Master's Thesis 2017 60 ECTS

Faculty of BioSciences

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SURVEY REPORT ON THE POTENTIAL OF ESTABLISHING TILAPIA FARM IN IVORY COAST

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PREFACE

This report was made during a 7 month survey on the potential of establishing tilapia farm in Ivory Coast. The aim of the report is to be a source of information on the technical and social aspects of establishing a tilapia farm in Ivory Coast. This is the basis on which NORAF will used to apply for funding and support from interested investors to establish the tilapia farm. Series of information and recommendations were complied mostly on the field and interaction with the locals. Information such as prices of land was obtain from the locals. Physical parameters such as temperature, water quality, available market and the availability of raw material for tilapia feed production indicates that conditions are well suited for establishing tilapia farm in Ivory Coast.

However, there are some critical issues that needs to be address before the project commencement of the project. Issues relating to rules and regulations regarding setting tilapia farm or any other activities near water bodies in Ivory Coast needs to be clarify. Information regarding the importation of new breed of species into the country needs to be obtain before importing the first fingerlings into the country. Permit needs to be obtained and other paper works need to be done before full commencement of the project.

Nonetheless, given the opportunities as well success of other tilapia projects, if all paper works are done and permit obtain, the tilapia project of NORAF would be a huge success.

This report can be used as a general guide and the discoveries and suggestions provided are intended to assist in identifying action plans as well as for the partners collaborating in support of establishing the tilapia farm in Ivory Coast.

ACKNOWLEDGEMENT

I wish to first and foremost thank the almighty God for His mercy, grace and protection throughout my stay in Norway and Ivory Coast. I would also like to thank my parent and my entire family for their support throughout every stage of my life. I would also like to thank my big sister and her family, Dr and Mrs Paintsil for their support, guidance and direction through my stay in Norway.

My profound gratitude is to Mr Helge B. Holgersen and the NORAF group for giving the opportunity to work and learn on this project. Mr Helge's dedication, commitment and support on this project has been second to none.

My profound gratitude is to my two supervisors Trond Storebakken and Bjørn Frode for the supervision and direction to the successful completion of this project.

My final gratitude is to everyone whose name have not been mentioned, but in one way or the other contributes to the successful completion of the project. God bless you all

1.0 INTRODUCTION

The world population has been growing for the past decade reaching 7.6 billion as at October 2017 (source https://en.wikipedia.org/wiki/World_population). The increase in world population has placed high demand on protein requirement, both plant and animal protein.

Due to these increases in world's population, there is the need to find alternative source of food with high protein and nutrient content to mitigate the food problem the increase in world population might cause.

Aquaculture is one of the fast raising food production sector and according to (Patricio & Doris 2016) aquaculture has grown by an average annual growth rate of 6.2% between 2000 and 2012. In 2012, farmed food fish contribute about 66.6 million tons (42.2%) of the total 158 million tons of fish produced by both captured fisheries and aquaculture combined (Patricio & Doris 2016). Aquaculture therefore has an important role to play by enhancing the supply and consumption of fish and other marine and freshwater products, which are mostly rich in proteins and essential fatty acids, vitamins and minerals. This has led to increase demand for fish and fish products.

Due to increase demand for fish, there has also been an increase in the price of fish as more people turn to shift from meat consumption to consumption of more fish. According to (Micah 2014), the global price of fish is steadily increasing due to high demand for a healthy protein.

But there has been stress of the supply of fish from world catch due to increase in world population and increase in more industry activities. According to (Micah 2014), water pollution and overharvesting have limited harvest and supply of wild-caught fish populations which are meant for human consumption. This has led to an increase in the farming of fish species so as to meet the demand from the increasing world population. Aquaculture pioneers have predicted that, since human population is increasing, the world will depend more on farmed fish than on captured fish (Micah 2014). Among the fishes whose farming as well as its price is increasing is tilapia. The production of tilapia is gaining increase all over the world.

According to (Patricio & Doris 2016), the farming of freshwater tilapia (Nile tilapia) is the most widespread type of aquaculture in the world. FAO (2014) recorded farm tilapia statistics for 135 countries and territories on all continent.

But without proper production system and plan, tilapia farming will lead to absolutely nothing for the farmer. According to (Micah 2014), for a fish farmer who want to survive the current market and make profit, one need to organize so as to maximize efficiency in production past what traditional pond culture is capable of achieving. Farm survivals in lots of instances may require that the farmer intensify production to stay profitable by producing more fish per unit area, cost per unit product is lowered and market access extended (Micah 2014).

The production system chosen should have the ability to produce tons of fish using fewer resources; water, land, ingredient for nutrients and energy are the topmost resources that are becoming scarce and expensive (Micah 2014).

There are different types of fish production system. This includes; 1. Open ponds, 2. Cages, 3. Raceways, 4. Circular tanks. The adoption of any type of production system depends most at times on the producer's geographical location. For instance, in the western world, example Norway, greater part of the year is freezing and cold, therefore it will be unwise to practices raceway culture. They therefore operate mostly cage and circulation production system. Same way it will be unwise and very expensive to practices operate the recirculating production system in the tropics, example Ivory Coast, where the weather and other environmental conditions favours production system such as Raceway system.

Nonetheless out of the production system mentioned above, raceway production system has the potential to emerge as the most cost effective and profitable system.

Due to the geographical location of our study area Ivory Coast, we realized raceway production system will be best and cost-effective system to culture tilapia for consumption and for profitability. Unlike the open ponds, cages and circular tank, where the cultured water is stagnant leading to reduction in oxygen level, in the raceway system, there is constant flow of water therefore the oxygen level in the raceway units are often replenish.

In ponds and circular tanks, since water is not flowing under gravity and continuously, there is high accumulation of waste in the ponds and tanks. This can lead to disease incidence and high mortality rate. But for raceway unit, since water is flowing under gravity and continuously, the waste products are moved from the centre of the raceway unit to the outlet end to be discharge to the receiving water body.

The development of the raceway production system originated in the trout industry decades ago and has since taken many forms, culturing number of different fish species including tilapia (Micah 2014).

Raceways are enclosed multiple fish channels system with relatively high rates of moving and flowing water (Micheal P. Masser and Andrew Lazur, 1997). Is also refer to as the flow through system. They are mostly constructed out of reinforced concrete or galvanized steel rings with PVC liner inside it (Fleuren & Nooijen). Each channel is equipped with and inlet and an outlet pipe. The channels are designed in such a way that no water is stagnant at anytime during the production period. Water flow is always maintained to provide the required water level (Fleuren & Nooijen). Maintenance of water flow also helps in preventing solid waste materials from accumulating in the raceway which becomes toxic to the fish. It also helps to dilute liquid waste (primarily ammonia) excreted by fish (Micheal & Charles 1991). It also helps to maintain the oxygen level in the farm (Amirkolaie 2008) The high rate of water flow gives raceway systems distinct advantages over other culture systems (Micheal P. Masser & Andrew 1997). Some of the advantages includes

1. Reduction of manpower
2. High stocking density
3. Improved water quality
4. Fish raised in raceways are subjected to continuous movement of water and in their attempt to overcome this pressure of water, they also continuously exercise.

Micah (2014) stated that, low amount of “not-good” water in a highly stocked raceway channels will result in rapid disease spread, less reaction time when problems occur and large volume of effluent water with diluted fish wastes

With high flow rate and stable water quality, the stocking density of raceway often tends to be higher than any other fish production system. Higher stocking densities tend to lower the breakeven prices, thereby attracting more fish farmers to practices in intensive fish production system using the raceway system even though the start-up capital is relatively high (Micah 2014). From economic standpoint, the high stocking rates of raceway systems are probably necessary to offset the cost of construction and operation (Micheal P. Masser & Andrew 1997)

There are 2 main water systems in aquaculture production. We have the Recirculating Aquaculture System and the Flow through system. In the Recirculating Aquaculture system, water from the farm is treated and reused on the farm. It is practices at localities where water is a scarcity.

In the flow through system, water from the farm is discharge into a receiving medium. In this system, water is not reused. So, the receiving medium could be a cultivated piece of land where the effluent water from the farm is used to fertilize the land or a water body different from the source water.

Since the production system picked is the raceway system of production, which requires continuous and constant supply of water, and for the fact that there is also available water all year round (in Ivory Coast), the best water system to go for is the flow through system of production. The flow through system of production helps in the reduction of operation cost by reducing the use of pumps in pumping water to the raceway units. It also helps in reducing the need for UV or Ozone treatment of the effluent water from the farm. The effluent water can be used to fertilize a cultivated land at the outlet end of each raceway unit

Also choosing the location of the farm for the raceway culture is very essential due to the fact that this production system depends largely on constant running water (Amirkolaie 2008). According to (Micheal & Charles 1991), fish cultured in raceway requires large quantity of good quality water preferably supplied by gravity flow from higher elevation. Micheal and Charles (1991) states that if pumping is required, operating cost may be high, and risks increased due to the possible failure of the pump. This is supported by (Micheal P. Masser & Andrew 1997)who stated that, water cannot be economically pumped through raceways, it must flow through them by gravity. It is therefore ideal to establish your raceway farm across the water source and alongside the source water so as to be able to control flow (Amirkolaie 2008). The best location of the source water to the farm should be near the discharge end of a hydropower dam which is built on a river, so the source water will be the river discharge from the hydropower dam.

Control and monitoring of water quality is of vital importance to the success or failure of the production system (Ariel & Jutta 2014). Water quality should be monitored frequently, and most important attributes of water, oxygen and ammonia, needs to be monitored as well to ensure that conditions remain suitable (Micheal & Charles 1991). Oxygen should be maintained above 60% saturation (Micheal & Charles 1991). Oxygen may be added to the water through different methods in the case where the oxygen in the raceway is low. These methods include,

1. Traditional aeration procedure.
2. Splash water.
3. Oxygen may be injected into the growing system.

Since the quality of water is one of the most important aspect of a successful raceway production system, feeding of the fish should also be taking into consideration. Fish should be fed in a manner that will not leave excess leftovers of uneaten feed that will cause the pollution of the water. One therefore needs to ensure that fish are not overfed or feeding rates are adjusted accurately to ensure efficient production. Poor feed conversion rates typically indicates improper feeding practices, inadequate diet composition and adverse environmental conditions (Micheal & Charles 1991). Feed should be given to the fishes several times per day in quantities that the fish will completely consumed (Auburn). The maximum daily input should be based on the relationship between feed requirement and oxygen (Auburn).

Raceway system like any other aquaculture production system generates waste from the fish. According to (Amirkolaie 2008), the amount and quantity of waste produced on the fish farm depends on the production system. When both dissolved and solid waste get accumulated in the raceway, the quality of the water tends to reduce considerably, and this can cause disease outbreak in the highly stock raceway channels.

To ensure high quality water on the farm, the polluted water from the farm must be discharged to a receiving water body. But these discharges if not treated properly can have adverse effect on the recipient water and the environment. According to (Amirkolaie 2008), the discharge from an aquaculture waste has be a major environmental concern since this aquaculture waste cause eutrophication to the receiving water. This was supported by (Ariel & Jutta 2014), who states that nitrogen and phosphorus which are considered as waste components of fish farming causes serious environmental conditions.

These environmental concerns have put an increasing pressure on fish farmers to treat their waste water before been discharge into the recipient water. This has led to farmers adopting different methods of treating discharge water from the fish farm of both solid and liquid waste before been discharge into the recipient water. Some of the methods include;

1. Fish should be excluded from at least 6-8 feet of each raceway unit by a screen as this allows an area of sedimentation of uneaten feed and faeces. Sediments should be

removed from the ends of the raceways at 1-2 days interval by suction or via a centre drain from treatment in the sedimentation basin (Auburn)

2. Feed quality should be improved with a greater bio-availability of phosphorus and proteins thereby reducing the amount excreta produce by the fish (Ariel & Jutta 2014)
3. Cultivation of food crops across or downstream of the raceway farm so that waste water from the farm can be used for irrigation of the food crops and in that way the waste can serve as nutrients for the crops

2.0 GEOGRAPHICAL LOCATION OF THE PROJECT

Ivory Coast is a country located in the Western part of Africa. It shares boundaries with Guinea and Liberia to the west, Burkina Faso and Mali to the North and Ghana to the east. It is located at 5°20′28″N 4°1′41″W. It has 2 main big cities; Yamoussoukro, which is the political city and Abidjan, been the economical and the largest city in Ivory Coast. Ivory Coast had their independence in 1960 led by Felix Houpouet-Boigny. They are one of the leading producers of cocoa and coffee. The official language is French, although there are several other local languages spoken among the locals. The population size of Ivory Coast is 22.6 million (African 2016)

Fig 1: Map of Ivory Coast (source: (African 2016))

2.1 ANALYSIS OF LOCALITIES

Three (3) main localities near 3 lagoons and 2 main rivers were visited. This localities are Abidjan, Taboo and

The first locality that was visited was at Abidjan and the first lagoon visited is Lagoon Aghien. These lagoon is located south of Ivory Coast in the district of Ivory Coast between latitudes 5.22 °N and 5.26 °N and longitudes 3.49 °W and 3.55 °W (Rose et al. 2017) . The main body of water inflows in the lagoon is the direct precipitation, the contributions of the two upstream tributaries and inflows of groundwater ((Rose et al. 2017).

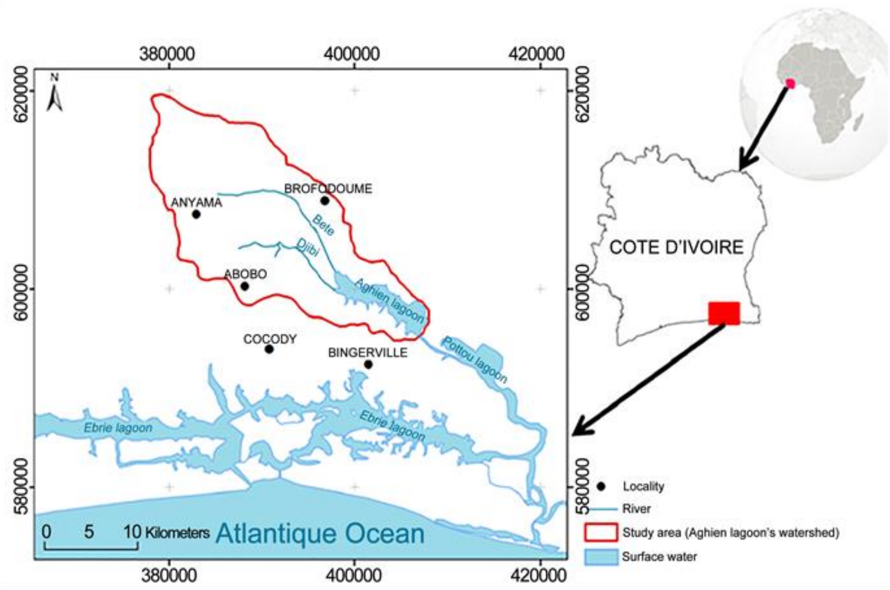


Fig 2: Map of Lagoon Aghien (source:(Effebi et al. 2017))

According to Mr Lamine, Lagoon Aghien is the cleanest lagoon and is been used as source of drinking water for the people of Abidjan. For this reason the government of Ivory Coast has made these lagoon a protected lagoon. For one to do any activity on or near the lagoon, one needs permission from the government with an environmental impact assessment done before permit will be granted. The site we located along Lagoon Aghien was located at a community called Bengerville. At these site is an already established tilapia farm with all the necessary facilities necessary for commercial production of tilapia available. This location will require extensive civil construction work such as preparing a Dam to feed the farm with continuous water supply since the source water is beneath the farm. Pumps will be needed to lift the water into the dam to supply continuous flow of water to each raceway units. This will add to the cost of electricity and will therefore increase the operation cost.

Fig 3: Facilities on the site near lagoon Aghien (source: Carl S.K. Dzadey)

The next sites visited in Abidjan was located along the lagoon Ebrie. Along Lagoon Ebrie, four (4) main sites were located along the banks of the Lagoon. The first site along theLagoon Ebrie was located at Abadjan Dumea with coordintes of 5.30691°N and 4.139629 °W. This site was very close to human settlement and is also not big enough for raceway farming or any other aquaculture related activities.

The second site along the Lagoon Ebrie was located at a community call sango. This site has coordinates of 5.312356 °N and 4.195549 °W. This site also has large human population already habituating the site, therefore there was not enough space for any aquaculture related activity.

The third and fourth site along Lagoon Ebrie are both located at sango as well. They have coordinates of 5.313707 °N and 4.202389 °W and 5.308806 °N and 4.183338 °W respectively. At both sites were sand winning activities. These activities are done with heavy machines. This cause the pollution of the water from fuel been drop in the water from the machines and other processes in relation to the sand winning activity. This makes the water unsuitable for any aquaculture activity.

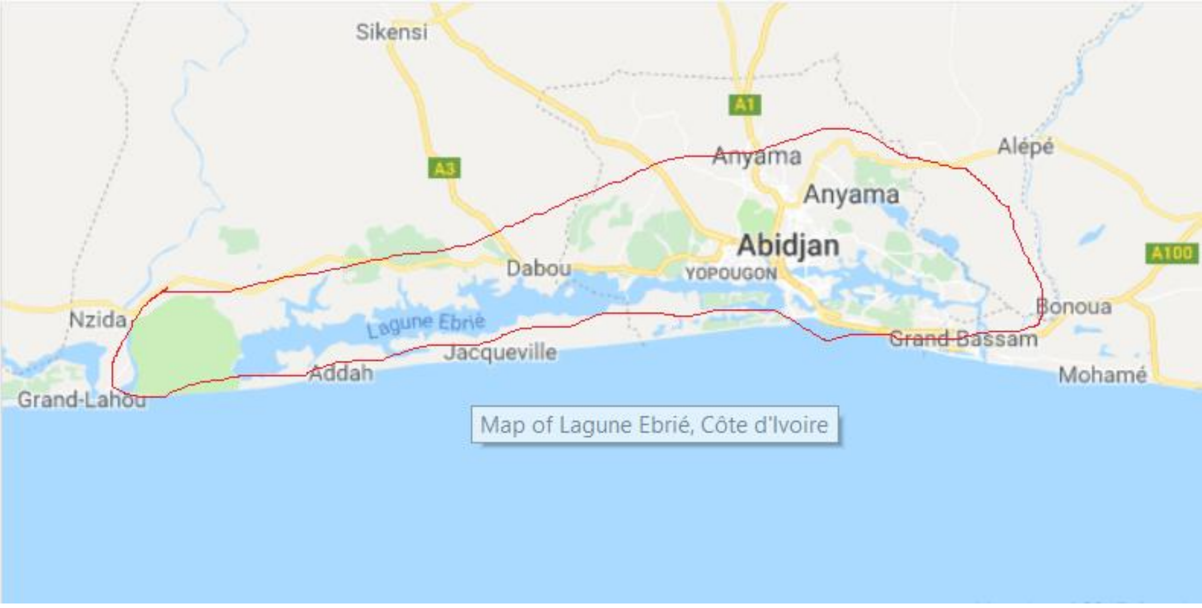


Fig 4: Map of Lagoon Ebrie (source: google map)

Fig 5: Various sites visited along lagoon Ebrie (From top left: Site 1, Site 2, Site 3 and Site 4, (source: Carl S.K. Dzadey)

Aside the proximity of human population and other activities along and on the Lagoon Ebrie, it has been documented that Lagoon Ebrie is the most polluted water source in Ivory Coast.

Lagoon Potoue was the next Lagoon visited. At these Lagoon, we located a site at du bac a M'bato-Bouake. This site has coordinates of 5.354582 °N and 3.784564 °W. At about 200meters to 300 meters from this site into the lagoon is heavily covered with thick vegetation. There is also heavy cultivation of palm fruits across the lagoon. The palm fruits are transported by ship to the where we located a site. With transport of palm fruits everyday across the lagoon, there is a high probability of fuel and palm fruit spillage that might cause pollution of the farm's source water. For these reasons, this site was not considered for the project of raceway production system.

Fig 6: The map of lagoon Potou (source: (Kouadio et al. 2011))

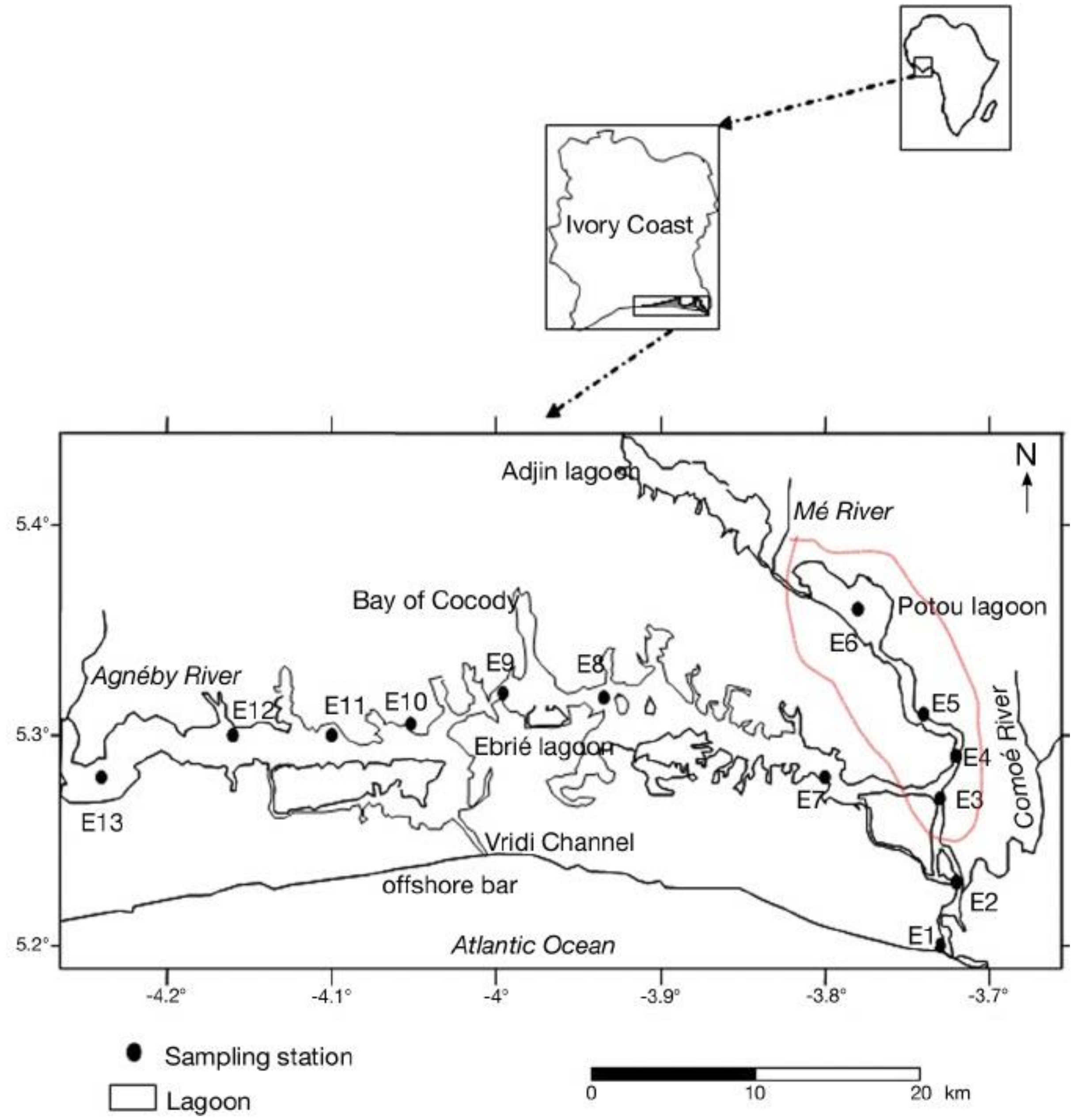

Ivory Coast
Adjin lagoon
Mé River
N
Bay of Cocody
Potou lagoon
Agnéby River
E12
E11
E10
E9
E8
E6
E5
E4
E3
E7
E13
E2
E1
Ebrié lagoon
Comoé River
Vridi Channel
offshore bar
Atlantic Ocean
5.4°
5.3°
5.2°
-4.2°
-4.1°
-4°
-3.9°
-3.8°
-3.7°
Sampling station
Lagoon
0
10
20 km

Fig 7: Site located along lagoon Potou (source: Carl S.K. Dzadey)

From Abidjan the next locality visited was Taabo. At Taabo I visited the Taabo Hydro Power plant. This is located north of Abidjan and the hydro power plant is on the Bandama River. The Bandama River is the longest river in Ivory Coast with a length of 800kilometers. The south flowing river is fed by the Marahove, Solomougou, Kan and Nzi Rivers and empties into the Togha Lagoon. The Bandama flows through Lake Kossou (a large artificial lake). The Taabo Hydro Power Dam is located central of Abidjan, Yamoussoukro and Bouake. These cities are the largest cities in Ivory Coast. This makes it a very vantage position for transporting and marketing of the harvested tilapia to the major consumers of the 3 main big cities of Ivory Coast.

The topography of the discharge end of the dam is sloppy causing the water discharge from the dam to flow under gravity. This is the biggest advantage of this locality in relation to the production system (raceway production system). With this locality, there would not be need for pumps to lift water up to the farm. The water flowing from the turbines is also saturated.

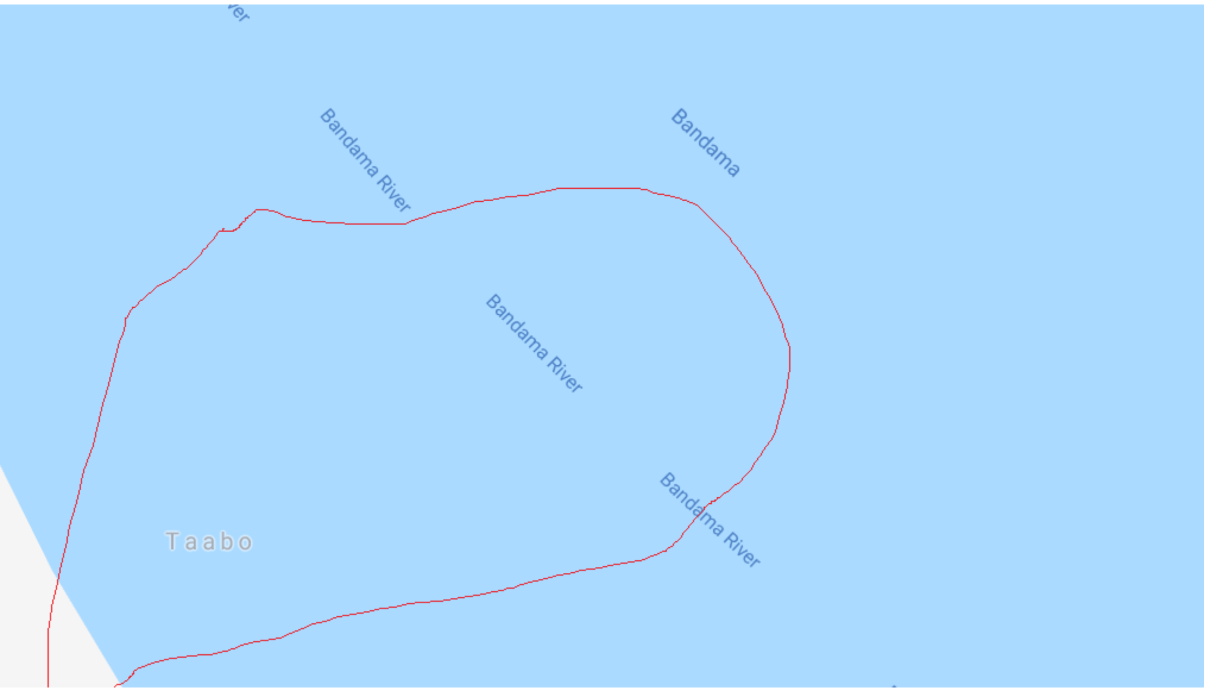


Fig 8: The map of the Bandama River showing where the Taboo Hydro power dam is located (source: google map)

Fig 9: The Taboo hydropower dam (source: Carl S.K. Dzadey)

From the Taabo locality the next locality visited was the Lac D Ayame. At Lac D Ayame, we again visited the Lac D Ayame Hydropower Dam. This dam is constructed on the Bia River. The Bia River enters Ivory Coast from Ghana and it flows to the Aby Lagoon. It has a total length of 260m. The topography of this land at the discharge end is not as sloppy as the topography of the Taabo Hydropower Dam. Therefore, it will require more civil construction to enable the water to flow by gravity to the farm. The nearest town is the Aboisso on which road is heavy traffic. This present a logistic challenge in terms of transporting harvested fish from the farm to the market centres.

Fig 10: Map showing the Bia River showing where the Lac D Ayame Hydropower Dam (source: google map)

2.2 GEOGRAPHICAL LOCATION OF FARM SITE

Since there was not enough information pertain to the locality at Taabo, it was agreed upon that the site located along lagoon Aghien will be considered for the purpose of this report. The site is located at Bingerville. The site is connected by good road networks that leads to the main road connecting to Abidjan. There are small villages close to the site which can provide cheap human resources. The source water which is Lagoon Aghien is of high quality which makes it suitable for the raceway culture.

2.3 DESCRIPTION OF THE BUILDING GROUND

The aim of this project is to plan and design and production plan for 2500 tons of tilapia (equating to 4,600,000 tilapia). On the site are already built structures such as office, and fish mill. These facilities and structures are not in use. There are also large circular tanks on the farm for holding frys, broodstock, fingerlings before they are transferred to the cages in the lagoon. The oxygen distribution in the circular tank is very poor, the tanks are not self-cleaning leading to massive accumulation of faeces and feed waste which produces toxic such as ammonia which affect the growth and health of the fish if not treated well.

The plan is to design and operate raceway system of production. This means that the tanks will be off no use if maintain on the site. Therefore, our intension is to demolish all the circular tanks and build raceway channels that allows continues flow of high quality water which helps in the even distribution of oxygen across the channels and which also helps in removing uneaten feed and faeces from the raceway channels to be discharge as effluent water into a receiving water.

The source water to this already existing farm is not flowing under gravity. Pumps are used to pump water to the fish farm. Pumps can failure at times and operating pump on fish farms increase the cost of operation. Therefore, the project intends to build a dam that will ensure continues and constant water flow through the raceway channels. This also help to reduce operating cost.

There is good accessibility of road to and from the site and there is also constant and uninterrupted supply of electricity on the site.

2.4 WATER SOURCE

The main water source to the farm is the Lagoon Aghien. There is a pipe from the farm that stretch 80m away from the bank of the lagoon into the lagoon. It is through this pipe that water is pumped into the farm.

The Lagoon Aghien is the largest reserve of fresh water near the district of Abidjan. It is located south of Ivory Coast and it is between latitudes 5.22 °N and 5.26 °N and longitudes 3.49 °W and 3.55 °W. It spreads across many location; Abidjan, Bingerville and Anyama. Lagoon Aghien has an area of 20 km2 for a perimeter of 40.72km. An estimated volume of 25 km3 and a maximum depth of 13m. Lagoon Aghien is heavily influenced by fresh water inputs consisting of river Bete and river Djibi which drains directly into the upstream basin and river Me intercepting its downstream course (Effebi et al. 2017).

2.5 DAM CONSTRUCTION

The climate of the study area is equatorial characterized by four (4) seasons; a long dry season from December to March, a big raining season from April to July, a small dry season from August to September and small season of rain from October to November. The long dry season period (from December to March) can affect the quantity and quality of the water in the case where water is not flowing by gravity but is been pumped to the farm from a lower elevation as in the case of the site where the farm is locted. It can also affect the continues and constant flow of water. To avoid water flow issues during this period (long dry season) we intend to construct a dam at a higher elevation to ensure the constant flow of water through the raceway channels throughout the entire. With the dam, we can also have control over the quality of water entering the raceway channels by treating and filtering the source water.

The lagoon will be diverted to the sloppy side of the farm (since the farm site is not beneath the water source) and away from the original lagoon bed. Dam construction will be done in the dry season to avoid the removed sand from going back to the dug dam. The foundation of the dam must be prepared by clearing the base area, by removing the surface soil and by treating the surface function. This all depends on the quality of the foundation's soil.

A cut-off trench along the centre of the dam will built to assist in anchoring the dam to its foundations. It will be necessary for us to build a water outlet which will preferably be placed out at the bed of the lagoon.

We will then mark the construction height of the dam and the crest width with stakes and lines on the basis of planned dam characteristics. We will set out the dam earthwork using templates at intervals of 25m or less and clearly showing the slopes of the sides. Because we will be using machinery in the dam construction, it will be best to establish an auxiliary base line outside the radius of operation of the machinery based on the topographical survey bench-marks.

2.6 WATER QUALITY AND TEMPERATURE

During the long dry season from December to March, water temperature turns to drop to as low as 24°C. My personal experience in Ghana on most tilapia farm is that, during this period the mortality rate on most farms is high among fries and fingerlings. Tilapia needs an optimum temperature of about 26 °C to 31 °C. Growth is best at temperature of about 26 °C-27 °C. A drop in temperature below this range can have adverse effect on the performance and growth of the tilapia.

From fig 8, we realized that March is the hottest month in Abidjan with an average temperature of 28 °C and the coldest month been September at 24 °C with most daily sunshine hours at 9 in March. In February, the average sea temperature is 29 °C

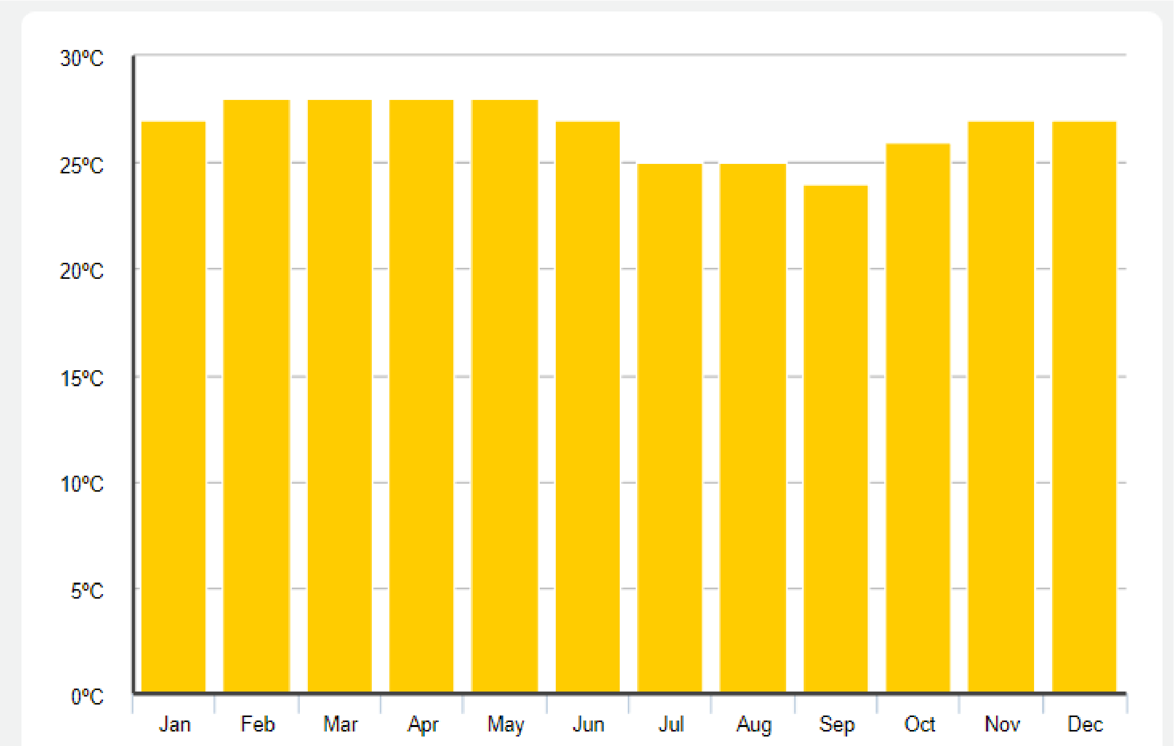


Fig 11: Average temperature in Abidjan (source: http://www.holiday-weather.com/abidjan/averages/)

2.7 EFFLUENT WATER

The topography of the site is sloppy. The depth of the lagoon is 13 meters and the depth of approximately 100 meters from the body is about 7 meters. Therefore, the outlet pipe, which discharge the effluent water from the farm should be about 200 meters to 300 meters from the bay of the lagoon. The outlet pipe can be about 500 meters long. With a projected production rate on the farm to increase to 10,000 tons (18,400,000 fish)

in a couple of years, the ability of the bay to absorbed the effluent nutrient needs to be put into consideration. As stated early, attempt should be made to cultivate some food crops/ vegetables across the outlet end of the raceway so that the effluent water can be pump as an irrigation water and a source of nutrient to the crops.

2.8 WEATHER AND CLIMATE

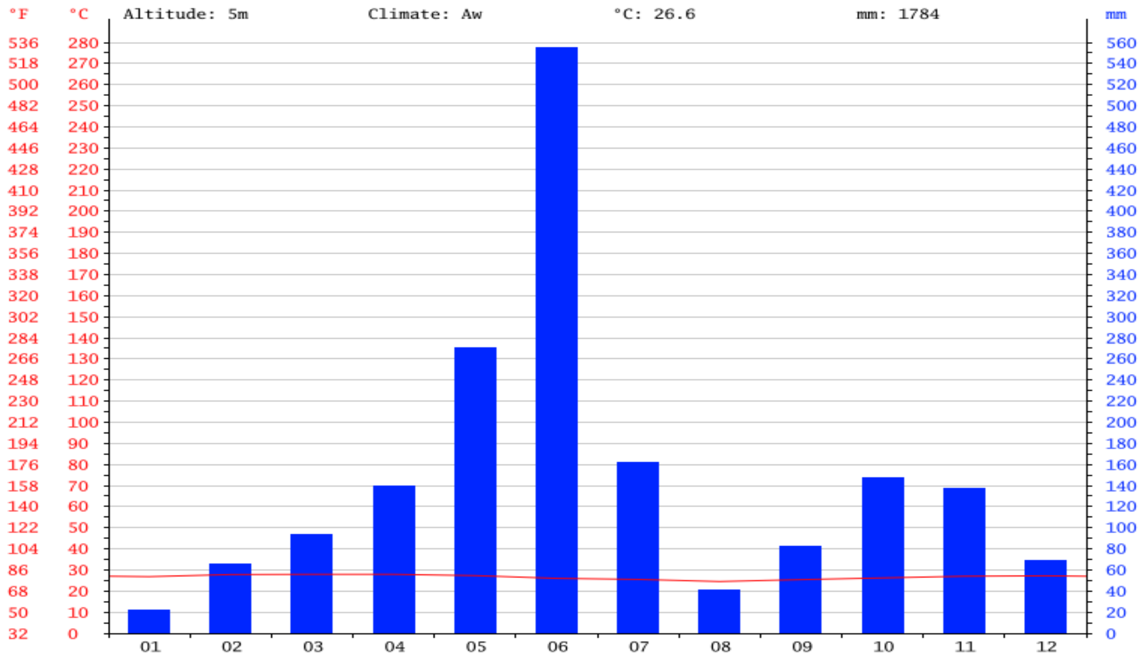


Fig 12: Climate graph of Abidjan (source: 5755 https://en.climate-data.org/location//)

Precipitation is lowest in January with an average of 22mm. Most precipitation falls in June with an average of 555mm (**https://en.climate-data.org/location/5755/)**

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	26.8	27.8	27.9	27.9	27.3	26	25.5	24.5	25.4	26.2	27	27.2
Min. Temperature (°C)	22.6	23.6	23.7	23.7	23.6	22.7	22.7	21.5	22.6	23.1	23.3	23.2
Max. Temperature (°C)	31.1	32.1	32.2	32.2	31.1	29.4	28.3	27.6	28.3	29.4	30.8	31.2
Avg. Temperature (°F)	80.2	82.0	82.2	82.2	81.1	78.8	77.9	76.1	77.7	79.2	80.6	81.0
Min. Temperature (°F)	72.7	74.5	74.7	74.7	74.5	72.9	72.9	70.7	72.7	73.6	73.9	73.8
Max. Temperature (°F)	88.0	89.8	90.0	90.0	88.0	84.9	82.9	81.7	82.9	84.9	87.4	88.2
Precipitation / Rainfall (mm)	22	66	94	139	270	555	162	41	82	147	137	69

Fig 13: Climate table/Historical Weather Data of Abidjan (source: https://en.climate-data.org/location/5755/)

Between the driest and wettest months, the difference in precipitation is 533mm. The average temperature varies during the year by 3.4 °C

3.0 PRODUCTION PLAN

The first step involved in initiating and projection of fish farm is to have an adequate production plan. With an adequate production plan, we will be able to accurately give an estimate of the needed infrastructure, number of rearing units and water requirement. With an adequate production plan, we should be able to reach the highest economic gain. Our production plan will be based on setouts due to temperature and other factors

3.1 TEMPERATURE

The inlet water might varies slightly depending on the season of the year. And this might affect other activities of the fish. For instance, spawning begins when temperatures reach 24°C. Therefore, the temperature in the hatchery should not be less than 24°C. According to (Amal & Zamri-Saad 2011), in subtropical regions with cool seasons, the number of fry produced will reduce when daily water temperature averages less than 24°C. Islam (2009) observed that after 16 to 20 spawning cycles with 227g Nile Tilapia, fry recovery was about 600 fries per female brooder at water temperature of 26°C, but only 250 fry per female was recovered at temperature of 23°C.

Therefore, the maintenance of optimal rearing temperature is essential. Temperatures below 24°C and above 35°C will lead to high egg mortalities and any hatchling may also be very weak and eventually die.

There will be no need for cooling or heating equipment as the temperature in Ivory Coast hardly falls below 24°C (as the coldest month, September, has a temperature of 24°C).

3.2 SPECIFIC GROWTH RATE AND INDIVIDUAL WEIGHT

The growth rate is under genetic control and largely influenced by temperature. Specific growth rate is the term used to determine the growth of the fish in relation to size and temperature. It is necessary to use growth table as this would act as a good reference for designing a production plan.

Individual weight of the fish is calculated on daily basis. The formula below is used for calculating the individual weight

$$V_1 = V_0 \bullet \left(1 + \frac{d}{100}\right)^t$$

V_1 = Final weight period
V_0 = Initial weight
d = Daily specific growth rate (SGR)
t = Number of days

TABLE (1): SGR VALUES WITH VARYING WEIGHT AND TEMPERATURES (source: Tilapia production plan, Bjørn Frode Eriksen)

Weight (g)	Temperature (C°) 15 C°	20 C°	25 C°	28 C°	30 C°	32 C°
1	6,8 %	10,2 %	17,0 %	20,4 %	23,8 %	20,4 %
2	6,0 %	9,0 %	15,0 %	18,0 %	21,0 %	18,0 %
5	5,2 %	7,8 %	13,0 %	15,6 %	18,2 %	15,6 %
10	4,2 %	6,3 %	10,5 %	12,6 %	14,7 %	12,6 %
15	3,6 %	5,4 %	9,0 %	10,8 %	12,6 %	10,8 %
25	3,1 %	4,6 %	7,7 %	9,2 %	10,8 %	9,2 %
35	2,4 %	3,6 %	6,0 %	7,2 %	8,4 %	7,2 %
50	1,8 %	2,0 %	4,5 %	5,4 %	6,3 %	5,4 %
60	1,2 %	1,8 %	3,0 %	3,6 %	4,2 %	3,6 %
70	1,0 %	1,5 %	2,5 %	3,0 %	3,5 %	3,0 %
80	0,8 %	1,3 %	2,0 %	2,5 %	2,9 %	5,0 %
90	0,8 %	1,2 %	2,0 %	2,4 %	2,8 %	2,4 %
105	0,8 %	1,1 %	1,9 %	2,3 %	2,7 %	2,3 %
120	0,7 %	1,1 %	1,8 %	2,2 %	2,5 %	2,2 %
130	0,7 %	1,0 %	1,7 %	2,0 %	2,4 %	2,0 %
145	0,6 %	1,0 %	1,6 %	1,9 %	2,2 %	1,9 %
160	0,6 %	0,9 %	1,5 %	1,8 %	2,1 %	1,8 %
175	0,6 %	0,8 %	1,4 %	1,7 %	2,0 %	1,7 %
190	0,5 %	0,8 %	1,3 %	1,6 %	1,8 %	1,6 %
205	0,5 %	0,7 %	1,2 %	1,4 %	1,7 %	1,4 %
225	0,4 %	0,7 %	1,1 %	1,3 %	1,5 %	1,3 %
235	0,4 %	0,6 %	1,0 %	1,2 %	1,4 %	1,2 %
250	0,4 %	0,5 %	0,9 %	1,1 %	1,3 %	1,1 %
265	0,3 %	0,5 %	0,8 %	1,0 %	1,1 %	1,0 %
275	0,3 %	0,4 %	0,7 %	0,8 %	1,0 %	0,8 %
285	0,2 %	0,4 %	0,6 %	0,7 %	0,9 %	0,7 %
290	0,2 %	0,3 %	0,5 %	0,6 %	0,7 %	0,6 %

3.3 MORTALITY

Mortality is dependent on different life stages. The highest mortality occurs in early life. We must consider that there is large variation and that it is dependent on various factors. When making a production plan, we must use low mortality numbers. The mortality rate is also dependent on the quality of eggs or fries received into the hatchery. With hatching substrate and low water level and flow, we can reduce the morality rate

TABLE (2): MORTALITY OF TILAPIA AT DIFFERENT STAGES OF LIFE (source: Tilapia production plan, Bjørn Frode Eriksen)

STAGES	MORTALITY RATE (%)
EGG	5-10
HATCHING	5
START FEEDING	5-10
ONGROWING STAGE	0.1-1
TOTAL SURVIVAL	70-90

3.4 BIOMASS

Biomass is estimated by multiplying the total number of fish by the individual weight of the fish. Biomass usually change due to the change in the individual weight of each fish. Determining the biomass helps in utilizing water volume at the same time preventing the use of too much water.

3.5 WATER REQUIREMENT

At low temperature, the oxygen level in the water is high. This means that at high temperature the dissolved oxygen concentration level in the will turn to decrease due to increase metabolic activity of the fish that requires the use of oxygen. But with raceway system, with constant flow of water through each raceway unit, the dissolved oxygen concentration turns to be replenished by. Tilapia can be tolerant to love dissolved oxygen concentration (DOC. Tilapia can survive normal morning drop in DOC to as low as 0.3mg/l. Growth is optimum at DOC above 3mg/l. Tilapia will grow better when morning DOC is prevented from falling below 0.7mg/l to 0.8mg/l. In cages, DOC should be maintained above 1mg/l, because a drop in DOC below this level will lead to decrease in metabolism, growth and resistance to diseases. DOC requirement also varies with size, smaller fish turns to require more oxygen than bigger fish, as can be seen in the table (3) below

To calculate the total water requirement, we need to know the water requirement for each kg of fish and multiply it by the total biomass of the fish.

TABLE (3): OXYGEN CONSUMPTION (MG O_2/ KG/ PER MIN) VALUES WITHDIFFERENT WEIGHT AND TEMPERATURES (MODIFIED FROM SANNI ET AL., 1993)

			Temperature (C°)			
Weight (g)	**15 C°**	**20 C°**	**25 C°**	**28 C°**	**30 C°**	**32 C°**
1	14,3	21,5	35,8	42,9	50,1	42,9
2	12,6	18,9	31,6	37,9	44,2	37,9
5	10,9	16,4	27,4	32,8	38,3	32,8
10	8,8	13,3	22,1	26,5	30,9	26,5
15	7,6	11,4	18,9	22,7	26,5	22,7
25	6,5	9,7	16,2	19,4	22,7	19,4
35	5,0	7,6	12,6	15,1	17,7	15,1
50	3,8	5,7	9,5	11,4	13,3	11,4
60	2,5	3,8	6,3	7,6	8,8	7,6
70	2,1	3,2	5,3	6,3	7,4	6,3
80	1,8	2,7	4,4	5,3	6,2	5,3
90	1,7	2,5	4,2	5,0	5,9	5,0
105	1,6	2,4	4,0	4,8	5,6	4,8
120	1,5	2,3	3,8	4,5	5,3	4,5
130	1,4	2,1	3,6	4,3	5,0	4,3
145	1,3	2,0	3,4	4,0	4,7	4,0
160	1,3	1,9	3,2	3,8	4,4	3,8
175	1,2	1,8	2,9	3,5	4,1	3,5
190	1,1	1,6	2,7	3,3	3,8	3,3
205	1,0	1,5	2,5	3,0	3,5	3,0
225	0,9	1,4	2,3	2,8	3,2	2,8
235	0,8	1,3	2,1	2,5	2,9	2,5
250	0,8	1,1	1,9	2,3	2,7	2,3
265	0,7	1,0	1,7	2,0	2,4	2,0
275	0,6	0,9	1,5	1,8	2,1	1,8
285	0,5	0,6	1,3	1,5	1,8	1,5
290	0,4	0,6	1,1	1,3	1,5	1,3

(source: Tilapia production plan, Bjørn Frode Eriksen)

4.0 ROOM PROGRAM

It is important to demarcate the whole production site. Each part of the production unit has different requirement in terms of amount of water required and speed of water flow, how each department should be handled, and the day to day activities that goes into running each department. This will help in achieving the set goals in the best possible way. The site programming is made to make production safer, better and more efficient.

On our production site, we will have an entrance where there will be a bath with disinfectant for disinfection of both cars and human entering the farm. This is to avoid foreign materials that might cause disease outbreak on the farm from entering the farm. The entrance will also have a reception from which visitors can make all the necessary enquiries.

Separated from the entrance will be a 6-7unit building which will contain the office, the washroom, the changing room, the feed storage room, the canteen, the cold room and the equipment storage room.

The office is where day to day activities of the farm are planned, recorded and work on. It is where every paper work pertaining to the fish, and the production activities are worked on. Connected to the office is the canteen where workers will go to eat during break time. Next to the canteen is the changing room, where farm workers change into their working cloth before work and change back to their normal cloth after work. Attached to the changing room is the feed storage room. This is where feed materials use for production of the feed on the farm are stored. It is also where already produce feed are kept being sold to other farmers and used on the farm to feed the fish. Next to the feed storage room is the equipment storage room. This is where tools and equipment (such as wheelbarrow, nets etc)

used for the day to day running of the farm are kept. The washroom comes after the equipment storage room. The washroom will be equipped with bathrooms and toilets that farm workers can use during working hours when they feel press and after working hours when they can bath before going home. The final room will be the cold room. This is where all harvested fish are kept avoiding them from going bad before they will be transported to the market.

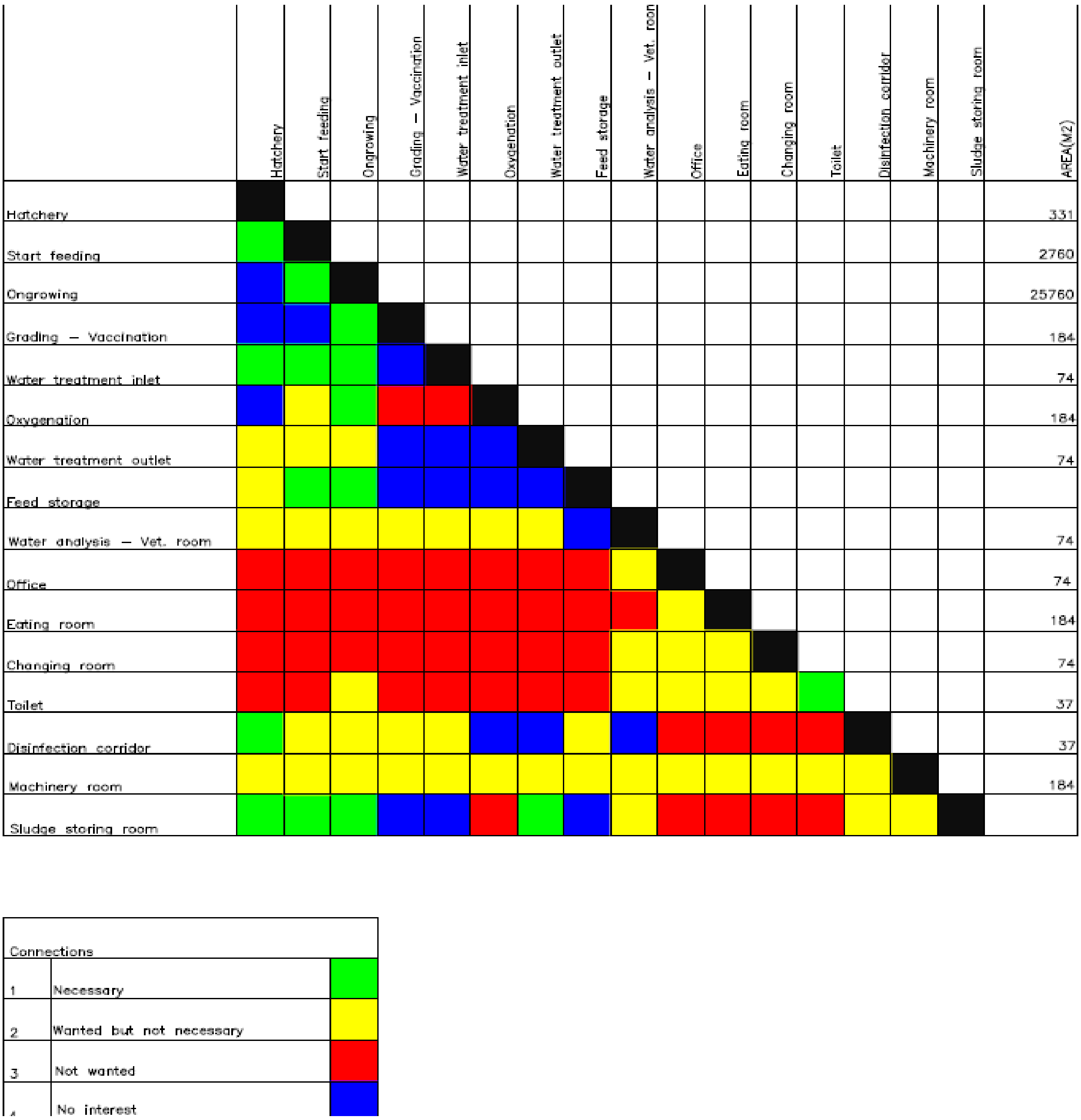


Fig 14: Room Program for 2500 tons of tilapia

4.1 HATCHERY

Since the hatchery is the most sensitive part of the production, it will be separated from other part of the production unit but closer to the on-growing raceway unit. At the entrance of the hatchery will be a disinfection barrier (footbath) where one have to dip his foot into for disinfection of all footwears before entering and leaving the hatchery. The hatchery will be placed strategically to the start feeding department so as to make it easy when moving de fries from the hatchery to the start feeding department with having adverse effect (through handling) on the fries.

4.2 START FEEDING DEPARMENT

From the hatchery, the fries are moved to the start feeding department. The start feeding department is located close to the hatchery so as to avoid stressing the fish when move them.

In the start feeding department, hatching substrate are placed in the raceway unit to protect the fries until they are ready to start swimming up. In this department, the flow rate should be low to avoid the fries from getting pressed against the outlet screen and causing high mortality on the farm. The fries will start to fill up their swim bladder and start to chase for food. Because of their small stomach and high specific growth rate, they turn to eat a lot but in small quantity, therefore feeding should be done 8 to 10 times in a day and it should be in small amount. Feeding in small amount also avoid feed wastage.

4.3 ON-GROWING DEPARMENT

From the start feeding department, the fish will then be transfer to the on-growing department where grading (separating performing fingerlings from non-performing ones) and vaccination (treating fingerlings of diseases and infections if there is any) are done. Water exchange in this department should be 180 exchanges per day, since raceways depends on water flow to be flush waste from each raceway units. The maximum tilapia density in raceways ranges from 160-185kg/m3 and maximum loading ranges from 1.2-1.5 kg/liter/min. A common production level in raceways is 10kg/m3/month as water supplies are often insufficient to attain maximum rates.

4.4 INLET AND OUTLET WATER TREATMENT

The water entering the farm especially the hatchery might contain unwanted material. Suspended clay can impact the health of the fish by deposing on the gills and reducing the oxygen assimilation of the fish. Unwanted animals may also enter the raceway or the hatchery through the water supply system. These animals can act as predators to newly hatched fries or fingerlings or may compete with fingerlings for food. It is therefore important to avoid their entrance at the inlet. The water also leaving the farm contains lots of toxic and waste products that will be harmful and alter the ecosystem of the receiving environment. It is therefore important to treat both the water entering the farm and the water leaving the farm.

One of the easiest and cheapest method to use for water treatment is the mechanical filtration. The mechanical filtration system prevents organic matter, mineral matter and unwanted animals from entering the raceway and hatchery. The most important elements of the mechanical filtration system are the screens (mesh) that must be placed at both the inlet and outlet pipes to avoid any movement of fish or other animals from the source water into the raceway units and to avoid escapes from raceway units to the discharge environment. Sludge collected in the mash will then be bagged and stored in the sludge room for use for cultivating food grows.

4.5 SLUDGE STORAGE

The amount of waste produce on the farm will depend on the biomass of production the feeding strategy adopted. For our sites, since we will be produce at least 2500 tons per year, there will be high amount of waste from there farm. To avoid high investment and operational costs, it will be to our advantage to cultivate large piece of land at the outlet end of the farm where the effluent water will be pump to the farm to provide water and nutrients to the crops. But assuming the space at the outlet end of the farm is not enough, then it will require that we build a sludge storage facility will be add to the investment and operation cost.

4.6 VETERINARY ROOM

This room will be used for diagnostic work in times of disease outbreak in any raceway unit or on the entire farm. Activities such as taking blood sample of the fish and dissection of fish to determine the cause of any disease on the farm will be carried out in this room. It will also be used for storing anesthetics and other disinfection and sex reversal chemicals.

4.7 DISINFECTION CORRIDOR

Disinfection corridor will mainly be located at the entrance of the hatchery, start feeding and on-growing departments. Disinfection corridor is mainly a footbath that will be used to disinfect any footwear entering and leaving the above-mentioned departments. It is used mostly by those working in the hatchery and those handling the manipulation process in the start feeding and on-growing department. The disinfection corridor is made to ensure high production rate and to decrease mortality especially in the hatchery.

4.8 MACHINERY ROOM

In this room is where pumps and other machines and tools needed for the proper functioning of the farm are kept.

4.9 OFFICE AREA

This part of the is reserved for workers who work on each department of the farm, it consists of the office, the canteen and the washroom. This area does not does not necessary needs to be disinfected, because this is the area where workers prepare before entering the production unit, eat and bath after work

5.0 PIPES AND PIPE DEMINSIONING

It is important for us to have a good water quality from a reliable source and with the right equipment to transfer water to and within the farm. The volume of the water needed depends on

- The size of the farm
- The type of tilapia species been farmed
- The production system been used (in our case raceway system)

The materials used for water transport includes

- Pipes (PVC and PE pipes)
- Pipe parts (fittings)
- Pumps

Since there is always a problem with water quality to the site during the dry season, we intend to set out our pipe about 80m from the bank of the lagoon into the lagoon. PVC pipe will be attached to galvanized pipes that will extend from the bank into the lagoon. This will be fitted with gate valves to control the flow of water into and out of the dam. Attached to the galvanized pipe into the dam will also be fitted with a PVC. Connecting from the dam to each raceway unit will also be PVC. Each raceway unit will be having an outlet fitted with PVC pipes that will be connected to the main outlet. The main outlet will also be fitted with a PVC pipe. PVC pipe will be used because it is easy to install, durable and makes control of water much easier than all other pipe materials.

It is very important to know the dimensions of the pipes as well as the velocity of water through the pipe so that we can get the head loss. The Darcy-Weisbach equation is use to calculate the head loss of the pipe.

Darcy-Weisbach equation:

$hf = f(v2/2g)*(l/d)$

hf = pipe friction head loss

f = friction factor – 0,03 in all calculations

v = fluid velocity (m/s)

g = gravity acceleration (m/s2)

l = length of pipe (m)

d = inside pipe diameter (m)

Area equations:

$A = Q/V$

A = the cross-sectional area (m2)

Q = the water flow (m3/s)

V = the water velocity (m/s)

$rr = \sqrt{aa/\pi\pi}$

r = the radius (m)

a = the cross-sectional area (m2)

Below is the table of the length of the pipes at each department, the velocity and the head loss.

TABLE (4): PIPE DEMINSIONING (Source: Bjørn Frode Eriksen, Tilapia Production Plan for Ivory Coast)

	Length(m)	Velocity(m/s)	Diameter(m)	Head loss(m)
Main outlet pipe	100	2.5	1.969	0.485
Inlet pipes	100	5.0	1.382	2.765
Header tank to hatchery	50	2.0	0.216	2.423
Header tank to ring pipe start feeding	100	1.5	0.291	1.181
Ring pipe start feeding	50	1.0	0.299	0.256
Outlet pipe start feeding	100	0.7	0.522	0.143
Header tank ring pipe on-growing	20	2.5	1.622	0.118
Ring pipe on-growing	30	2.5	1.622	0.177
Outlet on-growing (2 pipes)	50	1.0	2.180	0.035

6.0 COST ESTIMATE ANALYSIS OF BUILDING THE FARM

Development of any form of tilapia farm in Ivory Coast be it small or large scale will involve money. Money will be needed for the construction of the raceway units, hatchery, office complex, feed mill, cages and to pay workers on the farm. It is therefore very important to give a vivid and detail description of the cost of each item to be used in the construction so that money can be allocated to each item. It will ensure cost effectiveness and avoid unnecessary spending of money. Below are tables detailing the cost for each unit on the farm.

TABLE (5): COST ESTIMATE FOR RACEWAY CONSTRUCTION

	DESIGNATION	QUANTITY	UNIT COST (CFA)	TOTAL COST (CFA)
VARIABLE COST	LAND/ACRES	8	5,000,000	40,000,000
	RACEWAY CONSTRUCTION			
	REINFORCED CONCRETE	40	300,000	12,000,000
	INLET AND OUTLET PIPES	2	200,000	400,000
	PUMPS	2	1,000,000	2,000,000
	FILTERS	2	200,000	400,000
	FEED	2,500	20,000	50,000,000
	ELECTRICITY/YEAR	1	1,200,000	1,200,000
	OFFICE SPACE	1	20,000,000	20,000,000
	CONTINGENCY	10%		12,600,000
	TOTAL COST			138,600,000

TABLE (6): Cost Estimate for constructing the hatchery and operating the farm

DESIGNATION	QUANTITY	UNIT COST	TOTAL COST IN FCFA
VARIABLE COSTS			
BROODSTOCK/EGGS	726	8000	5,808,000
FEED (kg) (PELLETED FEED FOR BROODSTC	5040		
FUEL	1	2,500,000	2,500,500
ELECTRICITY BILLS	1		
INTERNET AND TELEPHONE BILLS	1	400,000	400,000
FEED FOR FRY (kg)	24200	1000	15,000,000
CONTINGENCY	10%		2,370,850
TOTAL			26,079,350
FIXED COST			
OFFICE MATERIALS	1	2,500,000	2,500,000
MAINTENANCE COST	1	1,500,000	1,500,000
SALARY FOR HATCHERY MANAGER	1	600,000	600,000
SALARY FOR NIGHT WATCH MAN	2	100,000	200,000
SALARY FOR TECHNICIANS	1	300,000	300,000
LABOURERES	6	150,000	900,000
TRANSPORT	1	3,000,000	3,000,000
ADMINISTRATION	1	3,000,000	3,000,000
CONTIGENCY	10%		1,200,000
TOTAL RUNNING COST			13,200,000
TOTAL COST FOR 1ST YEAR (INVESTMENT + RUNNING COST)			39,279,350

TABLE (7): TOTAL COST ESTIMATE FOR THE CONSTRUCTION OF THE FARM

LANDS AND CONSTRUCTIONS	DESIGNATION	QUANTITY	UNIT COST	TOTAL COST IN FCFA
	LAND/ACRES	10	5,000,000	50,000,000
	TANKS	10	300,000	3,000,000
	HATCHERY BUILDING	1	15,000,000	15,000,000
	DAM CONSTRUCTION	1	5,000,000	5,000,000
	FEEDMILL	1	40,000,000	40,000,000
	CONCRETE REARING UNITS (RACEWAY)	20	300,000	6,000,000
	OVERHEAD TANK	1	1,000,000	1,000,000
	CONTIGENCY	10%		4,300,000
	TOTAL			132,000,000
DEPRECIATION	Year depreciation of constructions and land for 10 years			4,730,000
EQUIPMENT				
	PUMPS	2	1,000,000	2,000,000
	WATER PARAMETER MEASURING INSTRUMENT (MULTIMETER	1	3,000,000	3,000,000
	MICROSCOPE	1	1,000,000	1,000,000
	REFRIGERATOR	1	600,000	600,000
	SCALE BALANCE	3	8,500	25,500
	60L PLASTIC CONTAINERS	13	18,000	234,000
	100L PLASTIC CONTAINERS	12	25,000	300,000
	100dm PIPE	1	130,000	130,000
	800dm PIPE	1	200,000	200,000
	400dm PIPE	1	160,000	160,000
	COMPUTER	1	400,000	400,000
	ELECTRIC GENERATOR	1	2,000,000	2,000,000
	WHEEL BARROWS	2	35,000	70,000
	SPADES	6	3,500	21,000
	ELECTRIC CABLES	1	1,500,000	1,500,500
	GRASS CUTTERS	2	300,000	600,000
	ELBOW JOINTS AND OTHERS	1		250,000
	CONTINGENCY	10%		1,229,100
TOTAL COST				13,520,100
DEPRECIATION OF EQUIPMENT OVER 5 YEARS PERIOD				2,704,020
OTHER COST				
	ENVIRONMENTAL IMPACT ASSESMENT	1		2,000,000
TOTAL COST OF INVESTMENT	Cost of land and constrcution + Cost of Equipments+Cost of Environmental Impact Assessment+Depreciation			154,954,120

6.1 FEED AND INPUT SOURCES

For fast growth and health of tilapia, they will be a need for a well-balanced nutritious diet. In their natural habitat, they (tilapia) feed on living organisms such as phytoplankton, zooplankton, insects and other food materials provided by nature which are balanced. But since we will be culturing them in the raceway, all the necessary nutrient requirements of tilapia need(Kouadio et al. 2011) to be provided in the farm prepared diet. Poor quality feed will result in poor growth and will affect the health of the fish (affects the immune system thereby making the fish less resistant to disease and parasite attacks)

A well-balanced tilapia diet should have 25-35% crude protein for adult tilapia and 32-50% crude protein for fry and juvenile tilapia; 6-8% of lipid, 30% of carbohydrate and 1% of minerals and vitamins (Lecture note AGN 251).

Depending on the size and growth stage of the fish, the shape and size of the feed fed to the tilapia varies. For fry, the feed fed is usually in a powdered form. For fingerlings and juveniles, the feed fed is in the crumble form and that of adult tilapia, pelleted size feeds are used to feed them. Pelleted feeds formulated are normally floating feeds so as to ensures high feed conversion ratio. Feed conversion ratio of 1.2-1.5 will be considered good enough on the farm.

The frequency of feeding the fish within a day depends on their life stages and the temperature of the day. At high temperature, the rate of feed consumption tends to increase due to increase metabolic activities caused by high temperature, and at low temperature, feed consumption tends to decrease Below is the table indicating the feeding frequency of tilapia at different life stages.

TABLE (8): A SUGGESTED CHART FOR TİLAPİA FEEDİNG FREQUENCY (source: Tilapia production plan, Bjørn Frode Eriksen)

Fish size	Time fed/day
0-0.5 g	8
0.5-1 g	6
1-10 g	4
10-50 g	3

50 g or more	2

There will be a need to produce own farm feed so as to reduce operational cost. Therefore, a research was conducted on the availability of high quality raw materials for producing feed locally. It was discovered that materials such as soybeans, maize, groundnut are available all year round. This was an encouraging discovery as this raw material can be used as a source of crude protein for the production of tilapia feed. The project can also acquire large hectares of land on which soybean and any other raw material can be cultivated that will be used to feed the feed mill for production of the feed.

Proper analysis and survey should be done on the crude protein content of other agriculture products such as cassava leaves that can be used as cheap protein source in the production of tilapia feed.

6.2 LOGISTIC AND MARKETING

Since the site is located outside Abidjan, there will be a need for logistical support such as cold storage rooms and facilities in which harvested tilapia will be kept before been transported to the market. There would also be a need for trucks that will be used to transport feed materials to the farm and transport fish to the market place. According to Mr Helge, he (Helge) owns certain percentage in a transport company located in Ivory Coast, so trucks fitted with cold storage facilities would be made available for transporting fish materials to the market centers all over Ivory Coast. Trucks will also be made available for transporting feed materials to and out of the farm.

There seems to be a good market for tilapia in Ivory Coast. Based on my personal observations, the people of Ivory Coast consumed lots of tilapia and chicken. Almost every local delicacy goes with either tilapia or chicken as the main protein source. But most of the tilapia in Ivory Coast are imported from both China and Columbia (about 60% of tilapia in Ivory Coast are imported from this two main countries). The quality of this imported tilapia from these two countries, especially from China, is not good and doesn’t taste as great as locally produce tilapia. Due to the bad quality of Chinese imported tilapia, the government of Ivory Coast has banned its importation to the country (personal communication with the locals). This has led to readily available market for the more tilapia to be produce locally.

This can then be seen to provide advantage to the project, as what ever is produce from the project will be readily and easily consumed by the people of Ivory Coast.

The prices of the imported tilapia are much higher than the locally produced ones. Below are the prices of the imported tilapia.

TABLE (9): PRICES OF IMPORTED FROM BOTH CHINA AND COLUMBIA (ALL IN 10 KG BAGS)

Size Tilapia	landed cost	sell price
300-500 g	8000.-CFA	17000.- CFA
500-800 g	10500.-CFA	17-18000.-CFA
800g	11000.-CFA	19000.-CFA

From the project's rough estimation, the selling price of 10kg of 300-500g of tilapia will be 17,000 CFA. This is the same as the imported ones, but with the quality from the project, the Ivorian people will have patronized and enjoy it more than the imported ones.

Communication with locals indicate their willingness to purchase locally produced tilapia as they assume it will be cheaper, fresher and tasty than the imported ones. Some even express their willingness to market the tilapia from the project provided there are sufficient quantities produced and available regularly.

7.0 DISCUSSION

The aim of this project is research into the potential of establishing tilapia farm in Ivory Coast by doing survey on suitable lands and water source that can be used in the production of tilapia on a large scale. Production will start with 2,500 tons of tilapia for the first year of production after which there will be an increase in production of year after year until production reaches 10,000 tons a year. It aims to produce and sell feed to other farmers. For this reason, a survey research was done to determine suitable site near a suitable source water flowing under gravity since the system of production (raceway units) requires large quantity of quality water flowing continuously. Three (3) main localities were visited (Abidjan, Taabo and Ayame). Visited at these 3 main localities were 8 sites located along 3 main lagoons and 2 main rivers. The lagoons are located at Abidjan locality while the rivers are located in the Taabo and the Ayame locality respectively. All sites located along the lagoons in the locality of Abidjan have the lagoons not flowing under gravity. This means working with any of these sites will be a great disadvantage to the project as it will have involved heavy civil construction and used of equipment such as pumps which will add to the operating cost. Pump failure might also occur, which may also increase the risk of high fish mortality.

Selecting the site near lagoon Aghien will come with lots of challenges. The source water is not flowing by gravity therefore there will be the need for dam construction and a pump to lift the water above ground level into the dam. Again, at this site there is no extra land for the discharge of effluent water from the farm. The effluent water will be discharge into the source water which when used again on the farm might cause high mortality. The effluent water would also have negative impact on the ecology of the source water. Treating 10,000 tons of fish waste with either UV light or Ozone is very difficult.

But incase there are no other option pertaining to the locality, the project might decide to go for this site. Because of all the negative aspect of the site near lagoon Aghien, we might have to consider different production options so as to be able to minimize the effect the effluent from the farm will have on the receiving water (same as source water).

The first production option is to have all production done in raceway units on the land. This option might not be favorable for site because the source water is not flowing be gravity. This means that there will be the need for construction of a dam where water can be pumping to supply constant water to each raceway units. There will therefore be need for pumps and the failure of the pumps to water to the dam at any particular point might lead to reduction in growth rate and eventually high mortality on the farm. The construction of the dam and the need for pumps will increase the production cost through the cost of electricity. The biosecurity of a fish farm is the most important and paramount thing. With this option the quantity of waste that will be produce will be too much making the treatment of effluent water before discharge more difficult.

The second production option is to have fingerling production on land and the rest of the production in cages. For this site this may seems a much better option. With this since is only fingerling production that is done on the land, there would not be any need for the construction of a large dam and there will be no need also for pumps. In this option, one will have a better control should a pump fail, or should there be limited oxygen in the production unit. Here also, the production of waste would not be as high as having all the stages of production on the land. It will therefore be easy treating effluent from the farm through simple methods such as sand filtration.

The project also aims to produce its own feed from the first year, with the aim of increasing production to 2,500 tons of feed. But on these site there is an already existing feed mill. But this feed mill does not have the capacity to produce 2,500 tons of feed per day, so there will be the need for reconstruction of the entire feed mill and the old machines replace with new and efficient machines that can produce high quality and quantity feed

Even though there is an already existing office complex, there is no cold storage room for storing harvested fish before been transported to the market. It will therefore be very important to construct a cold storage room in which harvest fresh tilapia can be stored before been transported to the market.

The preferred locality would have been any site at discharge end of the Taabo Hydropower Dam. With this locality we have to put into consideration the different production options mention for the site along lagoon Aghien. Since the land at the discharge end of the dam is sloppy and water is flowing under gravity, any production option will work perfectly in this locality.

For the first production option (all production in raceway on land), there would be the need to cultivate large acres of land at the outlet of the raceway units so that effluent water that is discharge from the farm would be used to fertilize the cultivated land. With this option there would be very little or no adverse effect of the effluent water on the receiving body. With this option there would be the need for the construction of dam where water can be stored to supply constant flow of water to each raceway units.

For the second production option (fingerling production on land and the rest in cages on the river), it will require less civil construction work in terms of the construction of dam. This option would help reduce production cost by reducing the size of land that will be needed in the construction of raceway units. With this option, the amount of waste that would be produce and need to be discharge will be less compare to when having all production unit on land. This option also helps in the reduction of production cost by reduction the number of equipment that will be needed on the farm for its day to day activities.

Monitoring in this option becomes very difficult since one does not have full control in this production option. Also, there will be the need high human security to watch over the cages especially at night, as there have been instances where fishermen fishing at night turns to steal the fishes from the various cages.

Since on this locality there is not existing farm, all facilities need on the farm would have to be constructed from the scratch. Therefore, there would be the need to get more information on issues relating to the proximity of setting feed mill and other facilities near the dam

7.1 CONSTRAINTS

- It was difficult visiting the sites. This was because the Ivorian partner who was supposed to organized for the visit to more water source has been very busy. This prevent the survey of more water source to determine the water source flowing under gravity.
- Language was also a huge barrier. It was difficult getting information about prices and other information relating to the project from the locals. Normally google translate was used as a mean of communication with the locals
- There was no work space from which to work from. This makes it difficult to get information and put the entire report together.

8.0 CONCLUSION

The project has a lot of potential to be successful and benefit the people of Ivory Coast. However serious survey needs to be done on other alternative (specifically hydro power) source of water that is flowing under gravity. Using the site Lagoon Aghien will increase the cost of production. Since water source at these site is not flowing under gravity, pumps would have to be installed to be able to lift water from the lagoon to the farm. This will increase the cost of electricity and thereby increasing the cost of production. It also increases the risk of high fish mortality. The success of any aquaculture depends on the security of the farm.

Research also need to be done into the availability of other agriculture products such as cassava leaves (which is rich in crude protein content, about 4, that can be used as an alternative source of crude protein for tilapia feed.

On the visit to the site near Lagoon Aghien, it was established that Lagoon Aghien has been marked as a protected zone by the government of Ivory Coast. The government intend to use this lagoon to provide fresh drinking water for the people of Abidjan in the near future as population growth increases. Therefore, it is not allowed to do any activity close to the Lagoon that will pollute the Lagoon (verbal communication with Mr Lamine). It will therefore be prudent that all the necessary information concerning permits, and all paperwork regarding obtaining permit for construction and importation of foreign species to Ivory Coast are obtain before the project commence.

9.0 APPENDIX

Production Plan 2500 ton Tilapia pr year

First Hatching 1.jan.

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Week no./ Comments	1	5	9	13	18	22	26	31	36	40	45	49
Inlet water temp	28	28	28	28	28	28	28	28	28	28	28	28
Mortality pr.month(%)	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %	5.0 %
Total no.(1000)	2989	1988	2989	1988	2989	1988	2989	1988	2989	1988	2989	1988
Ind.weight B1 (g)	0.02	6	81	262	475							
Ind.weight B2 (g)			0.02	6	81	262	475					
Ind.weight B3 (g)					0.02	6	81	262	475			
Ind.weight B4 (g)							0.02	6	81	262	475	
Ind.weight B5 (g)	475								0.02	6	81	262
Ind.weight B6 (g)	81	262	475								0.02	6
Biomass B1 (ton)	0	6	80	247	425	0	0	0	0	0	0	0
Biomass B2 (kg)	0	0	0	6	80	247	425	0	0	0	0	0
Biomass B3 (kg)	0	0	0	0	0	6	80	247	425	0	0	0
Biomass B4 (kg)	0	0	0	0	0	0	0	6	80	247	425	0
Biomass B5 (kg)	425	0	0	0	0	0	0	0	0	6	80	247
Biomass B6 (kg)	80	247	425	0	0	0	0	0	0	0	0	6
Biomass harvest (ton)	425		425		425		425		425		425	
Spes. Water req. average without oxygen (l/min pr kg)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
TOTAL WATER REQ. (m3/min)	303	152	303	152	303	152	303	152	303	152	303	152
TOTAL PRODUCTION VOLUME	10110	5070	10110	5070	10110	5070	10110	5070	10110	5070	10110	5070
TOTAL PRODUCTION AREA INCLUDED WALKWAYS 50% (m2)	5055	2535	5055	2535	5055	2535	5055	2535	5055	2535	5055	2535

INPUT VALUES	
Avg. Water requirement (l/min pr kg)	0.6
Assumed mortality pr month	5%
Assumed economical feed factor (prod. loss included)	1.5
Density in ongrowing (kg / m3)	50
Fry input pr Batch (1000)	1100
Water depth in raceways (m)	2
OUTPUT VALUES	
Total No. Harvested (1000)	5376
Production volume (m3)	10110
Max total water req.(m3/min)	303
Max total biomass (ton)	506
Total biomass produced	2552
Avg.retention time in fish tanks (min)	33
Feed pr.year ton)	3828
Production area incl walkways (m2)	5055

Bjørn Frode Eriksen:
This is full production with all fish in raceways on land.

SGR values for Tilapia in ponds

Generation G10 (Hans Magnus Gjøen 2008)

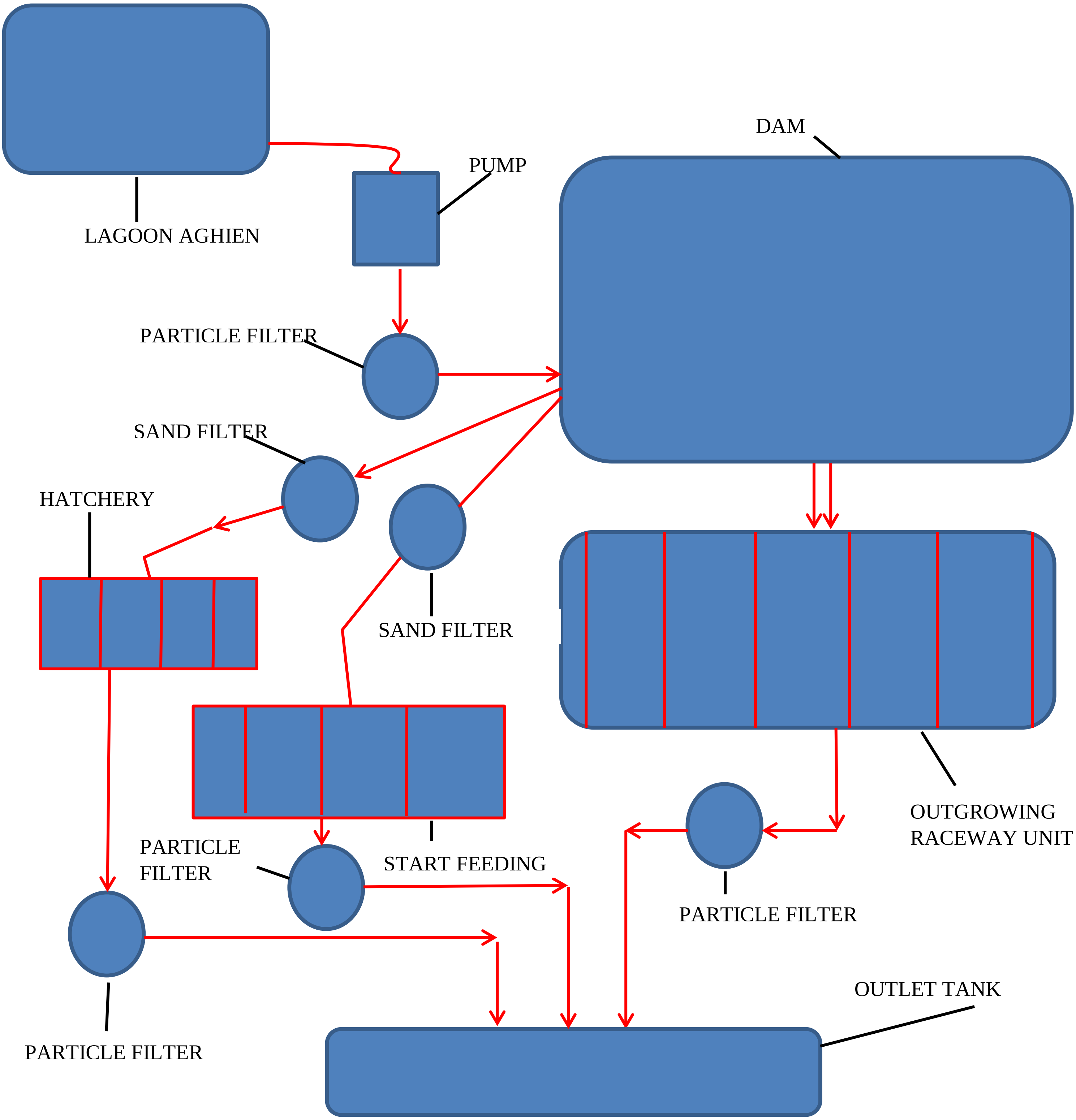
Temperature (°C)

Weight (g)	14 - 18	19 - 21	22 - 24	25 - 26	27 - 28	29 - 30	31 - 32
0	7,60 %	11,40 %	15,20 %	19,00 %	22,80 %	26,60 %	22,80 %
1	6,80 %	10,20 %	13,60 %	17,00 %	20,40 %	23,80 %	20,40 %
2	6,00 %	9,00 %	12,00 %	15,00 %	18,00 %	21,00 %	18,00 %
5	5,20 %	7,80 %	10,40 %	13,00 %	15,60 %	18,20 %	15,60 %
10	4,20 %	6,30 %	8,40 %	10,50 %	12,60 %	14,70 %	12,60 %
17	3,60 %	5,40 %	7,20 %	9,00 %	10,80 %	12,60 %	10,80 %
26	3,08 %	4,62 %	6,16 %	7,70 %	9,24 %	10,78 %	9,24 %
36	2,40 %	3,60 %	4,80 %	6,00 %	7,20 %	8,40 %	7,20 %
48	1,80 %	2,70 %	3,60 %	4,50 %	5,40 %	6,30 %	5,40 %
59	1,20 %	1,80 %	2,40 %	3,00 %	3,60 %	4,20 %	3,60 %
70	1,00 %	1,50 %	2,00 %	2,50 %	3,00 %	3,50 %	3,00 %
81	0,84 %	1,26 %	1,68 %	2,10 %	2,52 %	2,94 %	2,52 %
93	0,80 %	1,20 %	1,60 %	2,00 %	2,40 %	2,80 %	2,40 %
105	0,76 %	1,14 %	1,52 %	1,90 %	2,28 %	2,66 %	2,28 %
118	0,72 %	1,08 %	1,44 %	1,80 %	2,16 %	2,52 %	2,16 %
132	0,68 %	1,02 %	1,36 %	1,70 %	2,04 %	2,38 %	2,04 %
146	0,64 %	0,96 %	1,28 %	1,60 %	1,92 %	2,24 %	1,92 %
161	0,60 %	0,90 %	1,20 %	1,50 %	1,80 %	2,10 %	1,80 %
177	0,56 %	0,84 %	1,12 %	1,40 %	1,68 %	1,96 %	1,68 %
192	0,52 %	0,78 %	1,04 %	1,30 %	1,56 %	1,82 %	1,56 %
207	0,48 %	0,72 %	0,96 %	1,20 %	1,44 %	1,68 %	1,44 %
222	0,44 %	0,66 %	0,88 %	1,10 %	1,32 %	1,54 %	1,32 %
237	0,40 %	0,60 %	0,80 %	1,00 %	1,20 %	1,40 %	1,20 %
250	0,36 %	0,54 %	0,72 %	0,90 %	1,08 %	1,26 %	1,08 %
263	0,32 %	0,48 %	0,64 %	0,80 %	0,96 %	1,12 %	0,96 %
274	0,28 %	0,42 %	0,56 %	0,70 %	0,84 %	0,98 %	0,84 %
284	0,24 %	0,36 %	0,48 %	0,60 %	0,72 %	0,84 %	0,72 %
292	0,20 %	0,30 %	0,40 %	0,50 %	0,60 %	0,70 %	0,60 %

Source: Professor Bjørn Frode Eriksen

DRAWINGS

1. Flow chart
2. Farm with necessary rooms and departments



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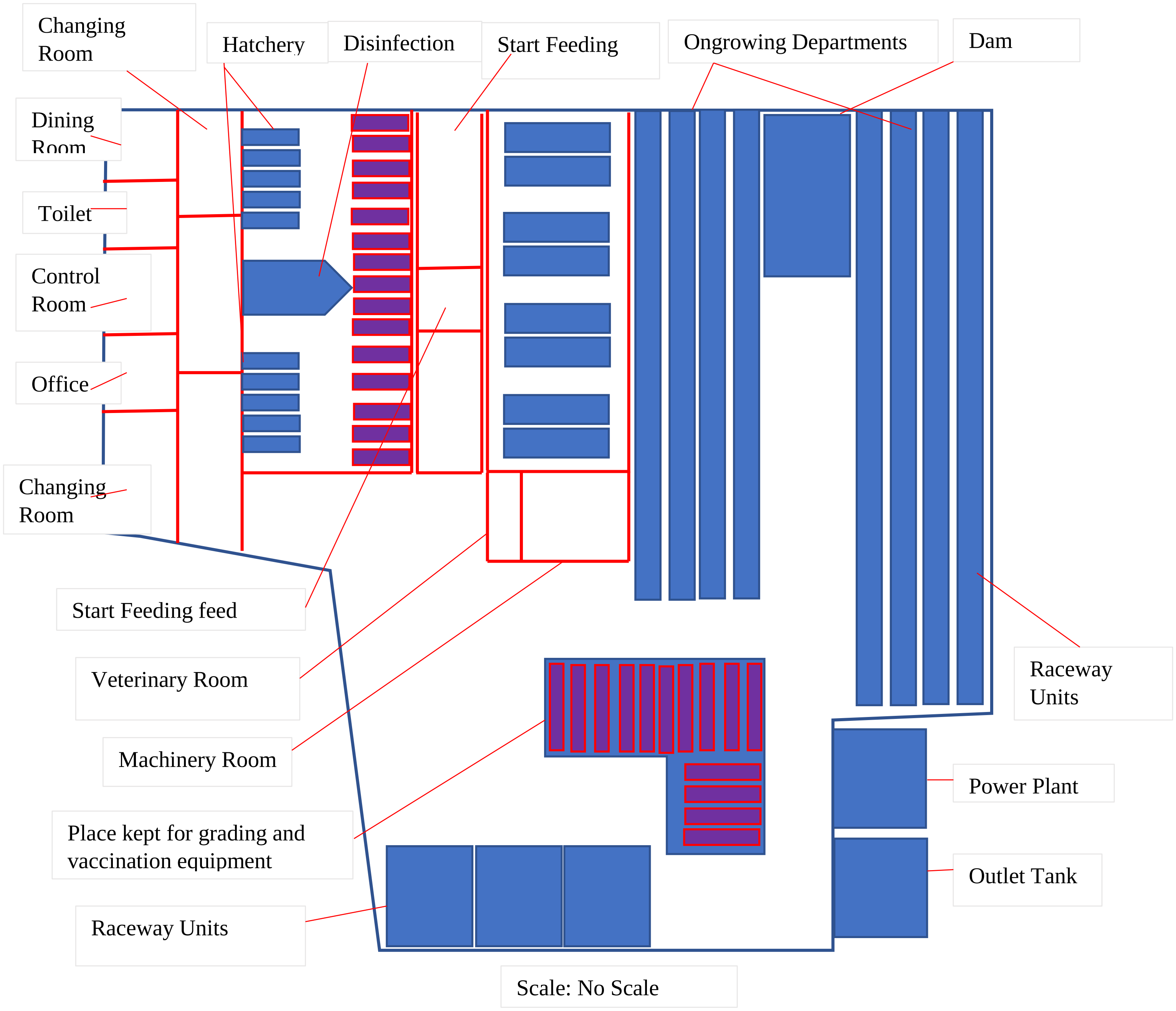

Changing Room
Hatchery
Disinfection
Start Feeding
Ongrowing Departments
Dam
Dining Room
Toilet
Control Room
Office
Changing Room
Start Feeding feed
Veterinary Room
Machinery Room
Place kept for grading and vaccination equipment
Raceway Units
Raceway Units
Power Plant
Outlet Tank
Scale: No Scale

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