country offers every Ugandan the right to and responsibility for creating a clean and healthy environment.
The Fisheries Act, 1970	Provides the framework for the management and sustainable use of fishery resources so that sustainable benefits are realized for the people of Uganda. It covers fisheries, access to lakes for fishing and aquaculture.
The Water Act, 1997	Provides the framework for the management of water resources in the country, its use and quality control.
The National Environmental Act, 1995	Relates to the protection and preservation of the environment. It provides for various strategies and tools for environment management that include Environmental Impact Assessments.
The Land Act, 2010	Provides the framework with which land, ground water, natural streams, wetlands are held, managed and utilized for the common good of the people of Uganda.
The Local Government Act, 1997	Provides for the decentralization and devolution of Government functions, powers and services from the central to local governments and sets the political and administrative functions of local governments. The local governments therefore are responsible for the protection of the environment at local levels.
Uganda Wildlife Act, 2000	Protects the wildlife resources of the country (wild plant and animal species native to Uganda or that migrate through Uganda). It provides the framework for the sustainable management of these resources.

Regulation	Content
The Fish (Aquaculture) Rules, 2003	Stipulates the guidelines for the farming, breeding and marketing of fish and other aquaculture products. Permits and licensing procedures for aquaculture are provided for in these rules.
Uganda Statute on BMUs, 2003	Guides community involvement in fisheries management. Enables fishing communities to have rights of access and decision-making in the use of fishery resources within the framework of the National Fisheries Policy.
The Water Resources Regulations, 1998	The water resources regulations provide for the control of the extraction, discharge and pollution.
The Environmental Impact Assessment Regulations, 1998	Regulate in consultation with the Lead Agencies the use of the country's natural resources to ensure compliance with the National Environment Act. It provides criteria and guidelines under which EIAs should be undertaken, evaluated and monitored.

Annex 4 –Result of the topography survey received



	Notes				
	Control Points				
Point ID	Northing (m)	Easting (m)	Height (m)	Contour Interval	0.25m
PESCA01	201533.019	421247.445	1039.723		
PESCA02	201560.73	421299.515	1039.799	Highest Contour	1051.68m
PESCA03	202488.031	421295.919	1032.499	lowest Contour	1013.58m
PESCA04	201556.79	421143.406	1037.081		
PESCA05	201101.948	420563.867	1043.8285		
PESCA06	199923.21	419609.058	1046.168		

Coordinate System: Arc 1960 UTM Zone 36N
Projection: Transverse Mercator
Datum: Arc 1960
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: 33.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

Annex 5 – TORs of the STTA (extract)

Specific work

1. *Site Suitability / Preliminary Design & Detailed Feasibility Study for AquaPark sites in Uganda*

- Review the aquaculture park concept within the context of the identified site for land-based culture (Apac, Uganda), to make final determinations and confirmations about site suitability, and other dynamics affecting optimal production of fish and environmental sustainability. This component of the study will be undertaken in conjunction with expertise from NaFIRRI / DiFR, which have previously undertaken site surveys and data analysis of the various sites in Apac. The report from this activity is available to the consultant.
  a) Conducting site suitability study on the proposed land-based site including topography, water sources and quality, and associated factors for environmentally sustainable and aligned operations.
  b) Conducting analyses on the identified AquaPark site using modelling to determine the maximum production the chosen site can sustain, whilst ensuring environmental protection and sustainable, profitable operations.

  The STE under this contract and the national team will work together to ensure information is clear and collaborative towards a final AquaPark site, design and operational structure.

  During this process, final confirmation of land availability to the Project will be concluded, although it is not foreseen that this will delay activities. The land confirmation is to be handled and finalised through the Project PMU.

- Define the critical components to finalize the preliminary design for all aspects of the AquaPark facilities and operations and how the site will be developed in terms of achieving the physical structures and support infrastructure required. Prepare final preliminary designs ready for commencement of detailed design (engineering drawings and BOQ preparation) activities and investment promotion components of the AquaPark activity.
  a) Taking previous studies into account (Poseidon 2013 and others, as well as updated information on site suitability from the intended NaFIRRI team), utilize updated information, as well as site visits to develop and finalize the AquaPark's preliminary design in terms of exact site location and required details for operational and functional elements including, but not limited to fish production (pond layout and design requirements), fish breeding/ seed production/ delivery, quality feed production/ delivery, laboratory, fish receiving areas and basic processing (assuming a marketing / sales function will be managed from this site), management offices, power (including back-up) and waste management, site security /access requirements, other structures to ensure a functioning sustainable site operation is achieved.
  b) Prepare a preliminary design defining the key elements, infrastructure including a sketch drawing and budget cost elements (capital and operating costs) suitable for the feasibility analysis. The design prepared should be such that it can be passed to design engineers for the detailed design and preparation for the construction phase of the work. Detailed design is to be undertaken by an engineering consulting firm scheduled to follow this feasibility study. This study is critical to approval of final layouts and facilities, so as to move quickly to the detailed engineering phase, that indicates acceptance of the final AquaPark set-up.
  c) During the study, adequate suitability for expansion should be a key criterion in addition to the biological, hydrological, infrastructure in place, services availability, market access and other key criteria that would affect the ultimate commercial performance of the site.
  d) The basis for design must bear in mind the need to attract investment to the sector in Uganda, so the site should be of a modern, professional standard and image that is oriented towards an expanding commercial aquaculture sector in the country; future-oriented and regionally competitive in all aspects. It is not envisaged that current production styles and approaches are to be adopted, but rather current, world-class designs and structures looking to promoting a professional future to the sub-sector in Uganda.

- Business modelling for sustainable, profitable operations is required from the perspective of both the core operating partner and sub-partners who invest in, rent, or lease pond sites, whilst they are involved in the AquaPark arrangement. This will be achieved through developing the best options for site design and costing and fully analysing the financial feasibility and operational activities required for each of the partners. Basically, a well-presented detailed feasibility study aligned to the various actors involved.
- Detailed and professional revenue/costing analysis is a critical requirement establishing the approach to how the AquaPark will be managed using a suitable PPP arrangement. This will include:

a) Carry out a detailed feasibility analysis for operating the AquaPark, with development of detailed financial models to inform business planning and attract investors. Analysis should include well-structured identification and description of capital costs, operating costs, financial performance indicators, such as ROI, NPV and IRR, as well as detailed sensitivity analysis for key performance factors. Versions should be included to show growth of sites in terms of capacity that fit profiles for targeted production per year, with appropriate injection of capital to achieve such step-wise growth as required.

b) Financial modelling should be presented in MS EXCEL with all formulas and calculations available for review in editable form, so that information presented in the final report can be analysed independently and where necessary formulas checked and further model development instigated. The financial modelling should span at least a 15 years, with realistic inclusion of possible start-up lag-time, problems related to loss of fish due to issues of disease or other factors, poor management performance and other delays and disruption that might occur, as well as repair and maintenance cycles that allow for associated costs and risks to be taken into account during the analysis; in short, the financial model needs to be realistic and based on an objective assessment of potential in the national context, given that this is for the first AquaParks to be set-up in Uganda and taking into account realistic growth based on realistic market scenarios. It should be borne in mind that various fish farms in Uganda and in the region have yet to show significant growth, partly for reasons of unfulfilled market performance.

c) Sensitivity analysis has to be backed by analysis of risk factors, particularly related to competitive pricing from national and regional development of the sector, as well as the import of other forms of protein (including fish), from for instance Asia. Pricing is particularly important in the analysis, as the profile of markets in Uganda is very price sensitive and volumes of sales should not be assumed without appropriate review of such market forces and comparison to other producers. Preliminary market data will be provided to the consultants, based on a current situation analysis which will guide realistic production planning.

d) Reference to domestic and regional markets must therefore form part of this assignment, with creative and innovative market approaches to ensure sustainable revenue is achieved. Serious consideration of imported fish (tilapia), particularly from Asia, as well as the competitive environment and production trends in the region must be undertaken during this component of the study to find the best fit and approach for the business model to be outlined. Particular attention should be given to marketing processes and related logistics to ensure efficient market access bearing in mind fish preservation and quality aspects of the products to be sold. It is expected that another STE will be undergoing a Market Assessment at the same time as this contract and so up to date information will be forthcoming for this purpose.

e) Inclusion of an examination of funding options based on a Public Private Partnership (PPP) model, that would attract investments in aquaculture, such as equity financing (large investors) and/or grant scheme (Aquaculture Production Grant Scheme) funding, and others. Consideration for large and small investors is imperative in this component of the study.

f) During the planning of funding options and with respect to financial performance models developed in this study, indications of realistic repayment options are to be described in the context of management structure and contractual arrangements for such a PPP arrangement. This should align with potential requirements and expectations of PPP ownership partners and their respective motivations and limits. Critical input from private sector investors should form the backbone of this component of the study.

- Consideration in terms of regulatory requirements concerning environment, legal status of land and water to provide an understanding for such requirements for the development of AquaParks. Highlight in detail, all requirements for alignment with the existing policy and regulatory environment and indicate where requirements for updates are required, especially with respect to the strategic objective of attractive serious investors to the sector in Uganda.
- Market positioning for performance of the AquaPark should be considered. This project is not intended to prove that production of fish is possible in an AquaPark structure per se, but to rather pilot Aquaparks as a production engine that can produce and sell the fish produced at the best possible price and profit, targeting suitable and reliable national and regional markets. Therefore, the operating designs and approaches should be based on a profit and investment return motive and this will affect feed and seed production and quality, as well as determination of preferred fish market size requirements for minimising costs, whilst maximising revenues for various market segments. Facility design also needs to be cost effective in its operational aspects to maximise this objective. Potential for using sustainable power sources, such as solar/ wind power would be a useful inclusion, if viable.
- A final report will be prepared and a stakeholder validation process at a workshop (timing to be determined) will be an important step.

Assignment outputs

(MS Office for written/ presentation materials, unless specified)

a) Comprehensive report covering all aspects described herein to be prepared, including editable financial analysis component in MS EXCEL format with all formulas available in that presentation
b) Agreed table of contents and detail requirements to be prepared before commencement together with the Project Management Unit in Uganda
c) Quality preliminary design drawings and cost estimates are critical for future project planning as provided by part of this study.
d) Presentation to be provided to various stakeholders for feedback / validation

During the implementation of this work, the contractor must comply with the latest **Communication and Visibility Manual** for EU External Action (see reference below:)
https://ec.europa.eu/europeaid/sites/devco/files/communication_and_visibility_manual_en_0.pdf

The compliance with this shall be made an output of the contract and the contractors shall include in its reporting what have been accomplished.

Annex 6 – Comments received and responses from the consultant

Annex 6A - APAC Aquaculture Park presentation 12 June 2019: Answers to Key issues by the Short-Term Expert

General comments

Comment to the Final Draft	Consultant answer	Reference to the study
i. Make the chronological flow in the report, executive summary should be refined to bring out key issues in a more precise and clear manner.	Executive summary has been rewritten and simplified	Page 8 - 14
ii. Ensure consistency in quoting the figures and units in the entire document especially production and productivity units.	All figures have been checked and corrected	Whole document
iii. The modal to start with small ponds is not acceptable because this will undermine commercialization of AquaParks and may not attract potential nucleus investors. We therefore recommend ponds with production of 20t/ha under the nucleus estate modal	I suggest keeping the small pond and small-scale aquaculture in the study. Detailed explanation is provided in the updated version of the study, the main arguments are: 1. Aquaculture development in Uganda must include the development of small-scale farming because this can have a large positive impact on the socio-economic development of rural areas. 2. Combining the most modern technologies (sex reversed fingerlings, water quality control, new pond fertilization approach) with the traditional extensive technologies can facilitate the break-thorough in small-scale farming. This will allow farmers to earn enough money to grow their business step by step. 3. The biggest challenge with the small-scale farming in Uganda is that the farmers do not have the capital to buy feed and can’t fully exploit the natural production. The small pond unit of the AquaPark will demonstrate the possibilities of the improved small-scale technologies and can provide income for 40-50 families.	Chapter 3.3.5 Page 28.-30.

	4. To keep the project more attractive for the investors, the small pond construction can be separated from the investment project and implemented by the government.	
iv. There is need to improve a SWOT analysis to cover all the value chain – refer to page 26. 3.3.3	SWOT analysis was added for all the 3 suggested technologies	Chapter 3.3, Page 25-30
v. Update the source of data to more current studies but not 1996 studies, which are now old	I am using various studies as references and old data are only used if they are still relevant. I have asked MAAIF staff during the first visit to receive the latest statistics and any data what can support my work.	

Technical comments

Comment to the Final Draft	Consultant answer	Reference to the study
i. Show the recommended use of the entire 200 hectares in the spatial layout of the land and recommend a phased expansion starting from the 54ha to cover the entire acreage.	The first phase/Pilot AquaPark area will use 71 ha finally. Detailed land use for the remaining areas will be provided as follows: • 0.3 ha lined static ponds for African catfish production, 20t/ha maximum production. 150 ponds on 50 ha • Storage buildings, offices, logistic centre for the lined ponds • Water reservoir for lined ponds • Water channels roads • Sedimentation pond and water treatment wetland for the lined ponds in the already allocated Phase 1 water treatment area • Fish processing plant with 4000 t/year processing capacity with service infrastructure and biosecurity area • Irrigated agricultural land to produce fish feed and valuable crops for human consumption Total area needed for the second phase 130 ha	Chapter 4.2, page 38, Updated Figure 6
ii. Relatedly to (i) above, provide projections of total fish production for the entire 200 ha to show the capacity and potential of the AquaPark at Optimum investment		Chapter 5.2.2. Increase of AquaPark activities in Phase 2, Page 45
iii. Fingerling and hatchery production quantities need to be revised upwards and there is need to include the hatchery production of tilapia	The hatchery capacity was increased to 5.6 million fingerlings/year capacity includes tilapia and African catfish production. This hatchery capacity is large enough to supply the whole AquaPark including the planned enlarged production. It is suggested to increase the capacity later, because large overcapacity will increase the operational and	Chapter 5.3.4, Page 49

	investment costs. Limiting the capacity of the AquaPark hatchery also can facilitate the involvement of other state owned and private hatcheries in the region (Gulu, Lira) in the regional development of aquaculture.	
iv. The proposal to purchase feeds should be indicated as short-term measure and the report should proposal options for long term sustainable measure as the Aquapark becomes more intensive	The proposal to establish a fish feed factory in Uganda is included in the study. If the AquaPark development project rules allows, this fish feed factory also can be built within the AquaPark (using the land planned for agriculture production.).	Page 45
v. All the recommended production systems and other facilities should be plotted and geo-referenced on the layout	Improved map and layout are incorporated in the study.	Annex 2/A-D drawings
vi. Avoid reuse of discharged effluent water and develop a model that each production unit is being fed by water independently.	Sludge separating area with drum filter and primary sedimentation is included in the technology.	Updated Figure 7. and Chapter 4.3.1, Page 40
vii. Before discharge back into the main river, there should be a discharge treatment point	The planned sedimentation pond and artificial wetland will provide the enough water treatment to release the same quality water to the river as it was taken out.	
viii. Avoid extensive and focus majorly on the intensive and semi-intensive production systems	See the answer at General Comments iii.	
ix. Make more realistic figures for stocking density Stocking density 200kg/m3 looks too ambitious	The production plan has 200 kg/m3 as maximum biomass as harvest density and this is clarified in the corrected draft. In flow-through systems the usual maximum harvest density is 300 kg/m3 but it is not recommended to go below 150 kg/m3. The experience shows that larger densities reduce the aggressive behaviour and help to remove the sludge from the bottom of the tanks.	
x. Provide indicative costs on alternative sources of power to guide investment	The use of solar panels is already described in the study and the detailed cost and area estimation is also detailed.	Chapter 5.3.12, Page 51

ANNEX 6B - Summary of Comments during the Validation meeting held on 25th –July -2019 at Botanical Beach Hotel –Entebbe

Responses of the consultant to the comments

Section of the report	Observations/ comments	Recommendations	Responses of the consultant
Page: 48 of 102 section 5.3.4 Hatchery operations.	1) 1g weight fingerlings to be sold to out growers is too low.	i. Increase stocking weight from 1g to 5g for both Tilapia and Catfish to reduce on the production period in the grow out ponds. ii. Segmentation of production right from the Hatchery up to grow out i.e. the Hatchery should be able to nurse fish up to 5g before releasing it to outgrow ponds.	1. For African catfish the 1 g hatchery size does not have any impact on the production, because the rearing will continue in a closed flow-through tank system, practically under hatchery conditions. 2. For tilapia the 1 g size was selected to keep the medium and small-scale farmer's costs lower. Because these farmers will use ponds, they will be able to insert a post-nursing period in hapas in their own ponds. This also will help to demonstrate and train this good aquaculture practice. 3. In case of higher need for 5g fingerlings, the hatchery capacity will be enough to produce about 1 million fingerling in this size and sell it on a higher price. The above mentioned aspects has been more clearly described in the relevant parts of the study.
Page: 44 of 102 Grow out FCR of 1.2 -1.3. Table 9.	2) Considering the environmental related factors and aspects of feed quality.	i. Change the FCR from 1.3 &1.2 to 1.5 for tilapia and catfish respectively because of aspects of type of feed and related environment.	1) The 1.3 FCR for catfish in intensive flow-through system is the higher value suggested by feed suppliers (Aller-Aqua, Alltech-Coppens) for production planning. This can be achieved by using good quality feeds which is also the base of the financial and technology plans of the study. This is because, it is an important role of the AquaParks to demonstrate that despite of higher feed costs, better quality feed will result higher profitability and less pollution. One of the mid-term aquaculture development goal of Uganda is to establish local, high quality feed production. 2) For tilapia ongrowing phase the 1.28 FCR is based on the conservative estimation that 20% of the wet body weight of the fish will be gained from the natural food (alga, zooplankton) produced in the pond. Calculating with the 1.6 feed based FCR (if the fish receive only formulated feed) the summarized FCR is 1.28

			which is higher than the 0.6-1.0 FCR values for semi-intensive pond cultures in the references (Edwards et al. 2000, El-Sayed at al. 2017, Bhujel 2013.) These were described on pages 45-55.
		ii. Maximum density for grow out should be 3kg/m^2 instead of 1.5kg/m^2 on both intensive and semi-intensive production systems. Then 2.3-2.5kg/m2 for the extensive production system	The stocking densities for intensive tank production of African catfish has to be planned to reach the 200-300 kg/m^3 harvest density. This require around 7kg/m^3 stocking of 50g fish in the on-growing tanks and this number is used in the production technology model. For the semi intensive model the suggested 1.5 kg/m^2 harvest density was used. For an extensive system the density has to be much lower than in semi intensive system because of the lower feed supply.
		iii. Change the prices of feed in relation to crude protein content. 45% crude protein content may be unrealistic to achieve. Even then the out grower segment may not afford to purchase such feed.	The aim of the study was to investigate the possibilities to introduce the latest aquaculture developments in Uganda. The intensive flow-through production of African catfish need high quality feed and the price of this feed was used in the financial feasibility model. I don't suggest to modify this in the study.
Page 68 Table 19.Details of the infrastructure and building CAPEX estimations.	3) Hatchery capacity is low at 5 million per year. This only can support the large scale minus the out grower segment.	iv. Recommendation by stakeholders is 7.1 million fingerlings per year. Because there is need to support the out grower segment.	The planned 5 million 1g fingerling capacity of the hatchery was calculated as a minimum. With increased densities in the tanks (using aeration and ozone) this can be increased up to 6-7 million. The Phase 1 requirement is 3.4 million fingerling and this can go up to 5 million if the market and environmental conditions will enable to increase the production. I suggest to avoid planning with higher capacities as minimal production because: • A large overcapacity in Phase1 will increase the OPEX without revenue to support it. • ii. Also. part of the aim is to involve and revitalise existing hatcheries in the region (Gulu, Lira). This issues were explained more detailed in the final version of the study.

		v. Segmentation of production right from the Hatchery up to grow out i.e. the Hatchery should be able to nurse fish up to 5g before releasing it to outgrow ponds.	See answer 1)/ii
Provide clear information on average number of people per household in northern Uganda in relation to per capita consumption.			6.2.5. Market Assumptions subchapter was inserted in the study (Page 61) and this issue is discussed there.
Feasibility study should clearly indicate involvement of the out grower farmer scheme.			2.3.2. Integration of out-growers subchapter in 2.3. Recommendation for land based AquaPark concept was inserted
Integrate prices, quantities based on local, Regional and International markets.			6.2.5. Market Assumptions subchapter was inserted in the study (Page 61) and this issue is discussed there.